University of Southern California

EE450: Introduction to Computer Networks

Final Exam, $2^{\underline{10}}$ hours

Dec 9, 2022

Last Name: ________________________ First Name: ___________________

Part 1 (T/F)	30%	
Part 2 (Fill-in-the-Blank)	30%	
Part 3 (Routing Algorithms)	15%	
Part 4: Subnetting	10%	
Part 5: TCP Congestion Control	15%	
Total	100%	

Notes:

- All your answers should be on the exam paper.
- You can work the problems in any order you wish (the goal is to try to accumulate as many points as you can).
- Try your best to be clean, and to show all the steps of your work

Rules:

- This is a closed book, closed notes exam. One 8"x11" containing formulas only is allowed along with a calculator. Any other electronic gadget including a smart phone or an IPad is strictly prohibited.

- Adherence to the University's **Code of Ethics** will be strictly monitored and enforced. Academic Integrity violations, such as cheating, will result in a series of actions and penalties including the student failing the class.

Part 1: True/False/Multiple Choice

1. A subnet mask is used to identify the boundary between network bits and host bits in an IP address

2. Unlike Routers, L2 switches built their tables based on destination MAC address.

3. An IPv.4 packet can be fragmented and reassembled multiple times in transit.

4. If Bob and Alice are two peers running behind a NAT, across a WAN, then they can not set up a TCP connection.

5. The following masks (in slash notation for simplicity) are only used as default masks: /8, /16 and /24 for classes A, B and C respectively.

6. Multiple TCP sessions, on a single host, can be distinguished using IP addresses and port numbers.

7. SSID is a technical term for a Wi-Fi network address

8. A smart phone can spread traffic to/from a single TCP connection over Wi-Fi and cellular interfaces at the same time

9. The purpose of TCP slow start is to avoid queue overflow in routers

10. In 802.11 CSMA/CA, the sender can detect a collision without feedback from receiver

11. In 802.11, when two stations transmit RTS frames simultaneously, a collision will occur, and no CTS frame is received. Each station will wait a random period and try again.

12. A host sends a segment with a sequence number 50 and payload size of 50 Bytes. The ACK sequence number in that segment is 100.

13. In an IP network, a malicious host claiming an IP address (IP address spoofing) outside its subnet will receive no packets

14. If an IP fragment does not arrive at the destination, the source host retransmits that fragment only, not the entire packet.

15. Every port of a router constitutes a broadcast domain while every port of a L2 switch constitute a collision domain.

16. UDP flow control guarantees the delivery of in-order datagrams to the application

17. At the network layer, a spanning tree is used to ensure that no redundant packets are received by any node

18. In 802.3 standard, if the coverage (distance) is increased, the minimum frame size would decrease.

19. In 802.3 standard, if the bandwidth is decreased, the minimum frame size would increase

20. In 802.3, if an ACK is not received within a specified time (timeout) the sender will retransmit the frame

21. The results of connecting multiple L2 switches together is increasing the size of the broadcast domains.

22. In Wi-Fi, a wireless host needs only the MAC address of the AP. It does not need the MAC address of the default router.

23. If a TCP and a UDP flows share the same "bottleneck", the UDP flow is more likely to get a greater percentage of the available bandwidth

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24. Suppose a Certificate Authority (CA) has Bob's certificate registered with it, binding Bob's public key to Bob. This certificate is signed with:

    a. Bob's public key.
    b. The CA's public key.
    c. Bob's private key.
    d. The CA's private key

25. A sender sends an unencrypted message and its encrypted digest over a network. Which of the following types of information assurance is provided in this scenario?

    a. Data Confidentiality
    b. Authentication
    c. Data Integrity
    d. None of the above

26. A sender sends a message encrypted by a public key of the recipient. Which of the following is NOT provided in this scenario?

    a. Data Integrity
    b. Data Confidentiality
    c. Authentication
    d. All the above

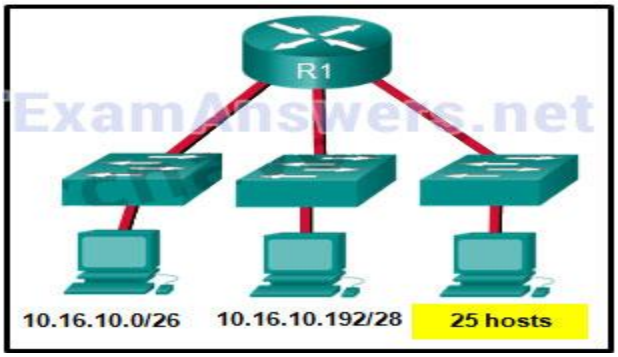
27. A sender sends a message encrypted by his own private key. Which of the following is NOT provided in this scenario?

    a. Data Confidentiality
    b. Authentication
    c. Data Integrity
    d. All the above

28. A switch will never learn a broadcast MAC address because

    a. Broadcast frames are never sent to the switch
    b. A broadcast address will never be the source address of a frame
    c. Broadcasts only use network layer addresses.
    d. A switch never forwards a broadcast frame.
    e. None of the above

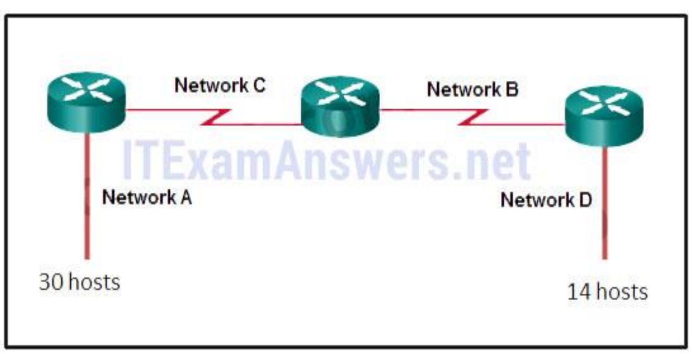
29. Considering the addresses already used and having to remain within the 10.16.10.0/24 network range, which subnet address could be assigned to the network containing 25 hosts?



a. 10.16.10.160/26
b. 10.16.10.128/28
c. 10.16.10.64/27
d. 10.16.10.224/26
e. 10.16.10.240/27
f. 10.16.10.192/27

30. Given the network address of 192.168.5.0 and a subnet mask of 255.255.255.224, how many total host addresses are unused in the assigned subnets?

a. 56
b. 60
c. 64
d. 68
e. 72



Part 2: Fill-in-the-Blank

1. Suppose a group of 10 nodes are connected to a 10 Mbps Ethernet hub. The average bandwidth available to each node is _______ Mbps. Now suppose these 10 nodes are connected to a 10 Mbps Ethernet Switch, the maximum bandwidth available to each node is _______ Mbps. The aggregate capacity of the switch is _______Mbps

2. A TCP sender is sending a full window of 2^{16} Bytes over a 1 Gbps channel that has a 10 msec one-way propagation delay.

   a. The link utilization is ____________ %

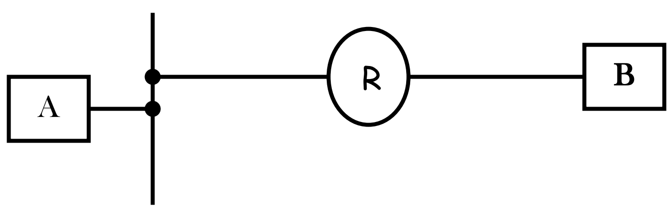
   b. The maximum throughput is ________________ Bytes/sec

3. Assume you have a 10 Mbps hub-based (i.e., shared) Ethernet network with 5 hosts. Each computer is connected to the hub with a cable of different length. Host H_1 is connected via a 100 m cable, Host H_2 is connected via a 200 m cable and so on up to host H_5 which is connected via a 500 m cable. The speed of propagation is 2.5 $x10^8$ m/sec. The minimum frame length used in this network so that CSMA/CD protocol will function correctly should be ___________ bits

4. Two nodes "A" and "B" that are attached at the opposite ends of 1000 m Ethernet cable. They both have a 1000-bit frame to send to each other. Both nodes attempt to transmit at t = 0. Assume the transmission rate is 10 Mbps and that CSMA/CD is used. After the first collision, node "A" will retransmit immediately after it senses the medium is idle. Assume that the speed of propagation is $2x10^8$ m/sec. You can ignore the jamming signal. Collision occurs at t = _______ sec. Station A will retransmit at t = _______ sec. The throughput of node A is __________ bps. Assume that node A is successful the second time.

5. An e-mail client application on host A needs to send a 1536 Bytes image over TCP (TCP adds a header of 20 Bytes) which in turn runs over IP (IP adds a header of 20 Bytes) which runs over Ethernet which has an MTU of 1500 Bytes. A router connected to the Ethernet is connected to host B through a point-to-point connection with an MTU of 512 Bytes. Assume the TCP in host A knows that the MTU of the Ethernet is 1500 Bytes. Answer the following questions

- The "minimum" number of segments created by TCP is _________
- The payload size of each of these segments is (separate by comma if more than one segment) _____________________ Bytes.
- The number of fragments delivered to B is _________
- Their offsets are (separate by comma) ________________________



6. An ISP has the following Routing Table depicting the 4 prefixes he has as customers. What is the smallest number of prefixes he will need to advertise to the outside world announcing reachability to all its customers **but no other**? If more than one prefix, list them separated by commas (This question is about address aggregation)

Prefix(es): ____

212.56.146.0/24
212.56.147.0/24
212.56.148.0/24
212.56.149.0/24

7. The following is the forwarding table of a router X

Destination Network	Subnet Mask	Outgoing Link Interface
223.92.32.0	/20	A
223.81.96.0	/19	B
223.112.0.0	/12	C
223.120.0.0	/14	D
128.0.0.0	/1	E
64.0.0.0	/2	F
32.0.0.0	/3	G

State, to what outgoing interfaces will these arriving packets, with the following destination IP addresses, be delivered?

a) Packet 195.145.34.2 delivered to _________

b) Packet 223.95.19.135 delivered to _________

c) Packet 63.67.145.18 delivered to __________

d) Packet 223.125.49.47 delivered to ____________

e) Packet 192.168.37.11 delivered to ____________

8. Consider the wireless topology below, comprised of 5 nodes. A (shown in the dotted, shaded circle), B, C, and D all have equal transmission ranges, while E has a smaller range. Assume that if the transmissions of two nodes' will interfere at a location if and only if they transmit at the same time and their transmission areas overlap. In these problems, assume that losses only occur due to collisions.

a. When node A transmits to node B, list the potential hidden terminals (in either direction, i.e., those who might clobber A's transmission or those who A's transmission might clobber) and exposed terminals.

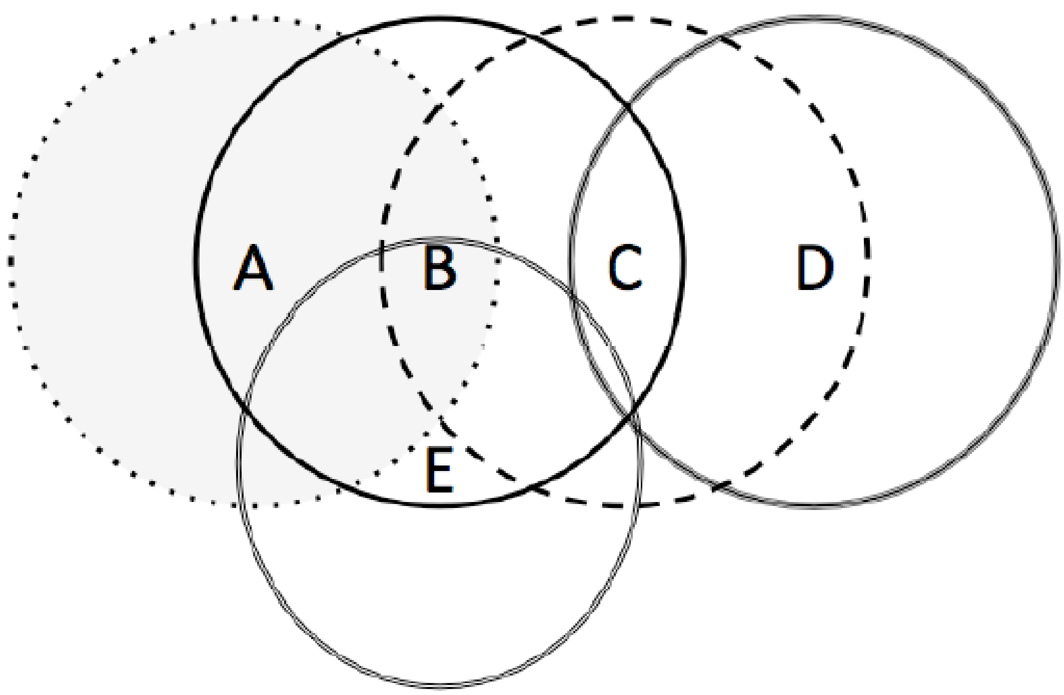
Hidden terminals: ______________

Exposed terminals: _____________

b. What about when node B transmits to node C?

Hidden terminals: _______________

Exposed terminals: _______________



9. A router interconnects three subnets. All hosts, in each of these subnets, are required to have a prefix of 223.1.17/24. Subnet A has 15 devices, subnet B has 12 devices and subnet C has 45 devices. The subnet address (in the form of a.b.c.d/n) of these subnets are:

   Subnet A: ________________________

   Subnet B: ________________________

   Subnet C: ________________________

10. A router receives an IP packet with destination 192.168.2.82. The router has the following entries in his routing table

Network Prefix	Subnet Mask	Interface
192.168.2.64	/27	I_1
192.168.2.0	/24	I_2
192.168.2.80	/29	I_3

The packet will be forwarded over Interface ______________________

11. Consider the following Scenario. A corporate network with three sites connected by the internet. The company's network administrator has configured the gateway routers at the three sites to use IPsec to encrypt all traffic going between the three sites.

a. If host A sends a packet to host C, what are the source and destination address fields in the packet header as it passes through the public internet? (Separate them by comma)

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b. If host B sends a packet to the Google server shown, what are the source and destination address fields in the packet header as it passes through the public internet? (Separate them by comma)

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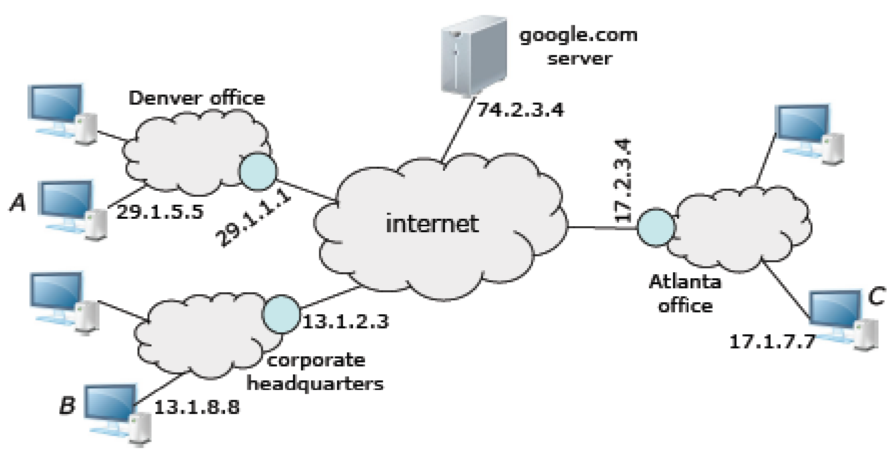
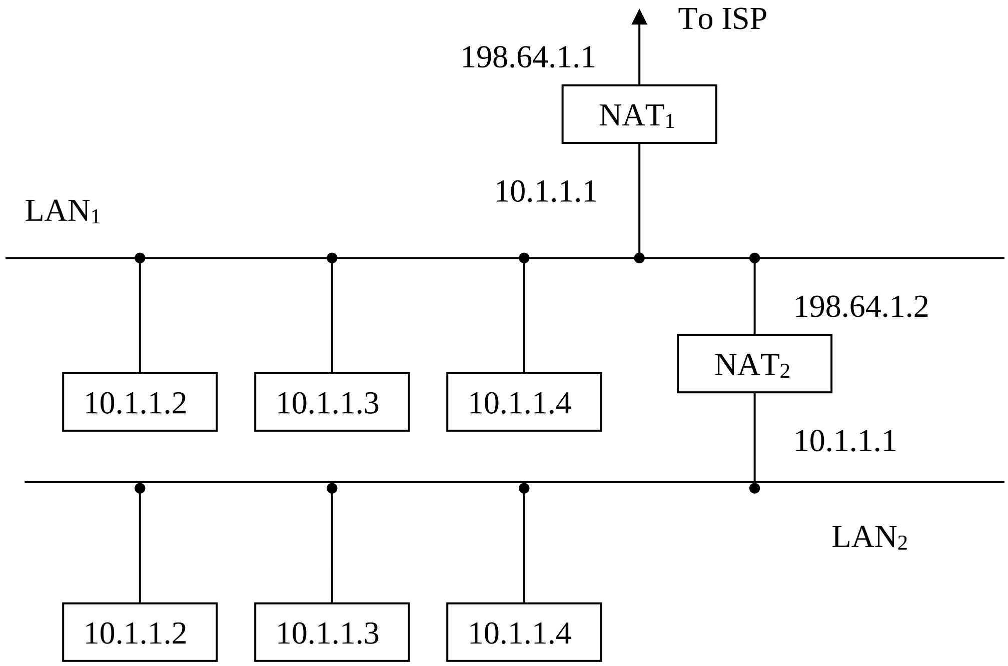


12. Suppose an organization has installed "nested NATs". NAT_1 with IP address 198.64.1.1 is connected directly to the ISP, while NAT_2 is connected internally as shown below. Both private networks are numbered from 10.0.0.0/8 private IP address space.



- If host 10.1.1.2 on LAN_2 sends an IP packet with destination address 10.1.1.3, which host (or hosts) will receive it? Identify the LAN

  Answer: ______________________________

- If host 10.1.1.2 on LAN_2 sends an IP packet with destination address 128.9.160.23, what source address will be on the packet when it arrives at the destination?

  Answer: ________________________________

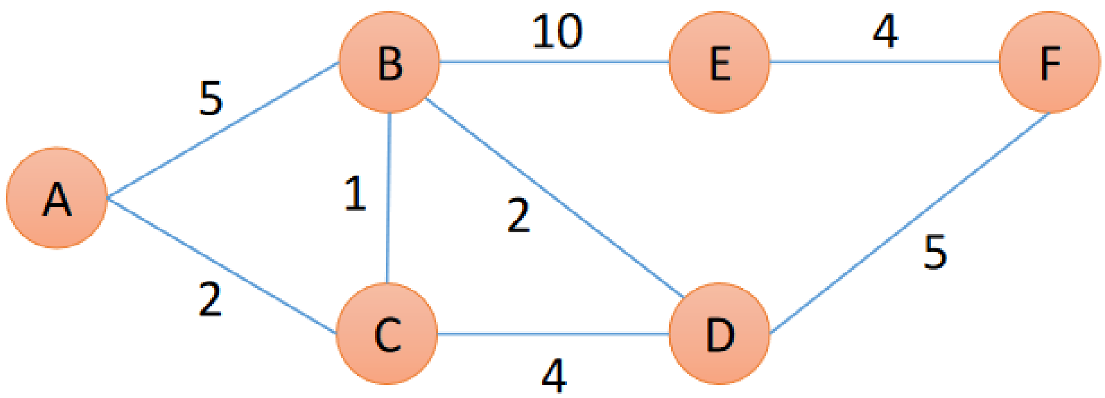
Work Sheet #1

Work Sheet #2

Work Sheet #3

Part 3 (Routing Algorithms)

a. Consider the following computer network where each node represents a router and the edge label is the corresponding link cost (Links are bi-directional). Use Dijkstra algorithm to find the shortest path from router "A" to every other router in the network. Show your work step-by-step (i.e. I am not interested in the final answer. I am interested in algorithm steps). **After you finish, Sketch the spanning tree.**



Work Sheet #4

b. This part is NOT related to part "a". Consider a Campus Network that runs RIP (a DV protocol), where router R_1 has the following routing Table

Destination	Distance	Route
Net 1	0	Direct
Net 2	0	Direct
Net 4	8	R_2
Net 17	5	R_3
Net 24	6	R_4
Net 30	2	R_5
Net 42	2	R_4

Router R_1 receives the following routing tables from R_3 and R_4 respectively

From R_4	Destination	Distance
	Net 2	1
	Net 4	2
	Net 17	6
	Net 21	4
	Net 24	5
	Net 30	7
	Net 42	3
From R_3	Destination	Distance
	Net 1	2
	Net 4	3
	Net 17	2
	Net 21	4
	Net 24	5
	Net 42	3

What will be R_1 Routing Table (3 columns as shown above) be after it incorporates this update from Router R_3 and R_4? Note: The information given in problem should enable you to figure out the distance between R_1 and R_3 and between R_1 and R_4.

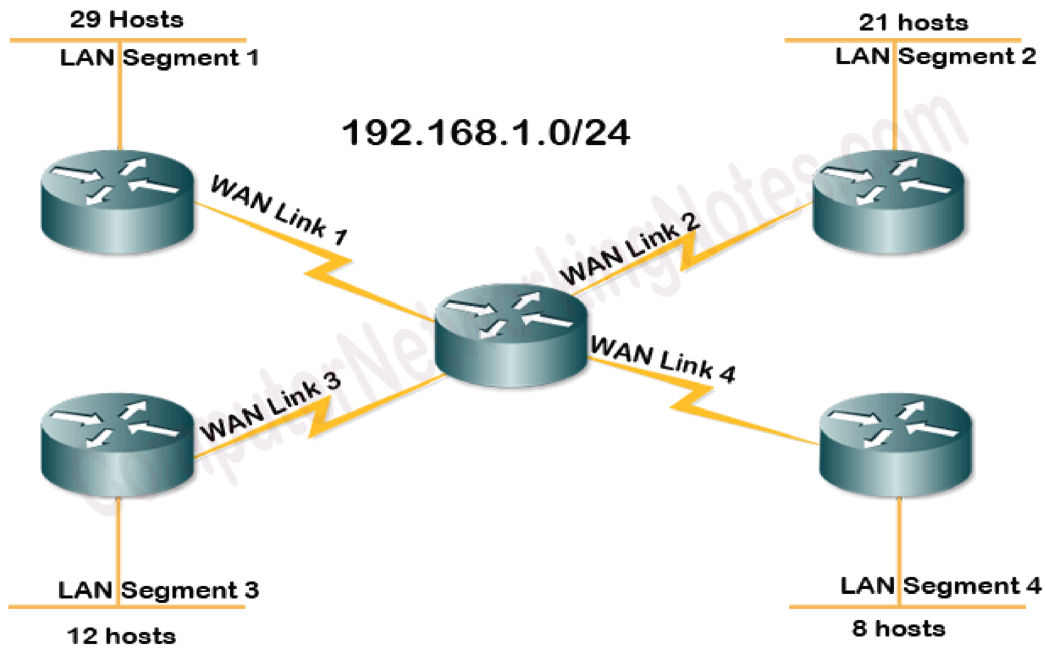
Work Sheet #5

Part 4: Subnetting/Addressing

An organization has the following CIDR block:192.168.1.0/24. The organization wants to create 4 subnets for different departments as shown

Department A: Requires 29 Addressable devices
Department B: Requires 21 Addressable devices
Department C: Requires 12 Addressable devices
Department D: Requires 8 Addressable devices

All departments are connected, using routers, with each other as shown below**.** You are required to create **8 subnets** (in the form of a.b.c.d/n), **<u>which will result in the "minimum waste" of the address space</u>**. How many addresses are reserved (i.e., available from the original block) for future use? Note: The all 0's and the all 1's can **NOT** be used in the host bits. Your answer should be in a Table format listing the **Subnet address**, the **subnet mask** and the **direct broadcast** for **each of these subnets**



Work Sheet 6

Work Sheet 7

Part 5: TCP Congestion Control

Consider a TCP sender that desire to upload a file whose size is 640 MSS with each MSS being 1000 Bytes long. The SS-threshold is set equal to the receiver advertised window size of 64MSS. The bandwidth of the link is 100 Mbps and the roundtrip time is RTT = 40msec. Congestion **occurs** when the number of Bytes transmitted exceeds the Bandwidth x Delay product. TCP Tahoe is implemented

a. How long does it take the host to upload half the file in the absence of any packet losses? What is the throughput up to this time? What is the link utilization? Sketch the diagram showing the evolution of the congestion window (start at t = 0). Will congestion occur while the sender is sending the rest of the file? If yes, when? If No why not?

b. Now suppose a bottleneck occurred and the bandwidth of the link is reduced to 10Mbps. How long does it take the host to upload half the file? What is the throughput up to this time? What is the link utilization? Sketch the diagram showing the evolution of the congestion window (start at t = 0)

Work Sheet 8

Work Sheet 9