CS 421: COMPUTER NETWORKS **FALL 2014**

FINAL
January 6, 2015
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) (5 pts) Suppose you are developing a multimedia networking application which requires a minimum data transfer rate from the network in order to function effectively. Which of the two transport layer protocols, TCP or UDP, will you prefer? Justify your answer.

b) (5 pts) Is it possible for an application to realize reliable data transfer even when the application runs over UDP? If so, how?

c) (6 pts) TCP uses cumulative acknowledgements as opposed to the individual acknowledgements. Give two advantages of using cumulative acknowledgements.

d) (7 pts) Assume that the bandwidth of a connection is 10 Mbits/sec (10×10^6 bits/sec) and the round-trip propagation delay for the connection is 20 msec. Assume that each data segment is 1000 Bytes long including the headers and the ACK packets are 40 Bytes long. Assuming that no packets are lost, what should be the **minimum window size (in terms of data segments)** in order to achieve full bandwidth utilization for this connection?

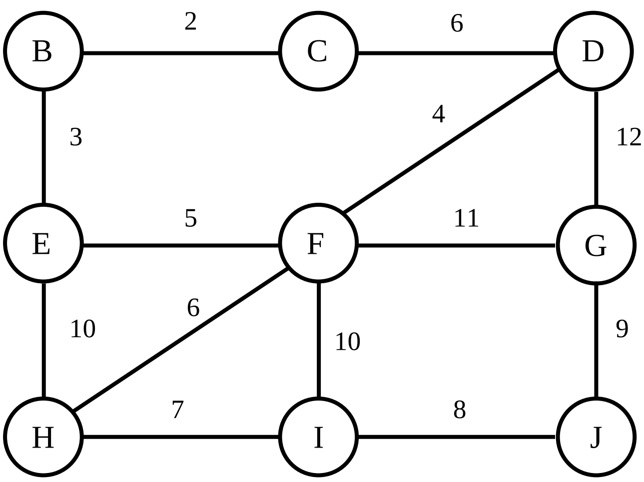
e) (8 pts) Suppose that a file composed of 32 segments, each with a size of 1250 Bytes, will be transferred over a TCP connection with a round-trip delay of 10 ms and bandwidth of 100 Mbps, i.e., 100×10^6 bps. Assume that no loss event occurs during the entire file transfer. Further assume that the slow 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. How long does it take to transmit the entire file and receive the final ACK?

2)

a) (7 pts) The Dikjstra algorithm that we studied in class is given below. Dijkstra's algorithm computes all least-cost (shortest) paths from node u to all other nodes in the network where the cost of a path (x_1, x_2, x_3,…, x_p), denoted as pc(x_1, x_2, x_3,…, x_p), is given by the sum of all the link costs along the path, i.e., pc(x_1, x_2, x_3,…, x_p) = c(x_1,x_2) + c(x_2,x_3) + … + c(x_{p-1},x_p). Now assume that we modified the definition of the path cost as the maximum of all the link costs along the path, i.e., pc(x_1, x_2, x_3,…, x_p) = max{c(x_1,x_2),c(x_2,x_3),…,c(x_{p-1},x_p)}. Use the following table to give the Modified Dijkstra Algorithm, which computes all least-cost paths from node u to all other nodes using the modified definition of the path cost.

Dijkstra Algorithm	**Modified Dijkstra Algorithm**
N' = {u}	
for all nodes v	
if v adjacent to u	
then D(v) = c(u,v)	
else D(v) = ∞	
Repeat	
find w not in N' such that D(w) is a minimum	
add w to N'	
for all v adjacent to w and not in N'	
D(v) = min(D(v), D(w) + c(w,v))	
until all nodes in N'	

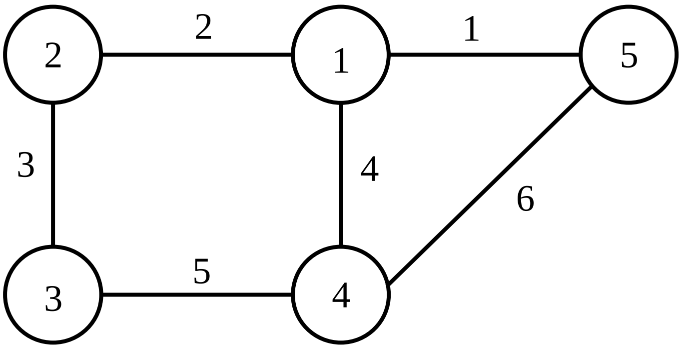
b) (7 pts) Execute the Modified Dijkstra algorithm that you developed in part 2.a) to the shortest path problem **at node B** for the network shown below by filling in the following table.



Step	***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)***

c) (8 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 (1,5) becomes 12. There are no further link cost changes.
- 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 5. 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	$D^1(5)$ via			$D^2(5)$ via		$D^3(5)$ via		$D^4(5)$ via		
	2	4	5	1	3	2	4	1	3	5
0.1										
0.5										
1.1										
2.1										
3.1										
4.1										
5.1										
6.1										
7.1										
8.1										

d) (4 pts) Consider the IP forwarding table entry at node 2 regarding destination node 5 in Question 2.c). Is there any change in the entry regarding destination 5 between its state before the link cost change occurs and its state after the algorithm reconverges following the link cost change? Justify your answer.

e) (6 pts) You are given the assignment of setting subnet addresses for 6 departments of your company. The number of Internet connected PCs in each department is given in the following table. Assume that the 139.179.128.0/19 address block is given to you for this purpose. Use the following table to show the addresses of the six subnets that you created.

Campus	**# of PCs**	**Subnet address (CIDR format)**
1	3000	
2	1000	
3	800	
4	500	
5	400	
6	200	

3)

a) (6 pts) Suppose the data sequence 0101100101 is transmitted using the generator sequence 1111011001. Compute the CRC bits and the transmitted bit sequence.

b) (6 pts) Consider an acoustic underwater network using the CSMA/CD MAC mechanism. The underwater network is running at 10 Kbits/sec, and the propagation speed for the signal over the acoustic underwater channel is 1500 m/sec. The distances between the nodes in this Ethernet are given in the following table. Compute the minimum frame size in bytes so that the CSMA/CD algorithm will work properly for this underwater network.

Distance (m)	A	B	C	D
A	-	100	300	450
B	100	-	360	540
C	300	360	-	200
D	450	540	200	-

c) (5 pts) Suppose that you implemented the underwater network described in 3.b) and observed that the probability of collision in the network is very high. Give an explanation for this high probability of collision.

d) (5 pts) Why does the efficiency of Ethernet increase as the frame lengths increase? Describe your reasoning in words instead of giving an equation.

e) Assume that there are four nodes A, B, C and D on a 100 Mbits/sec Ethernet. Suppose these four nodes are involved in a collision which is the first collision for A's frame, third collision for B's frame, fifth collision for C's frame and sixth collision for D's frame. After the collision is detected (we assume that all nodes detect the collision exactly at the same time), nodes calculate their backoff times according to the binary exponential backoff algorithm.

   i. (5 pts) What is the probability that the first transmission after the above collision will be a successful retransmission by A?

   ii. (5 pts) What is the probability that the first transmission after the above collision will be a successful retransmission by D?

   iii. (5 pts) What is the probability that the first transmission after the above collision will be another collision?