CS 421: COMPUTER NETWORKS **FALL 2010**

FINAL
January 10, 2011
150 minutes

Name: ______________________________

Student No: ___________________________

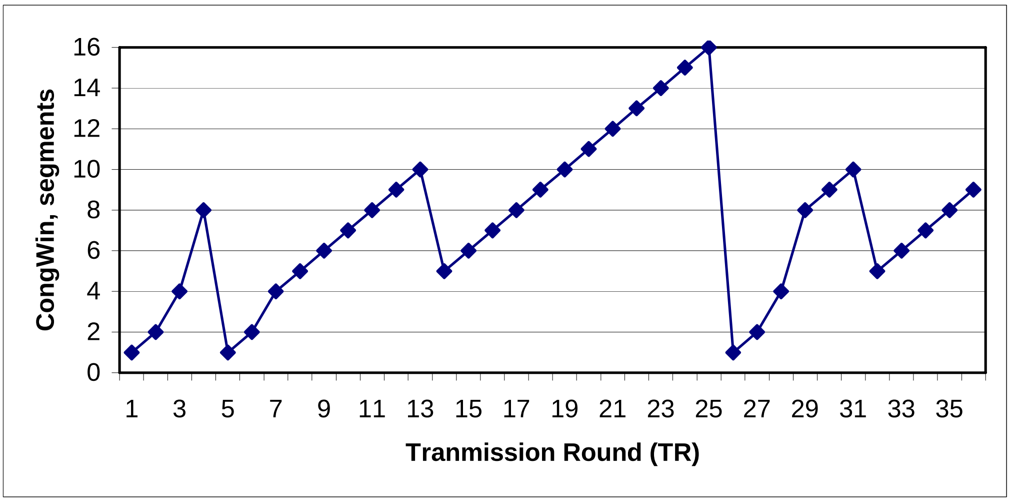
Show all your work very clearly. Partial credits will only be given if you carefully state your answer with a reasonable justification.

Q1	
Q2	
Q3	
TOT	

1)

a) (7 pts) Assume that the bandwidth of a connection is 10 Mbits/sec ($10x10^6$ bits/sec) and the round-trip propagation delay for the connection is 15 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 units of data segments)** in order to achieve full bandwidth utilization for this connection?

b) (7 pts) The following figure shows the evolution of the Congestion Window for a TCP connection as a function of time. The x-axis denotes the Transmission Round (TR), where each tick corresponds to one round-trip-time (RTT) (assume that all packets have negligible transmission times). The y-axis is the Congestion Window in segments at the beginning of each TR. Use the table below in order to identify the time intervals during which Congestion Control algorithm is in a certain phase, i.e., Slow Start (SS) or Congestion Avoidance (CA), the value of the Slow Start threshold (ssthresh) parameter during that time interval and the reason for the phase/parameter change which ends that time interval, for TR = 1,…,36.



Time Interval [starting TR,ending TR]	Phase (SS or CA)	ssthresh (in segments)	Event causing phase or parameter change
[1 ,]			
[,]			
[,]			
[,]			
[,]			
[,]			
[, 36]			

c) Suppose we have a web server and a web client connected by a link of rate R bits/sec. Let RTT be the round-trip delay of the link. Let S denote the maximum segment size of TCP. Suppose the client would like to retrieve a file of size F, F = 10*S, from the server using the HTTP protocol. Assume that the SYN, SYNACK, HTTP request and TCP ACK packets all have negligibly small sizes, i.e., their transmission times can be taken as 0. All data packets, i.e., packets containing file content, on the other hand have sizes equal to S. Ignore the sizes of all the protocols headers. Assume that the server and the client can send/receive an ACK while receiving/sending data. Let T be the period from the time at which the client initiates the TCP connection to the server until the time at which the client has completely downloaded the file. Calculate T in terms of S/R for each of the following values of RTT. Note that server will start in the slow-start phase with a congestion window of size 1 segment. Also assume that the slow-start threshold is infinitely large and there are no packet losses so that the TCP connection will be in the slow-start phase during the whole transmission of the file.

i) (5 pts) RTT = 0

ii) (7 pts) RTT = 4*(S/R)

d) (6 pts) Fill the table below. In the table, on the first column, some protocol names are listed. *For each protocol*, write down 1) the name of the directly-underlying (i.e. encapsulating) protocol whose name can be selected from the 1st column; 2) the layer to which the protocol belongs.

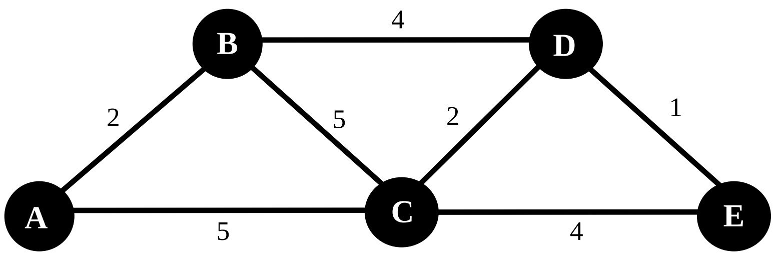
1st column: Protocol	Runs directly on top of which protocol (i.e., what is the encapsulating protocol)? *You can select a protocol from the 1st column.*	Considered as part of which layer? (application, transport, network, link-layer)
IP		
TCP		
UDP		
ARP		
Ethernet		
Physical Layer	XXXXX	XXXXX
HTTP		
DNS		
ICMP		

2)

a) (10 pts) The network below uses the distance-vector routing algorithm **without poisoned reverse**. 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 = k, k = 0, 1, 2, 3,..., each node sends and receives routing info instantaneously, and updates its routing table; the update is completed by time t = k+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 (D,E) becomes 8. 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 occurs at t = 1.0. *Note:* However, whenever a link cost change occurs, two nodes at the endpoints of this link immediately make corresponding changes in their distance tables.

Give the evolution of the distance tables with respect to destination E. Specifically, give the distance table entries for destination E at nodes A, B, C, D 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 denoting the distance from *i* to *j* .



t	**D^A(E), via**		**D^B(E), via**			**D^C(E), via**				**D^D(E), via**		
	B	C	A	C	D	A	B	D	E	B	C	E
0.1												
0.5												
1.1												
2.1												
3.1												
4.1												
5.1												

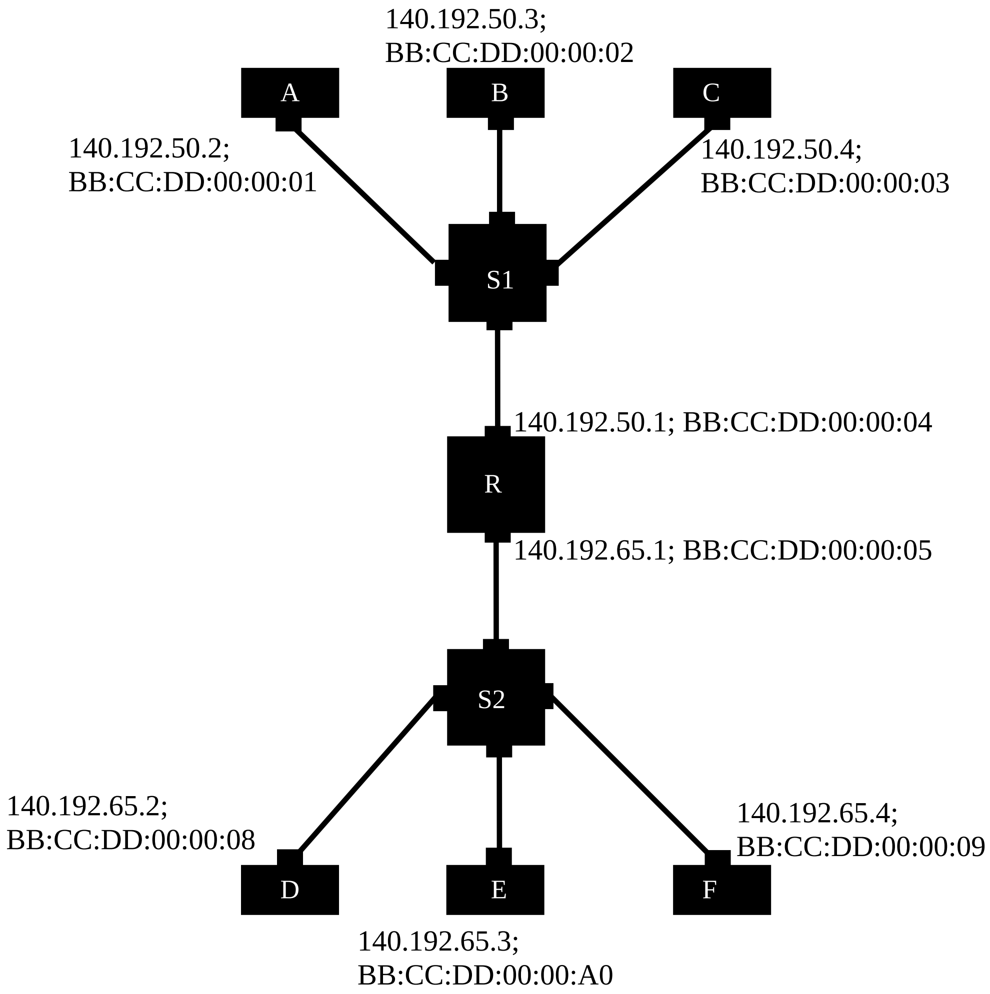
b) (3 pts) Give three reasons why IPv6 can process packets faster that IPv4.

c) (6 pts) Suppose a network contains four subnetworks 118.80.58/24, 118.80.59/24, 118.80.60/24, 118.80.61/24, 118.80.62/24 and 118.80.63/24. We want to announce these subnetworks using the **fewest number of CIDR prefixes** that exactly cover all of the above subnetworks. Find the prefixes making sure that all subnetworks are covered, no other addresses are included and minimum number of prefixes are used.

d) (6 pts) Assume a company has the network prefix 172.118.64.0/19 (i.e., this is the network address space of the company that it can use to generate subnets and assign IP addresses to hosts). Assume the company has 5 departments, each department having the number of hosts indicated in the table below. Assume you are the network administrator and you will generate subnets, one subnet per department. Show in the table below the subnets that you will generate.

Department	Host Count	Subnet Number (i.e. Prefix) (in form 172.118……/x)
1	2000	
2	2000	
3	2000	
4	1000	
5	1000	

e) Consider the below network with 6 hosts (A, B, C, D, E, F), 2 switches (S1 and S2) and 1 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 the switch tables of the switches and the ARP tables of the router and all hosts are initially empty. Assume that host A is sending an IP datagram to host E, and host A knows host E's IP address. Answer the following questions considering **all** the packets transmitted on the links until the IP datagram reaches E.



i) (3 pts) For **all** the packets that will be transmitted over link A-S1 (**in both directions**), provide the information requested in the table below. Note that some of the requested information on a line may not be applicable for some packets. Packets should be listed in the order of their appearance on the link.

Pkt	Type (ARP or IP)	Source Ethernet Address	Destination Ethernet Address	Source IP address in IP header (if any)	Dest IP address in IP header (if any)
1					
2					
3					

ii) (3 pts) For **all** the packets that will be transmitted over link S1-R (**in both directions**), provide the information requested in the table below. Note that some of the requested information on a line may not be applicable for some packets. Packets should be listed in the order of their appearance on the link.

Pkt	Type (ARP or IP)	Source Ethernet Address	Destination Ethernet Address	Source IP address in IP header (if any)	Dest IP address in IP header (if any)
1					
2					
3					

iii) (3 pts) For **all** the packets that will be transmitted over link S2-E (**in both directions**), provide the information requested in the table below. Note that some of the requested information on a line may not be applicable for some packets. Packets should be listed in the order of their appearance on the link.

Pkt	Type (ARP or IP)	Source Ethernet Address	Destination Ethernet Address	Source IP address in IP header (if any)	Dest IP address in IP header (if any)
1					
2					
3					

iv) (3 pts) For **all** the packets that will be transmitted over link S2-F (**in both directions**), provide the information requested in the table below. Note that some of the requested information on a line may not be applicable for some packets. Packets should be listed in the order of their appearance on the link.

Pkt	Type (ARP or IP)	Source Ethernet Address	Destination Ethernet Address	Source IP address in IP header (if any)	Dest IP address in IP header (if any)
1					
2					
3					

3)

a) (7 pts) Given the following 8-bit data sequence 11001010 and the generator sequence 1001, compute the CRC bits.

b) (6 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 and the maximum distance between any two adapters in the Ethernet LAN is 500 m. Calculate the minimum Ethernet frame size such that the CSMA/CD algorithm will work properly.

c) Assume that there are three active nodes (A, B, C) competing for access to a channel using the Slotted-Aloha MAC protocol. Assume that each node has infinite number of packets to transmit. Each node attempts to transmit in each slot with probability p. The first slot number is 1, the second is slot 2, and so on.

   i) (4 pts) Calculate the probability that some node (either A, or B, or C) makes a successful transmission in a given slot.

   ii) (4 pts) Calculate the probability that the first successful transmission among the three nodes occurs in slot 4.

   iii) (4 pts) Calculate the probability of a collision in a time slot.

d) (6 pts) Assume that the propagation delay in a given 802.11 wireless LAN is negligibly small. Can carrier sensing avoid all collisions? Fully justify your answer.