CS 421: COMPUTER NETWORKS **SPRING 2008**

FINAL
May 22, 2008
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) (8 pts) Consider an error-prone link that is used for transmission of a file of size M bytes. Assume that the probability that a byte being corrupted (received with error) is p, $0 < p < 1$. Each segment has a total length of S bytes including a header of H bytes. The probability that a segment is received correctly is thus equal to $(1-p)^S$. Assume Stop-and-Wait mechanism is used for the file transfer, and all acknowledgements are received error-free. Calculate the optimum segment size S so that the expected value of the total number of bytes transmitted is minimized. *Hints:* For simplicity, assume that M/(S-H), i.e., number of packets necessary for transferring the file, is an integer. Recall that $\sum_{k=1}^{\infty} k(1-q)^{k-1} = \frac{1}{q^2}$.

b) (10 pts) In this problem we compare the Selective-Repeat and Go-Back-N protocols. For each of the following three parts, choose one of these two protocols that you think is superior (better) in terms of the mentioned factor (you can simply state your answer without a justification).

i) Number of retransmitted segments
ii) Amount of receiver buffering required
iii) Amount of processing at the receiver

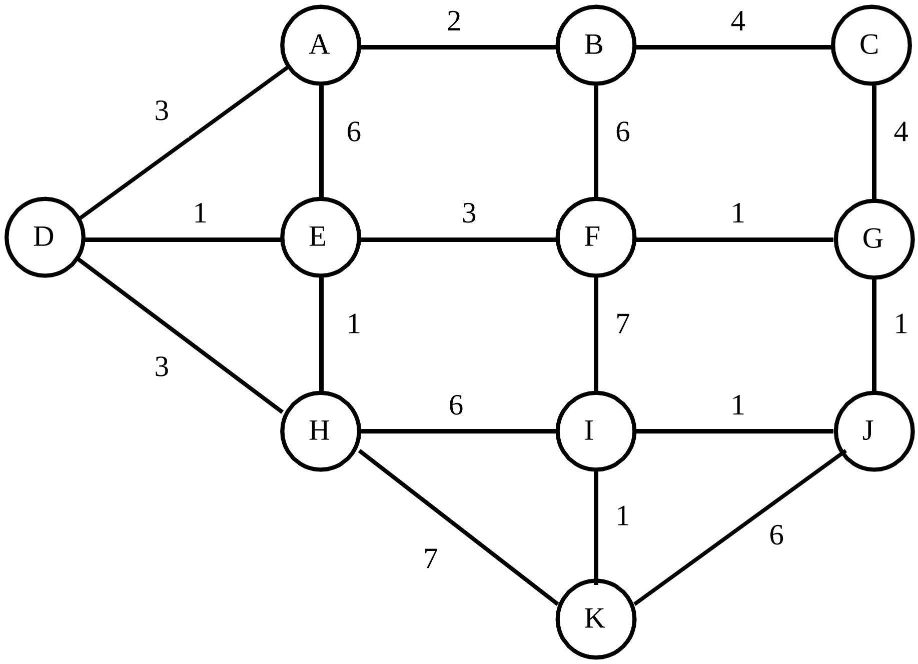
Answer the following two questions after weighing in all three factors mentioned in i)-iii).

iv) Which one of these two protocols would you use for a **low** bit error rate connection?
v) Which one of these two protocols would you use for a **high** bit error rate connection?

c) (10 pts) Assume that a TCP connection uses window scaling that allows receive window of up to 1 MBytes. Suppose that the TCP connection runs over a 1 Gbits/sec ($1x10^9$ bits/sec) link with a round-trip propagation delay of 100 msec and there is no other traffic on the link. We want to transfer a 1 MByte file over this TCP connection. Assume that TCP receive buffer is 1 MBytes, and the application process removes the data as soon as it is placed in the receive buffer. Assume further that TCP connection uses 1 KByte segments and no loss event occurs during the entire file transfer (for simplicity, assume that the whole file is transferred using 1000 segments). Further assume that the slow start threshold at the beginning of the connection is infinitely large. Ignore all processing and queueing delays. What is the total time from the beginning of the transmission of the first data segment until the sender receives the ACK for the last data segment?

2)

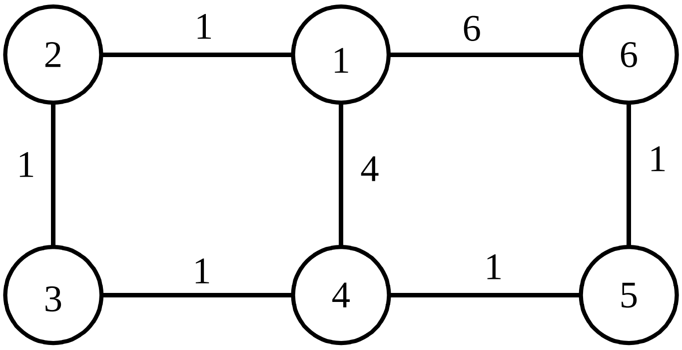
a) (12 pts) Execute the Dijkstra algorithm at node A for the network shown below by filling in the following table. In the table, you need to give both the distance *D(v)* and the previous node *p(v)*.



iter.	*N*	*D(B), p(B)*	*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) (12 pts) The network below uses the distance-vector routing algorithm. 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 = i, i = 0, 1, 2, 3,..., each node sends and receives routing info instantaneously, and updates its routing table; the update is completed by time t=i+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 cost of the link (5,6) becomes 10. 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 sec occurs at t = 1.0 sec. *Note:* However, whenever a link cost change occurs, the two nodes at the endpoints of this link immediately make corresponding changes in their distance tables.



Assume that the distance vector algorithm **does not use poisoned reverse**. Give the evolution of the distance tables with respect to destination 4. Specifically, give the distance table entries for destination 6 at nodes 1-5, 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 element denoting the distance from *i* to *j* .

Time, t	$D^1(6)$ via			$D^2(6)$ via		$D^3(6)$ via		$D^4(6)$ via			$D^5(6)$ via	
	2	4	6	1	3	2	4	1	3	5	4	6
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												
12.1												
13.1												
14.1												

c) You are given the assignment of setting subnet addresses for 4 buildings of your company. The number of Internet connected PCs in each building is given in the following table. Assume that the 148.118.128.0/18 address block is given to you for this purpose.

i. (8 pts) Use the following table to show the addresses of the four subnets that you have created.

Building	# of PCs	Subnet address (CIDR format)
1	3400	
2	2120	
3	1650	
4	450	

ii. (4 pts) What is the size of the **largest single** CIDR address block that you can assign from the unassigned addresses in the address block 148.118.128.0/18 remaining after you assigned the addresses to these four buildings?

d) (10 pts) Suppose host A transmits a 2100 byte IP packet (including the 20 Byte IP header) over a 2-hop path to host B. The MTU of the first link (A to router) is 1500 bytes (IP header plus data), and the MTU of the second link (router to B) is 500 bytes (IP header plus data). Assuming that IP header does not contain any options, indicate the length (in bytes), more flag, and offset field values **(specify the offset values in units of 8 bytes)** of the fragment(s) transmitted over each link in the tables below.

First link

Fragment	Length	Offset	Flag
1			
2			
3			
4			
5			
6			

Second link

Fragment	Length	Offset	Flag
1			
2			
3			
4			
5			
6			

3)

a) (8 pts) Suppose the data sequence 10111010 is transmitted using the generator sequence 100000111. Compute the CRC bits and the transmitted bit sequence. If the 2^{nd}, 8^{th}, 9^{th} and 10^{th} bits starting from the highest order bit in the received sequence are errored, determine whether this error can be detected by the receiver.

b) (6 pts) Consider an Ethernet LAN using CSMA/CD running at 100 Mbits/sec over a 1 km cable with no repeaters and with a maximum number of terminals equal to 20. The propagation speed for the signal over the cable is $2x10^5$ km/sec. Compute the minimum frame size for this network so that CSMA/CD protocol will run properly.

c) (6 pts) Suppose that nodes A and B are connected to the same Ethernet. Assume that nodes A and B are trying to retransmit two frames that have already experienced 2 and 5 collisions, respectively, i.e., collision counters are 2 and 5 for nodes A and B. Assume further that all other nodes on the Ethernet are inactive. Assuming that nodes A and B detect the last collision simultaneously, what is the probability that the first transmission after this collision will be a successful transmission by A?

d) (6 pts) Why is it necessary for network layer protocols running on top of the Ethernet, e.g. IP, to have a length field in their header?