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## EE 450 – Introduction to Computer Networks

Name: \_\_\_\_\_

USC ID: \_\_\_\_\_

Spring 2021

Final Exam

Thursday, May 6, 2:00 PM to 4:00 PM

**Notes:**

1. This is a closed book, closed notes exam.
2. Please read questions carefully and budget your time properly.
3. If you make any reasonable assumptions state them clearly.
4. Please write your answers as legibly as you can. If I can't read them I can't grade them.
5. Show all your work. Partial credit is possible for an answer, but only if you show the intermediate steps in obtaining the answer.
6. Good luck.

	Points	Your score
Question 1	24	
Question 2	22	
Question 3	18	
Question 4	16	
Total	80	

**Question 1. Fundamentals and Networks Concepts (24 Points)**

Give brief and concise answers (2 or 3 sentences) to the following:

- a) **(6 Points)** Consider a 100 Mbps link facing the situation resulting in 80 percent utilization. Equal sized packets arrive at 8,000 packets per second. The link capacity consumed by headers is 0.8 percent. (Use  $M = 10^6$ )
- i) Find the total size of each packet
  - ii) Find the header and data sizes of each packet
  - iii) If the header size is not changeable, what would be the size of packet to achieve 100 percent utilization?
- b) **(4 Points)** Apply CIDR aggregation on the following addresses:
- i) 150.97.28.0/24, 150.97.29.0/24, and 150.97.30.0/24
  - ii) 141.33.11.0/22, 141.33.12.0/22, and 141.33.13.0/22
- c) **(4 Points)** The Internet TCP uses a sliding window mechanism. Does this operate like a stop-and-wait, or Go-back-N, or Selective repeat?  
What is fast retransmit and why does it help improve the performance of TCP?
- d) **(4 Points)** What is flooding? How long (in terms of hops) it takes to complete?

e) **(2 Points)** What is the difference between a permanent address and a care-of-address? Who assigns a care-of-address?

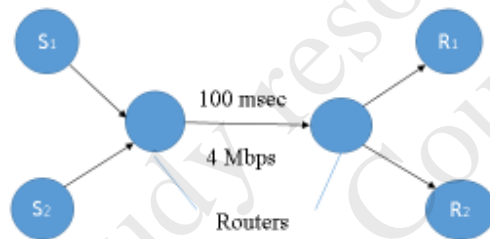
f) **(4 Points)** What are the four desirable properties of secure communication?

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## Question 2. TCP and Congestion Control (22 Points)

a) (2 Points) It is said that a TCP connection “probes” the network path it uses for available bandwidth. What is meant by that?

b) (8 Points) Figure shows two TCP senders transferring large files to a pair of receivers. Both senders use TCP Tahoe. Assume that the MSS is 1 KB, that the one-way propagation delay for both connections is 100 ms and that the link joining the two routers has a bandwidth of 4Mb/s. Let  $cwnd_1$  and  $cwnd_2$  be the values of the senders’ congestion windows and assume that  $cwnd_1 = cwnd_2$ . What is the smallest value of  $cwnd_i$  for which the link joining the two routers stays busy all the time?

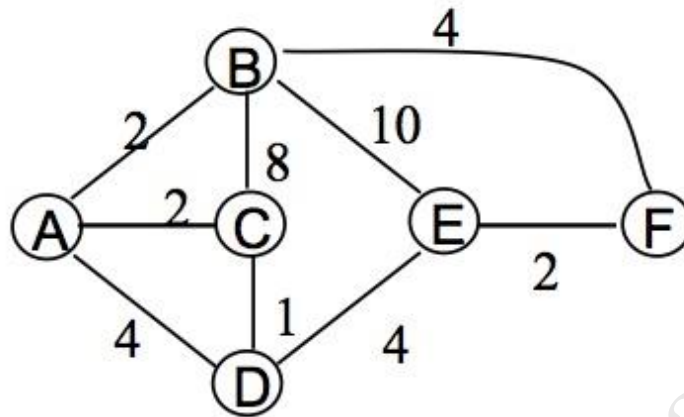


- c) **(8 Points)** The TCP starts out in slow-start with initial threshold *ssthresh* set to 32 Kbytes. A TCP connection established between two nodes has a round trip time of 40 msec. Assume that this time includes time to transmit a full window of packets, all the propagation delay, and the acknowledgment from the receiver to arrive at the sender. The receive window is 40 Kbytes and the MSS size is 1.5 KBytes. Assume that the sender transmits MSS segments according to the TCP Tahoe slow start algorithm and after 400 msec, a timeout occurs due to a segment being dropped by the network. What is the size of the congestion window after another 400 msec have elapsed?

- d) **(4 Points)** In the context of TCP over wireless links briefly explain I-TCP. Why is it that I-TCP said to violate the semantics of TCP?

### Question 3. IP and Routing (18 Points)

a) **(10 Points)** Consider the network shown in Figure. Show the operation of Dijkstra's (Link State) algorithm for computing the least cost path from **C** to all destinations. Show the forwarding table for node **C**.



b) **(4 Points)** Consider a datagram network using 8-bit host addresses. Suppose a router uses longest prefix matching and has the following forwarding table:

Prefix Match	Interface
000	0
001	1
01	2
10	2
11	3

For each of the four interfaces, give the associated range of destination host addresses and the number of addresses in the range.

- c) **(4 Points)** A router connects 4 different subnets with all interfaces required to have the address of the form 128.64.13/24. Subnet1 is required to support at least 48 interfaces, Subnet2 at least 15 interfaces, Subnet3 at least 100 interfaces, and Subnet4 at least 56 interfaces. Provide 4 CIDR network addresses of the form a.b.c.d/x that satisfy all these requirements.

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#### Question 4. Data Link and MAC Protocols (16 Points)

- a) **(6 Points)** Briefly describe the hidden terminal problem and suggest ways to handle this problem.

Consider the 4 node linear wireless network shown in figure where adjacent nodes having a link means they are in range. If transmissions can be perfectly scheduled what would be the maximum capacity in this network? A packet can be sent in a timeslot and capacity is average number of packet transmissions per slot.



- b) **(10 Points)** Frames of 1000 bits are generated at node *A* and sent to node *C* through node *B* as shown in Figure. Determine the minimum transmission rate required between nodes *B* and *C* so that the buffer at node *B* is not overflowed, based on the following:

- The data rate between *A* and *B* is 100 kbps
- The propagation delay is 10  $\mu$ sec/mile for both links
- There are full duplex links between the nodes
- All data frames are 1000 bits long; ACK frames are separate frames of negligible length
- Between *A* and *B*, a sliding window protocol with a window of 3 is used
- Between *B* and *C*, stop-and-wait protocol is used
- There are no errors

