

**FINAL**  
**May 21, 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.**

<b>Q1</b>	
<b>Q2</b>	
<b>Q3</b>	
<b>TOT</b>	

1)

a) (6 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) Complete the following table.

	Router	Switch	Hub
Layer of operation (1,2,3,4,5)			
Isolates network traffic (Yes,No)			
Does not require configuration from network administrator (Yes,No)			
May implement OSPF (Yes,No)			
Has store and forward capability (Yes,No)			

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 ( $10 \times 10^6$  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.,  $100 \times 10^6$  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) (10 pts) Four subnets are defined by the following IP prefixes:

Subnet	Subnet address
1	139.179.0.0/16
2	139.183.0.0/16
3	140.183.14.0/23
4	140.183.192.0/18

In the following table indicate to which subnets the following hosts with given IP addresses belong. If there are some hosts that do not belong to any of the subnets, mark them with a “-”.

Host	IP Address	Subnet
A	139.179.12.118	
B	139.183.12.16	
C	140.183.12.115	
D	140.183.190.55	
E	140.183.224.88	

- b) (6 pts) The largest IP router can hold 200,000 entries in its forwarding table while the largest Ethernet switch can hold 1,000,000 entries in its forwarding table. However, a large IP network can support many more hosts than a large Ethernet network. Why?

- c) (12 pts) The Dijkstra algorithm that we studied in class is given below. Dijkstra's algorithm computes all least-cost (i.e., shortest) paths from node  $u$  to all other nodes in the network where the cost of a path  $(x_1, x_2, x_3, \dots, x_p)$ , denoted as  $pc(x_1, x_2, x_3, \dots, x_p)$ , is given by the sum of all the link costs along the path; that is,

$$pc(x_1, x_2, x_3, \dots, x_p) = c(x_1, x_2) + c(x_2, x_3) + \dots + c(x_{p-1}, x_p).$$

Now assume that we modified the definition of the path cost as the product of the link costs along the path; that is,

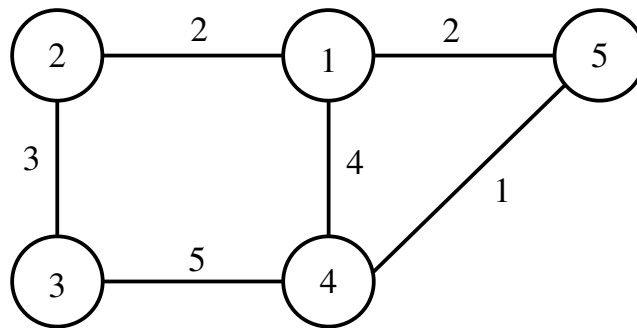
$$pc(x_1, x_2, x_3, \dots, x_p) = c(x_1, x_2) * c(x_2, x_3) * \dots * c(x_{p-1}, x_p),$$

where the costs are real numbers in the interval  $(0,1)$ . Considering that the costs are probabilities of links being intact (i.e., working), that the costs of links are independent of each other, and the task is to find the most reliable (i.e., **highest cost**) paths from node  $u$  to all other nodes in the network, use the following table to give a Modified Dijkstra Algorithm which solves this new problem.

Hint: Note that  $-\log(a * b) = -(\log a + \log b)$ .

Dijkstra Algorithm	Modified Dijkstra Algorithm
$N' = \{u\}$	
for all nodes $v$	
if $v$ adjacent to $u$	
then $D(v) = c(u, v)$	
else $D(v) = \infty$	
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 $N'$	

- 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  $t = i$ ,  $i = 0, 1, 2, 3, \dots$ , 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 (4,5) becomes 3. 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**.



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  $j$ .

[illegible]

3)

- a) (6 pts) Suppose the data bit sequence,  $D$ , to be transmitted is 4 bits long and the CRC bit sequence,  $R$ , to be transmitted is 3 bits long. That is,  $X = 2^3 D \text{ XOR } R$  is the bit sequence to be transmitted. If  $G = 1001$  is the generator bit sequence, give an error bit sequence  $E$  which will **not** be detected. In other words, give an example  $E$  for which  $X' = X \text{ XOR } E$  is perceived as being correct at the receiver.
- b) Suppose that nodes A, B and C are connected to the same Ethernet. Assume that each of these three nodes is trying to retransmit a frame. These frames have already experienced 2, 3, and 4 collisions, respectively, i.e., collision counters are 2, 3 and 4 for nodes A, B and C. Assume further that all other nodes on the Ethernet are inactive.
- (5 pts) Assume that all three nodes detected the last collision simultaneously. Node C chooses 5 as the random number according to the exponential backoff algorithm. What is the probability that A will be the first node initiating a retransmission attempt?
  - (5 pts) Consider part i. if node C chooses 2 as the random number (instead of 5). What is the probability that B will be the first node initiating a retransmission attempt?
- c) (6 pts) Consider a 100 Mbps 100BaseT Ethernet network with a star topology composed of 5 nodes where each node has a point-to-point connection with a hub in the middle. The distances from the 5 nodes to the hub are given by 100m, 200m, 500m, 900m and 1000 m, respectively. Calculate the minimum frame size that this LAN can support so that the CSMA/CD protocol will function correctly. Assume that the speed of propagation is  $2 \times 10^8$  m/s.

d) Consider the network given in the figure below, where hosts X, Y, Z, W are connected via Switches 1, 2 and 3. Initially assume that the switch (i.e., bridge) tables of all switches are empty. Recall that each switch applies the self learning algorithm to learn which hosts can be reached through which interfaces. Answer the questions below when the following events happen sequentially over time.

- i. (3 pts) First, X sends a packet to Z. Which switches learn where X is, and does Y's network interface see this packet?
- ii. (3 pts) Z now sends a packet to X (after X has sent to Z). Which switches learn where Z is, and does Y's network interface see this packet?
- iii. (2 pts) Next, Y sends a packet to X (after the above two packets). Which switches learn where Y is, and does Z's network interface see this packet?
- iv. (2 pts) Finally, Z sends a packet to Y (after the above three packets). Which switches learn where Z is, and does W's network interface see this packet?

