Instructions

This exam is open-book, open-notes, and open-Internet. You are allowed to use a calculator. You have 12 hours to complete the exam and must upload your exam papers to Canvas by May 20, 2020, 7:00PM.

You are required to write out and sign the honor pledges below.

Honor Pledges

"I affirm that I will not give or receive any unauthorized help on this exam, and that all work will be my own."

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and that all work will be my own

Your signature:

Shane Cinotta

CISC450/CPEG419: Computer Networks I
Final Exam
May 20, 2020 1:00PM-7:00PM

Name: **UD ID:** **Grade in Points:**

True or False (3 points each)

1. The link utilization ratio of any stop-and-wait protocol is strictly lower than one. (F)

2. During TCP connection establishment, three segments are sent between two hosts, and the first two segments carry no application-layer data. (T)

3. The flow table at a SDN-controlled switch is either computed by its routing component or configured by a remote logically centralized controller. (T)

4. Routers in the same autonomous systems (AS) can run different intra-domain routing protocols. (T)

5. Two-dimensional parity scheme is able to detect and correct a single bit error. (T)

Multiple Choices (5 points each)

6. (**Multiple answers**) Which of the following statements about TCP are true? (D)

- (A) During congestion avoidance, the value of `cwnd` is increased by one MSS every RTT.
- (B) During congestion avoidance, the value of `cwnd` is increased by one MSS for every ACK received.
- (C) During slow start, the value of `cwnd` is creased by one MSS every RTT.
- (D) During slow start, the value of `cwnd` is creased by one MSS for every ACK received.

7. (**Single answer**) Consider a datagram network using 5-bit host addresses. Suppose a router uses longest prefix matching and has the following forwarding table:

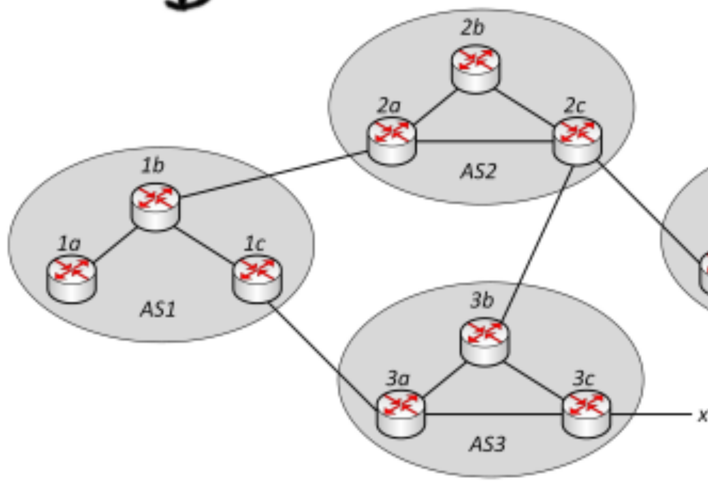
D

Prefix Match	Interface
01	0
101	1
1	2
111	3
otherwise	2

What is the address range of destination host addresses for interface 2? ( )

- (A) 00000 $\sim$ 00111 and 10000 $\sim$ 11111.
- (B) 00000 $\sim$ 00111 and 10000 $\sim$ 10011.
- (C) 00000 $\sim$ 00111, 10000 $\sim$ 10011, and 11000 $\sim$ 11111.
- (D) 00000 $\sim$ 00111, 10000 $\sim$ 10011, and 11000 $\sim$ 11011.

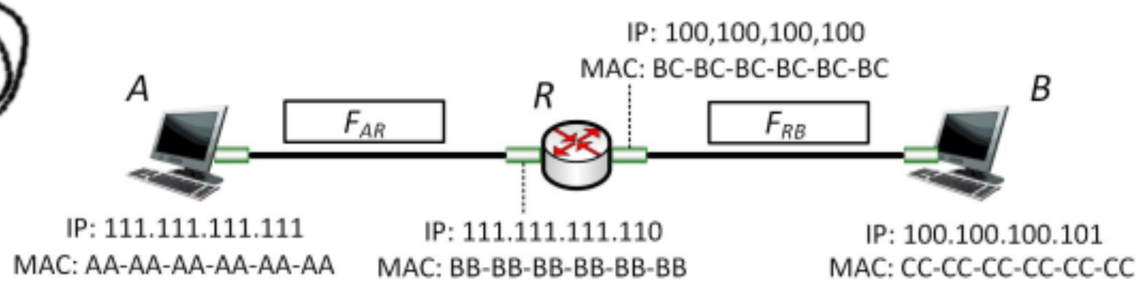
8. (**Single answer**) Consider the network shown below. Suppose that AS1 and AS2 are running RIP for their intra-AS routing protocol. Suppose that AS3 and AS4 are running OSPF for their intra-AS routing protocol. Further assume that eBGP and iBGP are used for the inter-AS routing protocol. Which of the following statement is [redacted] correct? (D)



- (A) Router $2b$ learns about prefix x from RIP.
- (B) Router $1a$ learns about prefix x from RIP.
- (C) Router $3a$ learns about prefix x from eBGP.
- (D) Router $4b$ learns about prefix x from iBGP.

9. (**Multiple answers**) Consider the following network. Suppose that host A sends a datagram to host B through router R, which results in link-layer frame F_{AR} sent from A to R and frame F_{RB} sent from R to B.

D



Which of the following statement about frames F_{AR} and F_{RB} are correct? ( )

- (A) Frame F_{AR} has source IP address 111.111.111.111 and destination IP address 100.100.100.101, and frame F_{RB} has source IP address 100.100.100.100 and destination IP address 100.100.100.101.
- (B) Frame F_{AR} has source IP address 111.111.111.111 and destination IP address 100.100.100.101, and frame F_{RB} has source IP address 111.111.111.111 and destination IP address 100.100.100.101.
- (C) Frame F_{AR} has source MAC address AA-AA-AA-AA-AA-AA and destination MAC address BB-BB-BB-BB-BB-BB, and frame F_{RB} has source MAC address BC-BC-BC-BC-BC-BC and destination MAC address CC-CC-CC-CC-CC-CC.
- (D) Frame F_{AR} has source MAC address AA-AA-AA-AA-AA-AA and destination MAC address CC-CC-CC-CC-CC-CC, and frame F_{RB} has source MAC address BC-BC-BC-BC-BC-BC and destination MAC address CC-CC-CC-CC-CC-CC.

Problem 10 [10 Points]: Consider sending a 2400-byte datagram into a link that has an MTU of 700 bytes. Suppose that the original datagram is stamped with the identification number 228. How many segments are generated? What are the values in the length, ID, fragment flag, and fragment offset in each fragment? (Assume 20 bytes of IP header)

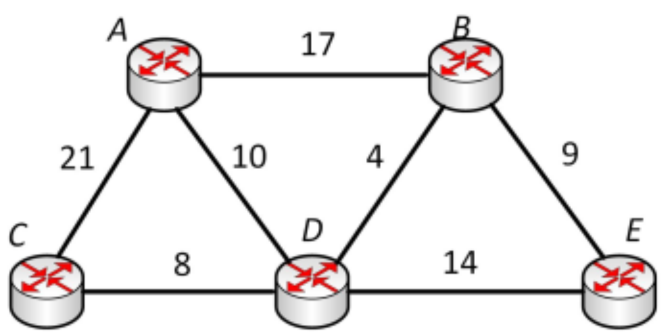
$$\text{fragments} = \frac{2400-20}{700-20} = 4$$

fragment #	size	ID	offset	flag
1	680	228	0	1
2	680	228	85	1
3	680	228	85	1
4	340	228	255	0

Problem 11 [15 Points]: Consider the following network with the indicated link costs that runs a distance vector protocol. At the beginning, every node only knows the link cost to its direct neighbor. For example, the initial routing table at node A is

Destination	Cost	Next Hop
B	17	B
C	21	C
D	10	D
E	∞	-

Answer the following questions.



- (a) Show the initial routing table of node E.

Destination	Cost	Next Hop
A	–	–
B	9	B
C	–	–
D	14	D

- (b) Show the routing table of node E after one iteration of the algorithm, i.e., every node sends its distance vector to its neighbor

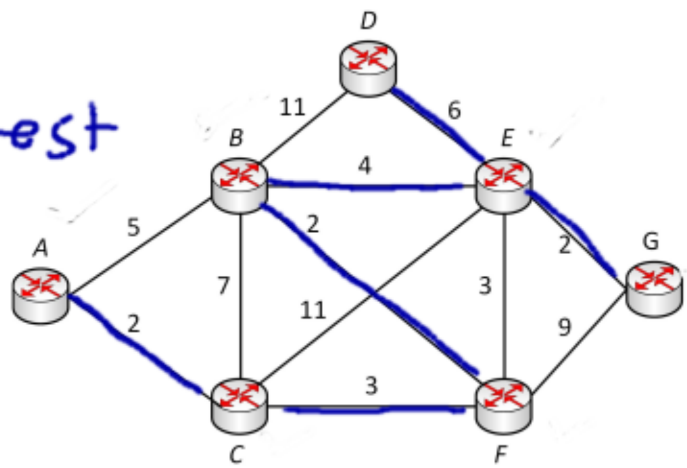
Destination	Cost	Next Hop
A	24	D
B	9	B
C	21	B
D	13	B

- (c) Show the routing table of node E after two iterations of the algorithm

Destination	Cost	Next Hop
A	14	A
B	9	B
C	21	C
D	13	D

Problem 12 [15 Points]: Consider the following network. With the indicated link costs, use Dijkstra's shortest-path algorithm to compute the shortest path from A to all network nodes. Show how the algorithm works by computing the table below.

Shortest Path



Step	N'	$D(B), p(B)$	$D(C), p(C)$	$D(D), p(D)$	$D(E), p(E)$	$D(F), p(F)$	$D(G), p(G)$
1	A	10 A	2A	–	–	–	–
2	AC	9 C	–	–	–	5C	–
3	ACF	7F	–	–	8F	–	14F
4	ACFB	–	–	18F	12F	–	–
5	ACEBE	–	–	17E	–	–	13F
6							
7							
8							

Problem 13 [10 Points]: Consider a cyclic redundancy check (CRC) code with 5-bit generator $G = 10101$. Suppose that data bits $D = 1111000101$. What is the value of CRC bits R?

$K-1=4$

$10101 \sqrt{11110001010000}$ Mod 2 div

result = 1101100b

remainder = 1010

Problem 14 [15 Points]: Consider three nodes, A, B, and C that use slotted ALOHA protocol to contend for a channel. Suppose that node A's retransmission probability is $2p$ and that B and C both have a retransmission probability p, where $0 < p < 0.5$. Prove that node A's average throughput measured by the probability of successful transmission is higher than the sum of nodes B and C's average throughput.

Prob. of avg throughput of A: $P_A(1-P)(1-P) = 2P(1-P)^2$

Prob Node B $= P_B(1-P_A)(1-P_C) = P(1-2P)(1-P)$

prob Node C $= P_C(1-P_A)(1-P_B) = P(1-2P)(1-P)$

$2P(1-P)^2 > 2P(1-2P)(1-P)$

Bonus Problem [10 Points]: Consider a link with transmission rate R and one-way propagation delay d is used to transmit data packet of size L bits. Both the header of data packet and the acknowledgement packet are of negligible size. Consider a go-back-N protocol with k_1 bits of sequence number and a selective repeat protocol with k_2 bits of sequence number. Under what conditions the selective repeat protocol can have higher maximum link utilization ratio than the go-back-N protocol?

Prop delay $= d$ Pck size $= L$

Trans rate $= R$, $T_{frame} = L/R$

$a = T_{prop} - T_{frame}$, Utilization $= \frac{W}{1+2a}$

GBN: $w = 2^{k_1} - 1$, SR: $W = 2^{k_2 - 1}$

$2^{k_2 - 1} > 2^{k_1} - 1 \Rightarrow 2^{k_2} > 4^{k_1} - 2 \Rightarrow$

$\Rightarrow k_2 > \log(4^{k_1} - 2)$