University of Southern California
EE450: Introduction to Computer Networks
Final Exam, 2:10 Hours
November 17, 2020

Last Name: _____ First Name: _____

Session (1, 2, 3, DEN): _____

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. Subnet masking is the process of extracting the network address from an IP address

2. TCP has the property of slow start to probe the congestion level in the network

3. The largest packet that can be sent over a link without fragmentation is called the MTU

4. An organization with 100,000 Private hosts can share a single public IP address if they are running behind a NAT/PAT.

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

6. In Link State routing each router receives information generated directly by neighboring routers

7. In DV protocol, shortest path computations and updates are asynchronous

8. In 802.11 CSMA/CA, when a station senses the medium to be idle it sends a frame immediately

9. TCP utilizes a single retransmission time-out mechanism. The RTO is picked at the start of the TCP session and remains fixed for the duration of the session

10. 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 of time and try again.

11. A host sends a segment with a sequence number 35 and payload of 5 Bytes. The ACK number in that segment is 40

12. TCP segments can only be lost when router queues overflow

13. If an IP fragment does not arrive at the destination, then only that fragment, not the entire packet, is retransmitted by the source host

14. The IP header changes each time a packet passes through an IP router

15. Suppose there are three routers between source host and destination host. Ignoring fragmentation, an IP packet sent from the source host to the destination host will travel over 6 interfaces and 3 forwarding tables need to be accessed along the way

16. After fast retransmit is invoked, fast recovery cuts the slow start period in half

17. In 802.3 standard, if the maximum size (coverage) were increased, the minimum frame size would decrease

18. In 802.3 standard, if the bandwidth isincreased, the minimum frame size would increase as well

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

20. In the case fragmentation is needed, the TCP/UDP headers always end up in the first fragment.

21. In TCP, the number of unacknowledged Bytes that a host can send cannot exceed the size of the receiver buffer

22. UDP is a best effort Protocol

23. If a TCP and a UDP flows share the same "bottleneck", the TCP flow is more likely will get a greater percentage of the bandwidth because it is a reliable protocol

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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. Confidentiality
    b. Integrity
    c. Authentication
    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. Confidentiality
    b. Integrity
    c. Authentication
    d. All of the above

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

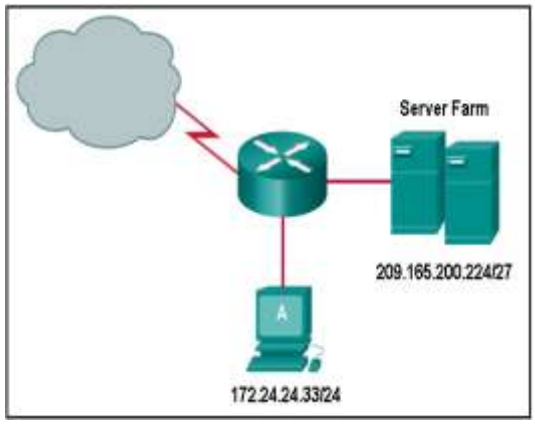
    a. Confidentiality
    b. Integrity
    c. Authentication
    d. All of the above

28. An ISP advertises the CIDR network address 192.3.48/20 (and no other addresses). What network addresses (all 24 bits) could this ISP own? (Select all that applies)

    a. 192.3.128
    b. 192.3.49
    c. 192.3.64
    d. 192.3.1
    e. 192.3.62

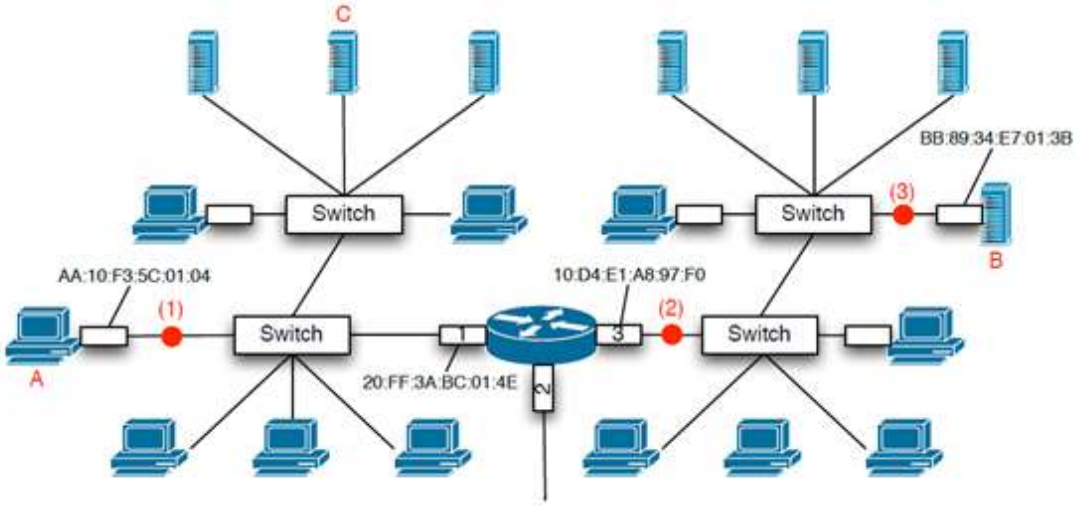
29. A network administrator discovers that host A is having trouble with Internet connectivity, but the server farm has full connectivity. In addition, host A has full connectivity to the server farm. What is a possible cause of this problem?

    a. NAT is required for the host A network.
    b. Host A has an incorrect subnet mask.
    c. Host A has an incorrect default gateway configured.
    d. The router has an incorrect gateway.
    e. Host A has an overlapping network address.



30. Consider the following configuration with Routers and L2 switches (Ignore the labels). The number of broadcast domains is

    a. 1
    b. 2
    c. 3
    d. 4



Part 2: Fill-in-the-Blank

1. Suppose a group of 5 stations are connected to a 10 Mbps Ethernet hub. The average bandwidth available to each station is _____Mbps. Now suppose these 5 stations are connected to a 10 Mbps Ethernet Switch, the maximum bandwidth available to each station 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 10msec round trip time.

    a. The link utilization is _____ %

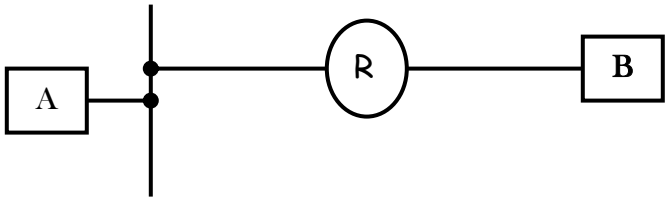
    b. The maximum throughput is _____ Bytes/sec

3. Assume you have a 10 Mbps CSMA/CD network interconnecting ten hosts. Each computer is connected to the hub with a cable of different length. Host H_1 is connected via a 50 m cable, Host H_2 is connected via a 100 m cable, and so on up to host H_{10} that is connected via a 500 m cable (ignore the signal degradation problem). The speed of propagation is 2.5×10^8 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 500 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. Station "B" will retransmit 50 μseconds after it senses the medium is idle. Assume that the speed of propagation is 2×10^8 m/sec. Assume no jamming signal is used. Collision occur at t = _____ sec. Station A will retransmit at t = _____ sec. The throughput of node A is _____ bps.

5. An e-mail client application on host A needs to send a 2000 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 7 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)

   # of Prefixes: _____

   Prefix (es): _____

192.166.10.0/25
192.166.10.129/25
192.166.11.0/24
192.166.8.0/24
192.166.9.0/24
192.166.12.0/22
192.166.16.0/21

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

Destination Network	Subnet Mask	Outgoing Link Interface
158.130.224.0	/26	A
158.0.0.0	/8	B
158.130.224.192	/26	C
158.130.128.0	/17	D
159.150.0.0	/16	E
158.130.0.0	/19	F
0.0.0.0	/0	G

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

a) Packet 158.131.76.34 delivered to _____

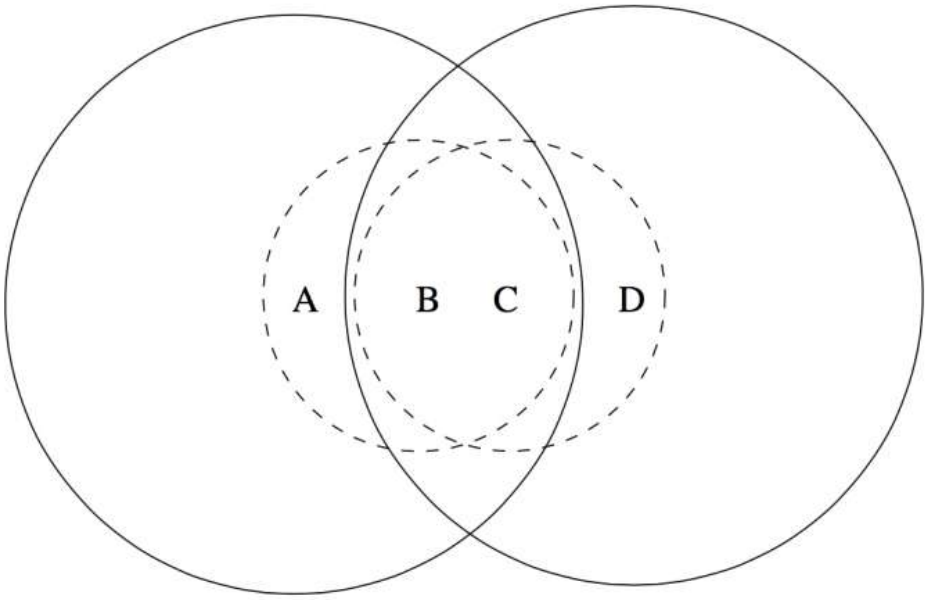
b) Packet 158.130.136.48 delivered to _____

c) Packet 158.130.224.7 delivered to _____

d) Packet 128.130.224.254 delivered to _____

e) Packet 10.34.61.86 delivered to _____

8. Consider the following WLANs topology. The solid circles represent the radio range of A and D respectively. The dashed circles represent the radio range of B and C. Two nodes will interfere at a location if they transmit simultaneously and their transmission areas overlap



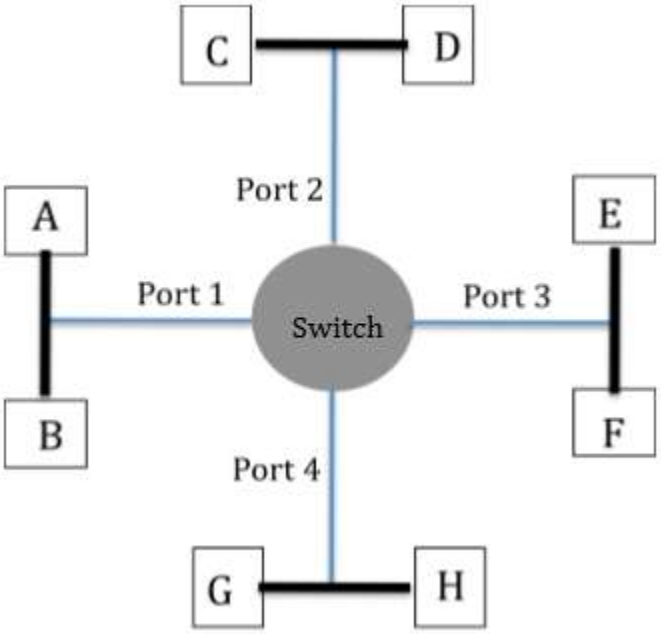
Case 1: A is sending a frame to B. List the hidden terminals (Those who might interfere with A's transmission or those who A's transmission might interfere with) and the exposed terminals

Hidden Terminals: _____
Exposed Terminals: _____

Case 2: Repeat case 1 when B is sending a frame to C

Hidden Terminals: _____
Exposed Terminals: _____

9. Consider the following set of four Ethernet segments connected by an L2 switch. Each Ethernet segment has two hosts on it. Assume at the beginning that the switch has no state about where each of the hosts reside, and will use self-learning to build its forwarding table during the sequence of transmissions listed below. For each step in this sequence of transmissions, list the ports the Ethernet frame is forwarded to by the switch (and, if the frame is not forwarded to any ports, just write drop)

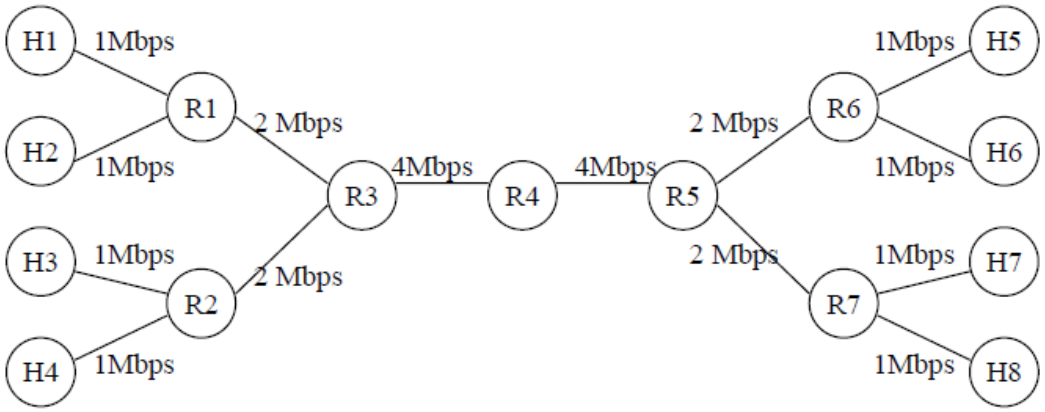


Sequence of Transmissions	Ports
A sends to E	
G sends to E	
E sends to A	
H sends to G	

10. Consider the network shown below which has eight hosts H1,..., H8 and seven routers R1,...,R7. All links are full-duplex with bandwidths as shown in the figure.

Routers that can't get congested: _____

Routers that can get congested: _____



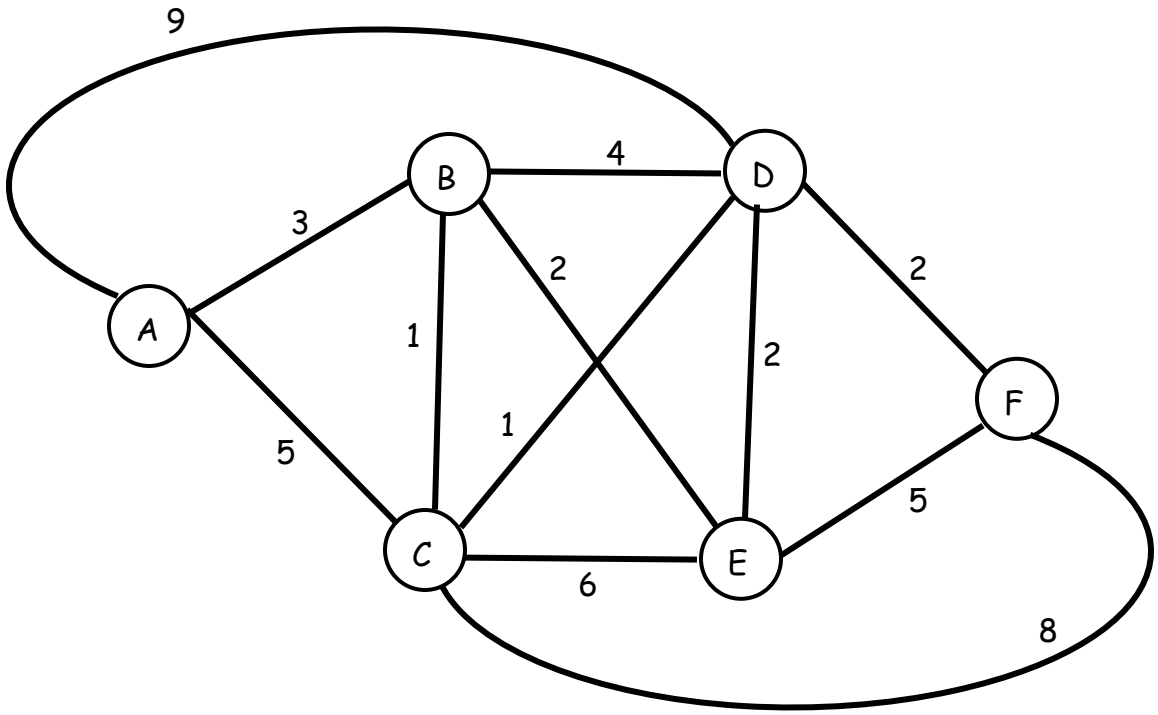
Work Sheet #1

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, where router R_1 has the following routing Table

Destination	Distance	Next Hop Router
Net 1	0	Direct
Net 2	2	R_5
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 table from R_4 from

Destination	Distance
Net 1	3
Net 4	2
Net 17	6
Net 21	1
Net 24	5
Net 30	8
Net 42	2

What will be R_1 Routing Table (3 columns as shown above) be after it incorporates this update from Router 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 90 Addressable devices
Department B: Requires 50 Addressable devices
Department C: Requires 25 Addressable devices
Department D: Requires 15 Addressable devices

There are a total of 180 devices

a. Design a possible addressing scheme for each department by filling the following table. How many addresses remain unused from the original block?

Subnet	Subnet Address	Subnet Mask	Broadcast Address	Max # of hosts
A				
B				
C				
D				

b. Now assume the organization decided to create another department E which requires 20 addressable devices. Suggest what the organization might do (Illustrate your answer without suggesting that the organization gets another block!!)

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

Work Sheet #10