COMP9121 Assignment 1 2024 S2

Due: 08 Sep 2024 at 23:59

Request for review:

Please read this instruction before you request a remark.

(1) Please firstly read the solutions and compare your answer against them.

(2) If you have no concern on each individual question, but you think there is a mistake in calculation the total mark, or late penalty, or special consideration, please send us an email titled, [COMP9121, Assignment 1, total mark calculation] and explain your situation. Send the email to liming.ge@sydney.edu.au.

(3) If you have concerns on individual questions, you can ask for remarking of those questions. Please give us reasons for each of them. You need to let us know which questions you want to remark and why you think your mark should be changed for those questions. Please note that we will remark the questions you ask for, but we do not guarantee that the final mark is the same or higher (it may be lower). Please send us an email titled, [COMP9121, Assignment 1, remark Qx, Qx …] (x is the question number) and explain your situation. Send the email to liming.ge@sydney.edu.au.

(4) If you do not follow the right procedure, your request may be ignored or there could be substantial delay in processing your request.

(5) We may ask you for an interview if we find your case is complicated.

In this assignment, some questions are student number dependent; you will get zero in that question if you use another student's number.

You need to show your progress. Giving a final answer only is not acceptable.

You can write your answers on paper and scan, or you can type your answers in your computer. Please merge all you answers in a single pdf file and upload in Canvas.

There are 10 question in total. Each question is equally weighted.

1. **CRC.**

(1) What is your student number? Convert your student number to binary and hexadecimal numbers.

(2) Let D be the binary number your derived above. The generator G starts with 1 and ends with 1, with all intermediate bits being zero, so G = 10…01. The CRC should be 1 byte in length. Calculate the CRC derived by D and G.

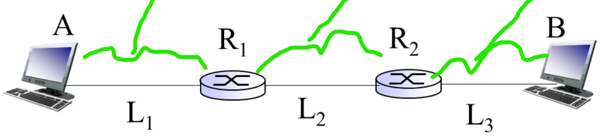
(1)-(2) depends on your student number. (1) 4 points (2) 6 points. We will verify your results.

(2) Since the CRC is 1 byte = 8 bits in length, the generator is 9 bits. Generator G = 100000001. (2 points, the result will be 4 points)

2. **Delay.**

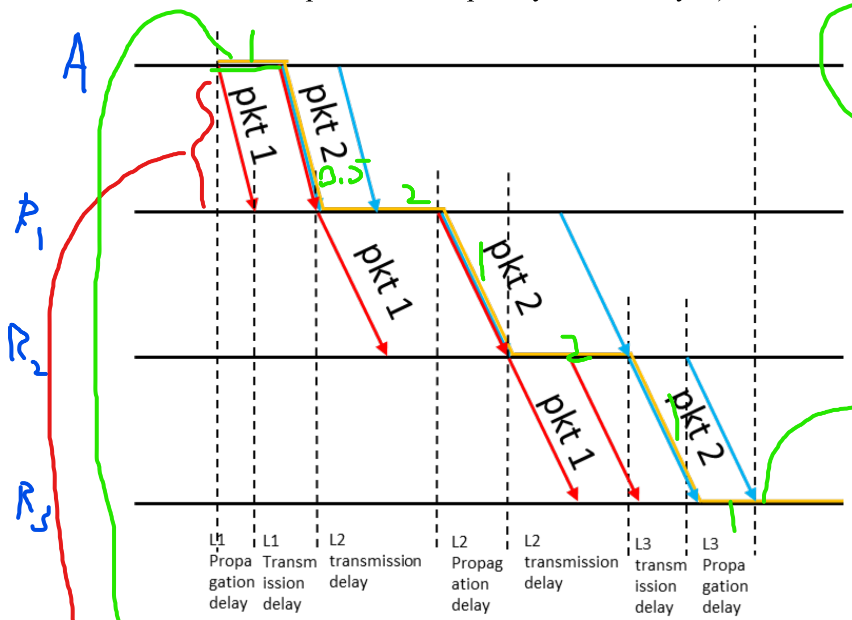
计算 T_{t1} T_{p1} T_{t2} T_{p2} ......

Consider two hosts, A and B, are connected by three links and two routers as shown the figure below. Suppose node A sends two packets consecutively to B. Each packet is with the size of 100 bytes. Each router applies store and forward. There is no bit error or packet loss.



We have: Bandwidth of L_1 = 0.8 Mbps. Bandwidth of L_2 = 0.4 Mbps. Bandwidth of L_3 = 0.8 Mbps. Length of L_1 = 100 km. Length of L_2 = 200 km. Length of L_3 = 200 km. Propagation speed of links = 2 × 10^8 (m/s).

(1) What is the overall delay to deliver the two packets? (From the start of sending first packet at A till the second packet is completely received by B)



1+0.5+2+2+1+1+1

see the yellow line

L1 transmission delay is t_{t1}=100*8/(0.8*10^6) s = 1 ms

L1 propagation delay is t_{p1}=100*10^3/(2*10^8) s = 0.5 ms

L2 transmission delay is t_{t2}=100*8/(0.4*10^6) s = 2 ms

L2 propagation delay is t_{p2}=200*10^3/(2*10^8) s = 1 ms

L3 transmission delay is t_{t3}=100*8/(0.8*10^6) s = 1 ms

L3 propagation delay is t_{p3}=200*10^3/(2*10^8) s = 1 ms

Overall delay is $t_{t1}+t_{p1}+2t_{t2}+t_{p2}+t_{t3}+t_{p3}$=8.5 ms

8 points, each delay 1 point and the final summation 2 point

(2) At $\frac{k}{10}$ ms, where is the first bit of the **second** packet? k is the last **two** digits of your student number. (0ms is defined as the instant when A starts sending the first bit of the first packet).

The location of the first bit of the second packet is shown on the yellow line in the figure above.

Time ($\frac{k}{10}$ ms)	Location

0-1	A
1-1.5	L_1
1.5-3.5	R_1
3.5-4.5	L_2
4.5-6.5	R_2
6.5-7.5	L_3
>7.5	B

2 points

3. **Parity**.

Using the last 6 bits of your student number in binary form (which you should have already calculated it in Question 1), to form a 6-bit information stream. Generate the parity bit and you can derive a 7-bit coded stream.

1) Send the coded stream through a random flipping channel with bit-flip probability p=0.05. Each bit is flipped independently. Assume that only the information bits may flip, and the parity bit will **not** flip. Please calculate the probability that some of the bits are flipped, but this is **not** detected by the parity check.

We need to calculate the probability that 2, 4, or 6 bits of the information bits are flip.

$$P = \binom{6}{2} p^2(1-p)^4 + \binom{6}{4} p^4(1-p)^2 + \binom{6}{6} p^6 = 0.030628609$$

You can also assume that 2-bit error is most common so that

$$P \approx \binom{6}{2} p^2(1-p)^4 = 0.030543984$$

Please note this is not related to your student number.

5 points (4 points formulat and 1 point final solution)

2) Send the coded stream into a random lossy channel with bit-lost probability p=0.05. Each bit is lost independently. Assume that only the information bits may be lost, and the parity bit will **not** be lost. Please calculate the probability that some of the bits are lost, but this is **not** detected by the parity check.

This depends your student number and depends how many zeros are there in the 6 information bits.

Assume l bits are 0 and the rest $k = 6 - l$ bits are 1.

Then, if any "0" is lost, the parity cannot detect. If any "1" is lost, the parity cannot detect if 2 of them are lost, or 4 of them are lost, or 6 of them are lost. 2 points

Probability at least one 0 is lost (we call it Event 0): $P_0 = 1 - (1-p)^l$, 1 point

Probability that 2 or 4 or 6 "1" are lost (we call it Event 1):

$$P_1 = 0, if\ k = 0\ or\ 1$$

$$P_1 = \binom{k}{2} p^2(1-p)^{k-2}, if\ k = 2\ or\ 3$$

$$P_1 = \binom{k}{2} p^2(1-p)^{k-2} + \binom{k}{4} p^4(1-p)^{k-4}, if\ k = 4\ or\ 5$$

$$P_1 = \binom{k}{2} p^2(1-p)^{k-2} + \binom{k}{4} p^4(1-p)^{k-4} + \binom{k}{6} p^6(1-p)^{k-6}, if\ k = 6$$

1 point

The overall probability:

Only

Event 0 happens AND event 1 happens + Event 1 happens AND event 0 does not happen +

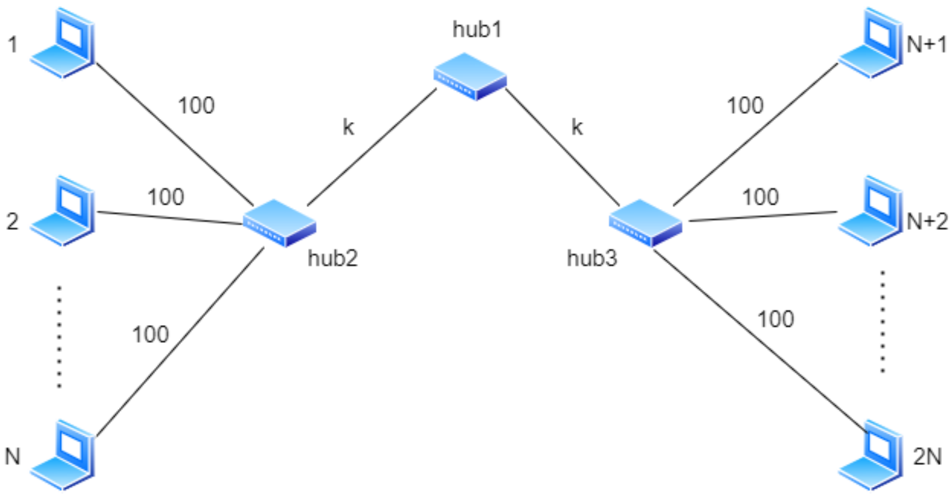
only Event 0 happens and there is no "1" lost.

$$P_0P_1 + P_1(1-P_0) + P_0(1-p)^k$$ k个1都 success

1 point

4. **CSMA-CD Performance.**

2N computers have been connected in a network as illustrated. The length of each link is written in meters. Let k be the last **three** digits of your student number. Each computer generates 1000 packets per second with each packet being 500 bytes. The maximum rate of all links is 1 Gbps. The propagation speed in the medium is 2.0×10^8 meters/second.



(1) What is the maximum number of nodes supported in the network if CSMA-CD is used on the shared medium?

$t_{prop}=(200+2k)/(2*10^8)$ s

2 points

$t_{trans}=4$ us

efficiency = $1/(1+5\frac{t_{prop}}{t_{trans}})$

1 point

2N=efficiency*10^9/(1000*500*8)

2 points

(2) Assume that hub1 is replaced with a switch. Find the maximum number of nodes supported in the network if CSMA-CD is used on the shared medium. Assume that 3/4 of the traffic is kept in its own side and 1/4 of the traffic goes to the other side.

If k>100, the span is 100+k m, if k<=100, the span is 200 m. Therefore, the span is 100 + max(100, k) m

$t_{prop}=(100+\max(100,k))/(2*10^8)$

2 points ?

t_{trans}=4 us

efficiency = $1/(1+5\frac{t_{prop}}{t_{trans}})$

$(N/4+N)=\text{efficiency}*10^9/(1000*500*8)$

Solve the equation to derive N, and then calculate 2N.

3 points

5. **Address allocation.**

A company has been granted a block of IP addresses starting with 150.12.32.0/20. The address space should be allocated to four subnets A, B, C and D. Let k be the last digit of your student number. Subnet A needs (k+18) addresses, subnet B needs (k+40) addresses, subnet C needs (k+80) addresses, and subnet D needs (k+253) addresses.

(1) The IP addresses have been assigned in the following order A, B, C, and D (subnet A has the smallest IP addresses and subnet D has the largest IP addresses). What is the starting IP address of subnets A, B, C, and D?

Subnet A requires 32 addresses; (5bits)

Subnet B requires 64 addresses; (6bits)

Subnet C requires 128 addresses; (7bits)

1 point

Subnet D requires 256 addresses if k is 0 or 1 (8 bits), requires 512 addresses otherwise. (9 bits)

1 point

Starting IP:

Subnet A: $150.12.32.000\underbrace{\text{X XXXX}}_{\text{5 bits}} \rightarrow 150.12.32.0/27$

Subnet B: $150.12.32.01\underbrace{\text{XX XXXX}}_{\text{6 bits}} \rightarrow 150.12.32.64/26$

Subnet C: $150.12.32.1\underbrace{\text{XXX XXXX}}_{\text{7 bits}} \rightarrow 150.12.32.128/25$

Subnet D:

If k is 0 or 1: $150.12.0010\ 0001.\underbrace{\text{XXXX XXXX}}_{\text{8 bits}} \rightarrow 150.12.33.0/24$

If $k \geq 2$: $150.12.0010\ 001\underbrace{\text{X. XXXX XXXX}}_{\text{9 bits}} \rightarrow 150.12.34.0/23$

1 point each for subnet A, B, C, and D.

(2) The IP addresses have been assigned in the following order D, C, B, and A. Redo the question (1).

If k is 0 or 1:
Subnet D: $150.12.0010\ 0000.\underbrace{\text{XXXX XXXX}}_{\text{8 bits}} \rightarrow 150.12.32.0/24$

Subnet C: 150.12.0010 0001. 0XXX XXXX → 150.12.33.0/25
7 bits

Subnet B: 150.12.0010 0001. 10XX XXXX → 150.12.33.128/26
6 bits

Subnet A: 150.12.0010 0001. 110X XXXX →150.12.33.192/27
5 bits

If k is larger or equal to 2:

Subnet D: 150.12.0010 000X. XXXX XXXX → 150.12.32.0/23
9 bits

Subnet C: 150.12.0010 0010. 0XXX XXXX → 150.12.34.0/25
7 bits

Subnet B: 150.12.0010 0010. 10XX XXXX → 150.12.34.128/26
6 bits

Subnet A: 150.12.0010 0010. 110X XXXX →150.12.34.192/27
5 bits

1 point each for subnet A, B, C, and D.

6. **NAT.** In the figure below, assume the address 134.31.44.2 is the public IP and 192.168.2.224 with subnet mask 255.255.255.248 are local IPs for the private network. Assume a web application is running on port 5500 on all hosts A, B, C, D, and E. Each web application in each host generates a packet to Server 1 (223.21.77.40, 80). We assume there is no other traffic.

(1) Assign local IP addresses to the A—E

A: 192.168.2.225

B: 192.168.2.226

C: 192.168.2.227

D: 192.168.2.228

E: 192.168.2.229

Only 192.168.2.225—192.168.2.230 can be used to allocated. (2 points)

(2) Following (1), generate the NAT translation table for all traffic in the network by considering that port numbers in the range of [63001, 63005] are available to be assigned in the NAT.

Internal IP Address	**Internal Port**	**External IP Address**	**External Port**
192.168.2.225	5500	134.31.44.2	63001
192.168.2.226	5500	134.31.44.2	63002
192.168.2.227	5500	134.31.44.2	63003
192.168.2.228	5500	134.31.44.2	63004
192.168.2.229	5500	134.31.44.2	63005

3 points

(3) Following (2), when the Server sends a reply packet to node C, what are the (IP address, port) fields in the packet header for both the source and destination?

Source: IP addr 223.21.77.40, port 80

Destination: IP addr 134.31.44.2, port 63003 (must be consistent to table in (2))

3 points

(4) Following (3), when the packet arrives at the NAT Router, how does the NAT Router process the packet?

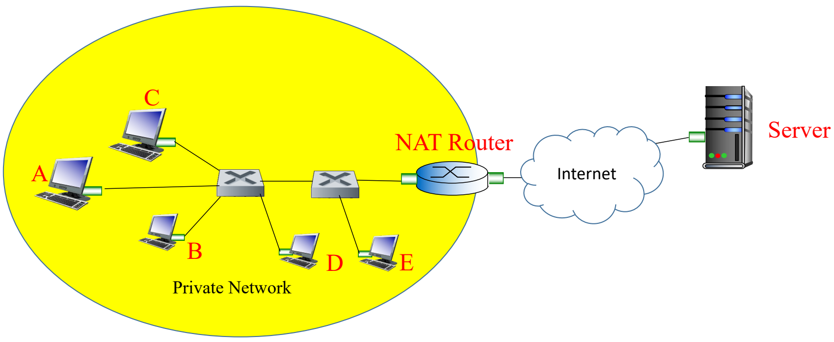
The NAT Router checks the destination IP address and port using the NAT translation table, and replace them by the internal IP address and port.

Destination IP address: 192.168.2.227 (must be consistent to table in (2))

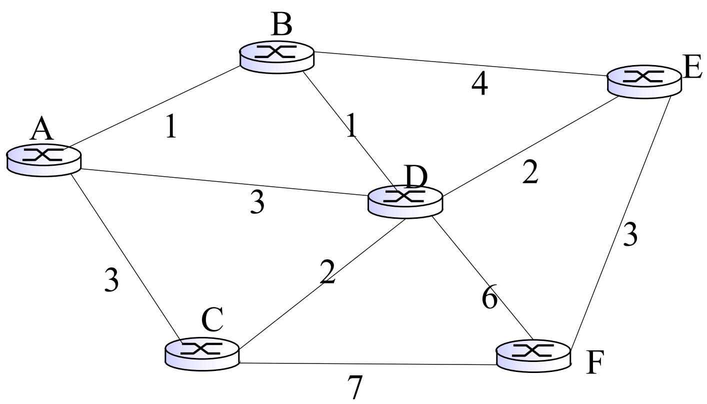
Destination Port: 5500.

The correct answer may not be unique.

2 points



7. Dijkstra. In the following network, using Dijkstra's algorithm to find the shortest distances from F to all other nodes in the network. The link costs are labelled.

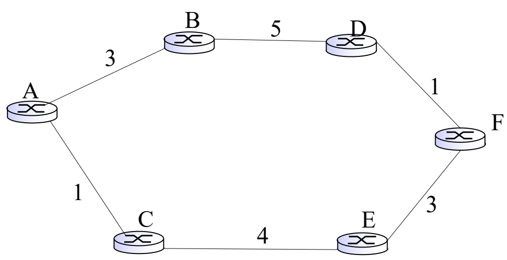


routers.

Step	Tree	A	B	C	D	E
Initial	{F}	(-1, inf)	(-1, inf)	(F,7)	(F,6)	(F,3)
1	{E,F}	(-1, inf)	(E,7)	(F,7)	(E,5)	
2	{D,E,F}	(D,8)	(D,6)	(D/F,7)		
3	{B,D,E,F}	(B,7)		(D/F,7)		
4	{A,B,D,E,F} It is also fine if C enters before A			(D/F,7)		
5	{A,B,C,D,E,F}	(B,7)	(D,6)	(D/F,7)	(E,5)	(F,3)

10 points, each row 1.5 points. Final answer 1 point.

8. Distance Vector. Consider the network topology presented in the figure below. The link costs are labelled.



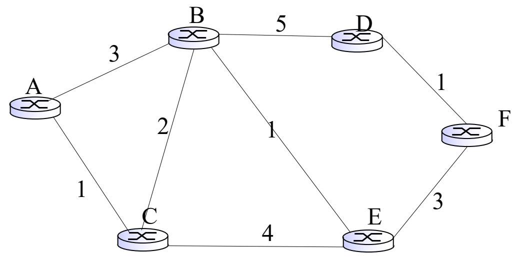
(1) Use the distance vector algorithm to find the shortest distances from all routers to router F by filling in the table below (assume that exchanges of routing information and routing table updates are synchronous). The table allows up to 8 iterations, but you can stop whenever the algorithm converges.

	A	B	C	D	E
Initial	−1,∞	−1,∞	−1,∞	−1,∞	−1,∞
1	−1,∞	−1,∞	−1,∞	F,1	F,3
2	−1,∞	D,6	E,7	F,1	F,3
3	C,8	D,6	E,7	F,1	F,3
4 (converge)	C,8	D,6	E,7	F,1	F,3

5 points, each row 1 point. (Row 4 is not necessary to be shown.) Final answer 1 point.

No progress-> 0 point.

(2) After the convergence of (1), assume that the links B − E and B − C are connected with costs shown below. Do NOT use split horizon or reverse poisoning. Fill in the table below using the distance vector algorithm to find the shortest distance from each router to router F. The table allows up to 8 iterations, but you can stop whenever the algorithm converges.

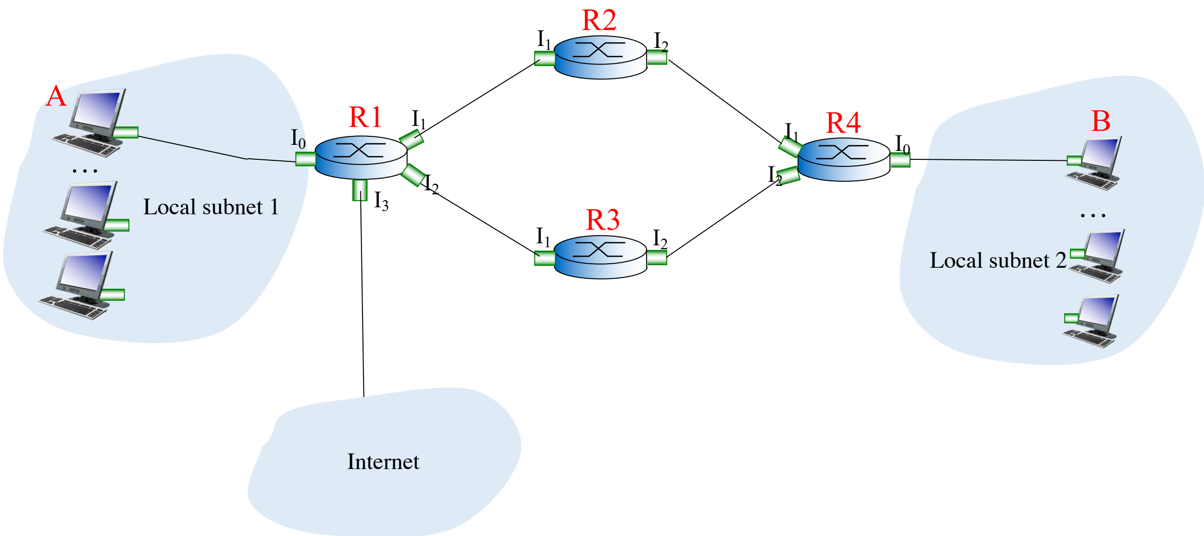


	A	B	C	D	E
Initial	C,8	D,6	E,7	F,1	F,3
1	C,8	E,4	E,7	F,1	F,3
2	B,7	E,4	B,6	F,1	F,3
3 (converge)	B/C,7	E,4	B,6	F,1	F,3

5 points, each row 1 point. (Row 3 is not necessary to be shown.) Final answer 2 points.

No progress-> 0 point.

9. Routing. The figure below shows the network. The IP address and MAC address of each interface are listed below and the forwarding tables of routers are also listed.



Interface		IP address	MAC address
A		192.168.64.35	AA-AA-AA-AA-AA-AA
B		192.168.79.42	BB-BB-BB-BB-BB-BB
R1	I_0	192.168.64.1	AA-00-00-00-00-AA
	I_1	192.168.65.1	AA-11-11-11-11-AA
	I_2	192.168.66.1	AA-22-22-22-22-AA
	I_3	192.168.67.1	AA-33-33-33-33-AA
R2	I_1	192.168.65.2	BB-11-11-11-11-BB
	I_2	192.168.68.1	BB-22-22-22-22-BB
R3	I_1	192.168.66.2	CC-11-11-11-11-CC
	I_2	192.168.69.1	CC-22-22-22-22-CC
R4	I_0	192.168.72.1	DD-00-00-00-00-DD
	I_1	192.168.68.2	DD-11-11-11-11-DD

	I_2	192.168.69.2	DD-22-22-22-22-DD

R1 forwarding table

192.168.64.0/21	I_0
192.168.72.0/21	I_1
192.168.78.0/23	I_2
Default	I_3

R2 forwarding table

192.168.64.0/21	I_1
192.168.72.0/21	I_2
Default	I_1

R3 forwarding table

192.168.64.0/21	I_1
192.168.78.0/23	I_2
Default	I_1

R4 forwarding table

192.168.64.0/21	I_1
192.168.72.0/21	I_0
Default	I_2

"A" sends a packet to "B", with source IP address 192.168.64.35 and destination IP address 192.168.79.42. It is successfully delivered.

(1) Does the system route the packet via A-R1-R2-R4-B or A-R1-R3-R4-B? Why?

At R1, we use the longest prefix matching.

192.168. 01000	I_0
192.168. 01001	I_1
192.168. 0100111	I_2
Default	I_3

Destination IP is 192.168. 01001111.42, which matches I_1 and I_2 but I_2 is the longest matching,

Therefore A-R1-R3-R4-B will be used.

(Also, you can verify that the packet will be forwarded from R3 to R4 and then forwarded from R4 to B.)

4 points. (3 points for longest prefix matching and 1 point for the conclusion)

(2) When this packet is being delivered on the R4-B hop, specify the source IP address, destination IP address, source MAC address, destination MAC address of the packet.

[Source IP: 192.168.64.35; Destination IP: 192.168.79.42; Source MAC: DD-00-00-00-00-DD; Destination MAC: BB-BB-BB-BB-BB-BB]

IP: does not change

MAC: Local addresses, R4 (I0) and B's MAC addresses.

(3 points, each wrong entry will -1 point but the minimum is 0)

(3) If your answer to (1) is A-R1-R2-R4-B, when the packet is being delivered at R2-R4 hop, specify the source IP address, destination IP address, source MAC address, and destination MAC address of the packet. If your answer to (1) is A-R1-R3-R4-B, when the packet is being delivered at R3-R4 hop, specify the source IP address, destination IP address, source MAC address, and destination MAC address of the packet.

R3-R4

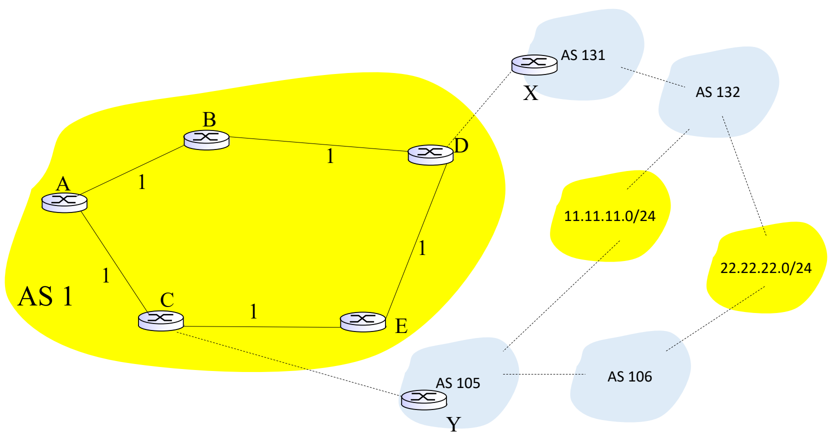
[Source IP: 192.168.64.35; Destination IP: 192.168.79.42; Source MAC: CC-22-22-22-22-CC; Destination MAC: DD-22-22-22-22-DD]

IP: does not change

MAC: Local addresses, R3 (I_2) and R4 (I_2)'s MAC addresses.

(3 points, each wrong entry will -1 point but the minimum is 0)

10. **Inter-AS**. Consider the network topology as follows. There are multiple ASes in the network. A–E indicate routers within AS1. X and Y are gateway routers of AS131 and AS105. Link costs in AS1 are labelled in the figure. AS1 is a customer network of AS105 and AS131. 11.11.11.0/24 is a customer network of AS132 and AS105. 22.22.22.0/24 is a customer network of AS132 and AS106.



(1) Are the following AS-PATHs allowed? Why or why not?

AS1-AS131-AS132-11.11.11.0/24

Yes, AS1 is a customer of AS131 and 11.11.11.0/24 is a customer of AS132

AS1-AS131-AS132-22.22.22.0/24

Yes, AS1 is a customer of AS131 and 22.22.22.0/24/24 is a customer of AS132

AS1-AS105-11.11.11.0/24

Yes, AS1 and 11.11.11.0/24 are customers of AS105

AS1-AS105-AS106-22.22.22.0/24

Yes, AS1 is a customer of AS105 and 22.22.22.0/24/24 is a customer of AS106

1 point each, reason must be correct for each entry. Only the correct answer but inaccurate reason will give 0.5 point at most. Answer correct but reason wrong will not be regarded as correct (0).

(2) Figure out entries in forwarding tables at different routers. Fill in the table below. (In “Next Hop”, choose one of the follows: A, B, C, D, E, X, Y.) Provide your reason for each entry.

0.6 point each entry, the answer (0.3) and reason (0.3) must be correct. Answer correct but reason wrong will not be regarded as correct (0). Answer correct but inaccurate reason will give 0.3 at most.

Router	Pre-fix	Next Hop
A	11.11.11.0/24	C shortest inter-AS route is AS1-A105-desitnation choose gateway C in the shortest path, next hop to C is C
A	22.22.22.0/24	C shortest inter-AS route is either AS1-AS105-AS106-destination or AS1-AS131-AS132-desitnation; choose C or D Shortest distance to C is 1, shotest distance to D is 2; choose C Next hop to C is C
B	11.11.11.0/24	A AS1-A105-desitnation, C is gateway Next hop to C is A
B	22.22.22.0/24	D tie in AS path, choose D instead of C as gateway and next hop is D
C	11.11.11.0/24	Y AS1-A105-desitnation, next hop is Y
C	22.22.22.0/24	Y Tie in AS path, choose C instead of D as gateway and next hop is Y
D	11.11.11.0/24	E AS1-A105-desitnation, C is gateway Next hop is E
D	22.22.22.0/24	X Tie in AS path, choose D instead of C as gateway and next hop is X
E	11.11.11.0/24	C AS1-A105-desitnation, C is gateway Next hop to C is C
E	22.22.22.0/24	C or D Tie in AS path, choose either C or D as gateway because the shortest distance to C and D are the same. If choose C as gateway, the next hop is C If choose D as gateway, the next hop is D