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16.36 Communication Systems Engineering

Spring 2009

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**16.36 Communication Systems Engineering
Quiz - 3, May 20, 2009**

Problem 1: Short Answer (45 pts)

Please provide brief explanations for your answers in order to receive full credit.

1. (5 pts) Suppose that the string 0110 is used as a flag.

a) What would the bit stuffing rule be?

b) How would the following string be stuffed?

1101100111110110110101110

2. (6 pts) For each of the following protocols indicate the minimum modulo that can be used for numbering packets.

a) Stop and Wait

b) Go-Back-N, with $N=7$

c) Selective Repeat (SRP), with $W=7$

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3. Buses arrive at a bus stop at a rate of 6 per hour.

a) (4 pts) What is the expected amount of time between successive busses?

b) (4 pts) You have just arrived at the bus stop. What is the expected amount of time between the last bus to arrive before you and the next bus?

4. (4 pts) A popular ice cream shop has an average arrival rate of 100 customers per hour. The shop can hold up to 50 people in line at any point in time. Give an upper bound on the average waiting time for a customer.

5. (6 pts) True or False: 2 points each, no explanation needed

a) For a graph, a minimum spanning tree (MST) is unique. _____

b) A shortest path only exists in acyclic graphs. _____

c) A spanning tree exists for every graph. _____

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6. (6 pts) After graduation, you go to work for NASA, where you are helping design a new geosynchronous satellite communication system. The satellite communicates to the ground terminals with round-trip propagation delay of 0.5 seconds, packet lengths of 1000 bits, and a transmission rate of 1 Mbps. The engineers there suggest using CSMA/CD for the MAC between the satellite and ground terminals. Would CSMA/CD be a good choice? If not, what would you recommend to use?

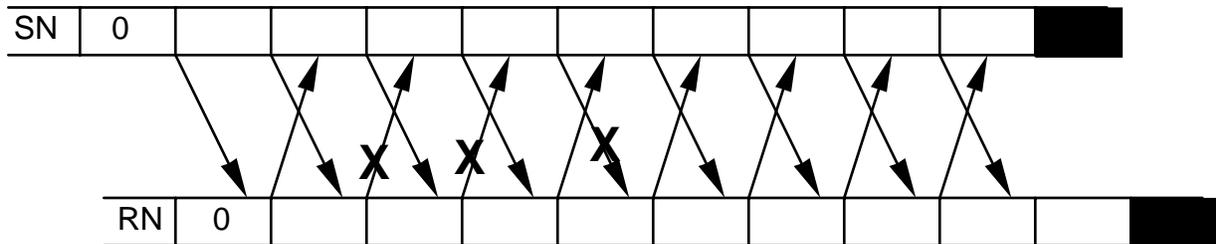
7. (5 pts) Briefly describe the hidden terminal problem.

8. (5 pts) An Aloha protocol uses immediate retransmission upon a collision. What would be the throughput of the protocol?

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Problem 2: Data Link Layer (15 points)

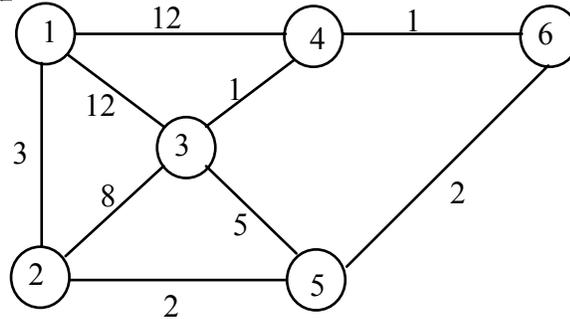
- a) (6 pts) For the diagram below, suppose you are using the Go-Back-N protocol (with $N=4$) and indicate, in the space provided, the sender's sequence numbers (SN) and the receiver's request numbers (RN). The first RN and SN are 0 and 0 as indicated in the diagram. Note that packets arriving in the middle of a transmission are not ACK'd until the next transmission.



- b) (9 pts) A GEO satellite link has a transmission rate of 1Mbps, a (round-trip) propagation delay of 500ms, and a data/ACK packet size of 10000 bits.
- Suppose you use Stop & Wait and the channel is error-free. What is the efficiency of the system?
 - Suppose you use Go-Back-N. What is the minimum window size would you use to achieve 100% efficiency for an error-free channel?
 - Suppose you use ideal Selective Repeat (SRP) with packet error rate $p = 10^{-1}$. What is the efficiency of the system?

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Problem 3: Routing (20 points)

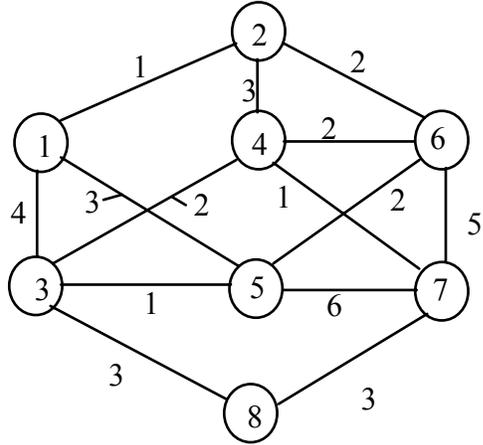


- a) (10 pts) Use the Bellman-Ford Algorithm to find the shortest path from node 1 to all other nodes. Show all of your steps in the table below!

H	D2 (path)	D3 (path)	D4 (path)	D5 (path)	D6 (path)
0					
1					
2					
3					
4					
5					

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- b) (10 pts) For the graph below find a minimum weight spanning (MST) tree using the Prim-Dijkstra algorithm (starting with node 1). Show all of your steps!



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Problem 4: Queuing (20 points)

You may use the following formula for average queuing delay in an M/G/1 system:

$$D_{queue} = \frac{\lambda \overline{X^2}}{2(1-\rho)}$$

- a) (10 pts) Packets arrive to a link at a rate of 1 per second and are all exactly 1000 bits long. The transmission rate is 2000 bps. What is the average total delay in the system (queue+transmitter)?
- b) (10 pts) Packets arrive to a link at a rate of 1 per second. Two-thirds ($\frac{2}{3}$) of the packets are 1000 bits long and one-third ($\frac{1}{3}$) are 2000 bits long. The transmission rate is 2000 bps. What is the average number of packets in the system?