CS 421: COMPUTER NETWORKS **FALL 2008**

FINAL
January 10, 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) An HTTP client and a server are connected by a TCP connection over a high speed network. The roundtrip time of the connection is 100 milliseconds. The client wants to download data from the server at a rate of 80 Mbps.

   i) (5 pts) What is the minimum receiver buffer space that is needed at the client in order to achieve a rate of 80 Mbps?

   ii) (5 pts) Can TCP achieve a rate of 80 Mbps in this scenario without using Options? Justify your answer.

b) You have developed a new reliable data transport protocol called Go4Bilkent. This protocol sends 4 segments in a row and then waits to receive a single ACK for all four segments. If one segment is received in error (assume no segments are lost), the receiver discards all other segments and it sends an NAK. When the sender receives a NAK, it has to retransmit all four segments. In this problem, you can ignore the processing times of segments and ACKs/NAKs at the hosts, but you need to take into account all other sources of delay. We have the following notation:

   - T_{prop} = one-way end-to-end delay (including propagation, queueing, store-and-forward and processing delays inside the network)
   - N_A = numbers of bits in an ACK or NAK segment
   - N_D = number of bits in a data segment (including header)
   - N_H = number of header bits in a data segment
   - P_f = probability that the transmission of a data frame fails (assume that ACKs are reliable)
   - R = transmission rate between sender and receiver

   i) (7 pts) Calculate the average duration for sending four segments and receiving the corresponding ACK. Recall that $\sum_{k=1}^{\infty} k(1-q)^{k-1} = \frac{1}{q^2}$.

   ii) (5 pts) Calculate the average utilization of the receiver, $U_{receiver}$, defined as the fraction of time receiver is busy receiving **data bits successfully**, occuring when all four segments are received correctly.

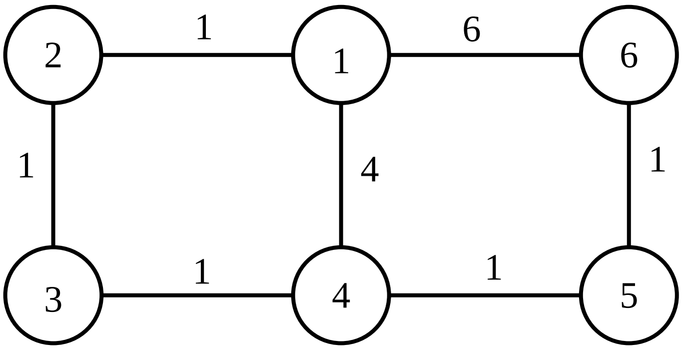
c) (4 pts) Consider hosts A and B in the Internet, such that there are two paths between A and B. Suppose that there is a single TCP connection for transporting data packets from A to B. Give an **advantage** and a **disadvantage** of using both paths concurrently, i.e., some data packets are routed over one path whereas other packets are routed along the other path.

d) (4 pts) What happens if UDP traffic shares the same bottleneck link with TCP flows? Would the capacity be split fairly between UDP and TCP flows? Why or why not?

2)

a) (10 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 15. 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. 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 **uses poisoned reverse**. 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												

b) (5 pts) The following is a forwarding table at router R, which uses CIDR.

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.

(i) 139.179.39.179
(ii) 139.179.72.68
(iii) 196.101.153.136
(iv) 139.179.39.108
(v) 196.101.153.115

c) (5 pts) Divide the network with CIDR prefix 139.179.0.0/17 into /20 subnetworks. Show each subnetwork in CIDR format.

d) (5 pts) Suppose the following four subnetworks are aggregated into a single subnetwork: 139.179.192.0/20, 139.179.208.0/20, 139.179.224.0/20, 139.179.240.0/20. Find the CIDR prefix that should be used in order to advertise this aggregated subnetwork.

e) (5 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 switch table. However, a large IP network can support many more hosts than a large Ethernet network. Why?

f) (5 pts) State two modifications of IPv6, from IPv4, that allow a router to process a packet faster.

3)

a) The original Ethernet invented at Xerox PARC was very similar to modern 10 Mbps Ethernet: it used the same sized Ethernet header (with 8 Byte preamble for synchronization, 6 Byte (each) source and destination addresses, 2 Byte type field and finally 4 Byte CRC at the trailer of the frame) as the modern 10 Mbps Ethernet and the same CSMA/CD MAC protocol. However, the transmission rate of the original Ethernet was 3 Mbps.

   (i) (5 pts) Assuming that the length and signal propagation speeds of the Ethernet cables were identical and keeping in mind that the minimum total frame size of 10 Mbps Ethernet is 64 Bytes, what should be the minimum frame size for the original Ethernet?

   (ii) (5 pts) However, unlike the modern Ethernet, the original Ethernet did not have a minimum frame size. Was this a mistake? If not, what could be the reason that the original Ethernet did not have a minimum frame size?

b) Consider two nodes A and B on a shared link, and both nodes need to transmit frames to node C which is also on the same broadcast link. Assume that there are no other nodes that currently want to transmit packets on the shared link. Assume that we use the Slotted Aloha protocol. Suppose that a collision just occurred when A and B transmit in then same slot.

   (i) (5 pts) In this part, assume that each node retransmits the collided frame with probability p in each slot. What is the maximum efficiency, i.e., maximum probability of a successful slot, for this system?

   (ii) (5 pts) Now assume that node A retransmits in each slot with probability p, whereas node B retransmits in each slot with probability 2p, where $p < 1/2$. What is the maximum efficiency in this case?

   (iii)(5 pts) Compare the results in (i) and (ii) in terms of efficiency. Does the efficiency evenly distributed between the two nodes in both scenarios? What is the penalty of achieving a higher efficiency?

c) Suppose that Ethernet became the only existing LAN technology, so every host in the Internet became part of an Ethernet local area network and therefore had a globally unique Ethernet MAC address.

   (i) (5 pts) As a network engineer to be, would you recommend to get rid of IP addresses by simply using Ethernet addresses instead of IP addresses? Why or why not?

   (ii) (5 pts) Now let’s ask the same question the other way around: Why don’t we simply assign IP addresses to network interfaces instead of Ethernet addresses so we don’t have to deal with both IP and Ethernet addresses?