CS542 Computer Networks I - Fundamentals
Assignment #1

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1. Please give and explain your answers to the questions below.
a. What is the range of addresses of the 64th block of Class A?
b. Consider fixed-length subnetting. What is the maximum number of created subnets if the desired number of subnets is:
- **a. 2**
- **b. 62**
- **c. 122**
- **d. 250**

Answer:

a) The range of addresses of the 64th block of Class A which can be calculated as follows:
Class A has 8 bit Netid and 24 bit Hostid : **N.H.H.H**
Class A is divided into 127 blocks : **0-127**
Each 8 bit can have values : **0-255**
The network address of 64th block of Class A : **64.0.0.0**
The broadcast address of 64th block of Class A : **64.255.255.255**
Range : 64.0.0.0 – 64.255.255.255

b) The maximum number of created subnets for the respective:

a) The desired number of subnets is 2,
Number of Subnets = $2^1 = 2$
The maximum number of subnets created is **2**.

b) The desired number of subnets is 62,
The smallest power of 2 that is greater than 62 is 6

Number of Subsets = 2^6 = 64
The maximum number of subnets created is **64**.

c) The desired number of subnets is 122,
The smallest number of 2 that is greater than 122 is 7
Number of subnets = 2^7 = 128
The maximum number of subnets created is **128**.

d) The desired number of subnets is 250
The smallest number of 2 that is greater than 250 is 8
Number of subnets = 2^8 = 256
The maximum number of subnets created is **256**.

2. A network administrator uses the subnet mask 255.255.252.0 in the network 191.168.0.0. How many total subnets have been created, and what's the size of each subnet? Assume classful addressing.

<u>Answer:</u>

The network administrator uses the subnet mask 255.255.252.0 in the network 191.168.0.0 i.e., 191.168.0.0 in classful addressing belongs to Class B and the mask for it is 255.255.0.0 (/16) but as the network administrator here has used the mask 255.255.252.0 (/22).

255.255.252.0/22 : 11111111 11111111 11111100 00000000

The total number of subnets that are created can be calculated,
Number of subnets = $2^{\text{extra bits}}$
Extra bits are 6
Subnets = 2^6 = 64 subnets are created using the mask 255.255.252.0/22.

Number of subnets = 64

The size of each subnet is calculated,
Number of addresses in each subnet = $2^h - 2$
h – number of host bits
We subtract 2 from them as the first is for network address and the last is for broadcast address
Size of each subnet = number of addresses in the subnet
Size of each subnet = $2^{10} - 2 = 1022$

Size of each subnet = 1022

There are 64 subnets and each subnet has a size of 1022.

3. If your subnet the network 10.0.0.0 with a subnet mask of 255.255.240.0, what's the maximum number of subnets and hosts per subnet? Assume classful addressing.

Answer:

The subnet mask 255.255.240.0 in the network 10.0.0.0 i.e., 10.0.0.0 in classful addressing belongs to Class A and the mask for it is 255.0.0.0 (/8) but here the used mask is 255.255.240.0 (/20).

255.255.240.0/20 : 11111111 11111111 11110000 00000000

The total number of subnets that are created can be calculated,
Number of subnets = $2^{\text{extra bits}}$
Extra bits are
Subnets = 2^4 = 16 subnets are created using the mask 255.255.240.0/20.

Number of subnets = 64

The size of each subnet is calculated,
Number of addresses in each subnet = $2^h - 2$
h – number of host bits
We subtract 2 from them as the first is for network address and the last is for broadcast address
Size of each subnet = number of addresses in the subnet
Size of each subnet = $2^{12} - 2 = 4094$

Size of each subnet = 4094

There are 64 subnets and each subnet has a size of 4094.

4. A network 10.5.6.0/24 is subnetted with a mask of 255.255.255.192. How many subnets are created and what is the third subnet's last usable IP address?

Answer:

The network 10.5.6.0/24 is subnetted with a mask of 255.255.255.192(/26),

255.255.225.192/26 : 11111111 11111111 11111111 11000000

The total number of subnets that are created can be calculated,
Number of subnets = $2^{\text{extra bits}}$
Extra bits are
Subnets = 2^2 = 4 subnets are created using the mask 255.255.225.192/20.

Number of subnets = 4

The number of addresses per subnet = $2^6 = 64$
The 4 subnets created are,
10.5.6.0 – 10.5.6.63
10.5.6.64 – 10.5.6.127
10.5.6.128 – 10.5.6.191
10.5.6.192 – 10.5.6.255
The third subnet's last usable IP address is:

10.5.6.190

5. An ISP has the block 192.100.0.0/16 and wants to allocate subblocks to organizations, each with 500 IP addresses. How many subblocks can be provided and what is their mask?

<u>Answer:</u>

The ISP block is : 192.100.0.0
The given mask is : 16
Subblocks with each having : 500 IP addresses

Steps:
Calculation of host bits from given IP addresses of each block-
Formula : $\log_2$(number of IP addresses per host)
The bits needed for host i.e., $\log_2 500 = 8.96 \sim 9$ bits.
The prefix length = 32 – 9
= 23
The new mask is 255.255.254.0/23

11111111 11111111 11111110 00000000

255.255.254.0

The number of subblocks created $= 2^{(\text{extra bits})}$
$= 2^7 = 128$

128 subblocks.

128 subblocks can be created with a mask of 255.255.254.0(/23) in block 192.100.0.0/16 having 500 IP addresses in each block.

6. Find the network address, the direct broadcast address, and the number of addresses in the network, if one of the addresses is 183.70.230.23/20.

Answer:

The network mask is /20
Dotted decimal representation of network mask: 255.255.240.0
Binary representation of network mask:11111111 11111111 11110000 00000000

Step1:
Calculate number of addresses-
The number of addresses in the network = 2^{32-20}
$= 2^{12} = 4096$
4096 number of addresses

Step2:
Finding the network address
It can be calculated by ANDing the address with the network mask:

Address(binary):	10110111	01000110	11100110	00010111
Mask(binary):	11111111	11111111	11110000	00000000
First address(binary):	10110111	01000110	11100000	00000000

Network address in dotted decimal notation : **183.70.224.0**

Step3:
Finding the direct broadcast address
It can be calculated by ORing the address with the complement (NOTing) of the network mask

Address(binary):	10110111	01000110	11100110	00010111
N(Mask(binary)):	00000000	00000000	00001111	11111111
Last address(binary):	10110111	01000110	11101111	11111111

Direct broadcast address in dotted decimal notation : **183.70.239.255**

7. Divide the network 126.168.24.0/24 into 4 subnets. What is the subnet mask? Give the range of IP addresses for each subnet. Which of these addresses cannot be assigned to hosts?

Answer:

The network : 126.168.24.0
Number of subnets : 4
The network mask : /24
Dotted decimal representation of network mask: 255.255.255.0
Binary representation of network mask:11111111 11111111 11111111 00000000

Step1
Calculating subnet mask
The number of subnets = 4 ($2^{\text{number of extra bits}}$)
: $2^2 = 4$, n = 2
The subnet mask = previous mask + extra bits
= 24 + 2
= 26

Subnet mask:
In slash notation /26
In dotted decimal notation **255.255.255.192.0**
In binary notation 11111111 11111111 11111111 11000000
Step2
Calculating the range of IP addresses for each subnet
The number of IP addresses for each subnet = 2^{32-26}
$= 2^6 = 64$
64 addresses for each subnet
Range of IP addresses:

126.168.24.0 - 126.160.24.63
126.168.24.64 - 126.160.24.127
126.168.24.128 - 126.160.24.191
126.168.24.192 - 126.160.24.255

Step3
Finding the addresses that cannot be assigned to host
Network address and broadcast address cannot be assigned to host so, the addresses that cannot be assigned are as follows:

Network addresses
126.168.24.0
126.168.24.64
126.168.24.128
126.168.24.192

Broadcast addresses
126.160.24.63
126.160.24.127
126.160.24.191
121.160.24.255

8. Can the following IP addresses be assigned to a host? Explain your answers.
a. 255.255.255.255
b. 127.32.45.0
a. 43.0.0.0 (assume classless addressing; note that the mask is not given)
b. 1.64.126.32 (assume classless addressing; note that the mask is not given)

__**Answer:**__

a) 255.255.255.255 : The IP address in binary representation contains all 1's and is reserved for **limited broadcast address** in the current network. When a device sends packet to this address, it is intended to reach all hosts on the local network, it is a special reserved IP address.

b) 127.32.45.0: It is a **loopback address**, when this address is used, a packet never leaves the machine; it simply returns to the protocol software. The loopback address can be used by a client process (a running application program) to send a message to a server process on the same machine. It can be used for testing and diagnostic purposes. this can be used only as a destination address.

a) 43.0.0.0 : In classless addressing it can be assigned to host, but it is important to note the mask to determine the exact range. To assign this to host we need to know the mask that defines the size and range of the network to which the IP address belongs.

b) 1.64.1226.32 : In classless addressing it can be assigned to host of a subnet, it could be a valid host address in the right context. However, the subnet mask is crucial to determine the network and host portions of the address and whether it falls within a valid range for host assignment. Without the mask, it's not possible to definitively determine if an IP address can be assigned to a host

9. The block 172.16.0.0/16 is given. Create 3 subnets with the number of hosts given below. Find the subnet addresses and the subnet masks for each subnet.

a. 1st subnet: 2000 hosts
b. 2nd subnet: 500 hosts
c. 3rd subnet: 100 hosts

Answer:

The network block : 172.16.0.0
Number of subnets : 3

a) 1st subnet : 2000 hosts

Step1:
Calculation of subnet mask
As there are 2000 hosts, $2^n = 2000$ i.e.,
n = 11 (11 bits for hosting)
Subnet mask:

Binary : 11111111 11111111 11111000 00000000
Slash : /21
Dotted-decimal : 255.255.248.0

Step 2:
Calculation of subnet addresses
Prefix : 21
Suffix : 32 – 21 = 11
Number of addresses per subnet : 2^{suffix}
$= 2^{11} = 2048$
2048 addresses per subnet

Range : 172.16.0.0 - 17.16.7.255

b) 2^{nd} subnet : 500 hosts

Step1:
Calculation of subnet mask
As there are 500 hosts, $2^n = 500$ i.e.,
$n = 9$ (11 bits for hosting)
Subnet mask:

Binary : 11111111 11111111 11111110 00000000
Slash : /23
Dotted-decimal :255.255.252.0

Step 2:
Calculation of subnet addresses
Prefix : 23
Suffix : 32 – 23 = 9
Number of addresses per subnet : 2^{suffix}
$= 2^9 = 512$

512 addresses per subnet

Range : 172.16.8.0 - 17.16.11.255

c) 3^{rd} subnet : 100 hosts

Step1:
Calculation of subnet mask
As there are 100 hosts, $2^n = 100$ i.e.,
$n = 7$ (11 bits for hosting)
Subnet mask:

Binary : 11111111 11111111 11111111 10000000
Slash : /25
Dotted-decimal : 255.255.255.128

Step 2:
Calculation of subnet addresses
Prefix : 25
Suffix : 32 – 25 = 7
Number of addresses per subnet : 2^{suffix}
$= 2^7 = 128$

128 addresses per subnet

Range : 172.16.12.0 - 17.16.12.127

10. An ISP is allocated the block 128.45.32.0/24. This ISP needs to assign 16 addresses per customer. Find the mask for each of these subnets and give the first and last usable IP addresses for the first three subnets.

Answer:

The allocated block : 128.45.32.0 /24
Addresses per customer : 16

Step1:
Calculating subnet mask
Calculation of host bits from given addresses per customer-
Formula : $\log_2$(number of addresses per customer)
The bits needed for host i.e., $\log_2 16 = 4$ bits.
The prefix length = 32 – 4
= 28
The new mask :

Dotted-decimal : 255.255.255.240
Slash : /28
Binary : 11111111 11111111 11111111 11100000

Step2 :
Finding first and last usable address for first 3 subnets
Range of first 3 subnets:

128.45.32.0 - 128.45.32.15 (first subnet)
128.45.32.16 - 128.45.32.31 (second subnet)
128.45.32.32 - 128.45.32.47 (third subnet)

	Usable first address	**Usable last address**
First subnet	128.45.31.1	128.45.31.14
Second subnet	128.45.31.17	128.45.31.30
Third subnet	128.45.31.33	128.45.31.46

11. A certain company wants to create two subnets to meet its network requirements. Find the suffix and prefix lengths for these subnets, one with 67 addresses and the other with 34 addresses.

<u>Answer:</u>

Number of addresses = $2^{(32 - \text{prefix length})}$

1. Number of addresses = 67.
   $67 = 2^{(32 - \text{prefix})}$
   32 – prefix length = log 2 (67)
   prefix length = 32 – log 2 (67)
   = 32 – log $2(2^8)$ [Since we want 67 addresses, we will use min 128 ~ 2^8]
   =32 – 8
   Prefix Length = 24 bits

   Suffix length = 32 – Prefix length => 32 – 24
   Suffix length = 8 bits

2. Number of addresses = 34
   $64 = 2^{(32 - \text{prefix})}$
   32 – prefix length = log 2(34)
   prefix length = 32 – log 2(34)
   = 32 – log $2(2^7)$ [Since we want 34 addresses, we will use min 64 ~ 2^7]
   =32 – 7
   Prefix Length = 25 bits

   Suffix Length = 32 – prefix length => 32 – 25
   Suffix Length = 7 bits

12. The block of addresses 146.157.224.0/19 is divided into 3 subblocks. The 1st subblock is allocated to a group of 12 customers, each of which needs 64 addresses. The 2nd subblock is allocated to a group of 9 customers, each of which needs 32 addresses. The 3rd subblock is allocated to a group of 5 customers, each of which needs 16 addresses.

a. Design the three subblock. Find the mask for each of them (i.e., for each subblock not for each customer).

b. What is the range of addresses (find the first and last of them) allocated to the 10th customer in the 1st subblock?

c. What is the range of addresses (find the first and last of them) allocated to the 5th customer in the 2nd subblock?

d. What is the range of addresses (find the first and last of them) allocated to the 3^{rd} customer in the 3rd subblock?

e. How many addresses are still available after this allocation in each of the three subblocks?

f. How many addresses are still available after this allocation in the entire original block?

Answer:

Original block: 146.157.224.0/19

a.

1^{st} subblock: 12 customers, each need 64 addresses.

Total number of addresses need to be allocated is = 12*64 = 768 addresses.

To accommodate 12 customers with 64 addresses each → $64 = 2^6$ => n=6
Subnet Mask = 32 – n = 32 – 6 = 26

2^{nd} subblock: 9 customers, each need 32 addresses.

Total number of addresses need to be allocated is = 9*32 = 288 addresses.

To accommodate 9 customers with 32 addresses each → $32 = 2^5$ => n=5
Subnet Mask = 32 – n = 32 – 5 = 27

3^{rd} subblock: 5 customers, each need 16 addresses.

Total number of addresses need to be allocated is = 5*16 = 80 addresses.

To accommodate 5 customers with 16 addresses each →$16 = 2^4$ => n=4
Subnet Mask = 32 – n = 32 – 4 = 28

b.

The 1st subblock has a mask of /26, which means it has 2^(32-26) = 2^6 = 64 addresses in total.
To find the range for the 10th customer, you can start with the base address of the subblock and calculate as follows:

Base Address for 1st subblock: 146.157.224.0/26
1^{st} Customer 146.157.224.0 → 146.157.224.63
2^{nd} Customer 146.157.224.64 → 146.157.224.127
3^{rd} Customer 146.157.224.128 → 146.157.224.191
4^{th} Customer 146.157.224.192 → 146.157.224.255
……
10^{th} Customer 146.157.226.64 → 146.157.226.127
12^{th} Customer 146.157.226.192 → 146.157.226.255

c.

The 2nd subblock has a mask of /27. To find the range for the 5th customer, you can start with the base address of the subblock and calculate as follows:

Base Address for 2nd subblock: 146.157.227.0/27
1st Customer 146.157.227.0 → 146.157.227.31
2nd Customer 146.157.227.32 → 146.157.227.63
3rd Customer 146.157.227.64 → 146.157.227.95
4th Customer 146.157.227.96 → 146.157.227.127
5th Customer 146.157.227.128 → 146.157.227.159
…..
9th Customer 146.157.228.0 → 146.157.228.31

d.

To find the range for the 3rd customer, you can start with the base address of the subblock and calculate as follows:

Base Address for 3rd subblock: 146.157.228.32/28
1st Customer 146.157.228.32 → 146.157.228.48
2nd Customer 146.157.228.49 → 146.157.228.64
3rd Customer 146.157.228.65 → 146.157.228.80
4th Customer 146.157.228.81 → 146.157.228.98
5th Customer 146.157.228.99 → 146.157.228.112

e.
As we have done continuous allocations in each subblock from the original block, there will be no addresses available in each subblock after allocation.

f.
Total number of addresses in original block is 2^(32-19) = 8192 addresses
Total addresses used in the three subblocks: 768 + 288 + 80 = 1136 addresses.
Available addresses in the original block: 8192 - 1136 = 7056 addresses.

13. Is the delivery direct or indirect?
a. A host with the IP address 131.16.192.4/16 sends a packet to a host with the IP address 132.16.128.19/18. Explain your answer.
b. A host with the IP address 87.136.56.126/25 sends a packet to a host with the IP address 87.136.56.111/25. Explain your answer.

Answer:

a. The delivery from a host with IP address 131.16.192.4/16 to a host with IP address 132.16.128.19/18 is indirect.
   The network address of 131.16.192.4 is 131.16.0.0, and the network address of 132.16.128.19 is 132.16.0.0. Since the network addresses are different, the two hosts

are not on the same network. Therefore, the delivery must be indirect, meaning that the packet must be forwarded by a router.

b. The delivery from a host with IP address 87.136.56.126/25 to a host with IP address 87.136.56.111/25 is direct.
Both 87.136.56.126 and 87.136.56.111 have the same network address, which is 87.136.56.0. This means that the two hosts are on the same network, so the delivery can be direct.

14. Why do we need both the IP addresses and the physical addresses in networking?

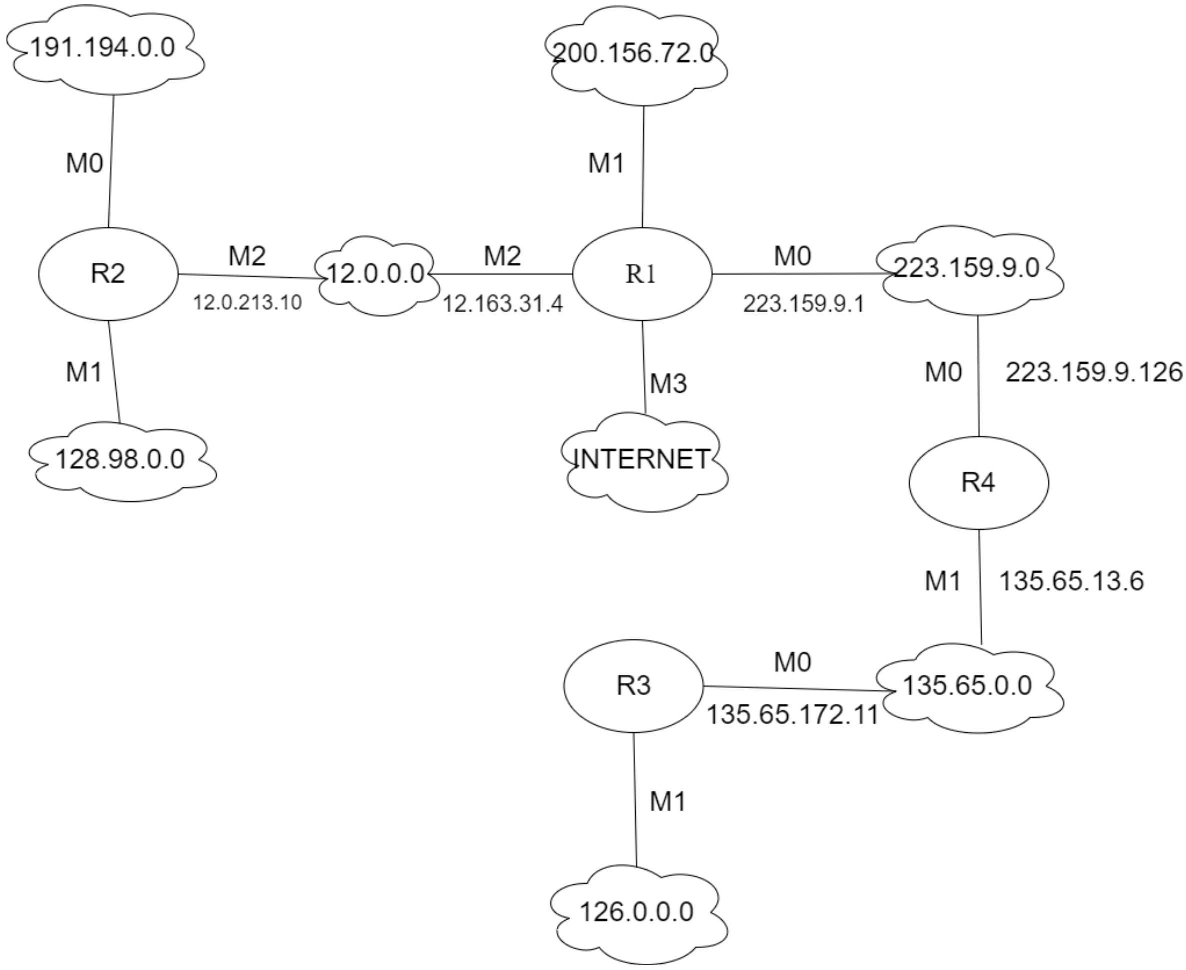
Answer:

IP addresses are logical addresses that identify devices on a network. They are used to route traffic between devices on different networks.

Physical addresses, also known as MAC addresses, are unique identifiers that are assigned to network interface cards (NICs). They are used to deliver traffic to the correct device on a local network.

In short, IP addresses are used to find the right network, while physical addresses are used to find the right device on that network.

15. For the routing tables given below, draw the network configuration including all the 4 routers (i.e. not each router separately). Indicate the next-hop addresses in the figure.



16. Consider the network configuration given below. Assume classful addressing.
a. Are there any errors in this figure? If so, correct them.
b. Create a routing table for each router given in this figure. Indicate class, network address, next-hop address, and interface number in each routing table.

<u>Answer:</u>

a. There are no errors in the network configuration figure.

b. Routing Table for R1:

Class A

Network Address	Next-Hop Address	Interface Number
95.0.0.0	---	M2
100.0.0.0	126.1.1.1	M1
126.0.0.0	---	M1

Class B

Network Address	Next-Hop Address	Interface Number
163.0.0.0	---	M0
191.54.0.0	126.10.10.10	M1

Class C

Network Address	Next-Hop Address	Interface Number
192.217.22.0	126.10.10.10	M1
223.0.144.223	126.126.11.119	M0

Default: 126.123.245.10 M1

Routing Table for R2:

Class A

Network Address	Next-Hop Address	Interface Number
95.0.0.0	126.126.11.119	M1
100.0.0.0	---	M0
126.0.0.0	---	M1

Class B

Network Address	Next-Hop Address	Interface Number
163.0.0.0	126.126.11.119	M1
191.54.0.0	126.10.10.10	M1

Class C

Network Address	Next-Hop Address	Interface Number
192.217.22.0	126.10.10.10	M1
223.0.144.0	126.1.1.1	M0

Default: 126.123.245.10 M1

Routing Table for R3:

Class A

Network Address	Next-Hop Address	Interface Number
95.0.0.0	126.126.11.119	M1
100.0.0.0	126.1.1.1	M1
126.0.0.0	---	M1

Class B

Network Address	Next-Hop Address	Interface Number
191.54.0.0	126.10.10.10	M1
163.0.0.0	126.126.11.119	M1

Class C

Network Address	Next-Hop Address	Interface Number
192.217.22.0	126.10.10.10	M1
223.0.144.0	---	M0

Default: - M2

Routing Table for R4:

Class A

Network Address	Next-Hop Address	Interface Number
95.0.0.0	126.126.11.119	M1
100.0.0.0	126.1.1.1	M1
126.0.0.0	---	M1

Class B

Network Address	Next-Hop Address	Interface Number
191.54.0.0	---	M0
163.0.0.0	126.126.11.119	M1

Class C

Network Address	Next-Hop Address	Interface Number
192.217.22.0	---	M2
223.0.144.0	126.10.10.10	M0

Default: 126.123.245.10 M1

17. Consider the network configuration given above in Question 16. Assume classful addressing. Explain how the following packets are routed in this network (consider the entire network, not a single router).

a. Host 100.235.37.18 sends a packet to destination 191.54.17.05

Sol) First the packet is sent to router R4 with next hop address 126.10.10.10 and interface M0. Then after reaching R4, it is a direct delivery and it is sent through interface M0.

b. Host 192.217.22.173 sends a packet to destination 223.0.144.2

Sol) Host 192.217.22.173 sends a packet, which belongs to class C because it is in the range 192 - 223. Its network address is 192.217.22.0. The destination address 223.0.144.2 is in the range 192 - 223, it belongs to class C. The network address is 223.0.144.0. The host belongs to Router 4 because the next hop address of 192.217.22.0 is null in R4 table. So, when we search for 223.0.144.0 network address in router R4 along with the respective class which is Class C the next hop address will be 126.123.245.10 and M1 interface.

c.Host 95.12.234.7 sends a packet to destination 127.201.165.11

Sol) There is no network with network address 127.0.0.0 in the network in class A bucket. So we assume that it is present in the rest of the internet. So we will use the default bucket for this. So the packet is routed from R1 to R3 with next hop address 126.123.245.10 and interface M1. Then from R3 router, the delivery will be direct delivery with interface M2.

18. Convert the hexadecimal IP address 0xC0A801A2 to the dotted decimal and binary notations. Determine the class of this address in each of these notations.

<u>Answer:</u>

Given hexadecimal number : C0A801A2

Step 1 – Dividing hexadecimal number into four segments i.e.,

<u>C0</u> . <u>A8</u> . <u>01</u> . <u>A2</u>

Step 2 – C*16^1 + 0*16^0 . A*16^1 + 8*16^0 . 08*16^1 + 1*16^0 . A*16^1 + 2*16^0

Step 3 – 12*16 + 0 . 10*16 + 8 . 0 + 1 . 10*16 +2

Step 4 – 192.168.1.162

192.168.1.162 is dotted decimal.

The first octet is 192, which means this is a Class C address.

For binary 192.168.1.162 → **11000000.10101000.00000001.10100010**

The first 3 bits are 110, which means this is a Class C address.

Therefore, the IP address 0xC0A801A2 belongs to Class C in both dotted decimal and binary notations.

19. Convert the decimal number 218892292 to the base 256 numbering system.

Answer:

The decimal number 218892292 can be converted to base 256 numbering system as follows:
We will be finding the 256-numbering system octet wise:

Step1:
Calculating the value of octet 4 –

218892292 / 256 = 855048.01562
855048 * 256 = 218892288
218892292 – 218892288 = 4

The value in 4^{th} octet is 4.

Step2:
Calculating the value of octet 3 –

855048 / 256 = 3,340.03125
3340 * 256 = 855040
855048 – 855040 = 8

The value in 3^{rd} octet is 8.

Step3:
Calculating the value of octet 2 –

3340 / 256 = 13.046875
13 * 256 = 3328
3340 - 3328 = 12

The value in 2^{nd} octet is 12.

Step4:
Calculating the value of octet 1 –

13 is left over. Since 13 is too small to divide by 256, **13 is the 1st octet.**

The result of 218892292 after conversion to base 256 is **13.12.8.4**

(Cross verify- $13*256^3+12*256^2+8*256^1+4*256^0 = 218892292$)