CS 421: COMPUTER NETWORKS **FALL 2013**

FINAL
January 8, 2014
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 that a packet composed of *N* bits is transmitted over a connection, where the probability of bit error is *p* for each bit, independent of other bits. Calculate the probability that the packet is received correctly.

b) (5 pts) Give an example of a protocol that we learned in this course which violates the layered protocol architecture of the Internet. Explain how the protocol in your answer violates the layering principle.

c) (5 pts) Assume that there is a TCP connection with a roundtrip time of 100 ms. What is the maximum possible data transfer rate, in bps, for this connection assuming that TCP Options are not used? *Hint:* Recall that the Receive Window field in the TCP header is 2 Bytes long.

d) Consider a home network which is connected to the Internet with an ADSL link that has a download rate of 10 Mbps. Assume that there are three file downloads from servers A, B and C sharing the link and the ADSL link is the only bottleneck link for all three downloads. The round-trip delays between the home network and servers A, B and C are 50 ms, 100 ms and 300 ms, respectively.

   i) (5 pts) Suppose TCP is used as the transport layer protocol for all three downloads. Calculate the throughput achieved by each download.

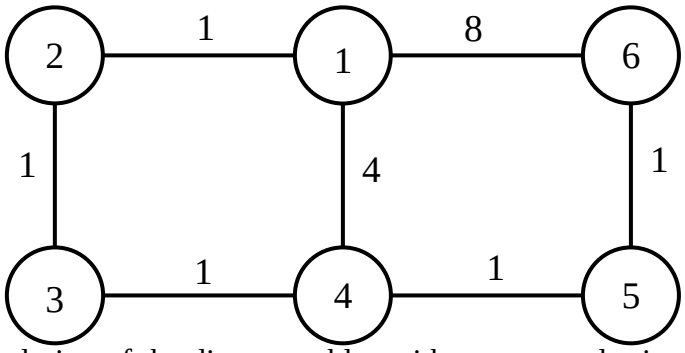
   ii) (5 pts) Suppose that UDP is used as the transport layer protocol for all three downloads. Servers A, B and C are sending data at rates of 4 Mbps, 6 Mbps and 10 Mbps, respectively. Calculate the throughput achieved by each download.

e) (8 pts) Suppose that a file composed of 50 segments, each with a size of 1250Bytes, will be transferred over a TCP connection with a round-trip delay of 10 ms and bandwidth of 10 Mbps, i.e., $10x10^6$ bits/second. 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. How long does it take to transmit the entire file and receive the final ACK?

2)

a) 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 (4,5) becomes 7. 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**.



i) (12 pts) Give the evolution of the distance tables with respect to destination 6. 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												

b) （8 pts） Suppose host A transmits a 3000 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 900 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			

c) （5 pts） You are given the assignment of setting subnet addresses for 5 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 five subnets that you created.

Campus	**# of PCs**	**Subnet address (CIDR format)**
1	3000	
2	1500	
3	1000	
4	400	
5	300	

d) (5 pts) Suppose router A sends a BGP path advertisement to router B. Router B is also connected to router C. Will router B always advertise this path to router C? Justify your answer.

e) (5 pts) Why does the distance vector routing algorithm RIP choose the infinity distance metric as 16, which is a relatively small value?

3)

a) (6 pts) Suppose the data sequence 111001001 is transmitted using the generator sequence 110011011. Compute the CRC bits and the transmitted bit sequence.

b) (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. The distances between the nodes in this Ethernet are given in the following table. Suppose node A started a transmission at time 0. Calculate the earliest time after which we can be sure that node A's frame will not collide with another transmission, if node A does not detect a collision by then.

Distance (m)	A	B	C	D
A	-	300	350	400
B	300	-	450	500
C	350	450	-	550
D	400	500	550	-

c) (5 pts) Why is Ethernet's exponential backoff algorithm better than randomizing retransmission attempts over a fixed-length time interval?

d) 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 second collision for A's frame, first collision for B's frame, second collision for C's frame and fifth 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 B?

e) Consider the network below with six hosts (A, B, C, D, E, F), two switches (S1 and S2) and one router (R). For each host and router interface, the figure shows the corresponding IP address and MAC address. Assume that the routers and hosts are correctly configured with correct routing information, i.e., their forwarding tables are correctly configured. Assume further that **ARP tables of the router and all hosts are fully populated** with the IP-MAC address mappings of all network interfaces in the LAN. On the other hand, the **switch tables of both switches are initially empty**.

i. (3 pts) Assume that host A is sending a single IP packet to host B. Which of the six hosts in the network will receive the frame containing the datagram sent by A to B? Justify your answer.

ii. (3 pts) Answer the question in i. if host A was sending the IP packet to host E.