Introduction to IP Addressing

- IPv4 address : 32 - bits ⇒ Total no. of addresses = $2^{32} \sim 4.2$ billion

Initially (during the 80s), this was divided into 2 fixed parts :

Network ID (NID) = 8 bits and Host ID = 24 bits ~ 16.7 million

8 bit	24 bits
NID	HID
↓ 2^8 networks	↳ 2^{24} hosts PER NETWORK

IANA : Internet Assigned Numbers Authority gives out the NIDs

<u>Issue with this</u> : 256 networks is WAY TOO LESS & 2^{24} hosts per network is WAY TOO HIGH. So, small organizations could not purchase a NID from IANA

<u>Solution</u> : Classful Addressing. Inspired by telephone networks :

In telephone networks, a number has 11 digits and is unique. It is split into 2 parts : STD code and TID code BUT the size changes DYNAMICALLY based on whether a place is a city, town or a village :

	STD	TID	eg.	
In cities :	3 digits	8 digits	012	12394876
In towns :	4 digits	7 digits	0120	7123946
In villages :	5 digits	6 digits	01123	183456

Similarly, in computer networks we have "classes" in classful addressing:

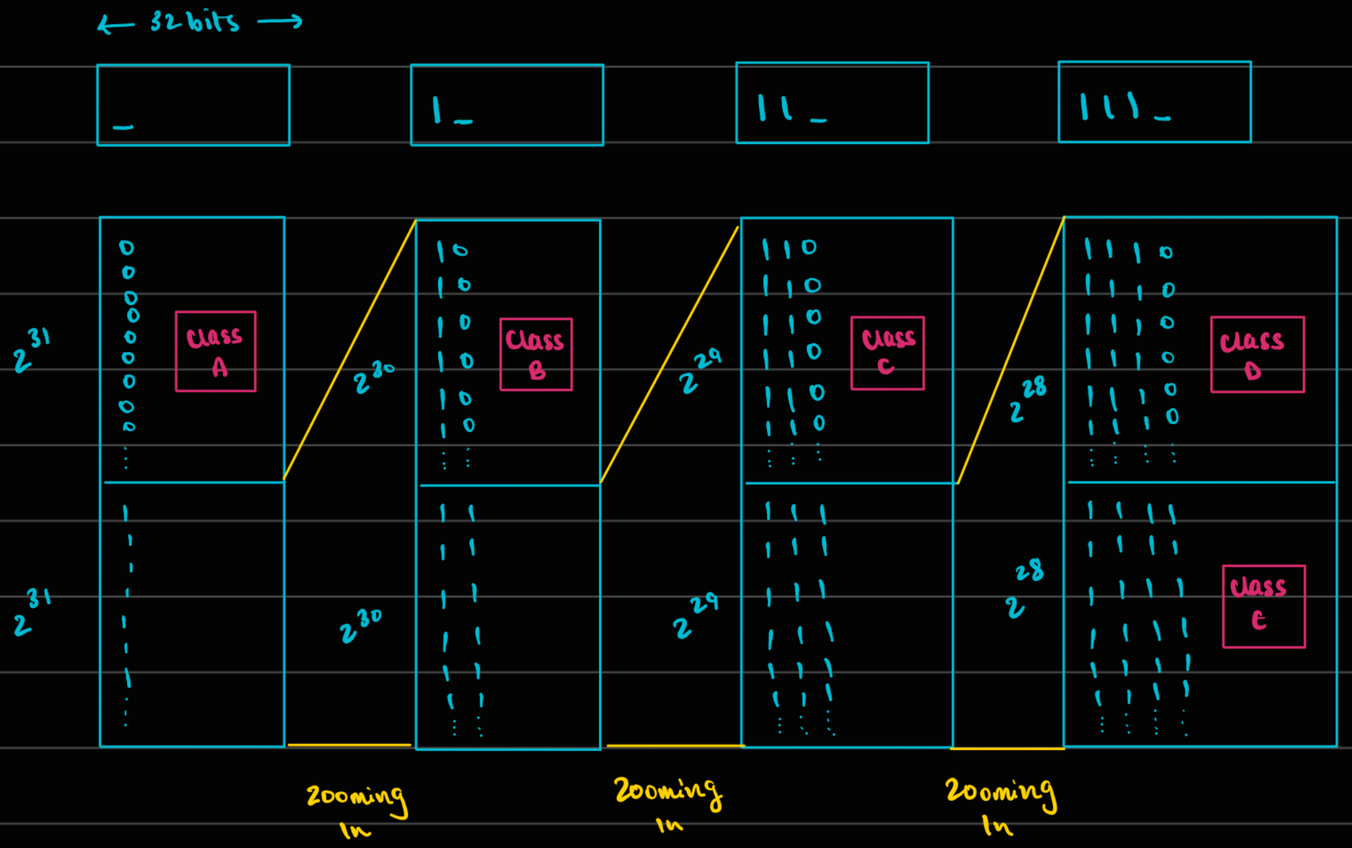
Classes	NID	HID	Designed for
A	8 bits	24 bits	large organizations like NASA
B	16 bits	16 bits	MNCs like IBM, Wipro, etc
C	24 bits	8 bits	small organizations like schools, etc
D	x	x	Multi-casting
E	x	x	Research & reserved for future

NOTE:

Class D and class E DOES NOT have any NID or HID

↑

IMP



Number of IP addresses:

- Class A : 2^{31}
- Class B : 2^{30}
- Class C : 2^{29}
- Class D : 2^{28}
- Class E : 2^{28}

How to identify classes:

Classes	Prefix
A	0
B	10
C	110
D	1110
E	1111

- **IP Address Representation :**

1. Binary : 11001000 . 11111100 . 00111111 . 11110111
2. Decimal : 200 . 252 . 63 . 247
3. Hexadecimal : CB . FC . 3F . F7

- **IP Address Ranges :**

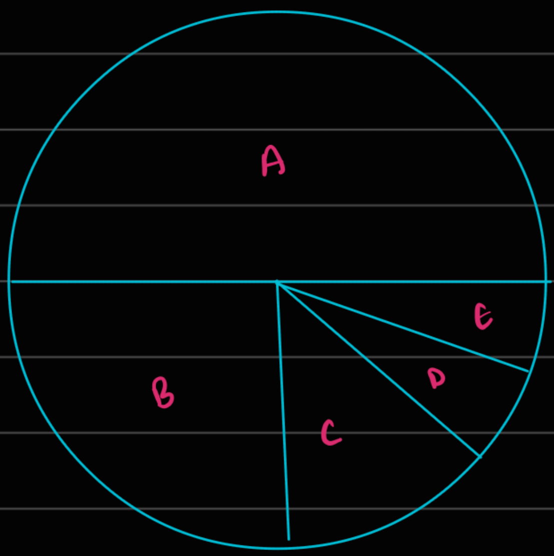
- If we have all 0s in either NID or HID, we CAN NOT assign these address to any computer as these are reserved for special purposes :

  0.0.0.0 → Default route or DHCP client

  127.x.x.x → self-connecting or loop-back testing or inter-process communication

Classes	Network Mask	NID	HID	Num. of networks	No. of hosts PER network	Range
A	255.0.0.0	8 bits	24 bits	$2^{8-1}-2$	$2^{24}-2$	1 to 127
B	255.255.0.0	16 bits	16 bits	$2^{16-2}=2^{14}$	$2^{16}-2$	128 to 191
C	255.255.255.0	24 bits	8 bits	$2^{24-3}=2^{21}$	$2^{8}-2$	192 to 223
D	x	x	x	x	x	224 to 239
E	x	x	x	x	x	240 to 255

- Class B : Prefix is 10. There is no way we get all 0s or all 1s. So we don't have the (-2) term. Same reason for class C. (-2) for class D & E does not make sense since they DO NOT have any NID or HIDs
- Bit-wise AND the network mask with any IP addr. to get the NID (present at places where the result has all 1) and the HID (similar but here, all 0)



A : 2^{24} IP addresses in one network

B : 2^{16} IP addresses in one network

C : 2^{8} IP addresses in one network

[Obviously, no. of hosts = No. of IP addresses − 2 for class A, B and C]

For eg. an organization requires 2^{20} IP addresses, we have to choose class A since max. no. of IP addresses in class B is only 2^{16}.

No. of wasted IP addresses : $2^{24} - 2^{20} = 2^{20}(2^4 - 1) = 15,728,640$

$\sim$ 15.7 million

NOTE : • whenever we have all 0s in HID, that IP address represents the NID of the entire network. That is why we can't assign this IP address to any host.

Finding NIDs : Set HID as 0

Eg. ① IP addr. : 10.32.92.108

⇒ Class A : NID is of 8 bits ⇒ NID : 10.0.0.0

② IP addr. : 157.163.92.97

⇒ Class B : NID is of 16 bits ⇒ NID : 157.163.0.0

③ IP addr : 200.139.24.67

⇒ class C : NID is of 24 bits ⇒ NID : 200.139.24.0

Types of Communication

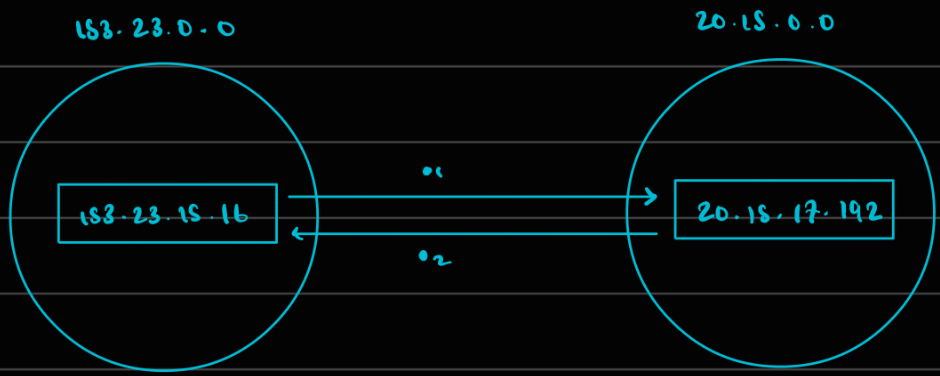
Types of communication

Unicast	Broadcast	Multi-cast
• one-to-one communication	• one-to-all communication	• one-to-many communication

• **Unicast** :

① Communication across different network (can be of different class)

Eg.

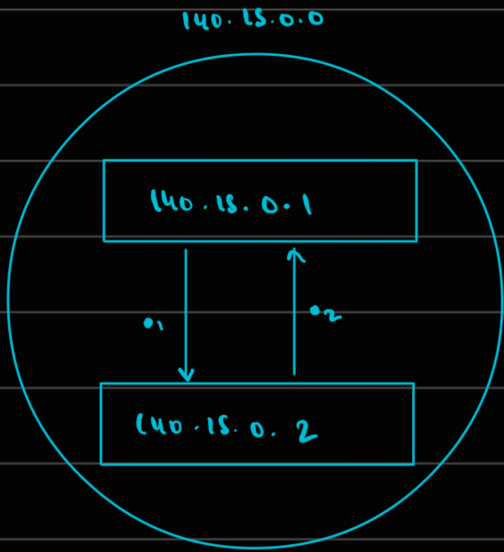


		Source IP	Dest. IP
•1	Data	153.23.15.16	20.15.17.192
•2	Data	20.15.17.192	153.23.15.16

⇒ Both are valid unicast communication

② Communication across same network :

Eg.



		Source IP	Dest. IP
•1	Data	140.15.0.1	140.15.0.2
•2	Data	140.15.0.2	140.15.0.1

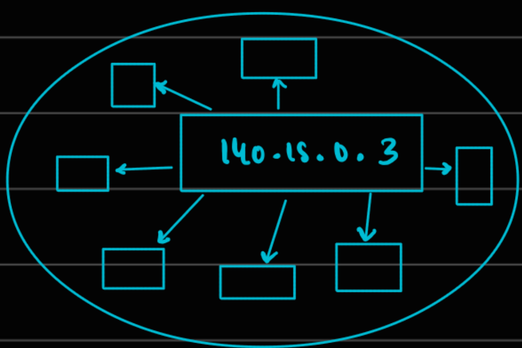
⟹ Both are valid unicast communication

- **Broadcast** :

① **Limited Broadcast** : (LBA : Limited Broadcast Address)

- Transmitting data from one computer to all computers in the SAME NETWORK
- In this case, DESTINATION IP IS ALWAYS 255.255.255.255 (LBA)
- LBA CAN NOT BE USED AS SOURCE IP ADDRESS. It is ALWAYS the dest. IP

Eg.



140.15.0.3

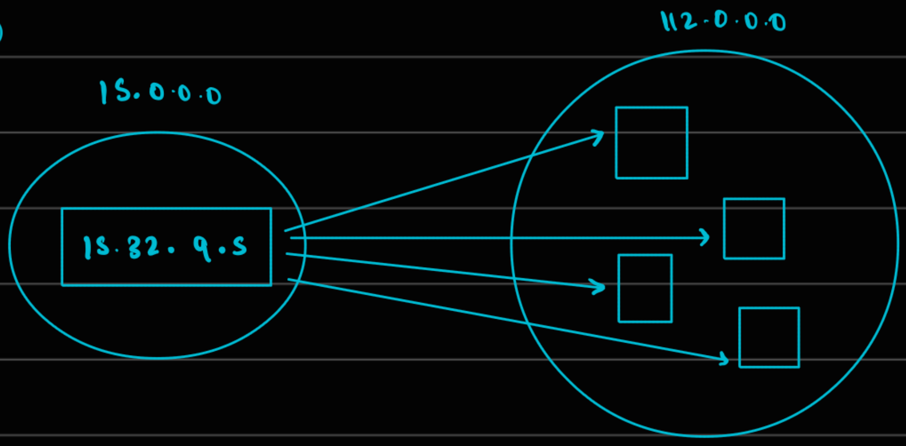
For all outgoing messages :

	Source IP	Dest. IP
Data	140.13.0.3	255.255.255.255

② Direct Broadcast : (DBA : Direct Broadcast Address)

- Transmitting data from one computer to all computers in DIFFERENT NETWORK (can be of different class)
- In this case, DESTINATION IP IS ALWAYS : NID of dest. 255. 255. 255 (DBA)
- DBA CAN NOT BE USED AS SOURCE IP ADDRESS. It is ALWAYS the dest. IP.

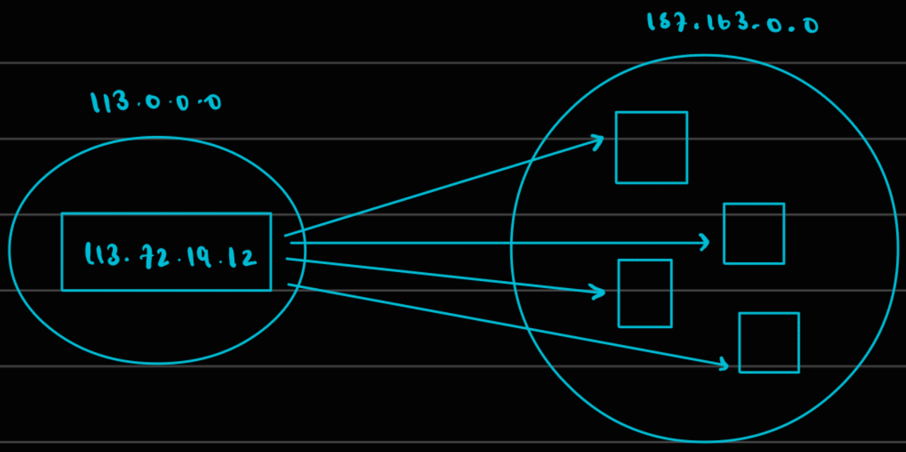
Eg. ①



For all outgoing communications :

	Source IP	Dest. IP
Data	15.32.9.5	112.255.255.255

②



For all outgoing communications :

	Source IP	Dest. IP
Data	113.72.19.12	187.163.255.255

Subnetting

- **Subnetting** : Here we borrow bits from HID

  - Process of dividing a big network to many smaller subnets is called subnetting. It is done to reduce the wastage of IP addresses

- **Alternate definition** : The process of borrowing bits from HID to generate the subnet ID is called subnetting. (No. of borrowed bits depends on our requirement)

Eg. ① 200.200.200.0 . No. of subnets required = 4

$\Rightarrow$ No. of bits to borrow from HID = 2

$\Rightarrow$ class C. So,

NID : 24 bits ;

HID : 8 bits

So, x x x x x x x x

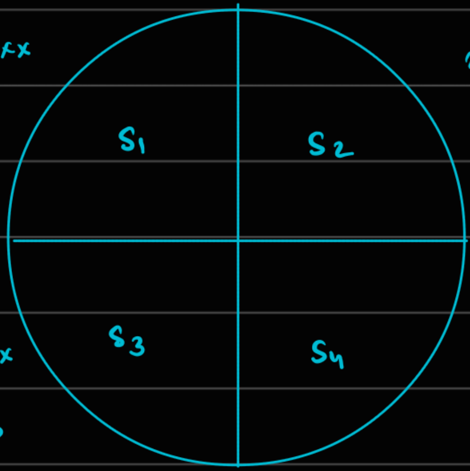
Subnet ID (first 2 bits) ; Host ID (last 6 bits)

$\therefore$ No. of hosts PER subnet $= 2^{(8-2)} - 2 = 2^6 - 2$

200.200.200.$\boxed{00}$xxxxxx

Start = 200.200.200.0

End = 200.200.200.63



200.200.200.$\boxed{01}$xxxxxx

Start = 200.200.200.64

End = 200.200.200.127

200.200.200.$\boxed{10}$xxxxxx

Start = 200.200.200.128

End = 200.200.200.191

200.200.200.$\boxed{11}$xxxxxx

Start = 200.200.200.192

End = 200.200.200.255

Start is the Subnet ID (SID)

End is the DBA for that subnet

So, for eg. in S_1, first host = 200.200.200.1 NOT 200.200.200.0

and second host = 200.200.200.2 NOT 200.200.200.1 and so on.

(2) 200.200.200.0 . No. of subnets required = 8

⇒ No. of bits to borrow from HID = 3

⇒ class C. So,

NID : 24 bits;

HID : 8 bits

So, $\underbrace{xxx}_{\text{Subnet ID}}\underbrace{xxxxx}_{\text{Host ID}}$

∴ No. of hosts PER subnet = $2^{(8-3)} = 2^5$

(3) 200.200.200.0 . No. of subnets required = 4

⇒ No. of bits to borrow from HID = 2

BUT, borrow bits from back not front of HID

⇒ class C. So,

NID : 24 bits ;

HID : 8 bits

So, $\underbrace{x\,x\,x\,x\,x\,x}_{\text{Host ID}}\,\underbrace{x\,x}_{\text{Subnet ID}}$

$\therefore$ No. of hosts PER subnet $= 2^{(8-3)} = 2^5$

Subnets :

S_1 : 200.200.200.xxxxxx $\boxed{00}$

Start : 200.200.200.000000 $\boxed{00}$

: 200.200.200.0

End : 200.200.200.111111 $\boxed{00}$

: 200.200.200.252

S_2 : 200.200.200.xxxxxx $\boxed{00}$

Start : 200.200.200.000000 $\boxed{00}$

: 200.200.200.1

End : 200.200.200.111111 $\boxed{00}$

: 200.200.200.253

S_3 : 200.200.200.xxxxxx $\boxed{00}$

Start : 200.200.200.000000 $\boxed{00}$

: 200.200.200.2

End : 200.200.200.111111 $\boxed{00}$

: 200.200.200.254

S_4 : 200.200.200.xxxxxx $\boxed{00}$

Start : 200.200.200.000000 $\boxed{00}$

: 200.200.200.3

End : 200.200.200.111111 $\boxed{00}$

: 200.200.200.255

Obviously these are not practical since IP addresses NEED to be sequential with diff. of 1. Here the sequence is :

S_1 : 200.200.200.0
200.200.200.4
200.200.200.8
⋮

Similar thing applies for other subnets as well

Subnet Mask :

- It is a 32-bit number used to indicate the no. of bits borrowed from HID And there positions based on the following rules :

    1. No. of 1's in subnet mask = NID + SID
    2. No. of 0's in subnet mask = HID

- Default subnet masks : (when no bits are borrowed from HID)

    - Class A : 255.0.0.0
    - Class B : 255.255.0.0
    - Class C : 255.255.255.0

Eg. ① NID = 200.200.200.0 ; Subnet mask = 255.255.255.224

This belongs to class C : NID = 24 bits ; HID = 8 bits

Subnet mask = 11111111.11111111.11111111.11100000

1. No. of 1's = 27 = NID + SID = 24 + SID

⇒ No. of bits borrowed from HID = 3

⇒ No. of subnets = $2^3 = 8$

2. No. of 0's = 5

⇒ No. of hosts PER subnet = $2^5 - 2 = 30$

Subnet IDs :

PTO

weights → 128	64	32		Subnet IDs :
0	0	0	→ 0	200.200.200.0
0	0	1	→ 32	200.200.200.0
0	1	0	→ 64	⋮
0	1	1	→ 96	⋮
1	0	0	→ 128	⋮
1	0	1	→ 160	⋮
1	1	0	→ 192	200.200.200.192
1	1	1	→ 224	200.200.200.224

② NID = 200.200.200.0 ; Subnet mask = 255.255.255.44

This belongs to class C : NID = 24 bits ; HID = 8 bits

Subnet mask = 11111111.11111111.11111111.00101100

•1 No. of 1's = 27 = NID + SID = 24 + SID

⇒ No. of bits borrowed from HID = 3

⇒ No. of subnets = $2^3 = 8$

•2 No. of 0's = 5

⇒ No. of hosts PER subnet = $2^5 - 2 = 30$

weights →	128	64	32	16	8	4	2	1
	0	0	1	0	1	1	0	0
	H	H	S	H	S	S	H	H

S → Subnet ID (SID)

H → Host ID (HID)

Subnet IDs :

PTO

32	8	4		Subnet IDs
0	0	0	→ 0	200.200.200.0
0	0	1	→ 4	200.200.200.4
0	1	0	→ 8	⋮
0	1	1	→ 12	⋮
1	0	0	→ 32	⋮
1	0	1	→ 36	⋮
1	1	0	→ 40	200.200.200.40
1	1	1	→ 44	200.200.200.44

[Again, these are not practical]

③ Class B network ; Subnet mask = 255.255.248.0 , Assume classful addressing. Max. no. of hosts PER subnet = ?

Subnet mask = 11111111.11111111.11111000.00000000

No. of bits borrowed from HID = 5

No. of subnets $= 2^5 = 32$

No. of bits remaining for HID $= 16 - 5 = 11$

No. of hosts PER subnet $= 2^{11} - 2 = \boxed{2046}$

④ Class B network , wants subnets for 64 departments. Subnet mask = ?

No. of subnets = 64

No. of bits required to borrow from HID = 6

No. of bits remaining for HID = 16 − 6 = 10

Subnet mask = 11111111.11111111.11111100.00000000

$= \boxed{255.255.252.0}$

⑤ IP address = 200.200.200.120 ; Subnet mask = 255.255.255.241.

HID & SID = ?

SID	=	IP address Bitwise AND Subnet mask
HID	=	IP address − SID

$$\left.\begin{array}{rl} & 200.200.200.(64+32+16+8) \\ \& & 255.255.255.(32+8+1) \\ \hline & 200.200.200.40 \end{array}\right\} \Rightarrow SID = 200.200.200.40$$

HID = 200.200.200.(120−40) = 200.200.200.80

⑥ Subnet mask = 255.255.255.224. Find : (224 = 11100000)

a) No. of IP addresses PER subnet $= 2^5 = 32$

b) No. of hosts PER subnet $= 2^5 - 2 = 30$

b) No. of subnets in class A :

Default mask of class A = 255.0.0.0 = 11111111.0.0.0

⇒ minimum 8 bits. No. of 1's in subnet mask = 27

⇒ 27 − 8 = 19 bits are available for HIDs

⇒ No. of subnets in class A $= 2^{19}$

c) No. of subnets in class B : $2^{(27-16)} = 2^{11}$

d) No. of subnets in class C : $2^{(27-24)} = 2^3$

⑦ Subnet mask = 255.255.224.0. No. of subnet = ?

No. of 1's in subnet mask = 19

Default subnet mask of class A = 8 $\Rightarrow 2^{(19-8)} = 2^{11}$ subnets

" 8 " = 16 $\Rightarrow 2^{(19-16)} = 2^{3}$ subnets

$\Rightarrow$ No. of subnets possible = $\{2^3$ and $2^{11}\}$

⑧ Subnet mask = 255.255.255.240. Which of the following can be DBA ?

a) 200.56.78.31

b) 200.56.78.15

c) 200.56.78.10

d) 200.56.78.47

Subnet mask = 255.255.255.11110000

For DBA, HID should be all 1. These bits must also be 1

Checking with the options :

a) ~~200.56.78~~.31 : x.x.x.00011111 ✓

b) ~~200.56.78~~.15 : x.x.x.00001111 ✓

c) ~~200.56.78~~.10 : x.x.x.00001010 ✗

d) ~~200.56.78~~.47 : x.x.x.00101111 ✓

Answer : a), b), d)

⑨ IP address : 200.200.200.80, subnet mask = 255.255.255.224; class C.

Subnet ID & subnet number = ?

Subnet mask = 11111111.11111111.11111111.11100000

$\underbrace{111}_{\text{Subnet ID}}\underbrace{00000}_{\text{Host ID}}$

(In subnet ID, the HIDs are all 0 any. So, we are not writing it here)

128	64	32				
0	0	0	:	0	:	1st subnet
0	0	1	:	32	:	2nd subnet
0	1	0	:	64	:	3rd subnet
0	1	1				⋮
1	0	0				⋮
1	0	1	:	160	:	6th subnet
1	1	0	:	192	:	7th subnet
1	1	1	:	224	:	8th subnet

64 < 80 < ...

⇒ Given IP address belongs to 2nd subnet

⇒ Subnet number = 2

⇒ SID = 001 = 32

⇒ Subnet ID = 200.200.200.32

(10) IP address = 157.157.52.80 (class B) ; subnet mask = 255.255.192.0.

Find : subnet ID, first host, last host and DBA.

Subnet mask = 255.255.11000000.00000000

$\underbrace{11}_{\text{Subnet ID}}\underbrace{000000.00000000}_{\text{Host ID}}$

157.157.$\boxed{00}$000000.00000000 → Subnet ID

157.157.$\boxed{00}$000000.00000001 → First host

157.157.$\boxed{00}$000000.00000010

⋮

157.157.$\boxed{00}$111111.11111110 → last host

157.157.$\boxed{00}$111111.11111111 → DBA

(11) IP address = 200.200.200.90 ; subnet mask = 255.255.255.224

Find 3^{rd} & 7^{th} subnet ID

Subnet mask = $255.255.255.\underbrace{111}_{SID}\underbrace{00000}_{HID}$

S.No	128	64	32		
0	0	0	0	→ 0	1^{st} subnet
1	0	0	1	→ 32	2^{nd} subnet
2	0	1	0	→ 64	3^{rd} subnet ⇒ SID : 200.200.200.64
3	0	1	1	⋮	⋮
4	1	0	0	⋮	⋮
5	1	0	1	⋮	⋮
6	1	1	0	→ 192	7^{th} subnet ⇒ SID : 200.200.200.192
7	1	1	1	→ 224	8^{th} subnet

Shortcut :
- To find n^{th} subnet, just write $(n-1)$ in binary using as many bits as SID and evaluate using those weights.
- To find n^{th} host, just write (n) in binary using as many bits as HID and evaluate using those weights

(12) IP address = 128.200.100.90 ; Subnet mask = 255.252.0.0. Find

a) 3^{rd} host in 2^{nd} subnet

b) 4^{th} host in 3^{rd} subnet

c) 1^{st} host in 4^{th} subnet

IP address = 125.200.100.90 ⇒ class A

Subnet mask = 255. 11111100.00000000.00000000

$\underbrace{111111}_{SID}\ \underbrace{00.00000000.00000000}_{HID}$

128 64 32 16 8 4 2 1 ⟶ weights

a) 2^{nd} subnet ⇒ (2-1) in binary using (SID bits) = 000001

⇒ Subnet ID = 125.200.100.1

3^{rd} host ⇒ (3) in binary using (HID bits)

⇒ Host ID = 000000000000000011

⇒ IP address of host = 125.00000100.00000000.00000011

= $\boxed{125.4.0.3}$

b) 3^{rd} subnet ⇒ (3-1) in binary using (SID bits) = 000010

4^{th} host ⇒ (4) in binary using (HID bits) = 0000000000000100

⇒ IP address of host = 125.00001000.00000000.00000100

= $\boxed{125.8.0.4}$

c) 4^{th} subnet ⇒ (4-1) in binary using (SID bits) = 000011

1^{st} host ⇒ (1) in binary using (HID bits) = 000000000000000001

⇒ IP address of host = 125.00001100.00000000.00000001

= $\boxed{125.12.0.1}$

(13) Subnet mask = 255.255.255.24 ; 3 machines with IP address :

M = 200.40.38.50 ; N = 200.92.48.40 ; P = 200.80.68.60

find which subnets these hosts belong to : (Class A)

For M : 200.40.38.$\underbrace{001}_{SID}\underbrace{10010}_{HID}$

128	64	32	16	8	4	2	1
0	0	1	1	0	0	1	0

$\Rightarrow$ 2^{nd} subnet ; 18^{th} host

SID = $(001)_{10} + 1$ HID = $(10010)_{10}$

= 1+1 = 2 = 18

For N: 200.92.48.$\underbrace{001}_{SID}\underbrace{01000}_{HID}$

$\Rightarrow$ 2^{nd} subnet ; 8^{th} host

SID = $(001)_{10}+1$ HID = $(01000)_{10}$

= 2 = 8

For P : 200.80.68.$\underbrace{001}_{SID}\underbrace{11100}_{HID}$

$\Rightarrow$ 2^{nd} subnet ; 28^{th} host

SID = $(001)_{10}+1$ HID = $(11100)_{10}$

= 2 = 28

(14) Class C network with 7 subnets and 25 hosts PER Subnet. Subnet mask = ?

Default subnet mask = 255.255.255.0

Total no. of hosts = 25 x 7 = 175 $\leq$ $2^8 - 2$ = 254 ✓

class C : 24 bit NID and 8 bits HID

7 subnet $\Rightarrow$ 3 bits will be borrowed from HID

$\Rightarrow$ HID = 5 bit ; SID = 3 bits ; NID = 24 bits

WKT, total no. of 1's in subnet mask = NID + SID = 27 and

total no. of 0's in subnet mask = HID = 5

Possible subnet masks :

11111111.11111111.11111111.(any permutation of 3 ones & 5 zeros)

But only 11111111.11111111.11111111.11100000 = 255.255.255.224 is practical & valid

(15) DBA = 200.200.200.31 . Which of the following can be a subnet mask :

a) 255.255.255.192 b) 255.255.255.224

c) 255.255.225.248 d) 255.255.255.128

200.200.200.31 → class C ⇒ NID = 24 bits ; HID = 8 bits

Default subnet mask = 255.255.255.0

WKT, in DBA, HID is all ones. So, possible answers :

200.200.200.00011111

→ possible subnet IDs

[That's why we can't say 11111 is HID since 1111, 111, 11 and 1 are also all ones. So without subnet mask, we can't uniquely determine the HID]

Verifying the options : Generating DBA for all subnets for all subnet masks

a) 255.255.255.192 :

$255.255.255.\underbrace{11}_{SID}\underbrace{000000}_{HID}$. Generating DBA for all subnets :

$S_1 : 00\,111111 = 63$; $S_2 : 01\,111111 = 127$

$S_3 : 10\,111111 = 191$; $S_4 : 11\,111111 = 255$

None of the DBA = 31 ⇒ a) is INCORRECT

b) $255.255.255.\underbrace{111}_{SID}\underbrace{00000}_{HID}$. Generating DBA for all subnets :

$S_1 : 111\,00000 = 31$ ✓ . . . . ⇒ b) is CORRECT

c) $255.255.255.\underbrace{11111}_{SID}\underbrace{000}_{HID}$. Generating DBA for all subnets :

$S_1 : 00000\,111$ . . . . at some point, we will have :

$S_n : \underbrace{00011}_{SID}\ \underbrace{111}_{HID} = 31$ ⇒ c) is CORRECT

d) $255.255.255.\underbrace{1}_{SID}\underbrace{0000000}_{HID}$. Generating DBA for all subnets :

$S_1 : 0\,1111111 = 127$; $S_2 : 1\,1111111 = 253$

None of the DBA = 31 ⇒ d) is INCORRECT

Shortcut : • Find max. no. of bits HID can have. Let it be N

• If HID in subnet mask ≤ N, the subnet mask is CORRECT else INCORRECT

Using Shortcut :

Max. no. of bits for HID = 5 (refer diagram above)

a) 255.255.255. $\underbrace{11}_{SID}\underbrace{000000}_{HID}$ ⇒ HID = 6 bits > 5 bits ✗

b) 255.255.255. $\underbrace{111}_{SID}\underbrace{00000}_{HID}$ ⇒ HID = 5 bits ≤ 5 bits ✓

c) 255.255.255. $\underbrace{11111}_{SID}\underbrace{000}_{HID}$ ⇒ HID = 3 bits ≤ 5 bits ✓

d) 255.255.255. $\underbrace{1111}_{SID}\underbrace{0000}_{HID}$ ⇒ HID = 4 bits ≤ 5 bits ✓

Answer : b), c) and d)

(16) DBA = 168.17.7.255. Which of the following could be its network mask ?

a) 255.255.248.0 b) 255.255.252.0 c) 255.255.254.0 d) All

Clearly, it belongs to class B : 168.x.x.x

DBA = 168.17. $\underbrace{00000}_{SID}\underbrace{111.11111111}_{HID}$

⇒ Max. no. of bits for HID = 11

Verifying the options :

a) $255.255.255.\underbrace{11111}_{SID}\underbrace{000.00000000}_{HID}$: HID = 11 bits ≤ 11 bits ✓

b) $255.255.\underbrace{111111}_{SID}\underbrace{00.00000000}_{HID}$: HID = 10 bits ≤ 11 bits ✓

c) $255.255.\underbrace{1111111}_{SID}\underbrace{0.00000000}_{HID}$: HID = 9 bits ≤ 11 bits ✓

Answer : d)

Note : If the 1's in the HID are NOT CONTINUOUS, we need to CHECK IT MANUALLY. Shortcut fails here.

Explanation :

For eg. DBA : 200.200.200.31 and subnet mask = 255.255.255.198

Min. no. of bits for HID = $\lceil \log_2 31 \rceil = 5$

Subnet mask = 255.255.255. 11000110 • → HID • → SID

Although HID = 4 bits ≤ 5 bits BUT it is not correct since the ones are NOT continuous. ∴ The subnet mask is invalid.

Think about it. 31 = 00011111. For the sake of explanation, let us take the 3rd bit in 31 = 0. There is no way to form 31 using that subnet mask's DBA since the 3rd bit there will have to be a 1 (since it is a DBA)

But if all those bits align then yes, that subnet mask's DBA can be considered.

(17) 3 machines M, N and P. Their IP addresses : M = 157.157.38.90, 157.157.48.90 and P = 157.157.68.90. Subnet mask = 255.255.192.0. Comment on which subnets these machines belong to.

IP addresses : 157.x.x.x ⇒ class B

Subnet mask : 255.255.$\underbrace{11}_{\text{SID}}\underbrace{000000.00000000}_{\text{HID}}$

To comment on the subnets, we just need to look at the SIDs of the machines instead of bitwise ANDing the IP addresses with the subnet mask since that is time-consuming.

SID of M : x.x.<u>00</u>100110.x = 00

SID of N : x.x.<u>00</u>110000.x = 00

SID of P : x.x.<u>01</u>000100.x = 01

⇒ M and N belong to the same subnet and P belongs to a different subnet from M and N

(18) Same question as above. Subnet mask = 255.255.240.0

Subnet mask = 255.255.$\underbrace{1111}_{\text{SID}}\underbrace{0000.00000000}_{\text{HID}}$

SID of M : x.x.<u>0010</u> 0110.x = 0010

SID of N : x.x.<u>0011</u>0000.x = 0011

SID of P : x.x.<u>0100</u> 0100.x = 0100

⇒ All of them belong to different subnets.

(19) IP address of various machines :

X = 192.168.1.97

Y = 192.168.1.80

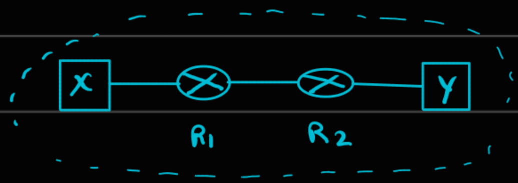
R_1 = 192.168.1.135 (with X)

192.168.1.110 (with R_2)

R_2 = 192.168.1.67 (with R_1)

192.168.1.155 (with Y)

Connection diagram :



Network N

netmask = 255.255.255.224

No. of distinct subnets that are guaranteed to already exist in the network = ?

Subnet mask = 255.255.255. $\underbrace{111}_{SID}\underbrace{00000}_{HID}$

(writing only the bits that are required i.e. only the SID bits)

				128	64	32
SID of X	=	97	≡	0	1	1
SID of R_1 with X	=	135	≡	1	0	0
SID of R_1 with R_2	=	110	≡	0	1	1
SID of R_2 with R_1	=	67	≡	0	1	0
SID of R_2 with Y	=	155	≡	1	0	0
SID of Y	=	80	≡	0	1	0

⇒ 3 distinct subnets are already present in this network

(20) IP address of A = 10.105.1.113 and B = 10.105.1.91. Both use the same netmask N. Which of the following values of N given below should NOT be used if A and B belong to the same network?

a) 255.255.255.0 b) 255.255.255.128

c) 255.255.255.192   d) 255.255.255.224

from IP address, we can infer that they are class A.

Same network ⇒ SID is same.

For A : x.x.x.01110001

For B : x.x.x.00101011

Verifying the options :

a) Obviously wrong because if we use this then A and B belong to the same network

b) 255.255.255.10000000 → Check 1^{st} bit of 0111001 = that of 00101011 ✓

c) 255.255.255.11000000 → Check first 2 bits " " ✓

d) 255.255.255.11100000 → Check first 3 bits " " X

Instead of counting the 1's we do this since the 1^{st} 3 octets of the IP addresses are the same.

(21) The address of a class B host is split into subnets with a 6-bit subnet number. What is the max. no. of subnets and max. no. of hosts in each subnet ? (GATE 2007)

a) 62 subnets and 262142 hosts

b) 64 " " 262142 " "

c) 62 " " 1022 " "

d) 64 " " 1024 " "

Default subnet mask = 255.255.0.0

6 bits from HID is borrowed = $x.x.\underbrace{111111}_{SID}\underbrace{00.00000000}_{HID}$

Max. no. of subnets $= 2^6 = 64$

Max. no. of hosts PER subnet $= 2^{10} - 2 = 1022$

⇒ None of the options match. (according to latest RFC)

NOTE:
- According to old RFC (950), if we have n-bits for SID, then no. of subnets $= 2^n - 2$ (we don't consider all 0's and all 1's for SID)
- According to new RFC (present), then it is 2^n like we normally do

Answer: c) [according to old RFC. The question was from 2007. So, at that time, they have considered the old RFC]

Always follow the latest RFC. Meaning, don't consider as $2^n - 2$ subnets but consider 2^n subnets like we normally do.

(22) Routing table of a router:

Destination	Subnet mask	Interface
144.16.0.0	255.255.0.0	Eth0
144.16.64.0	255.255.224.0	Eth1
144.16.68.0	255.255.255.0	Eth2
144.16.68.64	255.255.255.224	Eth3

Packet's destination address = 144.16.68.117. This packet arrives at the router. On which interface it will be forwarded to?

Procedure is simple : Bitwise AND the packet's destination address with the subnet masks and see which destination address from the router matches the result.

If multiple destination IP addresses from the routing tables are matched, then the router forwards the packet to the interface having the longest subnet mask i.e. the subnet mask having more no. of 1's.

SHORTCUT : In these type of questions, start from the longest subnet mask

Checking with the interface's destination IP :

Packet dest. IP = 144.16.68. 01110101

& Subnet mask of Eth3 = 255.255.255. 01100000

144.16.68.96 ✗

Packet dest. IP = 144.16.68. 01110101

& Subnet mask of Eth2 = 255.255.255. 00000000

144.16.68.0 ✓

No need to check for Eth1 and Eth0 (since the one with the longest subnet mask already matched)

Answer : Eth2

(23) Class C network address : 204.204.204.0 . 3 subnets : X with 100 hosts ; Y with 50 hosts ; Z with 50 hosts. Which of the following options suggests a feasible set of subnet address / subnet mask pairs ?

(N_1 = 204.204.204 and N_2 = 255.255.255)

a) X : N_1.0 and N_2.128
Y : N_1.128 and N_2.192
Z : N_1.192 and N_2.192

b) X : N_1.128 and N_2.128
Y : N_1.0 and N_2.192
Z : N_1.64 and N_2.192

a) X : N_1.0 and N_2.128
Y : N_1.192 and N_2.192
Z : N_1.128 and N_2.192

a) X : N_1.128 and N_2.128
Y : N_1.64 and N_2.192
Z : N_1.0 and N_2.192

Class C $\Rightarrow$ NID = 24 bits and HID = 8 bits

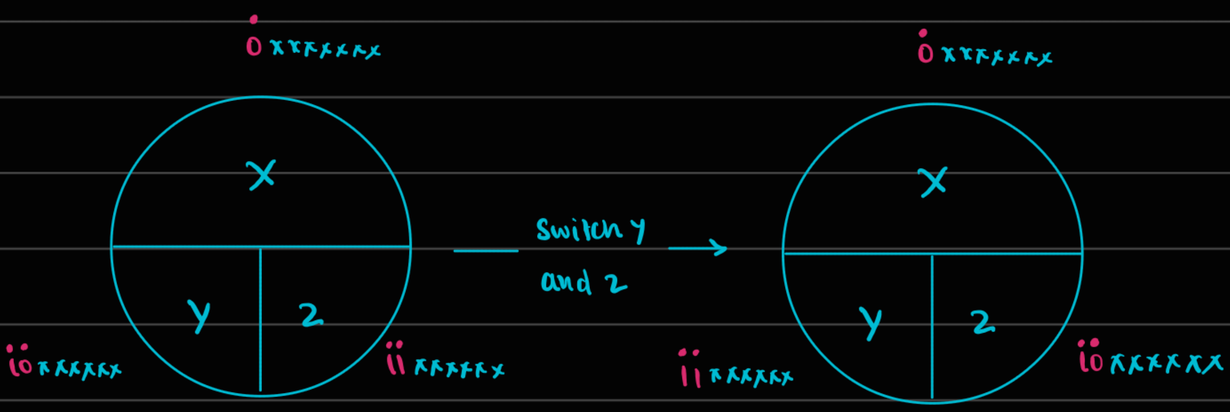
Total no. of hosts = $200 \le 2^8 - 2 = 252$ ✓
No. of subnets required = 8
No. of bits to borrow from HID = 2
No. of hosts per subnet = $2^{8-2} - 2 = 2^6 - 2 = 62$

Y and Z's host requirement is satisfied BUT not X's.
So, fixed length subnet mask (FLSM) fails

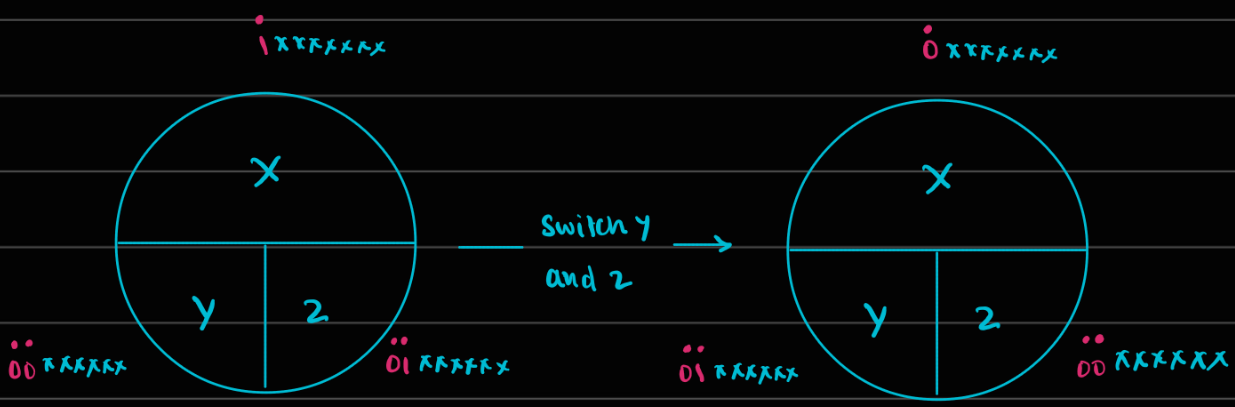
$\Rightarrow$ We need variable length subnet masks (VLSM)

We have 2^8 IP addresses. Possible splits : (• → borrowed bit(s) from HID)

Case 1 Case 2



Case 3 Case 4



For Case 1 :

x : Subnet mask = 204.204.204.00000000

SID = 255.255.255.128

No. of 1's in the subnet mask = 24 (default subnet mask) + 1 (no. of bits borrowed from HID)

= 25

SID = 255.255.255.1000000

Y : Subnet mask = 204.204.204.10000000

SID = 255.255.255.11000000

= 255.255.255.192

Z : Subnet mask = 204.204.204.11000000

SID = 255.255.255.11000000

= 255.255.255.192

Do the same for all cases.

Answer : a), b), c) and d)

Classless Addressing

- **Classless Addressing :**

  - Notation : a.b.c.d / n where n = no. of bits in NID or subnet mask

$\longleftarrow$ 32 bits $\longrightarrow$

n	32-n
Prefix	Suffix

Prefix : NID and Suffix : HID

Needless to say, no. of IP address = $2^{(32-n)}$

- **CIDR (Classless Inter-Domain Routing) :**

- Whenever a customer wants a block of IP address, IANA or the local ISP will create a block and assign it to the customer.

- Rules to be followed by IANA / ISP while creating a block:

  1. <u>All IP addresses must be contiguous</u>

     For eg. 10.1.127.1, 10.1.127.2, ... ✓

     10.1.127.1, 10.1.127.3 ✗

     10.1.127.1, 10.2.127.1 ✗

  2. <u>Block size must be a power of 2</u>

     $\boxed{\text{Reason: when the block size is } 2^n \text{, the no. of bits in HID} = n}$

     Idea: Take any number. When you divide it by the n^{th} power of its base, first 'n' bits are the quotient & remaining bits is the remainder.

For eg.

$(8192)_{10}$ ÷	Q	R
10^1	819	2
10^2	81	92
10^3	819	2
10^4	8192	0

$(10101)_2$ ÷	Q	R
2^1	1010	1
2^2	101	01
2^3	10	101
2^4	1	1010
2^5	0	10101

So, block size of 1000 can not exist, only 1024. Block size of 200 can't exist, only 256 and so on.

• 3 First IP address of the block must be divisible by the size of the block

$\longleftarrow$ n-bits $\longrightarrow$

Obviously :

(n-k) bits	k bits
NID (Q)	HID (R)

divide by 2^k

Given that $R = 0 \Rightarrow$ k bits are 0

$\Rightarrow$ First IP address :

(n-k) bits	k bits: 00000....
NID (Q)	HID (R)

Obviously since first address is the block ID (BID) (similar to NID) (all zeros in HID)

• 4 Last address of the block must have all 1's in HID (If all the above rules pass, this will obviously pass)

Eg. ① Is this a valid block : (X = 100.100.100) X.64, X.65, ..., X.126, X.127 ?

Contiguous ✓

No. of IP addresses $= 127 - 64 + 1 = 64 = 2^6$

Block size $= 2^6$

$\Rightarrow$ $X.64 / 2^6 = X.\underbrace{01000000}_{\text{Remainder} = \text{HID}}$ $\Rightarrow$ 1^{st} address of block has all 0's in HID

All rules pass : The block is VALID

- **CIDR Representation :**

  - Pick Any IP address in a given block and simply add /NID (we know NID since we know the block size) at the end.

for eg. 100·100·100·64

100·100·100·65 → Say we pick this

⋮

100·100·100·126

100·100·100·127

Block Size = 127 − 64 + 1
= 64
= 2^6
⇒ HID = 6 and
NID = 26

$\underbrace{100\cdot100\cdot100\cdot01}_{NID}\underbrace{000001}_{HID}$ / 26

So, 1st addr. = 100·100·100·01000000 = 100·100·100·64 → BID

2nd addr. = " ".01000001 = " ".65 → First Host

⋮

63rd addr. = " ".01111110 = " ".126 → last Host

64th addr. = " ".01111111 = " ".127 → DBA

Pick any IP in the block, we can get all the IP addresses from it. REASON : IP addresses are made using combinations HID bits.

- **Subnetting In CIDR :**

  - Similar to that in classful addressing. Just be careful while assigning /n to the subnets.

For eg. ① Network : 100.100.100.14 / 25 . Required no. of subnets = 4 = 2^2

NID = 25 bits and HID = 32 - 25 = 7 bits

we need to borrow 2 bits from HID for the subnets.

⇒ No. of IP addresses = 2^7 = 128

⇒ No. of hosts = $2^7 - 2$ = 126

Now, $\underbrace{100.100.100.0}_{NID}\ \underbrace{0001110}_{HID}$.

Subnets : $100.100.100.0\ \underbrace{--}_{SID}\ \underbrace{-----}_{HID}$ / 27

Not 25 or 23 since we borrowed bits from HID and /n represents NID (along with SID)

S_1 : 100.100.100.000 - - - - -

⇒ SID = 100.100.100.0 / 27

⇒ DBA = 100.100.100.31 / 27

S_2 : 100.100.100.001 - - - - -

⇒ SID = 100.100.100.32 / 27

⇒ DBA = 100.100.100.63 / 27

S_3 : 100.100.100.010 - - - - -

⇒ SID = 100.100.100.64 / 27

⇒ DBA = 100.100.100.95 / 27

S_4 : 100.100.100.011 - - - - -

⇒ SID = 100.100.100.96 / 27

⇒ DBA = 100.100.100.127 / 27

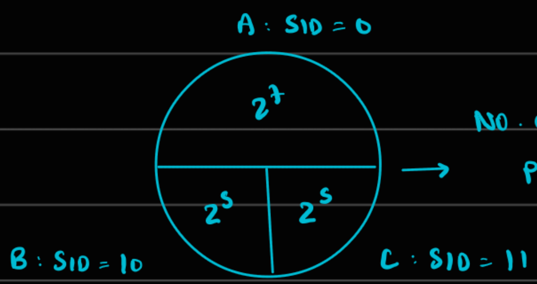
② Network : 100.100.100.14 / 25 . 3 subnets : A with 60 hosts ; B and C with 30 hosts each.

NID = 25 bits ; HID = 7 bits

⇒ No. of IP addresses = 2^7 = 128

⇒ No. of hosts = $2^7 - 2$ = 126

Total no. of hosts = 120 ≤ $2^7 - 2$ = 126 ✓



→ No. of IP addresses PER subnet

There are 4 cases, we are only considering one of them

Now, $\underbrace{100.100.100.}_{NID}\underbrace{00001110}_{HID}$. The no. of bits to borrow from HID depends on the subnet:

<u>Subnets:</u>

S_A : 100.100.100.0 _ _ _ _ _ _ _

⇒ NID = 100.100.100.0 / 26

⇒ DBA = 100.100.100.63 / 26

S_A : 100.100.100.10 _ _ _ _ _ _

⇒ NID = 100.100.100.64 / 27

⇒ DBA = 100.100.100.95 / 27

S_C : 100.100.100.11 _ _ _ _ _ _

⇒ NID = 100.100.100.96 / 27

⇒ DBA = 100.100.100.127 / 27

<u>NOTE</u> : S_B and S_C can also be interchanged. Also, S_A could have SID = 1. So there are a total of 4 CASES

③ Network : 200.10.11.144 / 27. 4^{th} octet (in decimal) of last IP addr. that can be assigned to a host = ?

NID = 27 bits ; HID = 5 bits

So, $\underbrace{200.10.11.100}_{NID}\underbrace{10100}_{HID}$

Last host IP = 200.10.11.10011110

= 200.10.11.154

Not 155 since all ones is DBA not the last host

⇒ last octet of last IP = 154

④ Block granted to an org. : 150.36.0.0/16. Admin wants to create 512 subnets. What is the subnet mask ?

NID = 16 bits ; HID = 16 bits

So, $\underbrace{150.36.}_{NID}\underbrace{\text{- - - - - - - - - . -}}_{SID}\underbrace{0000000}_{HID}$

Total no. of subnets = 512 = 2^9

No. of bits to borrow from HID = 9

Total no. of ones in subnet mask = NID + SID = 25

Total no. of zeros in subnet mask = HID = 7

Subnet mask = 11111111.11111111.11111111.10000000 / 25 (16+9)

= 255.255.255.128 / 27

⑤ Block contains 64 IP addresses. Which of the following can be first address of the block ?

a) 200.50.60.32 b) 200.50.60.192 c) 200.50.60.191 d) None

Block size = 64 = 2^6

$\Rightarrow$ HID = 6 bits

We know that, first IP address of the block MUST BE divisible by its block size. Meaning HID must be all 0's.

Verifying the options :

a) 200.50.60.00100000 : 100000 $\neq$ 000000 ✗

b) 200.50.60.11000000 : 000000 = 000000 ✓ Answer : b)

c) 200.50.60.10111111 : 111111 $\neq$ 000000 ✗

d) ✗

Supernetting

- **Supernetting** : Here we borrow bits from NID

  - Process of combining 2 or more networks to get a single network
  - We CAN NOT supernet a single network (obviously)
  - Rules for subnetting :

① Network ID must be contiguous :

- •1 128.56.24.0/24 ; 128.56.25.0/24 ; 128.56.26.0/24 ✓
- •2 128.56.24.0/25 ; 128.56.25.0/25 ; 128.56.25.0/25 ✗

(for •2 , 2^{nd} should have been 128.56.24.129/25 and so on)

② Size of network must be same

- •1 128.56.24.0/24 ; 128.56.25.0/24 ; 128.56.26.0/2 ✓
- •2 128.56.24.0/24 ; 128.56.24.0/25 ; 128.56.25.0/25 ✗

(In •2 , network sizes are different)

③ No. of networks must be a power of 2 :

Can not combine 3, 5, etc. networks

Can combine 2, 4, 8, etc. network

④ First network ID must be divisible by size of the total supernet

[same reason as the block creation by ISP : First IP here would be the Supernet ID (SuID)]

- 1. 128.56.24.0/24 ; 128.56.25.0/24 ; 128.56.26.0/24 ✗

  (as no. of networks is NOT a power of 2

- 2. 128.56.24.0/24 ; 128.56.25.0/24 ; 128.56.26.0/24 ; 128.56.27.0/24 ✓

Rules ① to ③ are satisfied here. Checking for rule ④ :

Total size of supernet $= 4 \times 2^8 = 2^{10}$

First IP address of combined network = 128.56.24.0/24

= 128.56.00011000.00000000/24

Dividing first IP with supernet size $= \underbrace{128.56.000110}_{\text{Quotient}}\underbrace{00.00000000}_{\text{Remainder}} \div 2^{10}$

Remainder = 0. ∴ Rule ④ is also satisfied here.

- <u>Supernet mask</u> :

  - It is a number used to generate a single IP address for the group of networks based on the following rules :

    ① <u>No. of 1's</u> in the supernet mask indicate <u>fixed part</u>

    ② <u>No. of 0's</u> in the supernet mask indicate <u>variable part</u>

For eg. N_1 : 128.56.24.0/24 ; N_2 : 128.56.25.0/24 ;

N_3 : 128.56.26.0/24 ; N_4 : 128.56.27.0/24

N_1 : 10000000 . 00111000 . 000110 | 00 . 00000000

N_2 : 10000000 . 00111000 . 000110 | 01 . 00000000

N_3 : 10000000 . 00111000 . 000110 | 10 . 00000000

N_4 : 10000000 . 00111000 . 000110 | 11 . 00000000

Fixed Part | Variable Part

Supernet mask : 11111111 . 11111111 . 11111100 . 00000000

: 255 . 255 . 252 . 0

Similar to : IP addr. BITWISE AND Subnet mask = Subnet ID,

IP addr. BITWISE AND Supernet mask = Supernet ID

<u>Shortcut</u> :

- •1 Supernet ID = First IP address of supernet
- •2 Supernet mask : Find total size of supernet. Let it be 2^K.
  - No. of 0's in supernet mask = K
  - No. of 1's in Supernet mask = 32 − K
- •3 Final IP address after Supernetting : x.x.x.x / NID = x.x.x.x / 32 − K

Eg. ① Perform CIDR aggregation on the following IP addresses :

57.6.96.0/21 ; 57.6.104.0/21 ; 57.6.112.0/21 ; 57.6.120.0/21

NID = 21 bits ; HID = 11 bits

Network size = 2^{11}

Total no. of network = 4 = 2^2

Total size of supernet = $4 * 2^{11} = 2^{13}$

- •1 Contiguous ✓
- •2 Power of 2 networks ✓
- •3 Same network size ✓

$\underline{56.6.011}\underline{00000.00000000} \div 2^{13}$ • 4 First IP addr. divisible ✓ by supernet size

Quotient Remainder

Remainder = 0

⇒ Supernet mask : 11111111.11111111.11100000.00000000 / 19 $\begin{bmatrix} HID = 13 \text{ bits} \\ NID = 19 \text{ bits} \end{bmatrix}$

: 255.255.224.0 / 19

⇒ Supernet ID = First IP addr. of supernet

= 57.6.96.0 / 19

② Perform CIDR aggregation on the following IP addresses :

194.24.0.0/21 ; 194.24.8.0/21 and 194.24.16.0/20

No. of blocks is not a power of 2 and is not contiguous. THIS IS WRONG.

N_1 : 192.24.0.0/21 : NID = 21 bits and HID = 11 bits ⇒ 2^{11} IP addresses

N_2 : 192.24.8.0/21 : NID = 21 bits and HID = 11 bits ⇒ 2^{11} IP addresses

N_3 . 192.24.16.0/20 : NID = 20 bits and HID = 10 bits ⇒ 2^{10} IP addresses

• 1 Contiguous :

N_1 : 192.24.0.0/21 to 192.24.7.255/21

N_2 : 192.24.8.0/21 to 192.24.15.255/21

N_3 : 192.24.16.0/20 to 192.24.31.255

⇒ N_1, N_2 and N_3 are contiguous

• 2 Same network size and no. of supernets must be power of 2 :

N_1 : 2^{11} and N_2 : 2^{11}

2 networks = 2^1 and same size ✓. So, combine them into N_4. Then combine N_3 and N_4.

Make sure to check rule 4 (divisibility) in : ($N_1 + N_2$) step AND ($N_3 + N_4$) step.

- 1 $N_3 = N_1 + N_2$:

Total no. of networks $= 2 * 2^{11} = 2^{12}$

HID = 12 bits and NID = 20 bits

Supernet mask = 255.255.11110000.00000000 / 20 = 255.255.240.0 / 20

Supernet ID = First IP address of supernet

= 194.24.0.0 / 20

- 2 $N_5 = N_3 + N_4$:

Total no. of networks $= 2 * 2^{12} = 2^{13}$

HID = 12 bits and NID = 19 bits

Supernet mask = 255.255.11100000.00000000 / 19 = 255.255.224.0 / 19

Supernet ID = First IP address of supernet

= 194.24.0.0 / 19

Answer : 194.24.0.0 / 19

Make sure to look for these " CASCADING COMBINATIONS "

Good Question →

③ Organization's routing table is given below. Which of the following prefines in CIDR notation can be collectively used to correctly aggregate all of the subnets in the routing table ?

Subnet Number	Subnet mask	Next Hop
120.20.164.0	255.255.252.0	R_1
120.20.170.0	255.255.254.0	R_2
120.20.168.0	255.255.254.0	Interface 0
120.20.166.0	255.255.254.0	Interface 1
Default	-	R_3

a) 12.20.164.0/21 b) 12.20.164.0/22

c) 12.20.168.0/22 d) 12.20.164.0/20

Networks:

N_1 : 12.20.164.0/22 ; N_2 : 12.20.170.0/23

N_3 : 12.20.168.0/23 ; N_4 : 12.20.166.0/23

At first, it might look like these networks can not be supernetted due to them violating all the rules of supernetting even when we try cascading combinations. But, that is WRONG. Take a look at the network ranges.

Network Ranges:

N_1 : 12.20.164.0 to 12.20.167.0 ☆

N_2 : 12.20.170.0 to 12.20.171.255

N_3 : 12.20.168.0 to 12.20.169.255

N_4 : 12.20.166.0 to 12.20.167.255 ☆

⇒ Clearly N_4 is a subset of N_1. So, N_4 can be IGNORED while supernetting.

Supernetting N_1, N_2 and N_3 :

- $N_5 = N_2 + N_3$: contiguous ✓

Total no. of networks $= 2 * 2^9 = 2^{10}$

HID = 10 bits and NID = 22 bits

Supernet ID = First IP address of supernet

= 12.20.10101000.00000000

Remainder = 0 ✓

- $N_6 = N_5 + N_1$: contiguous ✓

Total no. of networks $= 2 * 2^{10} = 2^{11}$

HID = 11 bits and NID = 23 bits

Supernet ID = First IP address of supernet

= 12.20.10100100.00000000

Remainder ≠ 0

Since remainder ≠ 0, we CAN NOT COMBINE N_1 and N_5.

Question states "collectively used to correctly aggregate". So, the networks are : • Supernet N_5 : 12.20.168.0/22 and network N_1 : 12.20.164.0/23

Answer : b) and c)

- ## Supernetting in classful Addressing :

  - Nothing different. Just take care of classes (which are basically /8, /16 and /24)

Eg. ① Supernet these : 200.96.86.0 ; 200.96.87.0 ; 200.96.88.0 and 200.96.89.0 .

This is a class C network $\Rightarrow$ NID = 24 bits and HID = 8 bits

Checking NID we can see that they are contiguous

Total size of supernet $= 4 \times 2^8 = 2^{10}$

HID = 10 bits and NID = 22 bits

Supernet ID = 200.96.010101$\underline{10.00000000}$

Remainder $\neq 0$

$\Rightarrow$ Supernetting is NOT possible.

② Supernet these : 198.47.32.0 ; 198.47.33.0 ; 198.47.34.0 and 198.47.38.0.

This is a class C network $\Rightarrow$ NID = 24 bits and HID = 8 bits

Checking NID we can see that they are contiguous

Total size of supernet $= 4 \times 2^8 = 2^{10}$

HID = 10 bits and NID = 22 bits

Supernet ID = 198.47.001000$\underline{00.00000000}$

Remainder = 0

= 192.47.32.0

Supernet mask = 255.255.111111$\boxed{00}$.00000000

= 255.255.252.0

These bits are BORROWED from NID. They are called Supernet bits.

No. of bits borrowed from NID = 2 bits

$\Rightarrow$ No. of networks that can be supernetted $= 2^2 = 4$ networks

③ Supernet these : 128.56.24.0 ; 128.56.25.0 ; 128.56.26.0 and 128.56.27.0.

These are class B networks. ⇒ NID = 16 bits and HID = 16 bits

NID for all networks = 128.56

⇒ All the given networks belong to a single network with NID = 128.56

⇒ Supernetting is NOT possible.

Subnet mask	Supernet mask
• In subnetting, we borrow bits from HID	• In supernetting, we borrow bits from NID
• No. of 1's in the subnet mask ≥ NID bits	• No. of 1's in supernet mask < NID bits
• Subnet mask is applicable for a SINGLE network	• Supernet mask is applicable for 2 OR MORE networks.

Following that, we can answer questions like: Can a given address be used as a subnet or a supernet mask? For eg.

Address	Class A	Class B	Class C
255.0.0.0	Subnet mask	Supernet mask	Supernet mask
255.255.252.0	Subnet mask	Subnet mask	Supernet mask
255.255.255.0	Subnet mask	Subnet mask	Subnet mask

255.224.0.0 Subnet mask Supernet mask Supernet mask

NOTE: For these kind of questions, check for either subnet OR supernet mask.
If it can not be used as a subnet mask, it can be used as a supernet mask and vice-versa.