CS 421: COMPUTER NETWORKS **FALL 2004**

FINAL
January 11, 2005
150 minutes

Name: ______________________________

Student No: ___________________________

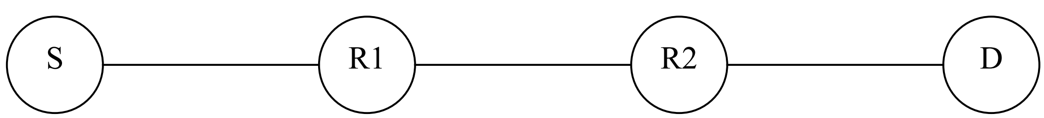
1)

a) (10 pts) Consider a 1 Mbits/sec channel with a 20 msec one-way propagation delay, i.e., 40 msec roundtrip delay. We want to transfer a file of size 8000 Bytes. Each packet has a total size of 1000 Bytes including the 40 Bytes header. When there is data to be transmitted, each packet contains the maximum number of bytes. Assume that ACK packets are of 125 Bytes long and there is a processing delay of 2 msec after a packet is fully received at the receiver until the transmission of the corresponding ACK is started. Selective Repeat protocol is used with a window size of N = 6 packets. Assume that every 6^{th} packet crossing the forward channel is lost while ACKs are not lost or corrupted. How much time is required to complete the transfer of the whole file and receive the final ACK at the sender?

b) (8 pts) Suppose that a TCP connection has a RTT (including all propagation, processing, queuing and store-and-forward delays) of 40 ms. The transmission time for each packet is 5 msec, and ACK packets have negligible transmission times. The TCP sender starts with the Slow Start phase, and the Threshold is initially set to 6 segments. How long does it take until the sender reaches the Congestion Avoidance phase?

c) (6 pts) Suppose upon receiving a segment containing *N* Bytes of data, the TCP receiver divides the received data into *M* parts, where $M \leq N$, and sends *M* separate acknowledgements each covering one of the *M* distinct pieces of the received data sequence instead of sending a single acknowledgement. Is there any advantage for the TCP receiver obtained as a result of this behavior? **Use at most three sentences.**

d) (10 pts) We want to transfer of a file of size M Bytes from S to D in the datagram based packet switching network shown below using UDP as the transport layer protocol. Node S segments the file into packets of size P Bytes and adds a 40 Byte header to each packet, i.e., each packet contains P+40 Bytes. Assume that links (S-R1), (R1-R2) and (R2-D) have transmission rates of R bits/sec, and each link has propagation delays of Δ seconds in each direction. Also assume that there is a fixed processing delay of τ seconds at R1 and R2 and all queuing delays are negligible. Determine the value of P that minimizes the total delay of transferring the file from S to D. For simplicity, you can assume that M is an integer multiple of P.



2)

a) (10 pts) The following is a routing table using Classless Interdomain Routing (CIDR) at router R. Address bytes are shown in dotted decimal notation. The notation "/12" in 196.80.0.0 / 12 denotes that the leading 12 bits constitute the network portion of the address.

Destination Network	**Next Hop**
196.80.0.0 / 12	A
196.94.16.0 / 20	B
196.96.0.0 / 12	C
196.104.0.0 / 14	D
128.0.0.0 / 1	E
64.0.0.0 / 2	F

Suppose packets with the following destination IP addresses arrive at router R. State to what next hop each of these packets will be delivered (Give **only one** answer for each destination.)

(i) 176.94.16.0
(ii) 96.94.19.135
(iii) 196.94.32.128
(iv) 196.100.100.100
(v) 196.105.100.18

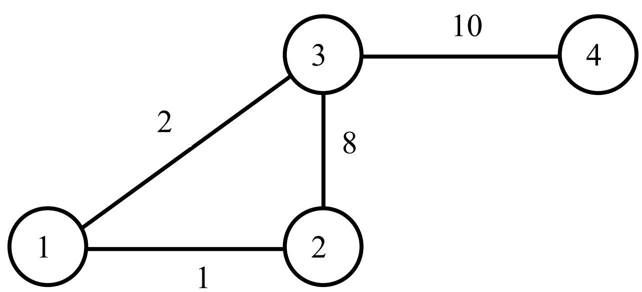
b) (10 pts) You are the network administrator for University of Uranus (UoU), which owns the address block 192.180.208.0/20. UoU has a total of 11 departments: 5 departments each with 500 hosts, and the remaining 6 each with 250 hosts. Show in the following table how you assign IP addresses to each department. Use notation similar to 192.180.208.0/20 in order to denote the address blocks.

Department	# of hosts	Address Block
1	500	
2	500	
3	500	
4	500	
5	500	
6	250	
7	250	
8	250	
9	250	
10	250	
11	250	

c) (10 pts) The network below uses the distance-vector routing algorithm **with 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 = 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 (1,3) becomes 10. 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. *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.

Give the evolution of the distance tables with respect to destination 4. Specifically, give the distance table entries for destination 4 at nodes 1-3, 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* .



Time, t	$D^1(4)$ via		$D^2(4)$ via		$D^3(4)$ via		
	2	3	1	3	1	2	4
0.1							
0.5							
1.1							
2.1							
3.1							
4.1							
5.1							

d) (6 pts) Suppose you would like to build a core router with large number of input/output ports (e.g., 100) each with high line rates (e.g., 10 Gb/s). Explain why using a router architecture with output buffering, but no input buffering is technologically very challenging for this application.

3)

a) (8 pts) Consider a 100 Mbits/sec Ethernet segment having a length of d km. There is a repeater on the segment which introduces a delay of 1μs, in each direction. Assuming that the minimum frame size is 64 Bytes and that the propagation speed is 2.5×10^8 m/sec, what is the maximum cable length d that can be supported for proper operation of the CSMA/CD protocol?

b) Consider a pair of stations A and B on a 10 Mbits/sec Ethernet. Suppose nodes A and B are involved in a collision which is the first collision for A and third collision for B. After the collision is detected (we assume that both nodes detect the collision exactly at the same time), both nodes calculate their backoff times according to the binary exponential backoff algorithm.

   i) (5 pts) What is the probability that A and B will start the next retransmission at the same time?

   ii) (5 pts) Suppose A and B collided again. What is the probability that there will be another collision in the next retransmission after this collision, i.e., they start their next retransmission again at the same time?

c) (6 pts) Why is it necessary for protocols configured on top of the Ethernet, e.g. IP, to have a length field in their header? **Use at most three sentences.**

d) (6 pts) Why is there a maximum frame size requirement of 1500 Bytes for Ethernet? **Use at most three sentences.**