

### 1. CRC.

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

(2) Let D be the binary number you derived above. The generator G starts with 1 and ends with 1, with all intermediate bits being zero, so  $G = 10\ldots01$ . The CRC should be 1 byte in length. Calculate the CRC derived by D and G.

(1) 490051481

Binary Number:

$$\begin{array}{r}
 2 | 490051481 & 1 \\
 2 | 245025740 & 0 \\
 2 | 122512870 & 0 \\
 2 | 61256435 & 1 \\
 2 | 30628217 & 1 \\
 2 | 15314108 & 0 \\
 2 | 7657054 & 0 \\
 2 | 3828527 & 1 \\
 2 | 1914263 & 1 \\
 2 | 957131 & 1 \\
 2 | 478565 & 1 \\
 2 | 239282 & 0 \\
 2 | 119641 & 1 \\
 2 | 59820 & 0 \\
 2 | 29910 & 0 \\
 2 | 14955 & 1 \\
 2 | 7477 & 1 \\
 2 | 3738 & 0 \\
 2 | 1869 & 1 \\
 2 | 934 & 0 \\
 2 | 467 & 1 \\
 2 | 233 & 1
 \end{array}$$

$$\begin{array}{r}
 2 \left[ \begin{array}{c} 116 \\ 58 \end{array} \right] \\
 \sum \left[ \begin{array}{c} 0 \\ 0 \end{array} \right] \\
 2 \left[ \begin{array}{c} 29 \\ 14 \end{array} \right] \\
 2 \left[ \begin{array}{c} 7 \\ 7 \end{array} \right] \\
 2 \left[ \begin{array}{c} 3 \\ 3 \end{array} \right] \\
 2 \left[ \begin{array}{c} 1 \\ 1 \end{array} \right]
 \end{array}$$

0

|   |     |      |      |      |      |      |      |
|---|-----|------|------|------|------|------|------|
| 1 | 110 | 0011 | 0101 | 1001 | 0111 | 1001 | 1001 |
|---|-----|------|------|------|------|------|------|

Hexadecimal Number :

$$\begin{array}{r}
 16 \left[ \begin{array}{c} 49005148 \end{array} \right] \quad 9
 \end{array}$$

<sup>10 11 12 13 14 15</sup>  
 abcdef

$$\begin{array}{r}
 16 \left[ \begin{array}{c} 30628217 \end{array} \right] \quad 9
 \end{array}$$

$$\begin{array}{r}
 16 \left[ \begin{array}{c} 1914263 \end{array} \right] \quad 7
 \end{array}$$

1d359799

$$\begin{array}{r}
 16 \left[ \begin{array}{c} 11964 \end{array} \right] \quad 9
 \end{array}$$

$$\begin{array}{r}
 16 \left[ \begin{array}{c} 7477 \end{array} \right] \quad 5
 \end{array}$$

$$\begin{array}{r}
 16 \left[ \begin{array}{c} 467 \end{array} \right] \quad 3
 \end{array}$$

$$\begin{array}{r}
 16 \left[ \begin{array}{c} 29 \end{array} \right] \quad 13
 \end{array}$$

$$\begin{array}{r}
 16 \left[ \begin{array}{c} 1 \end{array} \right] \quad 1
 \end{array}$$

0

### 1. CRC.

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

(2) Let D be the binary number you derived above. The generator G starts with 1 and ends with 1, with all intermediate bits being zero, so  $G = 10\ldots01$ . The CRC should be 1 byte in length. Calculate the CRC derived by D and G.

$$(2) D = 1 \underline{110} \underline{001} \underline{1010} \underline{100} \underline{0111} \underline{1001} \underline{100}$$

$$CRC \quad G = 1 \dots 0 \dots 1 = 1000,0000,1$$

since CRC code is 8 bits, so CRC Generator is 9 digits

| G |      | 1110 1001 0100 0101 1111 1001 0011 0 |      |      |      |      |      |   |     |       |   |
|---|------|--------------------------------------|------|------|------|------|------|---|-----|-------|---|
| 1 | 110  | 1001                                 | 0100 | 0101 | 1111 | 1001 | 0011 | 0 | 000 | 00000 | 0 |
| 1 | 000  | 0000                                 | 1    |      |      |      |      |   |     |       |   |
| 1 | 110  | 1001                                 | 00   |      |      |      |      |   |     |       |   |
| 1 | 00   | 0                                    | 0000 | 0    |      |      |      |   |     |       |   |
| 0 | 10   | 1001                                 | 01   | 1    |      |      |      |   |     |       |   |
| 1 | 0    | 00000                                | 0    | 1    |      |      |      |   |     |       |   |
| 0 | 0    | 1001                                 | 0100 | 1    |      |      |      |   |     |       |   |
| 1 | 000  | 0000                                 | 0    | 1    |      |      |      |   |     |       |   |
| 0 | 0001 | 0100                                 | 0100 | 0    | 100  | 0001 | 0000 | 0 | 000 | 00000 | 0 |
| 1 | 0000 | 0000                                 | 0    | 0    | 1    | 000  | 0000 | 0 | 0   | 00000 | 0 |
| : |      |                                      |      |      |      |      |      |   |     |       |   |
| 0 | 0    | 0100                                 | 010  | 10   |      |      |      |   |     |       |   |
| 1 | 00   | 0000                                 | 0    | 1    |      |      |      |   |     |       |   |
| 0 | 000  | 0101                                 | 111  | 11   |      |      |      |   |     |       |   |
| 1 | 000  | 0000                                 | 0    | 1    |      |      |      |   |     |       |   |

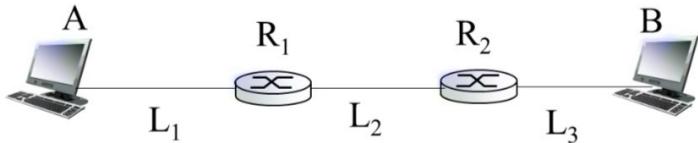
|      |      |      |    |  |
|------|------|------|----|--|
| 00   | 1111 | 1000 |    |  |
|      | 0000 | 0001 |    |  |
| 0    | 1111 | 1001 |    |  |
|      | 0000 | 0000 |    |  |
| 111  | 1001 | 01   |    |  |
|      | 00   | 0000 | 01 |  |
| 011  | 1001 | 000  |    |  |
|      | 0    | 0000 | 00 |  |
|      | 100  | 0010 |    |  |
|      | 0100 | 0001 |    |  |
| 100  | 0011 | 1    |    |  |
|      | 000  | 0000 | 1  |  |
|      | 0011 | 0000 |    |  |
|      | 0000 | 0001 |    |  |
| 0100 | 1000 | 1000 |    |  |
|      | 0000 | 0001 |    |  |
| 0    | 0001 | 0010 |    |  |
|      | 0000 | 0001 |    |  |
| 0000 | 0001 | 0    |    |  |
|      | 0001 | 0011 | 0  |  |

Hence the redundancy is 00100110  
append it to the data, we have:

1 110 00 | 1 010 | 100 | 011 | 100 | 100 | 00 | 00110

## 2. Delay.

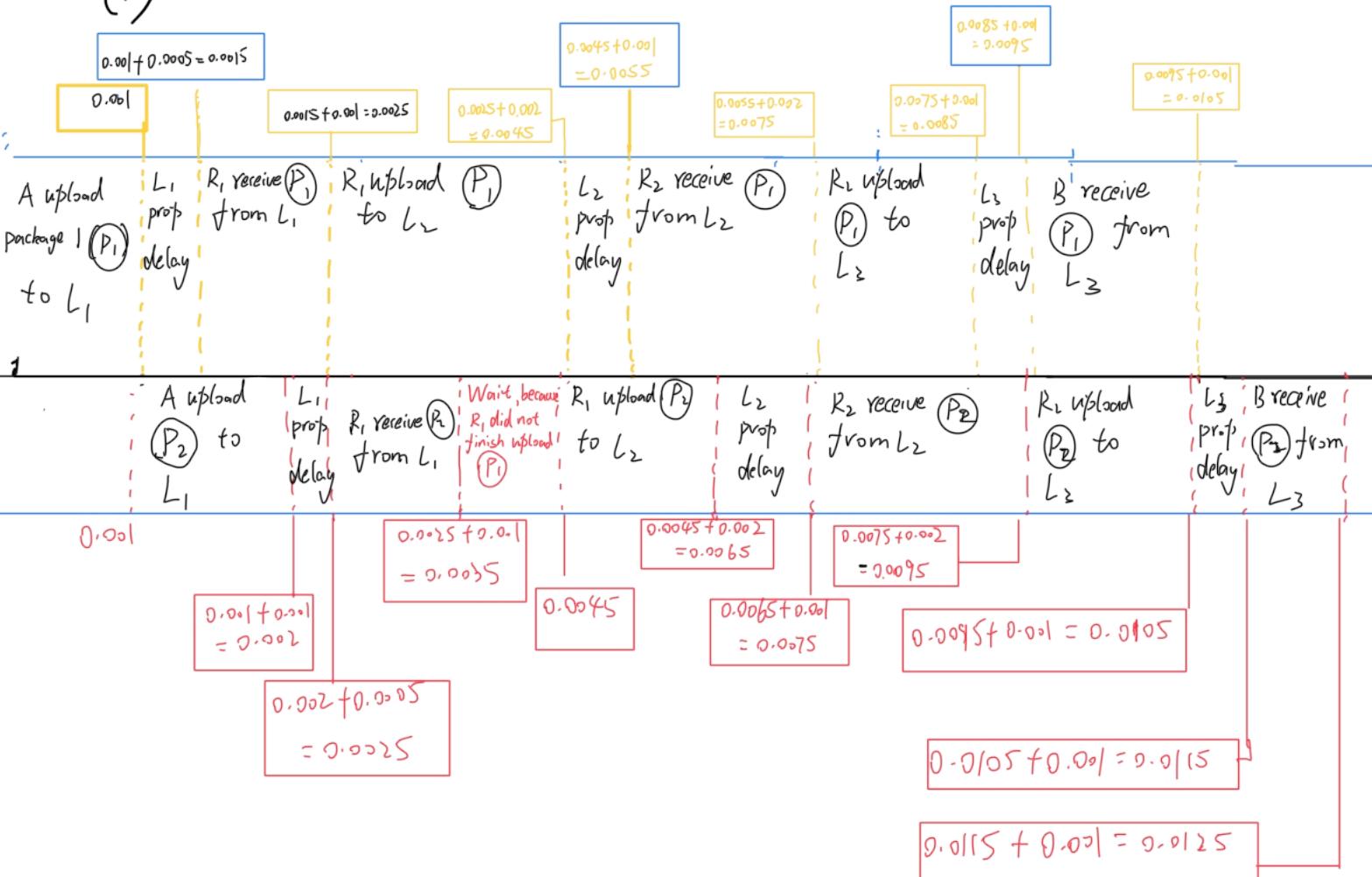
Consider two hosts, A and B, are connected by three links and two routers as shown the figure below. Suppose node A sends two packets consecutively to B. Each packet is with the size of 100 bytes. Each router applies store and forward. There is no bit error or packet loss.



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 =  $2 \times 10^8$  (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)
- (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).

Q2  
(1)



$$t_{prop} = \frac{100 \times 10^9}{2 \times 10^8} = 0.0005 ; t_{prop} = \frac{200 \times 10^9}{2 \times 10^8} = 0.01 = t_{prop}$$

$A \rightarrow R_1$        $R_1 \rightarrow R_2$        $R_2 \rightarrow B$

$$t_{trans} = \frac{100 \times 8}{0.8 \times 10^6} = 0.001 ; t_{trans} = \frac{100 \times 8}{0.4 \times 10^6} = 0.002 ; t_{trans} = \frac{100 \times 8}{0.8 \times 10^6} = 0.001$$

$A \rightarrow R_1$        $R_1 \rightarrow R_2$        $R_2 \rightarrow B$

- Using above info, I draw the diagram, and it also include a timeline

According to above graph, the overall delay is

0.0125 seconds

$$(2). k=81, \Rightarrow \frac{81}{10} = 8.1 \text{ ms} = 0.0081 \text{ s}$$

According to (1), the 1<sup>st</sup> bit of the  $(P_2)$  is locate at  $R_2$

### 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.

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.

Binary form = 01 100 | | # we should have even number of 1's after received the data

$$(1) \cdot p = 0.05$$

- Parity bit will not flip, so  $n = 6$
- Want to know the Prob when bits flipped but not detected. (i.e. even number bits flipped)

① 2 flipped

$$P\left(\frac{6}{2}\right) \times (1-p)^4 p^2 = 15 \times (0.95)^4 \times 0.05^2 = 2.036 \times 10^{-3}$$

② 4 flipped

$$P\left(\frac{6}{4}\right) \times (1-p)^2 p^4 = 15 \times 0.95^2 \times 0.05^4 = 8.461 \times 10^{-5}$$

③ 6 flipped

$$P\left(\frac{6}{6}\right) \times p^6 = 1 \times 0.005^6 = 1.5625 \times 10^{-14}$$

$$P(\text{even number bits flipped}) = ① + ② + ③ = 2.121 \times 10^{-3}$$

(z) 0110011  
a b c d e f

The only case to lose even number of 1's is to lose two 1's

① lose 1 digits:

will not cause "not detected" scenario, because it is not possible to lose even number of 1's (not include 0 1's)

② lose 2 digits:

. there are only 3 possibility will lead to "not detected" scenario

$\begin{cases} bc \\ bf \\ cf \end{cases}$

$$\begin{aligned} P &= 3 \cdot P^2(1-P)^4 = 3 \times 0.05^2 \times 0.95^4 \\ &= 6.109 \times 10^{-3} \end{aligned}$$

③ lose 3 digits

. There are 9 possibility to lead to "not detected" scenario (i.e. lose even number of 1's)

|      |      |      |
|------|------|------|
| bc a | bf a | cf a |
| d    | d    | d    |
| e    | e    | e    |

$$P = 9 \times P^3 \times (1-P)^3 = 9 \times 0.05^3 \times 0.95^3 = 9.645 \times 10^{-4}$$

#### ④ lose 4 digits

- There are 18 possibilities to lead to "not detected" scenario
- $\begin{matrix} bc \text{ a d} \\ e \end{matrix}$     $\begin{matrix} bf \text{ a d} \\ e \end{matrix}$     $\begin{matrix} cf \text{ a d} \\ e \end{matrix}$
- $\begin{matrix} d \text{ a} \\ e \end{matrix}$     $\begin{matrix} d \text{ a} \\ e \end{matrix}$     $\begin{matrix} d \text{ a} \\ e \end{matrix}$
- $\begin{matrix} e \text{ d} \\ a \end{matrix}$     $\begin{matrix} e \text{ d} \\ a \end{matrix}$     $\begin{matrix} e \text{ d} \\ a \end{matrix}$
- $P = 18 \times P^4 \times (1-P)^2 = 1.015 \times 10^{-4}$

#### ⑤ lose 5 digits

- There are only 3 possibilities

$bc \text{ a d e}$     $bf \text{ a d e}$     $cf \text{ a d e}$

$$P = 3 \times P^5 \times (1-P) = 8.906 \times 10^{-7}$$

#### ⑥ lose 6 digits

It is impossible, since we must lose odd number of 1's in this case

Combine ②③④⑤, we get

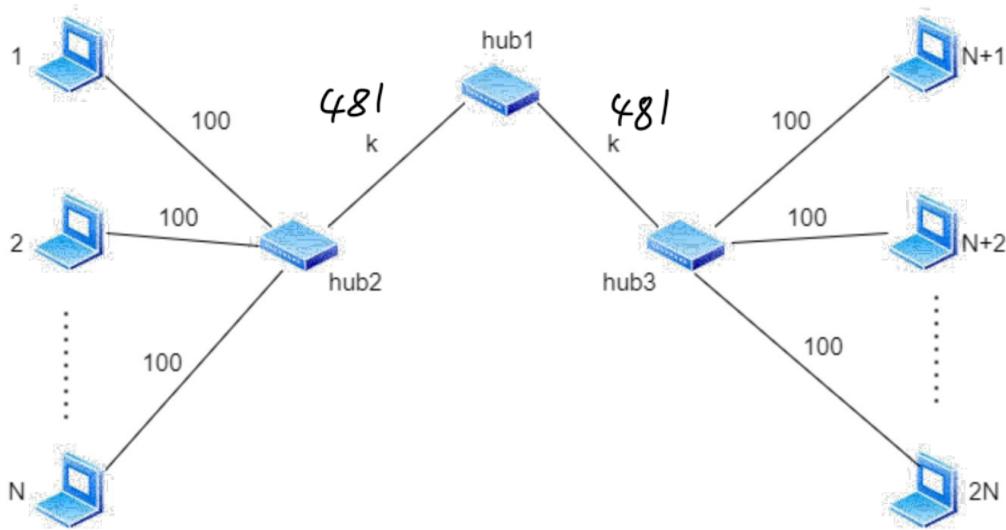
$$P = 6.109 \times 10^{-3} + 9.645 \times 10^{-4} + 1.015 \times 10^{-4}$$

$$+ 8.906 \times 10^{-7}$$

$$= \boxed{7.176 \times 10^{-3}}$$

#### 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  $2.0 \times 10^8$  meters/second.



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

(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.

- 1 packet = 500 bytes
- max distance =  $100 + 481 + 481 + 100$   
 $= 1162 \text{ m}$
- $k \approx 481$
- channel rate = 1 Gbps
- propagation delay =  $2.8 \times 10^8 \text{ m/s}$

$$(1) t_{\text{trans}} = \frac{\text{1 packet size}}{\text{Channel rate}} = \frac{500 \times 8 \text{ bits}}{10^9 \text{ bps}} = 4 \times 10^{-6}$$

$$t_{\text{prop}} = \frac{\text{max cable length}}{\text{propagation speed}} = \frac{1162 \text{ m}}{2.8 \times 10^8 \text{ m/s}} = 4.15 \times 10^{-6}$$

$$\text{efficiency} = \frac{1}{1 + 5 \frac{4.15 \times 10^{-6}}{4 \times 10^{-6}}} = 0.1616$$

$$2N = \frac{0.1616 \times 10^9}{1000 \times 500 \times 8}$$

$$= 40.4 \approx \boxed{40}$$

(2)

$$t_{\text{trans}} = \frac{\text{1 packet size}}{\text{Channel rate}} = \frac{500 \times 8 \text{ bits}}{10^9 \text{ bps}} = 4 \times 10^{-6}$$

$$t_{\text{prop}} = \frac{200}{2 \times 10^8} = 10^{-6}$$

$$\text{efficiency} \approx \frac{1}{1 + 5 \frac{10^{-6}}{4 \times 10^{-6}}} = 0.444$$

$$N + \frac{3}{4}N = \frac{0.444 \times 10^9}{1000 \times 500 \times 8} = 111$$

$N = 63.4$  (I know  $N$  cannot be float number)

↓

$$2N = 126.857 \approx \boxed{126}$$

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

$$(1) . k=1 \quad A: 19 \leq 2^n - 2 \Rightarrow n=5 \text{ bits}$$

$$B: 41 \leq 2^n - 2 \Rightarrow n=6 \text{ bits}$$

$$C: 81 \leq 2^n - 2 \Rightarrow n=7 \text{ bits}$$

$$D: 254 \leq 2^n - 2 \Rightarrow n=8 \text{ bits}$$

• 150.12.32.0/20



150.12. 0010 0000 . 0000 0000  
Can be assigned

150.12.0010

A : 5 bits

0000 0000 0010 starting ✓

0000 0001 1111 Ending

B : 6 bits

0000 0010 0000 X

0000 0100 0000 starting ✓

0000 0111 1111 Ending

C : 7 bits

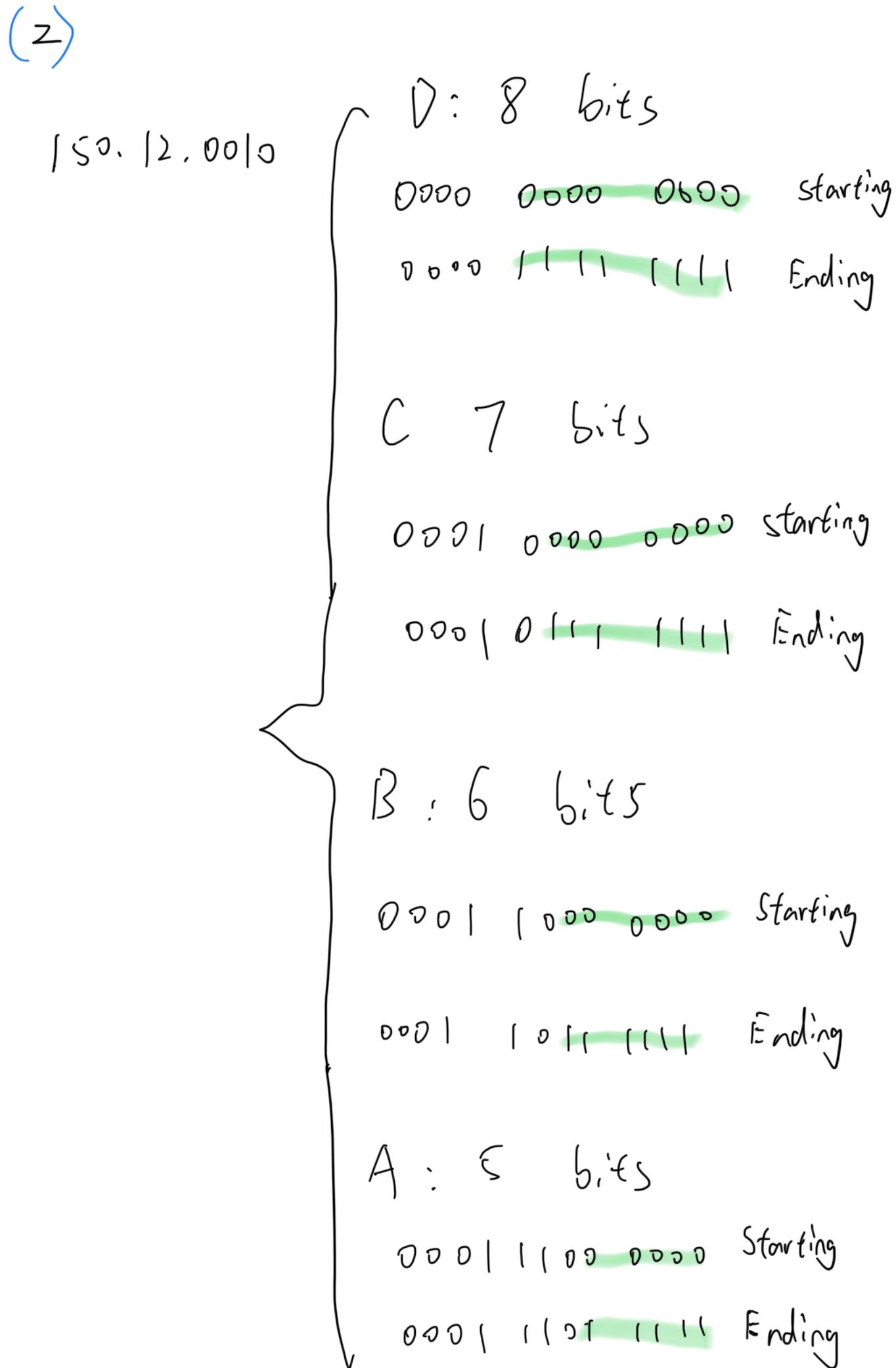
0000 1000 0000 starting ✓

0000 1111 1111 Ending

D : 8 bits

0001 0000 0000 starting ✓

0001 1111 1111 Ending



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

(2)

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.

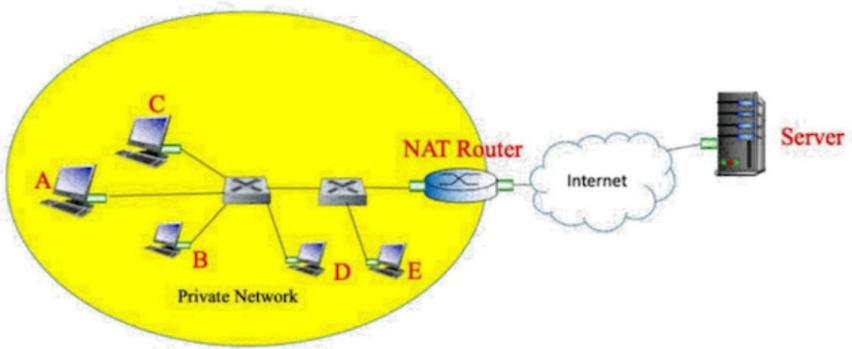
(1) Assign local IP addresses to the A—E

(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.

(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?

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

The correct answer may not be unique.



① Public IP Address : 134.31.44.2

② Local IP Address : 192.168.2.224/29

$$\begin{array}{r} 2 \longdiv{248} \\ 2 \longdiv{124} \\ 2 \longdiv{62} \\ \hline & 0 \\ & 0 \\ & 0 \end{array} \quad \left. \begin{array}{l} \text{only have } 3 \text{ can} \\ \text{be assigned} \end{array} \right\}$$

$$4 \times 8 - 3 = 29$$

$255.255.255.248 \rightarrow$

255.248

$$\begin{array}{r} 2 \longdiv{31} \\ \hline & 1 \end{array}$$

$$\begin{array}{r} 2 \longdiv{15} \\ \hline & 1 \end{array}$$

$$\begin{array}{r} 2 \longdiv{7} \\ \hline & 1 \end{array}$$

$$\begin{array}{r} 2 \longdiv{3} \\ \hline & 1 \end{array}$$

$$\begin{array}{r} 2 \longdiv{1} \\ \hline & 0 \end{array}$$

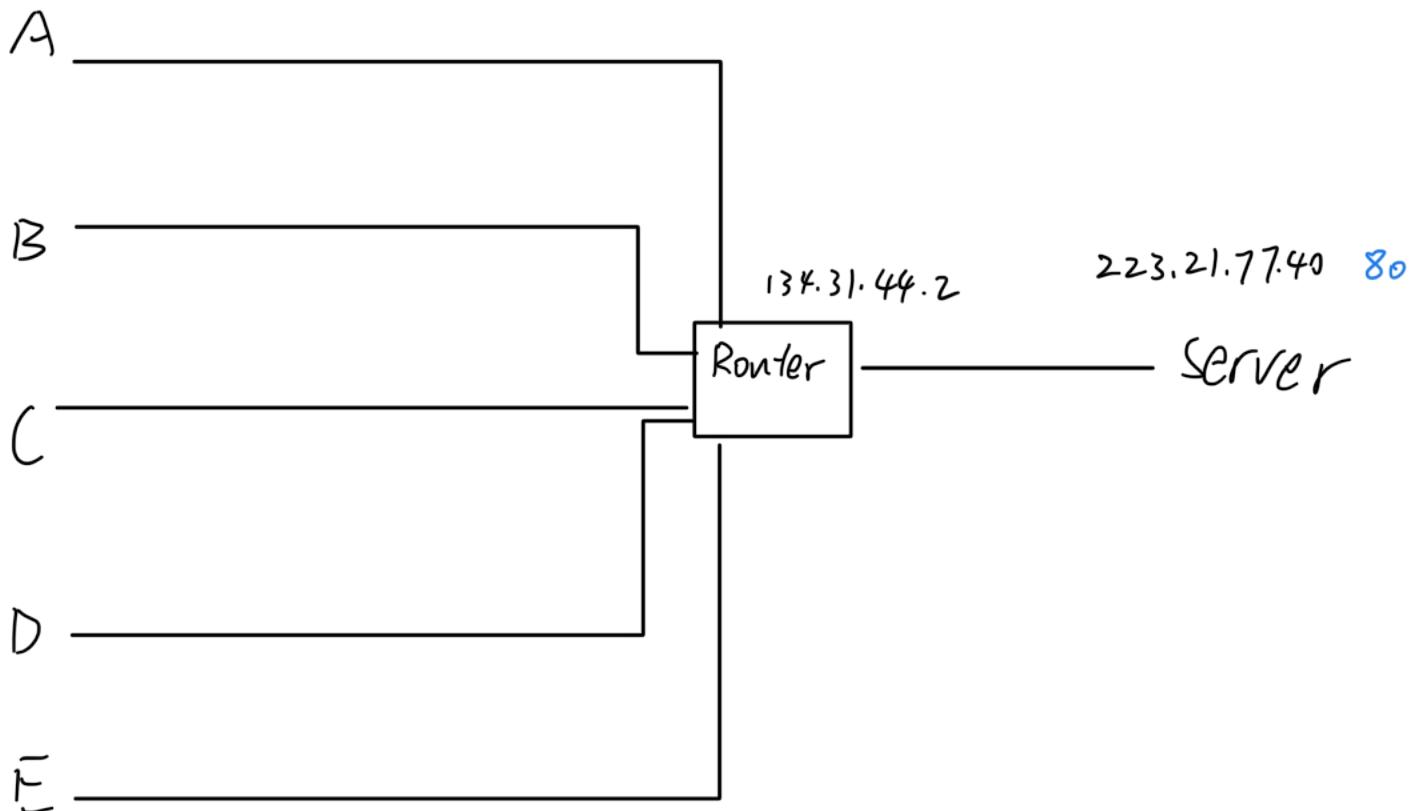
(1) 192.168.2.1110 0000 used for Network address

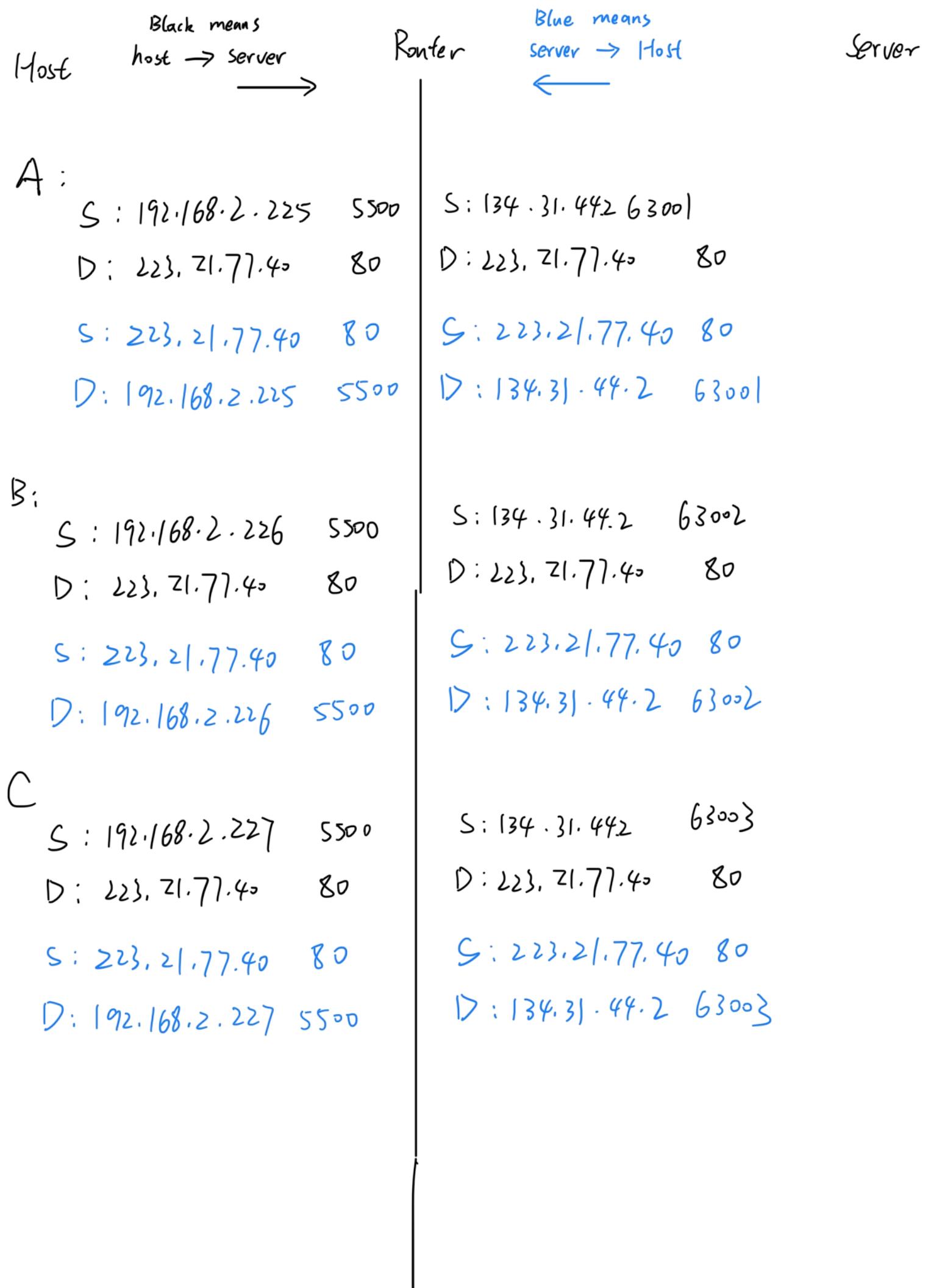
24 bits      5 bits

192.168.2.1110 0111 used for broadcast address

|                        |           |          |
|------------------------|-----------|----------|
| A. 192.168.2.11100 001 | ..... 225 | 2 / 24 0 |
| B. 192.168.2.11100 002 | ..... 226 | 2 / 12 0 |
| C 192.168.2.11100 003  | .... 227  | 2 / 14 0 |
| D 192.168.2.11100 004  | ... 228   | 2 / 7 1  |
| E 192.168.2.11100 005  | .. 229    | 2 / 3 1  |
|                        |           | 2 / 1 1  |
|                        |           | 0        |

(2) I will imitate translation table in week 4 Page 48





D:

S: 192.168.2.228 5500

D: 223.21.77.40 80

S: 223.21.77.40 80

D: 192.168.2.228 5500

S: 134.31.44.2 63004

D: 223.21.77.40 80

S: 223.21.77.40 80

D: 134.31.44.2 63004

E:

S: 192.168.2.229 5500

D: 223.21.77.40 80

S: 223.21.77.40 80

D: 192.168.2.229 5500

S: 134.31.44.2 63005

D: 223.21.77.40 80

S: 223.21.77.40 80

D: 134.31.44.2 63005

(3) IP address port

Source 223.21.77.40 80

Destination 134.31.44.2 63003

(4) I think I clearly explain this in part (2). But I will still use plain English to describe it.

Since IPv4 is limited, we have to use NAT to solve this problem

- NAT has global IP address, and all hosts in its subnet will use this global IP address to communicate with other hosts/server which has different global IP Address

• In order to avoid ambiguity, each subnet has local IP Address, and correspond to a different port in router

• In this question, different host in subnet use different local IP address and same port number "local" (5500)

• Wherever they want to send msg to server, they need go through router, which will change source address to global address, and port(5500) to Router port number

host to server  
• Notice that, each host correspond to a different port in router, for example, A corresponds to

port 63001.

- Then router will use its global IP address and corresponding port number to send msg to server
- Whenever server want to send msg to host, it also need to go through router
- In order to ~~know~~<sup>clarify</sup> the destination of msg, server need to send msg to corresponding port in router
- For example, if server want to send to A, then it need send msg to port 63001 in router
- After msg reach router, router will send this msg to host according to the port number.

**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.

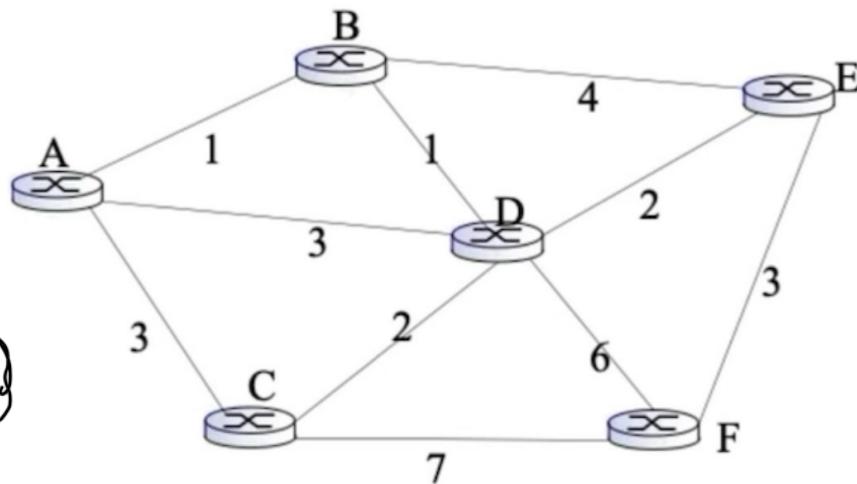
$$N_A = \{C, B, D\}$$

$$N_E = \{B, D, F\} \quad N_F = \{C, D, E\}$$

$$N_B = \{A, D, E\}$$

$$N_C = \{A, D, F\}$$

$$N_D = \{A, B, C, E, F\}$$



| Iteration | Tree             | A       | B       | C      | D      | E      |
|-----------|------------------|---------|---------|--------|--------|--------|
| Initial   | F                | (-1, ∞) | (-1, ∞) | (F, 7) | (F, 6) | (F, 3) |
| 1         | F, E             | (-1, ∞) | (E, 7)  | (F, 7) | (E, 5) |        |
| 2         | F, E, D          | (D, 8)  | (D, 6)  | (F, 7) |        |        |
| 3         | F, E, D, B       | (B, 7)  |         | (F, 7) |        |        |
| 4         | F, E, D, B, C    | (B, 7)  |         |        |        |        |
| 5         | A, B, C, D, E, F | (B, 7)  | (D, 6)  | (F, 7) | (E, 5) | (F, 3) |

A

B

C

D

E

A → B → D → E → F      cost is 7

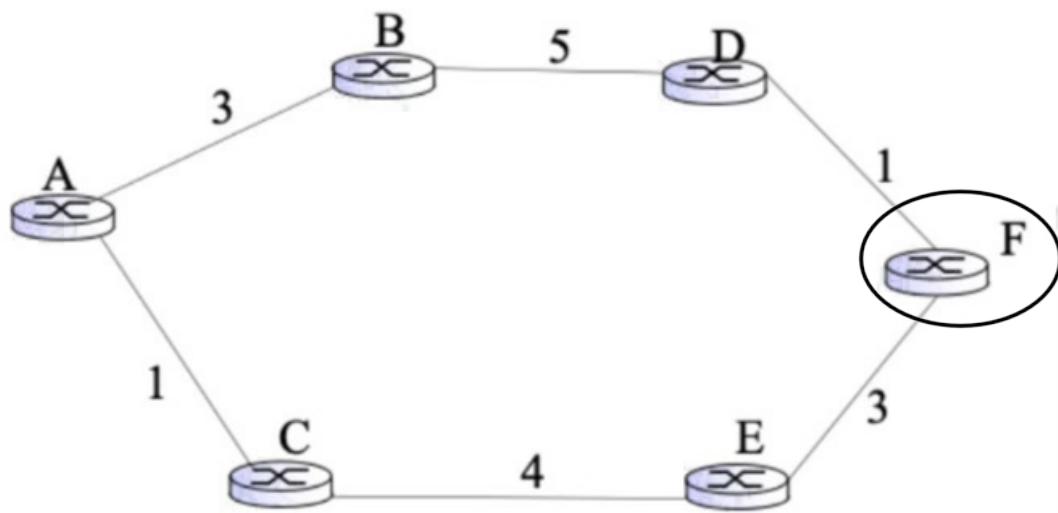
B → D → E → F      cost is 6

C → F      cost is 7

D → E → F      cost is 5

E → F      cost is 3

Q8.



- (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       | C,8  | D,6  | E,7  | F,1  | F,3  |
| 5       |      |      |      |      |      |
| 6       |      |      |      |      |      |
| 7       |      |      |      |      |      |
| 8       |      |      |      |      |      |

$$A = \min \{ 3 + D(B), 1 + D(C) \}$$

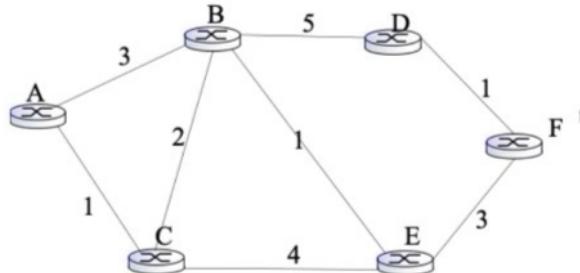
$$B = \min \{ 3 + D(A), 5 + D(D) \}$$

$$C = \min \{ 1 + D(A), 4 + D(E) \}$$

$$D = \min \{ 5 + D(B), 1 \}$$

$$E = \min \{ 4 + D(C), 3 \}$$

(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       | B, 7 | E, 4 | B, 6 | F, 1 | F, 3 |
| 4       |      |      |      |      |      |
| 5       |      |      |      |      |      |
| 6       |      |      |      |      |      |
| 7       |      |      |      |      |      |
| 8       |      |      |      |      |      |

Q9

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

(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.

(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.

100011                    101010

|                  |        |        |
|------------------|--------|--------|
| S: 192.168.64.35 | 2[35]1 | 2(42)0 |
| D: 192.168.79.42 | 2[17]1 | 2[21]1 |
|                  | 2[8]0  | 2[10]0 |
|                  | 2[4]0  | 2(5)1  |
|                  | 2[2]0  | 2[2]0  |
|                  | 2[1]1  | 2[1]1  |
|                  | 0      | 0      |

(1) we need to use Longest Prefix Matching to choose interface for R1, we use Forwarding Table for R1

|  |        |        |
|--|--------|--------|
| I <sub>1</sub> : 192.168.01001000.00000000 | 2(72)0 | 2(78)0 |
|  | 2[36]0 | 2[39]1 |
| I <sub>2</sub> : 192.168.01001110.00000000 | 2[18]0 | 2[19]1 |
|  | 2[9]1  | 2[9]1  |
| D: 192.168.0100111.00101010                | 2[4]0  | 2[4]0  |
|  | 2[2]0  | 2[2]0  |
|  | 2[1]1  | 2[1]1  |
|  | 0      | 0      |

Because I<sub>2</sub> has longest address prefix that matches destination address, hence we choose A → R1 → R3 → R4 → B

(2)

IP

MAC

S: 192.168.64.35

DD-00-00-00-00-00-DD

D: 192.168.79.42

B13-BB-BB-B13-BB-BB

$$\begin{array}{r}
 2 | 79 & 1 \\
 2 | 39 & 1 \\
 \hline
 2 | 19 & 1 \\
 2 | 9 & 1 \\
 \hline
 2 | 4 & 0 \\
 2 | 2 & 0 \\
 \hline
 2 | 1 & 1 \\
 \hline
 0
 \end{array}$$

(3)  $R_3 \rightarrow R_4$

That's  $R_3 \underline{I}_2 \rightarrow R_4 \underline{I}_2$

IP

MAC

S 192.168.64.35

CC-22-22-22-22-CC

D 192.168.79.42

DD-22-22-22-22-DD

Q10.

(1)

all AS-PATHs are allowed, but some of them are not optimal AS-PATH.

• They are allowed because

① all AS appear in above graphs and

② they are ordered in AS-PATHs

③ Include a prefix in the AS-PATH

• AS1 - AS131 - AS132 - 11.11.11.0/24 is not optimal because there is a shorter AS-PATH

(2) For this question, we need to use shortest AS-PATH Hot potato rules. We do not need to use local preference because network manager did not set it in this problem.

| Router | Pre-fix       | Next Hop |
|--------|---------------|----------|
| A      | 11.11.11.0/24 | C        |

we need go through Y to get shortest AS-PATH, and C is the closest route in AS1

A 22.22.22.0/24 C

We get Tie in this case.

. Then we use Hot potato rule which indicate that C is the closest route

in AS 1. and  $A \rightarrow C$  is the shortest path to C

B 11.11.11.0/24 A

we need go through Y to get shortest AS-PATH, and  $B \rightarrow A \rightarrow C$  is shortest in AS 1

B 22.22.22.0/24 D

We get Tie in this case.

. Then we use Hot potato rule which indicate that  $B \rightarrow D$  is the shortest path to gate in AS 1

C 11.11.11.0/24 Y

we need go through Y to get shortest AS-PATH, and C is the closest route in AS 1  
to Y

C 22.22.22.0/24 Y

We get Tie in this case.

. Then we use Hot potato rule which indicate that C is the closest route in AS 1

D 11.11.11.0/24 E

we need go through Y to get shortest AS-PATH, and  $D \rightarrow E \rightarrow C$  is shorter than  $D \rightarrow B \rightarrow A \rightarrow C$

D 22.22.22.0/24 X

We get Tie in this case.

. Then we use Hot potato rule which indicate that D is the closest route

E 11.11.11.0/24 C

we need go through Y to get shortest AS-PATH, and C is the closest route in AS1. And  $E \rightarrow C$  is the shortest path to C

E 22.22.22.0/24 Either D or C

We get Tie in this case.

. Then we use Hot potato rule

And we find  $E \rightarrow C$  and  $E \rightarrow D$  have same distance to AS1 gate. Hence we can choose any of them as next stop