Class A	0 – 127
B	128 – 191
C	192 – 223
D	224 – 239
E	240 – 255

Class	No of Addresses	Percentage
A	$2^{31} = 2147483648$	50%
B	$2^{30} = 1073741824$	25
C	$2^{29} = 536870912$	12.5
D	$2^{28} = 268435456$	6.25
E	$2^{28} = 268435456$	6.25

CFA 2/9

Address are divided into – Netid & hostid.
(Except class D & E).

CLASSES & BLOCKS

CLASS A = 128 blocks

First block = 0.0.0.0 to 0.255.255.255 (netid = 0)
Third " = 1.0.0.0 to 1.255.255.255 (" " = 1)
⋮
Last block = 127.0.0.0 to 127.255.255.255 (netid = 127)

First & Last blocks are reserved for special purposes

Block with netid = 10 is used for private addresses.

Remaining 125 blocks can be assigned to organizations

Each block = 16,777,216 addresses

First address in block = network address.

CLASS B 16384 blocks, 16 blocks reserved
∴ 16368 blocks for organizations.

Each block = 65,536 addresses

CLASS C 2097152 blocks, 256 blocks = private addresses
2096896 " for organizations.
Each block = 256 addresses.

CLASS D One block & it is used for multicasting. Each address in this class is used to define one group of hosts on the Internet.

CLASS E One block, Reserved for future purposes

125.60.50.40

11111 255.0.0.0

N/w ~~Add~~ 125.0.0.0

C

255.255.0.0

/28

//

125.60.50.40/~~8~~0

CIDR

11111111 11000000

2^{32}

CF 4 4/9

MULTIHOMED DEVICES Device has different address for each network connected to it.

LOCATION OF DEVICE Internet address defines N/W location of a device, not its identity.

Moving a computer from one N/W to other N/W implies that its IP address must be changed.

SPECIAL ADDRESSES

SPECIAL ADDRESSES	Netid	Hostid	Source or Destination
Network Address	Specific	All 0s	None
Direct Broadcast "	"	All 1s	Destination
Limited " "	All 1s	All 1s	Dest
This host on this N/W	All 0s	All 0s	Source
Specific host on this N/W	All 0s	Specific	Dest
Loopback Address	127	Any	Dest

<u>N/W Address</u> First address in a block.

<u>Direct Broadcast Address</u>: used by router to send a packet to all the hosts in a specific N/W.

<u>Limited Broadcast Address</u>: used by a host to send a packet to every host on the same N/W. Packet is blocked by Router, so as to confine it to LAN.

<u>This Host on this N/W</u>: used by host at bootstrap time when it doesn't know its IP address. Host sends IP packet to a bootstrap server using this address as source address & limited broadcast address as dest address to find its own address.

Specific host on this N/W; used by a router or host to send message to specific host on the same N/W. Packet is blocked by Router.

Loopback Address: to test software on a machine. Packet never leaves the machine; it simply returns to protocol software. It can be used to test IP software. For e.g application known as "ping" can send packet with a loopback address as dest address to check if IP software is capable of receiving & processing a packet. second example could be that, loopback address can be used by client process to send a message to a server process on same m/c.

PRIVATE ADDRESSES Not recognized globally. These addresses used either in isolation or in connection with network address translation techniques

class	Netids	Blocks
A	10.0.0	1
B	172.16 to 172.31	16
C	192.168.0 - 192.168.255	256

Unicast, Multicast, Broadcast Addresses

1. Unicast ~~address~~ is communication is ONE to ONE.
   Unicast address is class A, B or C address.
2. Multicast Addresses is one to many communication.
   " " are class D addresses.

Multicasting can be at local or global level
At global level hosts on different N/Ws can form a group & assigned a multicast address.

CFA 5/9

Broadcast Address One to all communication.
Internet allows broadcasting at the local level.

SUBNETTING & SUPERNETTING

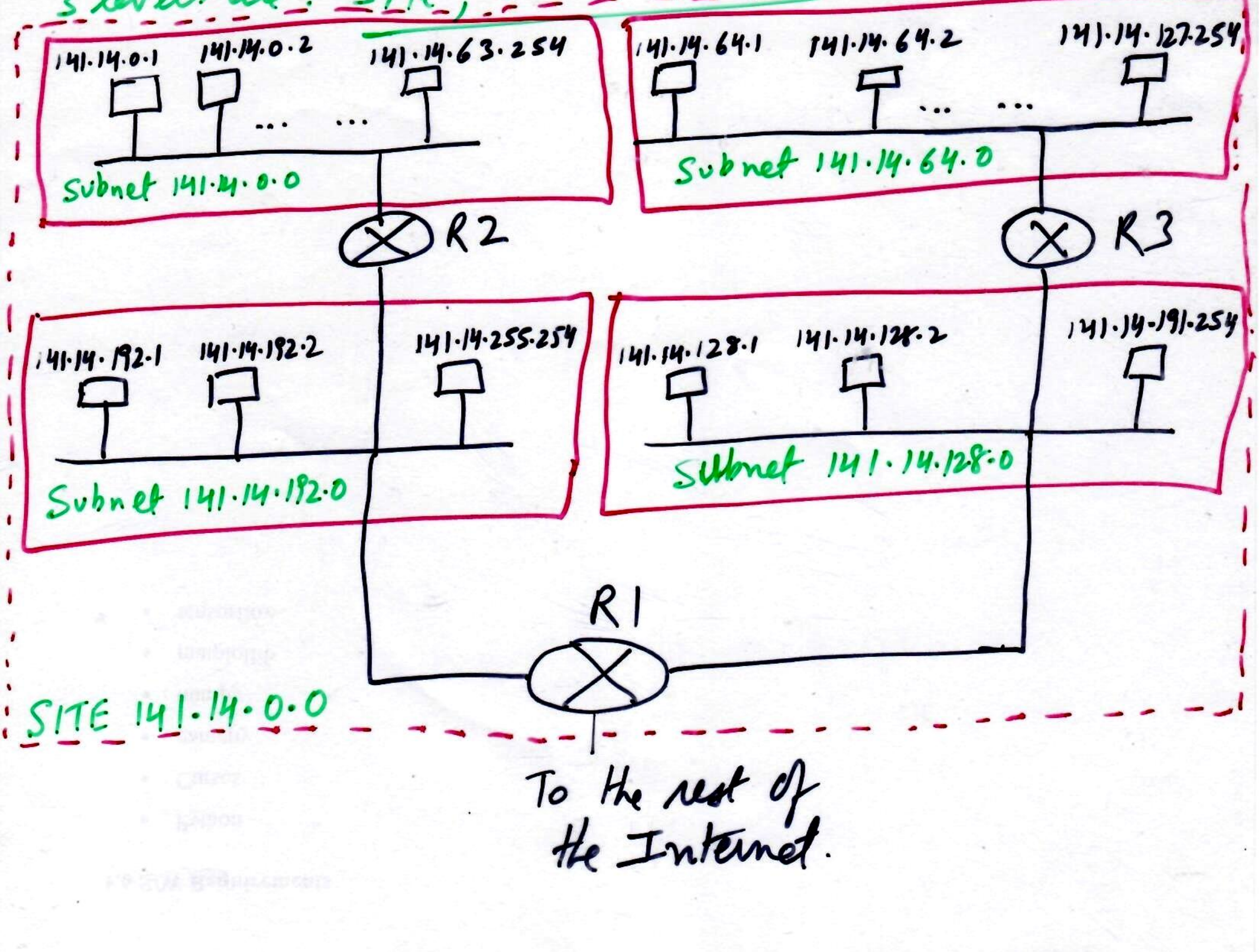
Solutions for assignment for address which are close to depletion.

Subnetting N/w divided into smaller subnetworks with each subnetwork (subnet) having its own subnet address.

Two levels of Hierarchy of IP address. One level = netid, second level = hostid.

Three levels of Hierarchy subnetworks create an intermediate level of hierarchy in IP addressing system.

3 levels are: site, subnet, host.



CFA 7/9

141 . 14 . 192 . 2 — W/O Subnetting

Netid | Hostid

141. 14 . 192 . 2 — With Subnetting

Site | Subnet id | hostid

Subnet Mask has more 1s than default mask.

Default mask creates N/W Address

Subnet " " subnetwork Address.

W/O Subnetting

Default Mask 255.255.0.0

141.14.72.24 (IP Address) → AND → 141.14.0.0 (Network Address)

With subnetting

Subnet mask 255.255.192.0

141.14.72.24 (IP Address) → AND → 141.14.64.0 (Subnet Address)

Default Mask & Subnet Mask

Default Mask (255.255.0.0)	11111111	11111111	00000000	00000000
Subnet Mask (255.255.224.0)	11111111	11111111	111 | 00000	00000000

3 | 13

No of subnetworks = extra 1s added to default mask

For e.g above subnets = $2^3 = 8$ (∵ 3 extra 1s)

No of addresses per subnet = No of zeros in subnet mask

For e.g in fig above $2^{13} = 8192$ addresses (∵ No of zeros = 13)

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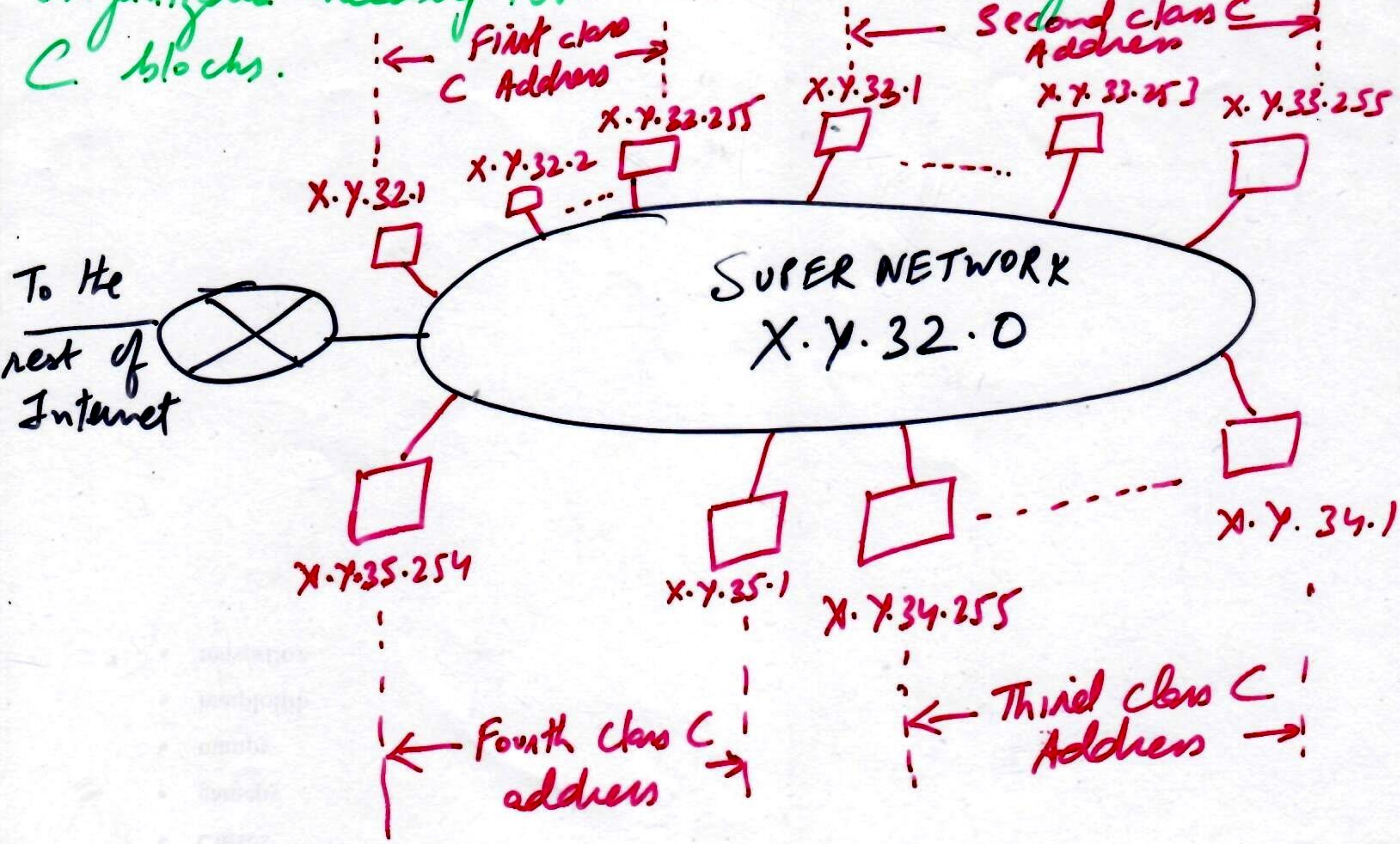
First Address in each subnet is Subnetwork Address.
Last Address in each subnet is reserved for limited broadcast inside the subnet.

CIDR Notation 141.14.92.3/16 = Class B address with default ~~sw~~ mask.

141.14.92.3/18 = [redacted] address with subnet mask of 255.255.192.0

Supernetting Size of class C block not sufficient for an organization. ∴ more than one blocks can be given to an organization.

Solution is thro supernetting. For e.g an organization needing 1000 addresses can be given 4 class C blocks.



SUPERNET MASK when several blocks are combined, first address in block & supernet mask are reqd to define range of addresses & no of blocks. CFA 9/9 CLA 1/7

Supernet mask has less 1s than default mask.

For e.g if 8 blocks are combined for a superblock then there are three 1s less than 1s of default mask.

CIDR Notation 141.14.192.3/24 = class B address
141.14.192.3/21 means a mask of 255.255.248.0

But with the introduction of class addressing supernetting & subnetting are becoming obsolete.

IP Addresses: CLASSLESS ADDRESSING

Problem 1: Small business needs only 16 address?
Problem 2: A household needs only 2 addresses?

ISP is granted large range of addresses & then subdivides the addresses in groups of 2, 4, 8, 16 & so on.

To overcome problem of classful addressing, in 1996, the Internet authorities announced new architecture called classless addressing.

Variable Length Blocks are assigned that belong to no class. Entire address space of 2^{32} addresses is divided into blocks of different sizes.

Addresses in a Block

Restriction : No of addresses in a block = power of 2

First Address of Block : Must be evenly divisible by no of addresses. E.g if block = 16 addresses, first address must be divisible by 16.

If block addresses ≤ 256, check right most byte.

If block addresses ≤ 65536, " 2 right most bytes.

Address in classless addressing

x.y.z.t/n

n = no of bits that remain same in every address in block.

Prefix & Prefix Length

Prefix = common part of the address range (similar to netid).

Prefix Length = length of prefix (n in CIDR notation).

Suffix & Suffix Length

Suffix = varying part (similar to hostid)

Suffix Length = length of suffix (32 − n) in CIDR notation.

First Address in Block

ANDing of Address & Mask to find 1st address.

For e.g if one of addresses is 167.199.170.82/27

Prefix length = 27 ∴ keep 27 bits as it is and change remaining 5 bits to 0s

Address in Binary	10100111	11000111	10101010	01010010
Keep the Left 27 bits	10100111	11000111	10101010	01000000

First Address is 167.199.170.64/27

No of Address in Block 2^{32-n}

Last Address of Block

E.g 140.120.84.24/20

Mask = 20 1s & 12 0s

Complement of mask = 20 0s & 12 1s

i.e 00000000 00000000 00001111 11111111

0.0.15.255

First address = 140.120.80.0

New Mask 0.0.15.255

Last Address 140.120.95.255 /20

SUBNETTING

Finding subnet mask

No of desired subnets = subnet prefix

If subnets = S, then extra 1s in prefix length is

$\log_2 S$, where $S = 2^{\text{No of extra 1s.}}$

Example subnets = 4, block granted is 130.34.12.64/26

$\log_2 4 = 2$ (i.e two more 1s to prefix length)

∴ subnet prefix = 28

Total address in site $= 2^{32-26} = 2^6 = 64$ addresses

Each subnet has $\frac{64}{4} = 16$ addresses.

First address in 1st subnet is 130.34.12.64/28

Last " of subnet is found by adding 15 to 1st address

Last address is 130.34.12.79/28

First address in IInd subnet is 130·34·12·80/28 (Found by adding 1 to last address of previous subnet)

Last address = 130·34·12·95/28 (Adding 15 to 1st address)

First address, IIIrd subnet 130·34·12·96 /28

Last " " " 130·34·12·111 /28

First Address IVth subnet 130·34·12·112/28

Last " " " 130·34·12·127/28

VARIABLE LENGTH SUBNETS

E.g block of addresses given to organization with 1st address 14·24·74·0/24. There are $2^{32-24} = 256$ addresses in this block. 11 subnets are reqd as follows

a. 2 subnets, each with 64 addresses.

b. 2 subnets, " " 32 "

c. 3 " , " " 16 "

d. 4 " , " " 4 "

Sol. Subnet Mask is based on addresses reqd in this subnet

In (a) addresses = 64 i.e six zeros in right most byte, ∴ 2 1s in last byte

∴ subnet mask is /26

Similarly in (b) addresses = 32 i.e 5 0s in last byte ($\because 2^5 = 32$)

∴ 3 1s in last byte

Hence subnet mask for this subnet is /27

Similarly for (c), subnet mask is /28
" " (d), " " " /30.

CLA 5/7

Now Site address = 14.24.74.0/24

For part (a) 1st subnet address is 14.24.74.0/26
(64 addresses)

2nd " " is 14.24.74.64/26
(64 Addresses)

14.24.74.00000000
AND.g 255.255.255.11000000

14.24.74.0

Address Range = 14.24.74.0 — 14.24.74.63 (64 Address)

2nd subnet in part (a)

Address Range is 14.24.74.64 — 14.24.74.127
{64 Addresses}

For part (b) Address range is 14.24.74.128 to ~~14.24.74.~~
14.24.74.159

An ISP is granted a block of addresses starting with 190.100.0.0/16 (65536 addresses). The ISP needs to distribute these addresses to three groups of customers as follows:

(a) 1st group has 64 customers, each needs 256 addresses
(b) 2nd group has 128 customers, each need 128 "
(c) 3rd " " " " , " " 64 "

Design the subblocks & find out how many addresses are still available after these allocations.

<u>Sol</u> <u>Group 1</u> For this group each customer needs 256 addresses. This means suffix length = 8 ($2^8 = 256$). The prefix length is 32 − 8 = 24. The addresses are

1st customer 190.100.0.0/24 − 190.100.0.255/24
2nd " 190.100.1.0/24 − 190.100.1.255/24
⋮
64th " 190.100.63.0/24 − 190.100.63.255/24

Total address = 64 × 256 = 16384

<u>Group 2.</u> Each customer needs 128 addresses. So suffix length = 7 ($2^7 = 128$). Prefix length = 32 − 7 = 25
The addresses are:−

1st Customer 190.100.64.0/25 190.100.64.127/25
2nd Customer 190.100.64.128/25 190.100.64.255/25
⋮
128th customer 190.100.127.128/25 190.100.127.255/25

Total address = 128 × 128 = 16384

CLA 7/7

Group 3 Each customer needs 64 addresses. Suffix length $= 6$ ($2^6 = 64$). The prefix length $= 32 - 6 = 26$. The addresses are

1st customer		190.100.128.0/26	190.100.128.63/26
2nd	"	190.100.128.64/26	190.100.128.127/26
128th	"	190.100.159.192/26	190.100.159.255/26

Total addresses $= 128 \times 64 = 8192$

No of granted addresses to the ISP $= 65536$

No of allocated addresses by the ISP $= 40960$

No of available addresses $= 24576$

(a) Total No of addresses = 64 × 256 = 16384

Base of IP addresses is 256 ∴ divide by 256

$\frac{16384}{256} = 64$

When we add 1 address less than total addresses in subnet we get last address

For e.g. if addresses in subnet = 16, we add 15 to first address of subnet to get last address

Similarly we add 16383 address to first address of subnet.

Putting 16383 in 4 octets we get

0 . 0 . 63 . 255 (∵ 63 × 256¹ + 255 × 256⁰
= 16128 + 255
= 16383)

∴ Last address in part (a) of Ques is

190.100.0.0 + 0.0.63.255

i.e 190.100.63.255/24