COMP 4621 Computer Communication Networks I

Spring Semester 2012

Final Examination

Date: May 21, 2012 **Time: 12:30 pm – 2:30 pm**

Name:____________________ **Student ID**: _______________**Email**:_________________

Instructions

1. Please write your name, student ID and email address on this page.
2. Please answer all questions within the space provided on the examination paper. You may use back of the pages for your rough work.
3. Please be **concise**, and this is **NOT** an essay contest.
4. This paper consists of **8** questions and **13** pages.
5. Please read each question very carefully and answer the questions clearly to the point. Make sure your answers are neatly written, legible, and readable.
6. Show all the steps used in deriving your answer, wherever appropriate.

Question	Points	Score
1	22	
2	15	
3	10	
4	10	
5	12	
6	8	
7	13	
8	10	
Total	**100**	

1. (22 points) Please answer the following questions in 2-3 sentences.

   (a) Why is an ARP (Address Resolution Protocol) query sent by using a broadcast frame? Why is an ARP response sent within a frame with a specific destination MAC address? (4 points)

   Answer:
   An ARP query is sent in a broadcast frame because the querying host does not know the MAC address corresponds to the IP address in question. For the response, the sending node knows the MAC address to which the response should be sent, so there is no need to send a broadcast frame.

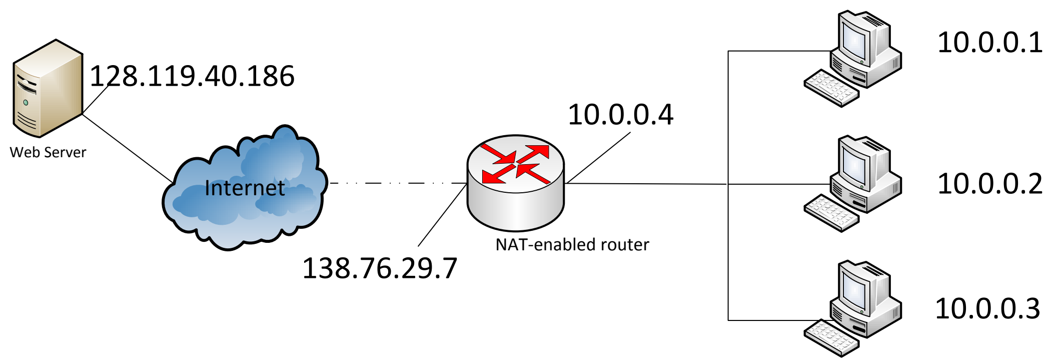
   (b) Why do we refer that TCP is a hybrid of GBN (Go-back-N) and SR (Selective Repeat) protocol? (3 points)

   Answer:
   A hybrid of GBN (single timer and cumulative ACK) and SR (receiver can buffer out of order arrivals) (1 point each)

   (c) What are the two advantages of CSMA/CD protocol over unslotted ALOHA protocol? (4 points)

   Answer:
   CDMA/CD protocol improves over the ALOHA in two aspects, 1) it listen to the channel (Carrier Sense) before transmission, 2) it continues monitoring the channel after transmission. When there is a collision detected (CD), it will abort the transmission.

   (d) Consider the scenario shown in following figure. Suppose that host 10.0.0.2 initiates a connection, using source port 5500 to a Web server listening at port 80 at 128.119.40.186. (5 points)



1. Complete the NAT translation table for this TCP connection. (3 points)

Answer:

NAT translation table	
WAN side	LAN side
138.76.29.7, 5002	10.0.0.2, 5500

Note that the use of 5002 on the WAN side is arbitrary. The NAT box will simply use an unused port number.

2. Please specify the source and destination IP addresses and the source and destination port numbers of the IP datagram sent by the Web server arriving to the WAN side of the router with interface address 138.76.29.7? (2 points)

Answer:

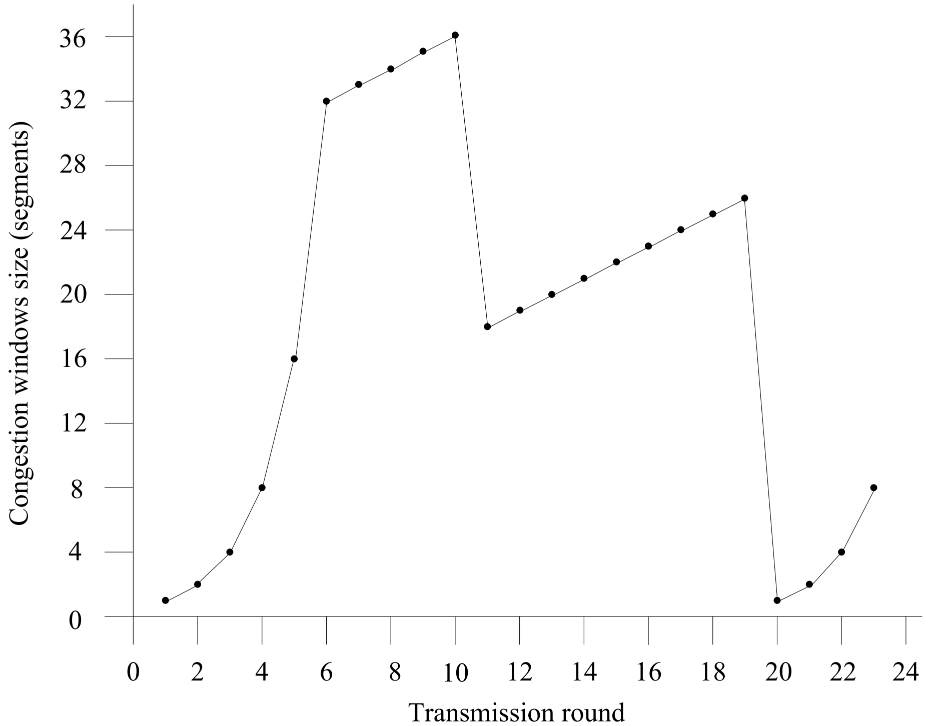
For the datagram returning from the Web server: source IP: 128.119.40.186, source port: 80, dest. IP: 138.76.29.7, dest. Port: 5002.

(e) What is "fast retransmission" in TCP congestion control? What is the rationale or reason behind fast retransmission (6 points)

Answer:
If a sender receives three duplicate ACKs, a sender takes as an indication that the segment following the ack'ed segment is lost, so the sender will retransmit the segment without waiting for the timeout (3 points)

A TCP sender often sends a large number of segments back to back, if one segment is lost, there will be likely many back-to-back duplicate ACK (2 points). On the other hand, a timeout value is often too long (3 points).

2. (15 points) Consider the following plot of TCP window size as a function of time.



Assuming TCP Reno is the protocol experiencing the behavior shown above, answer the following questions. Please briefly justify your answers.

(a) What are values of threshold (ssthresh) at the 5th, 14th and 22th round, respectively? (3 points)

Answer: 32 for round 5, 18 for round 14, and 13 for round 22.

(b) Please indicate all intervals when TCP congestion avoidance is operating. (2 points)

Answer: [6, 10], [11, 19]

(c) After the 10th round, is the segment loss detected by a triple duplicate ACK or by a timeout? (1 point)

Answer: triple duplicate ACK

(d) After the 19^{th} round, is the segment loss detected by a triple duplicate ACK or by a timeout? (1 point)

Answer: timeout

(e) Please indicate all intervals when TCP slow start is operating. (2 points)

Answer: [1, 6], [20, 23]

(f) Suppose the segment size is 50kb and the RTT time is 200msec, please calculate the average throughout during the interval [12, 16]. (3 points)

Answer: 21 * segment size / RTT

(g) There are in total 399 segments being sent out during the interval [1, 19]. Please calculate at which transmission round the 460^{th} segment will be sent out. Assume that there is neither timeout nor duplicate ACK after the 20^{th} round. (3 points)

Answer:
1+2+4+8+16+32+33+34+35+36+18+19+…+25+26=31+170+198=399
20:1, 21:2, 22:4, 23:8, 24:13, 25:14, 26:15, 27:16
460th segment will be sent out at the 27th round.

3. (10 points) Suppose that in TCP, the sender window is of size N, the base of the window is at sequence number x, and the sender has just sent a complete window's worth of segments. Let RTT be the sender-to-receiver-to-sender round-trip time, and let MSS be the segment size.

(a) Is it possible that there are ACK segments in the receiver-to-sender channel for segments with sequence numbers lower than x? Justify your answer. (6 points)

Answer: It is possible. Suppose that the window size is N=1. The sender sends packet x-1, which is delayed and so it timeouts and retransmits x-1. There are now two copies of x-1 in the network. The receiver receives the first copy of x-1 and ACKs. The receiver then receives the second copy of x-1 and ACKs. The sender receives the first ACK and sets its window base to x. At this point, there is still an ACK for x-1 propagating back to the sender.

ACK x or pkt x was delayed on the channel; pkt x timeouts later on; sender retransmit the pkt x; but shortly after the retransmission, ACK x was received; the retransmitted pkt x was till on the channel.

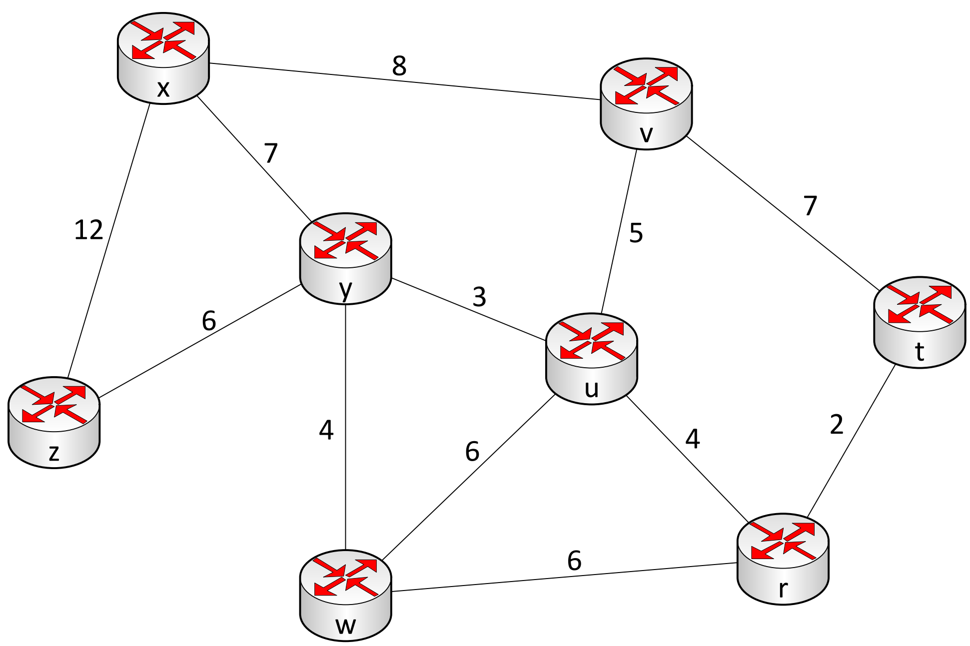
(b) Assuming no loss, what is the throughput of the sender-to-receiver connection? (2 points)

Answer: Assume that N is measured in segments. The sender can thus send N segments, each of size MSS bytes every RTT sec. The throughput is N*MSS/RTT

(c) Suppose TCP is in its congestion avoidance phase. Assuming no loss, what is the window size after the N segments are ACKed? (2 points)

Answer: N + 1

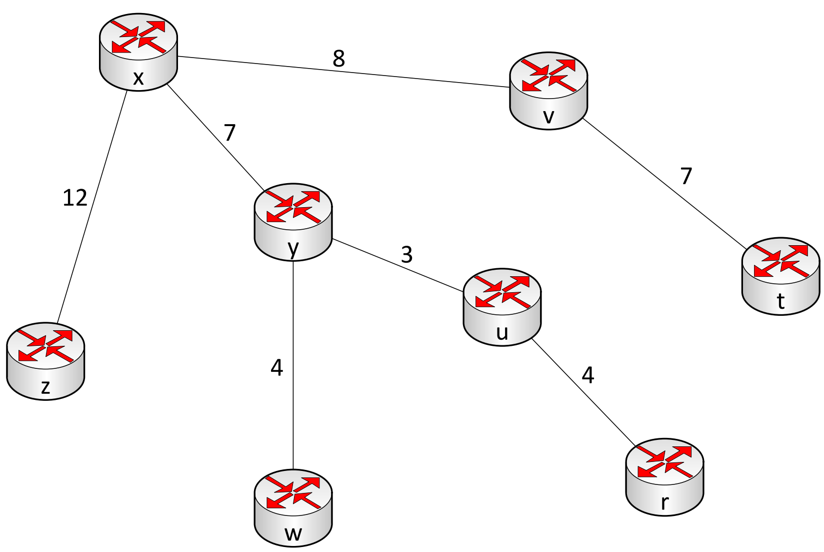
4. (10 points) Consider the following network of which the link cost is given.



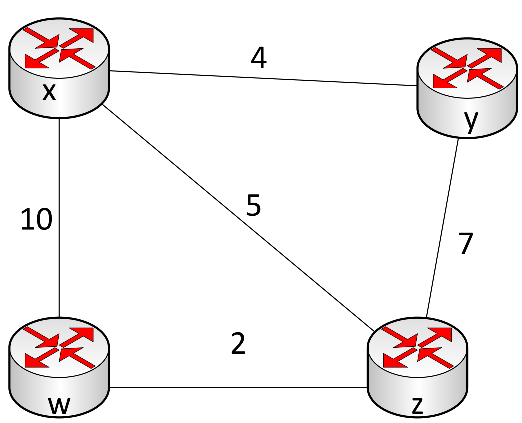
(a) Use Dijkstra's shortest-path algorithm to compute the shortest path from y to all other network nodes. If two distance values are equal during computation, choose the first corresponding node in accord with the sequence: x, y, z, u, v, w, r, t. (6 points)

Step	N	D(x),p(x)	D(z),p(z)	D(u),p(u)	D(v),p(v)	D(w),p(w)	D(r),p(r)	D(t),p(t)
0	y	7,y	6,y	3,y	∞	4,y	∞	∞
1	y,u	7,y	6,y		8,u	4,y	7,u	∞
2	y,u,w	7,y	6,y		8,u		7,u	∞
3	y,u,w,z	7,y			8,u		7,u	∞
4	y,u,w,z,x				8,u		7,u	∞
5	y,u,w,z,x,r				8,u			9,r
6	y,u,w,z,x,r,v							9,r
7	y,u,w,z,x,r,v,t							

(b) Show the shortest-path tree from node x to all other nodes. You just need to draw the tree without intermediate steps. (4 points)



5. (12 points) Consider the network shown below, and assume that each node initially knows the costs to each of its neighbors.



(a) Consider the distance-vector algorithm and show the distance table entries of each node until all table reaches stable state. (8 points)

Answer:

x tab.	x	y	z	w
x	0	4	5	10
y	∞	∞	∞	∞
z	∞	∞	∞	∞
w	∞	∞	∞	∞

x tab.	x	y	z	w
x	0	4	5	**7**
y	4	0	7	∞
z	5	7	0	2
w	10	∞	2	0

x tab.	x	y	z	w
x	0	4	5	7
y	4	0	7	9
z	5	7	0	2
w	7	9	2	0

y tab.	x	y	z	w
x	∞	∞	∞	∞
y	4	0	7	∞
z	∞	∞	∞	∞

y tab.	x	y	z	w
x	0	4	5	10
y	4	0	7	**9**
z	5	7	0	2

y tab.	x	y	z	w
x	0	4	5	7
y	4	0	7	9
z	5	7	0	2

z tab.	x	y	z	w
x	∞	∞	∞	∞
y	∞	∞	∞	∞
z	5	7	0	2
w	∞	∞	∞	∞

z tab.	x	y	z	w
x	0	4	5	10
y	4	0	7	∞
z	5	7	0	2
w	10	∞	2	0

z tab.	x	y	z	w
x	0	4	5	7
y	4	0	7	9
z	5	7	0	2
w	7	9	2	0

w tab.	x	y	z	w
x	∞	∞	∞	∞
z	∞	∞	∞	∞
w	10	∞	2	0

w tab.	x	y	z	w
x	0	4	5	10
z	5	7	0	2
w	**7**	**9**	2	0

w tab.	x	y	z	w
x	0	4	5	7
z	5	7	0	2
w	7	9	2	0

(b) Suppose after the stable state, the link cost c(x,w) is changed from 10 to 1. Both node x and w see the change of the link cost and update their distance vectors. Then show the computation process in following tables. (4 points)

Answer:

x tab.	x	y	z	w
x	0	4	5	7
y	4	0	7	9
z	5	7	0	2
w	**7**	**9**	2	0

x tab.	x	y	z	w
x	0	4	**3**	**1**
y	4	0	7	9
z	5	7	0	2
w	**7**	**9**	2	0

x tab.	x	y	z	w
x	0	4	3	1
y	4	0	7	9
z	5	7	0	2
w	1	5	2	0

x tab.	x	y	z	w
x	0	4	3	1
y	4	0	7	5
z	3	7	0	2
w	1	5	2	0

y tab.	x	y	z	w
x	0	4	5	7
y	4	0	7	9
z	5	7	0	2

y tab.	x	y	z	w
x	0	4	5	7
y	4	0	7	9
z	5	7	0	2

y tab.	x	y	z	w
x	0	4	3	1
y	4	0	7	**5**
z	5	7	0	2

y tab.	x	y	z	w
x	0	4	3	1
y	4	0	7	5
z	3	7	0	2

z tab.	x	y	z	w
x	0	4	5	7
y	4	0	7	9
z	5	7	0	2
w	**7**	**9**	2	0

z tab.	x	y	z	w
x	0	4	5	7
y	4	0	7	9
z	5	7	0	2
w	**7**	**9**	2	0

z tab.	x	y	z	w
x	0	4	3	1
y	4	0	7	9
z	**3**	7	0	2
w	1	5	2	0

z tab.	x	y	z	w
x	0	4	3	1
y	4	0	7	5
z	3	7	0	2
w	1	5	2	0

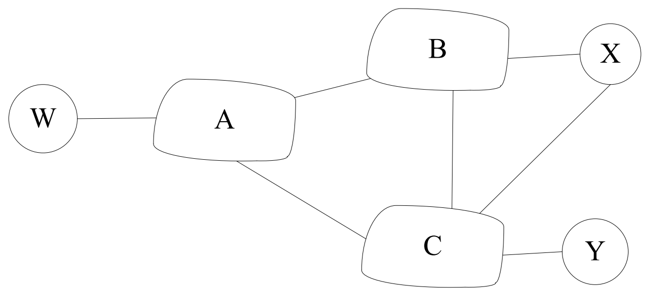
w tab.	x	y	z	w
x	0	4	5	7
z	5	7	0	2
w	**7**	**9**	2	0

w tab.	x	y	z	w
x	0	4	5	7
z	5	7	0	2
w	**1**	**5**	2	0

w tab.	x	y	z	w
x	0	4	3	1
z	5	7	0	2
w	1	5	2	0

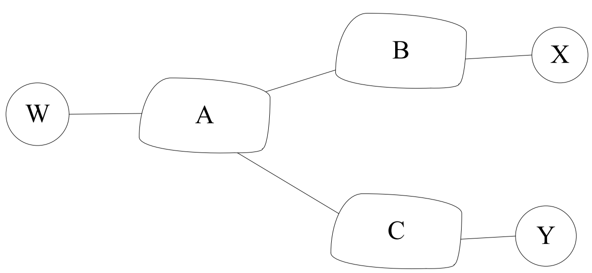
w tab.	x	y	z	w
x	0	4	3	1
z	3	7	0	2
w	1	5	2	0

6. (8 points) Consider the network topology in the following figure that shows six interconnected autonomous systems: A, B, C, W, X, and Y. Suppose A, B, C are provider networks and W, X, Y are customer networks. The customer network (even though multi-homed) does not forward traffic for other network. If the lengths of two AS-Paths are equal, either path is acceptable. Based on the path information available at each customer network, please draw the respective views of the network topology at W, X, and Y.

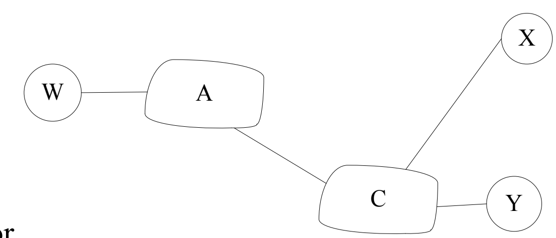


Answer:

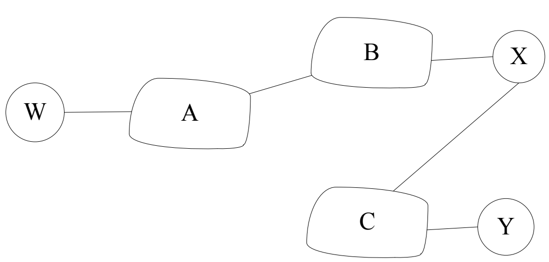
W's view of the topology



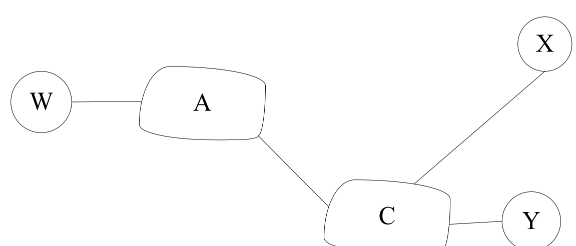
or



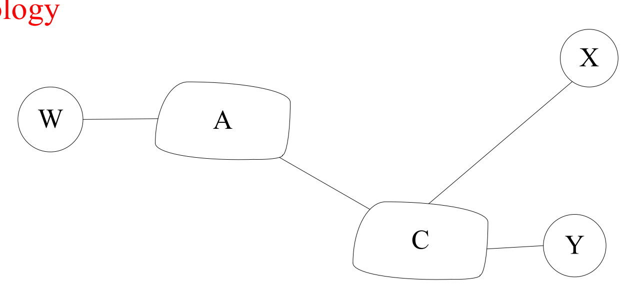
X's view of the topology



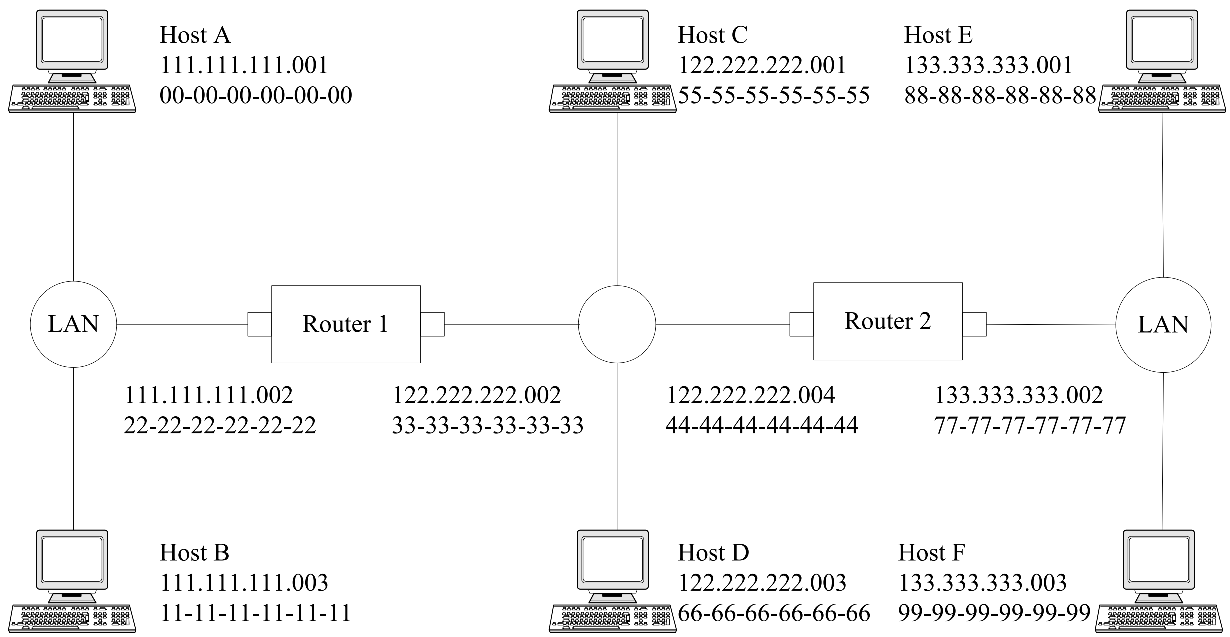
or



Y's view of the topology



7. (13 points) Consider the network in the following figure. The IP address and MAC address of each host and router are given in the figure.



(a) How many subnets are in this network? Suppose the network part of the address has 24 bits, what are their respective subnet addresses in the form a.b.c.d? (3 points)

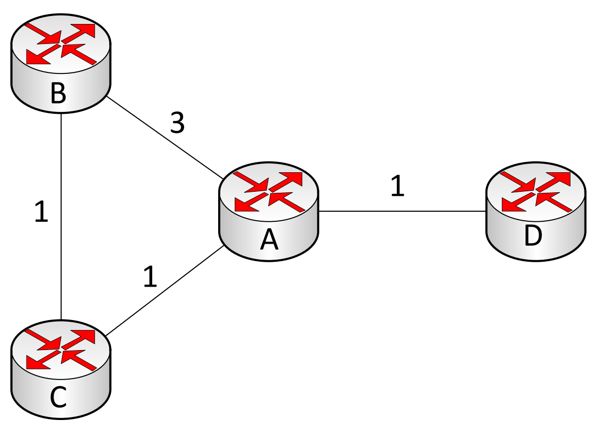
Answer: 3 subnets, 111.111.111.0, 122.222.222.0, 133.333.333.0

(b) Suppose Host A wants to send an IP datagram to Host F, and Host A only knows the IP address of Host F. Suppose all ARP tables are empty (all hosts and routers). How many frame exchanges are required for the delivery of IP datagram from Host A to Host F? Please illustrate the type, the IP address (source/destination), and the MAC address (source/destination) of each frame exchange. (10 points)

Answer: 9 frame exchanges

	IP address		MAC address	
Type	Source	Destination	Source	Destination
ARP	111.111.111.001	133.333.333.003	00-00-00-00-00-00	FF-FF-FF-FF-FF-FF
ARP	111.111.111.002	111.111.111.001	22-22-22-22-22-22	00-00-00-00-00-00
IP	111.111.111.001	133.333.333.003	00-00-00-00-00-00	22-22-22-22-22-22
ARP	122.222.222.002	133.333.333.003	33-33-33-33-33-33	FF-FF-FF-FF-FF-FF
ARP	122.222.222.004	122.222.222.002	44-44-44-44-44-44	33-33-33-33-33-33
IP	111.111.111.001	133.333.333.003	33-33-33-33-33-33	44-44-44-44-44-44
ARP	133.333.333.002	133.333.333.003	77-77-77-77-77-77	FF-FF-FF-FF-FF-FF
ARP	133.333.333.003	133.333.333.002	99-99-99-99-99-99	77-77-77-77-77-77
IP	111.111.111.001	133.333.333.003	77-77-77-77-77-77	99-99-99-99-99-99

8. (10 points) For the network shown below, distance vector algorithm is used to compute routing table. Poisoned reverse is used and steady state has been reached at time t=0. The steady distance tables of A, B, C and D are already given below.



Shortly after t=0, link A-D fails and its cost is thus increased to infinity, and only node A notices this link cost change. Node A performs table updates and sends distance vectors to neighbors at time t=1,4,7,10,13…, Node B performs updates and sends distance vectors to neighbors at time t=2,5,8,11,14,…, and Node C performs updates and sends distance vectors to neighbors at time t=3,6,9,12,15….

Please fill the distance tables at nodes A, B, C after updates at t=1, t=2, t=3, and t=4. During the computation, if a distance table remains the same as the previous time, then you can just mark "Not changed" in the middle of the table. (Note: We assume after node B receives a new distance vector from A at $t=1^+$, it will not update its table until t=2.)

A	A	B	C	D
A	0	C2	1	1
B	2	0	1	3
C	1	1	0	∞
D	1	∞	∞	0

A	A	B	C	D
A	0	C2	1	**B6**
B	2	0	1	3
C	1	1	0	∞

A	A	B	C	D
A				
B	Not changed			
C				

A	A	B	C	D
A				
B	Not changed			
C				

A	A	B	C	D
A	0	C2	1	B6
B	2	0	1	3
C	1	1	0	∞

(Or "Not changed")

B	A	B	C	D
A	0	2	1	1
B	C2	0	1	C3
C	1	1	0	2

B	A	B	C	D
A				
B	Not changed			
C				

B	A	B	C	D
A	0	2	1	∞
B	C2	0	1	C3
C	1	1	0	2

B	A	B	C	D
A				
B	Not changed			
C				

B	A	B	C	D
A				
B	Not changed			
C				

C	A	B	C	D
A	0	∞	1	1
B	∞	0	1	∞
C	1	1	0	A2

C	A	B	C	D
A				
B	Not changed			
C				

C	A	B	C	D
A				
B	Not changed			
C				

C	A	B	C	D
A	0	∞	1	6
B	∞	0	1	∞
C	1	1	0	**A7**

C	A	B	C	D
A				
B	Not changed			
C				

D	A	B	C	D
A	0	2	1	1
D	1	A3	A2	0

t=0 t=1 t=2 t=3 t=4