LAN Technologies

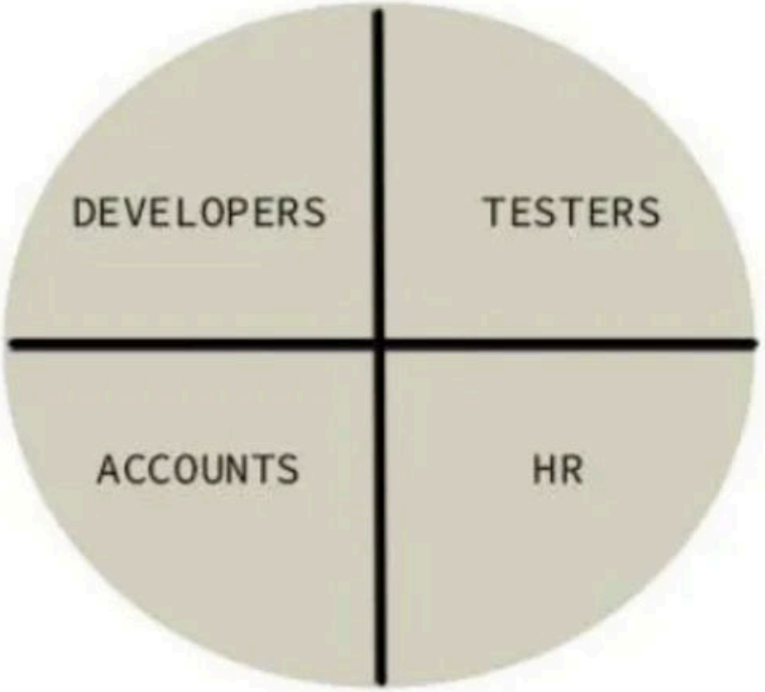
Complete Course on Computer Networks - Part I

Ravindrababu Ravula • Lesson 6 • Jan 23, 2021

Computer Networks

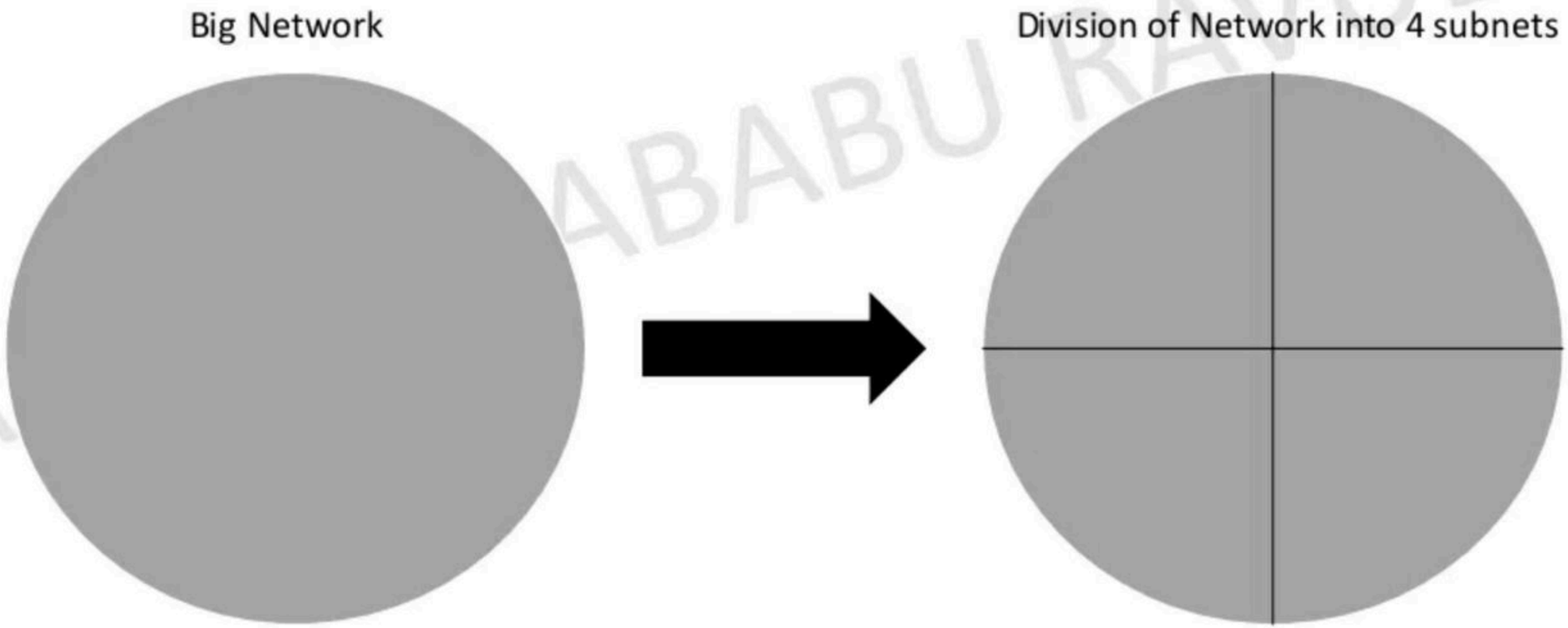
Subnet, Subnet Mask, Routing

UNDERSTANDING SUBNETTING WITH AN EXAMPLE

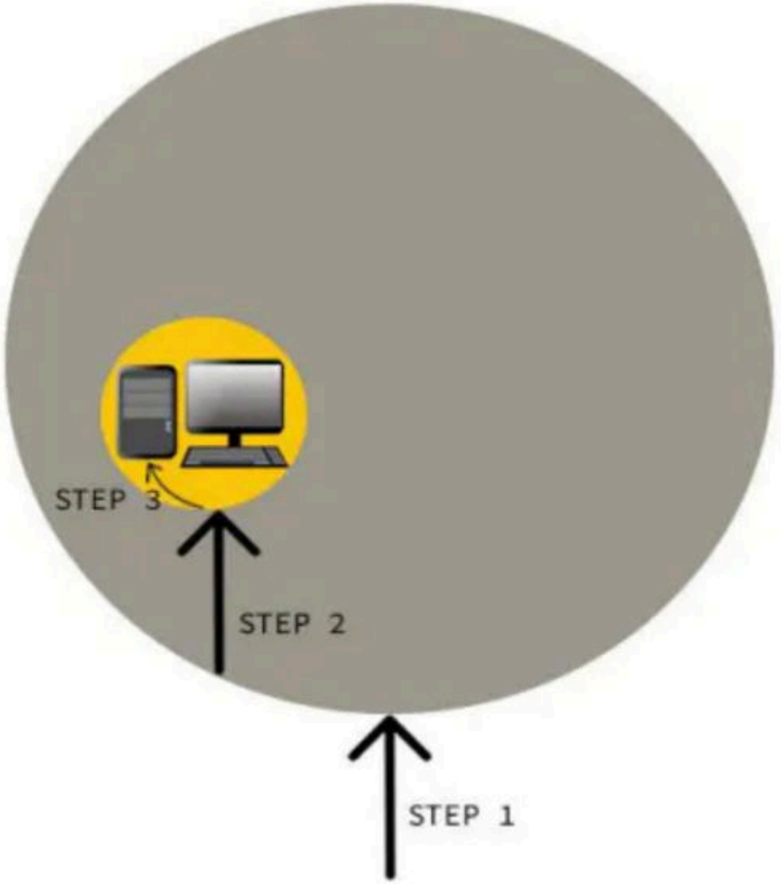


Subnetting

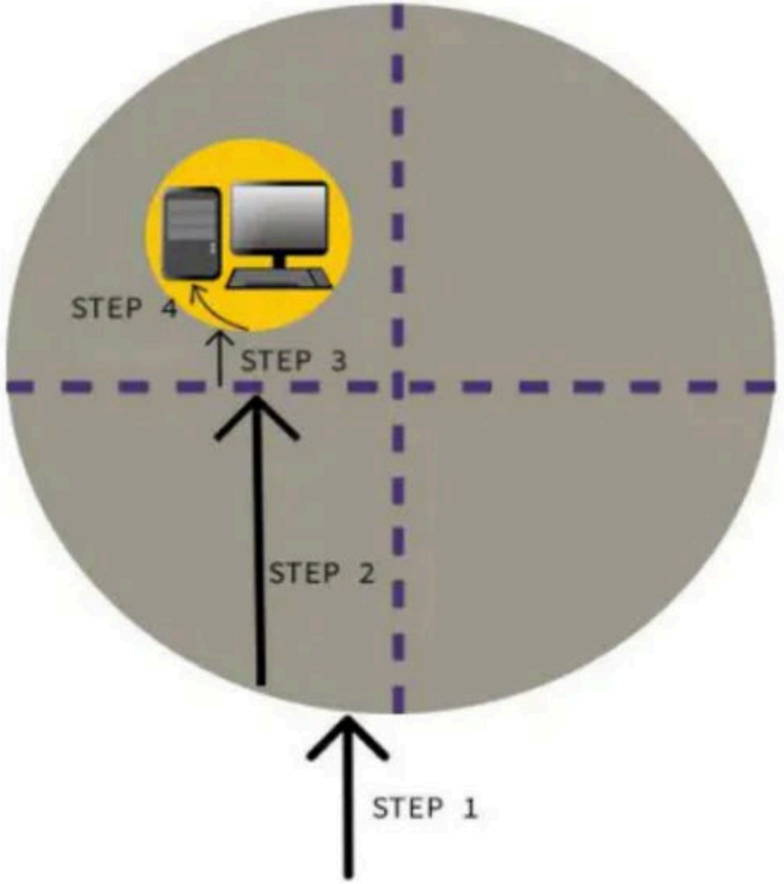
The process of dividing a single network into multiple sub networks is called as subnetting.
The sub networks so created are called as subnets.



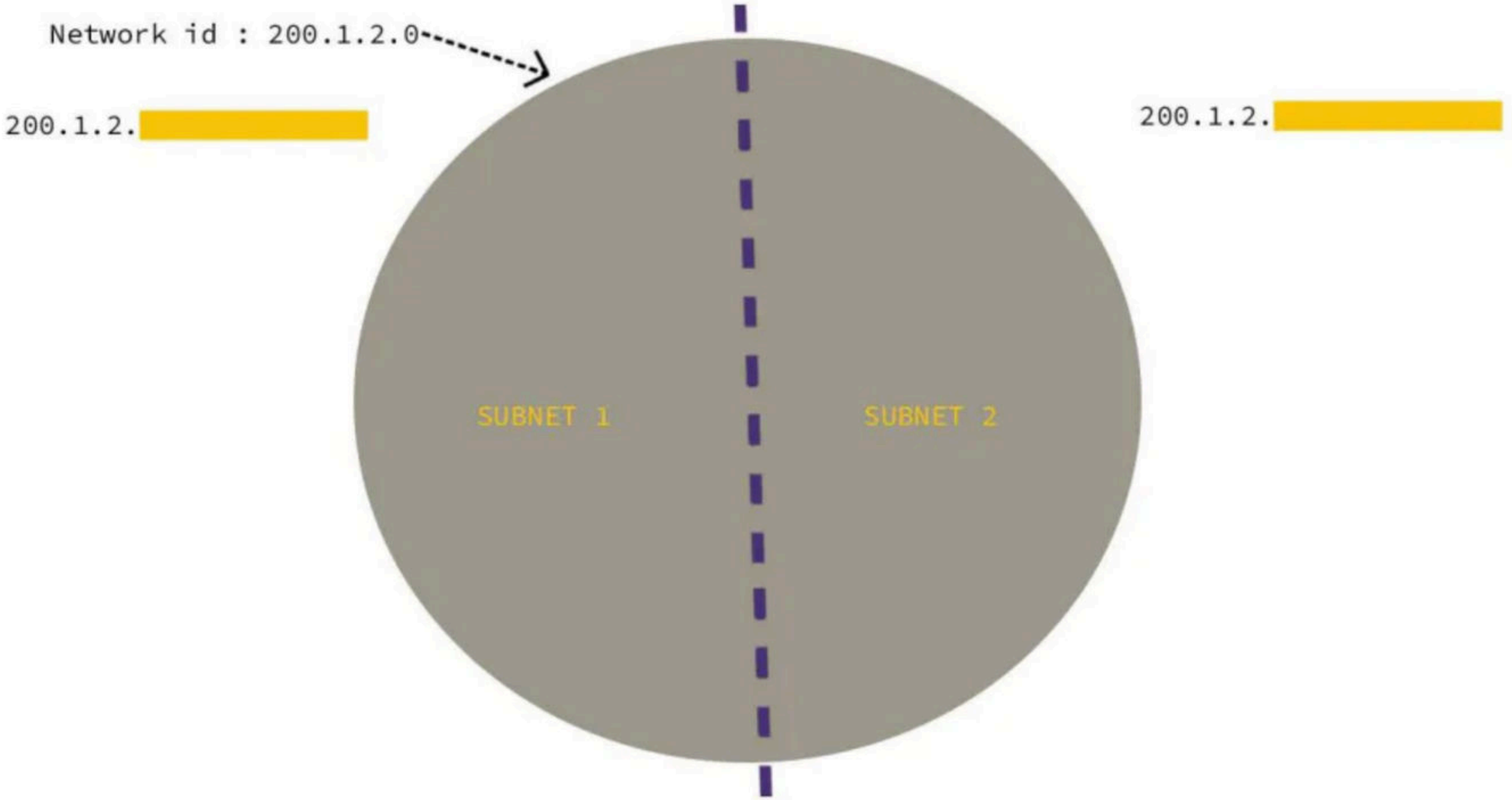
REACHING A HOST WITHOUT SUBNETTING



REACHING A HOST WITH SUBNETTING



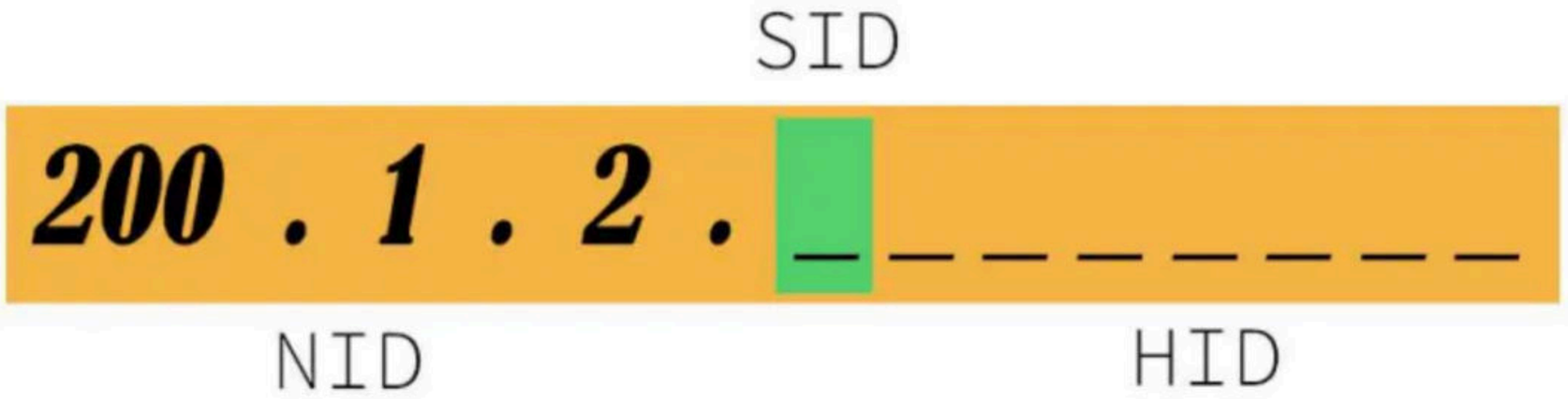
Dividing the Network into 2 subnets

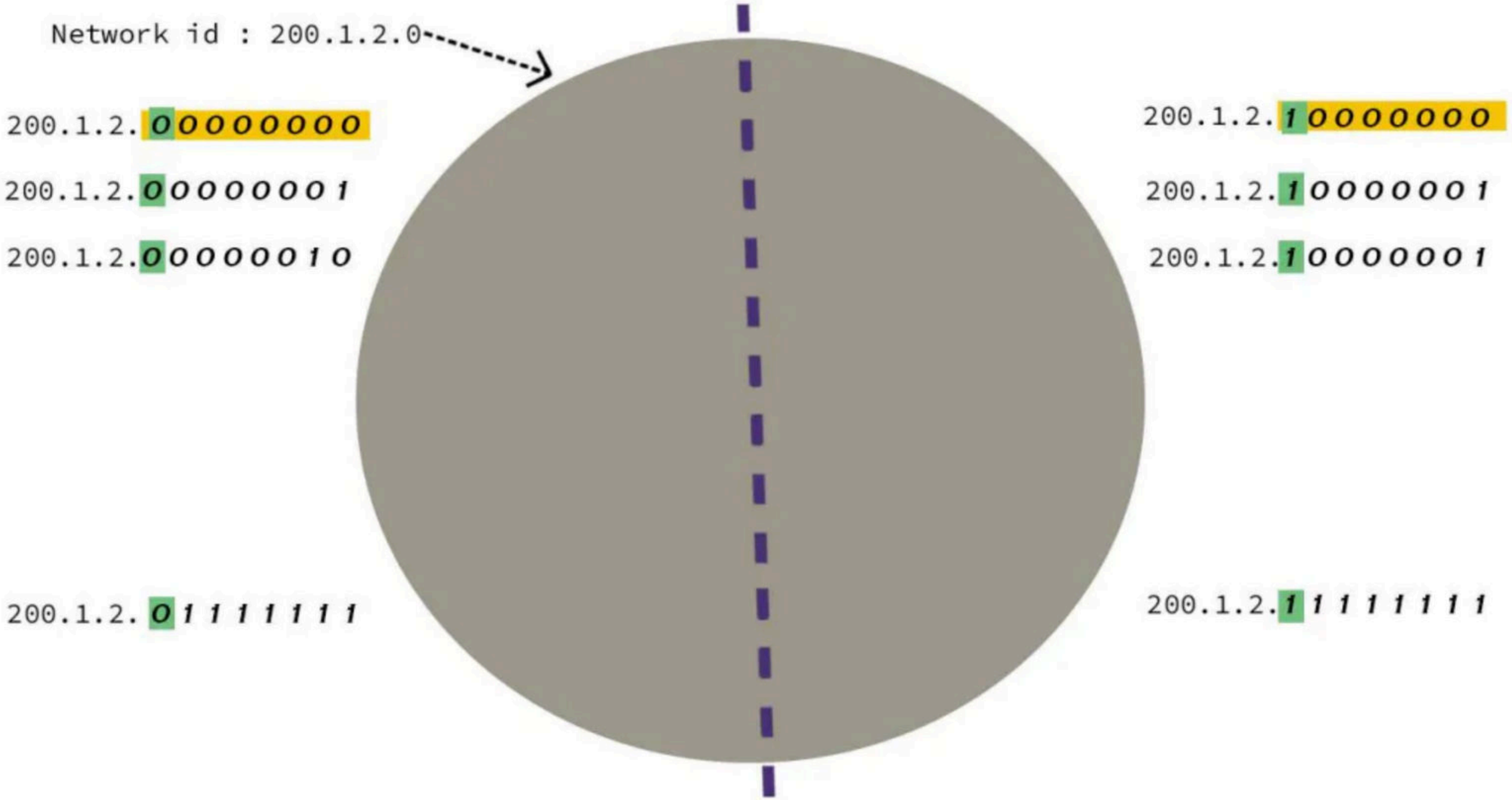


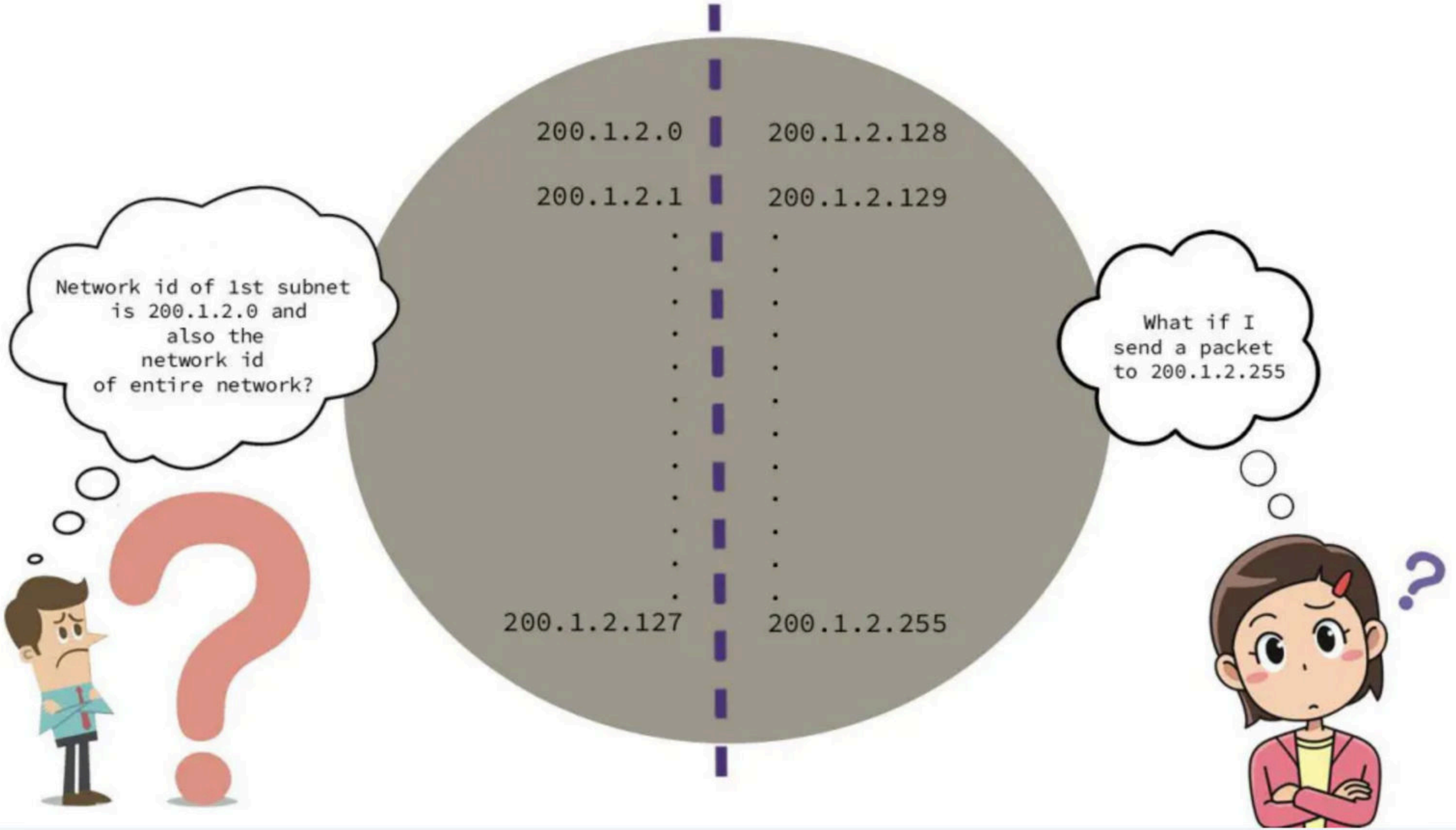
For creating two subnets and to represent their subnet IDs, we require 1 bit.

So,

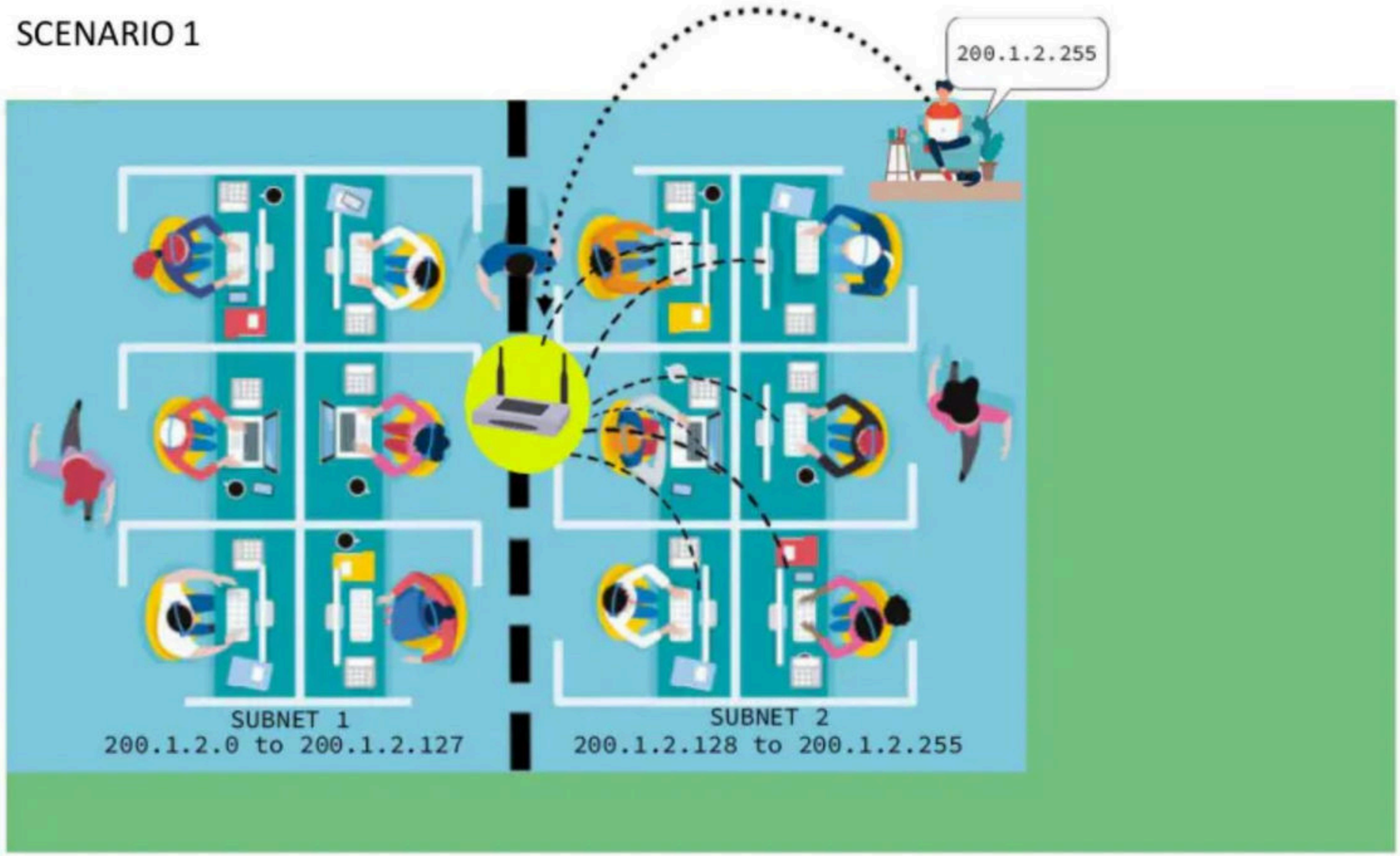
We borrow one bit from the Host ID part.
After borrowing one bit, Host ID part remains with only 7 bits.



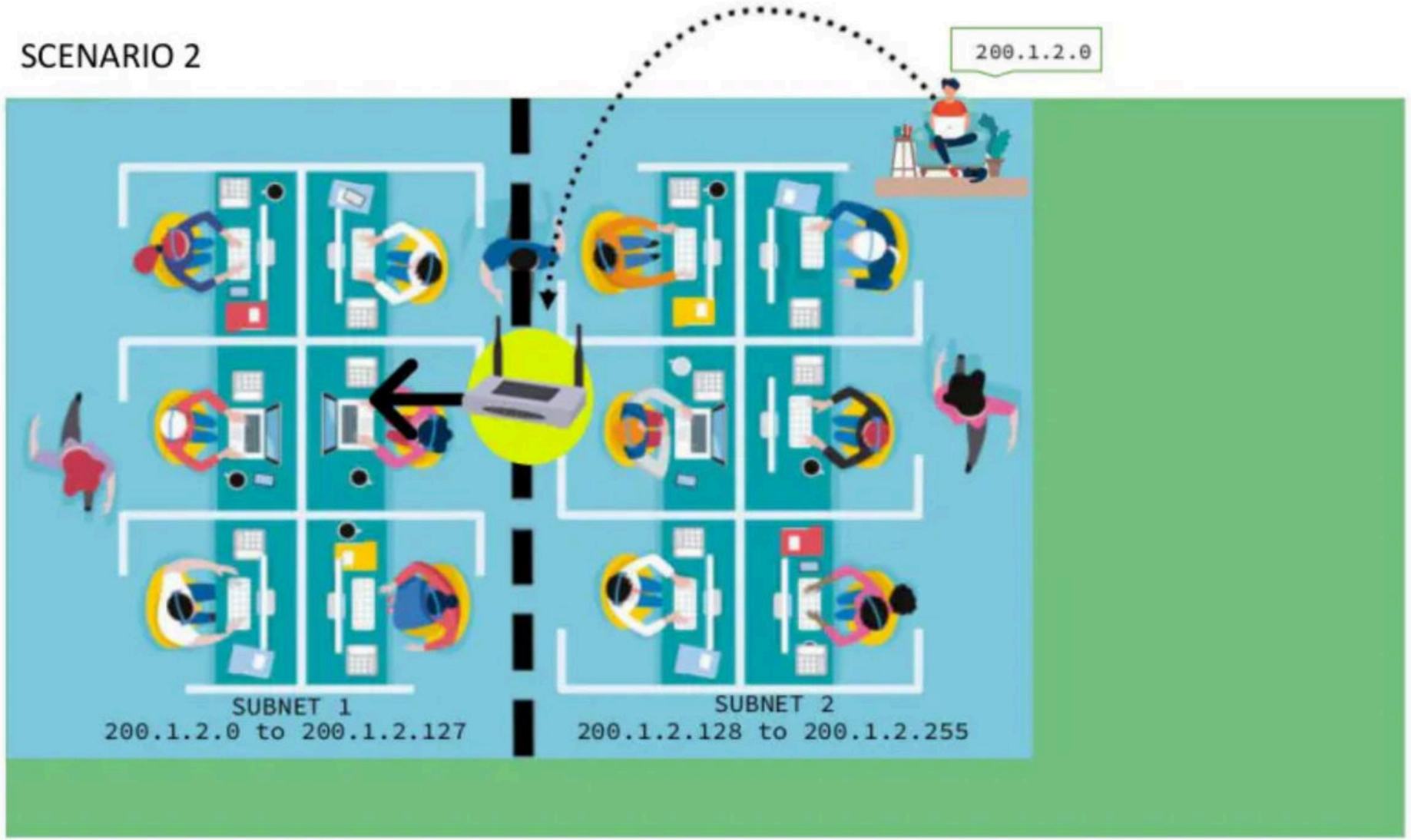

Network id : 200.1.2.0
200.1.2.00000000
200.1.2.00000001
200.1.2.00000010
200.1.2.01111111
200.1.2.10000000
200.1.2.10000001
200.1.2.10000001
200.1.2.11111111


Network id of 1st subnet is 200.1.2.0 and also the network id of entire network?
200.1.2.0
200.1.2.128
200.1.2.1
200.1.2.129
200.1.2.127
200.1.2.255
What if I send a packet to 200.1.2.255

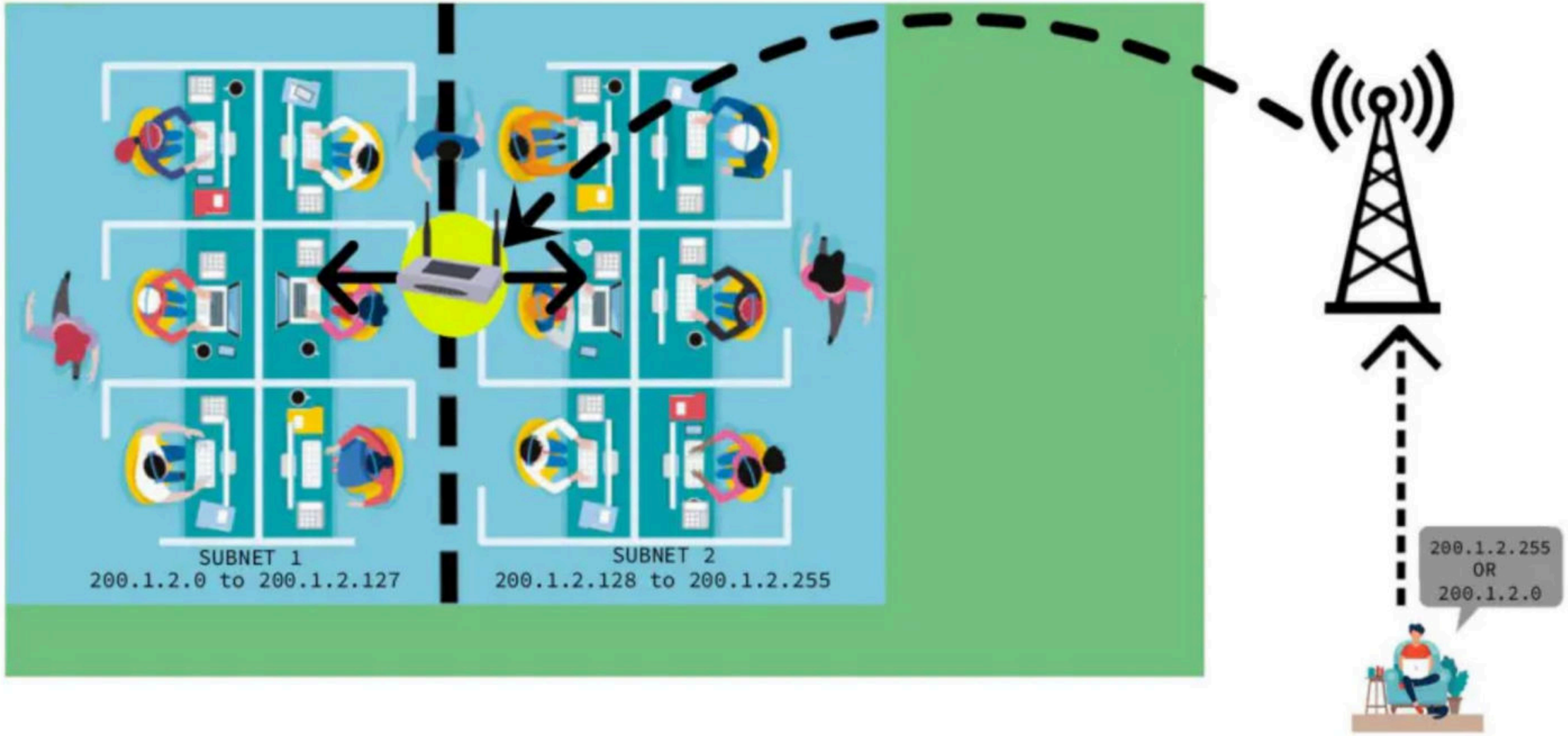
SCENARIO 1

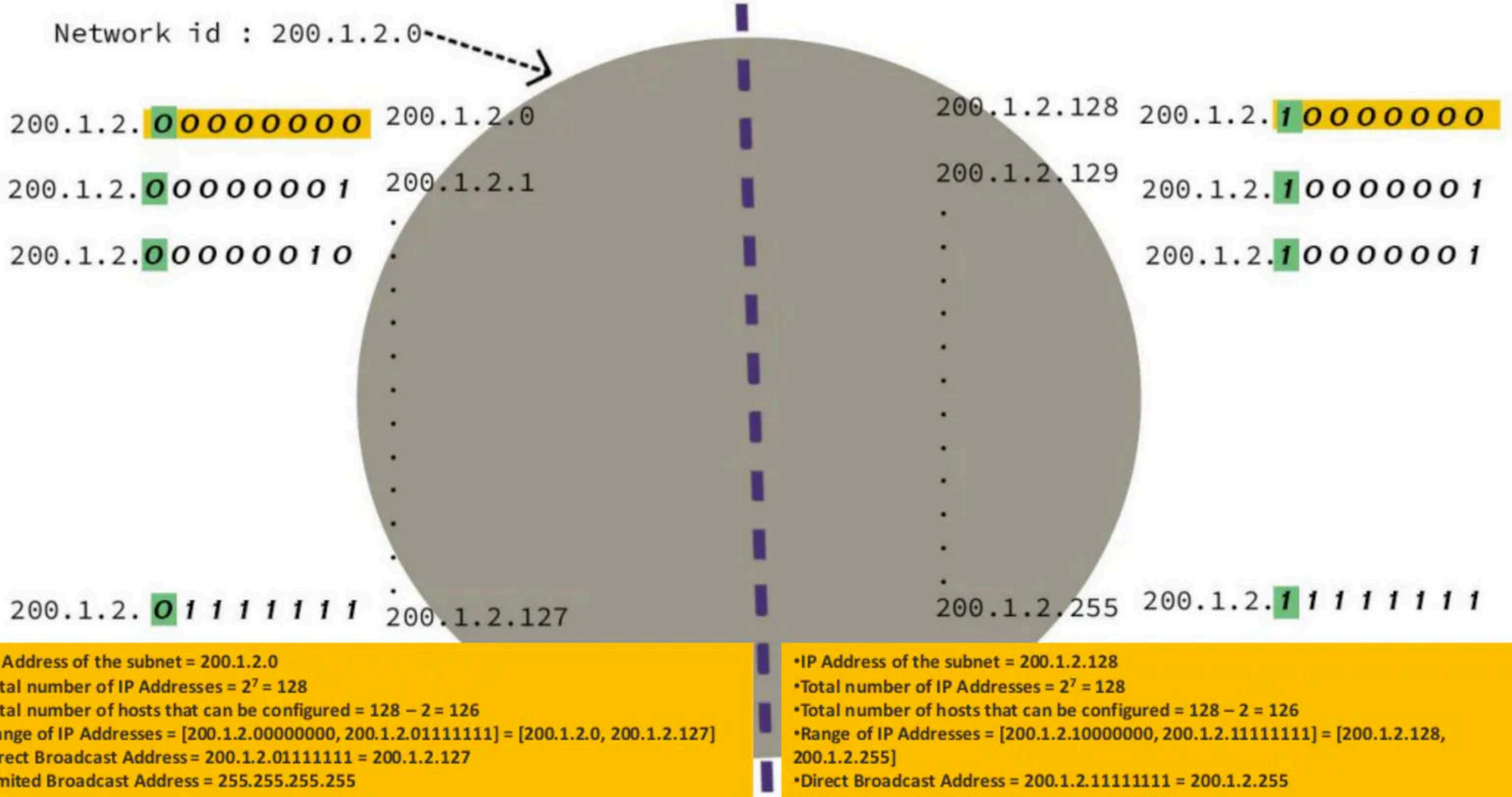

200.1.2.255
SUBNET 1
200.1.2.0 to 200.1.2.127
SUBNET 2
200.1.2.128 to 200.1.2.255

SCENARIO 2


200.1.2.0
SUBNET 1
200.1.2.0 to 200.1.2.127
SUBNET 2
200.1.2.128 to 200.1.2.255

SCENARIO 3

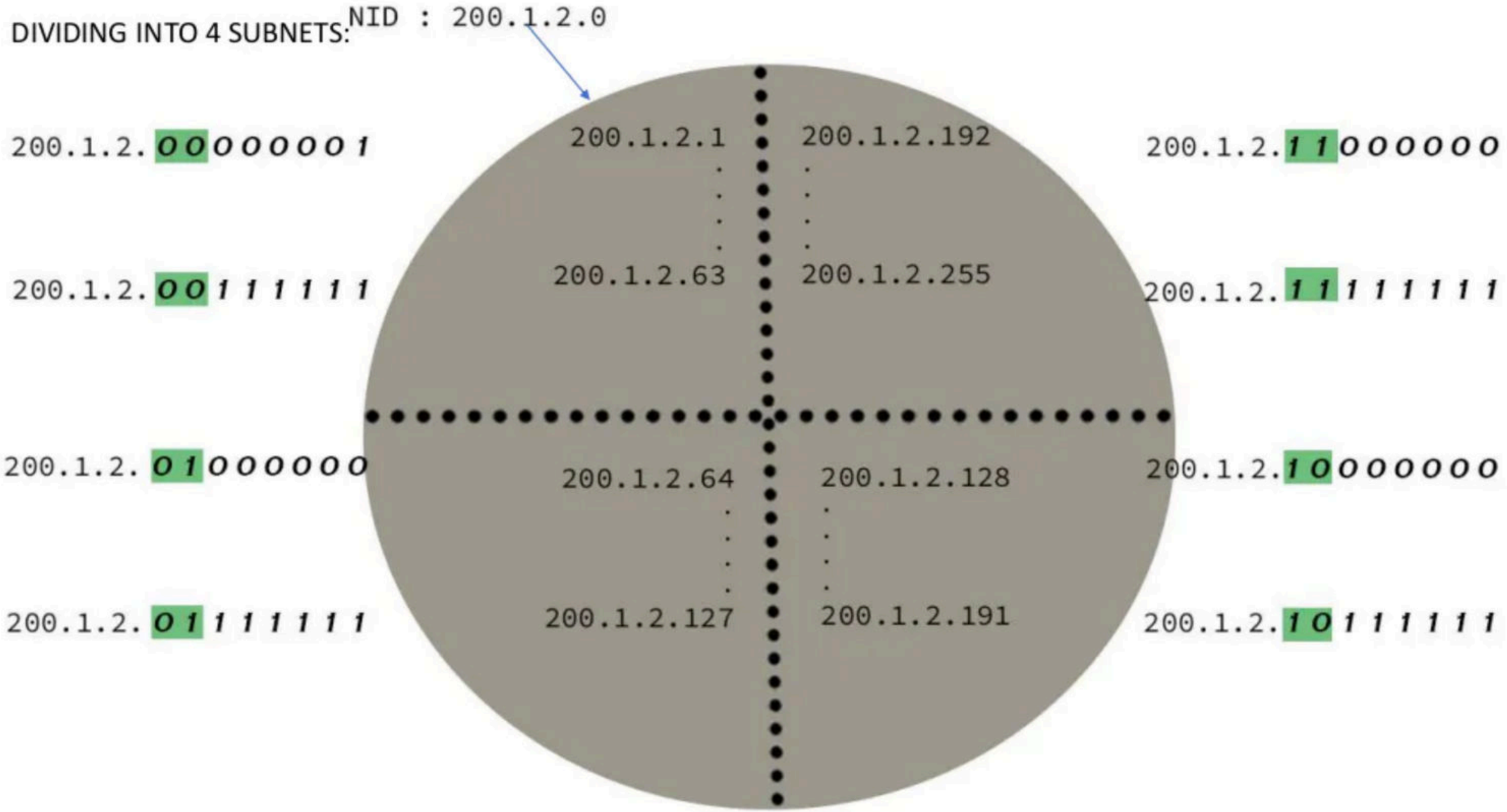

SUBNET 1
200.1.2.0 to 200.1.2.127
SUBNET 2
200.1.2.128 to 200.1.2.255
200.1.2.255
OR
200.1.2.0



- IP Address of the subnet = 200.1.2.0
- Total number of IP Addresses = 2^7 = 128
- Total number of hosts that can be configured = 128 – 2 = 126
- Range of IP Addresses = [200.1.2.00000000, 200.1.2.01111111] = [200.1.2.0, 200.1.2.127]
- Direct Broadcast Address = 200.1.2.01111111 = 200.1.2.127
- Limited Broadcast Address = 255.255.255.255

- IP Address of the subnet = 200.1.2.128
- Total number of IP Addresses = 2^7 = 128
- Total number of hosts that can be configured = 128 – 2 = 126
- Range of IP Addresses = [200.1.2.10000000, 200.1.2.11111111] = [200.1.2.128, 200.1.2.255]
- Direct Broadcast Address = 200.1.2.11111111 = 200.1.2.255
- Limited Broadcast Address = 255.255.255.255

DIVIDING INTO 4 SUBNETS:



IP Address of the four subnets are-

- 200.1.2.**00**000000 = 200.1.2.0
- 200.1.2.**01**000000 = 200.1.2.64
- 200.1.2.**10**000000 = 200.1.2.128
- 200.1.2.**11**000000 = 200.1.2.192

For 1st Subnet-

- IP Address of the subnet = 200.1.2.0
- Total number of IP Addresses = 2^6 = 64
- Total number of hosts that can be configured = 64 – 2 = 62
- Range of IP Addresses = [200.1.2.**00**000000, 200.1.2.**00**111111] = [200.1.2.0, 200.1.2.63]
- Direct Broadcast Address = 200.1.2.**00**111111 = 200.1.2.63
- Limited Broadcast Address = 255.255.255.255

For 2nd Subnet-

- IP Address of the subnet = 200.1.2.64
- Total number of IP Addresses = 2^6 = 64
- Total number of hosts that can be configured = 64 – 2 = 62
- Range of IP Addresses = [200.1.2.**01**000000, 200.1.2.**01**111111] = [200.1.2.64, 200.1.2.127]
- Direct Broadcast Address = 200.1.2.**01**111111 = 200.1.2.127
- Limited Broadcast Address = 255.255.255.255

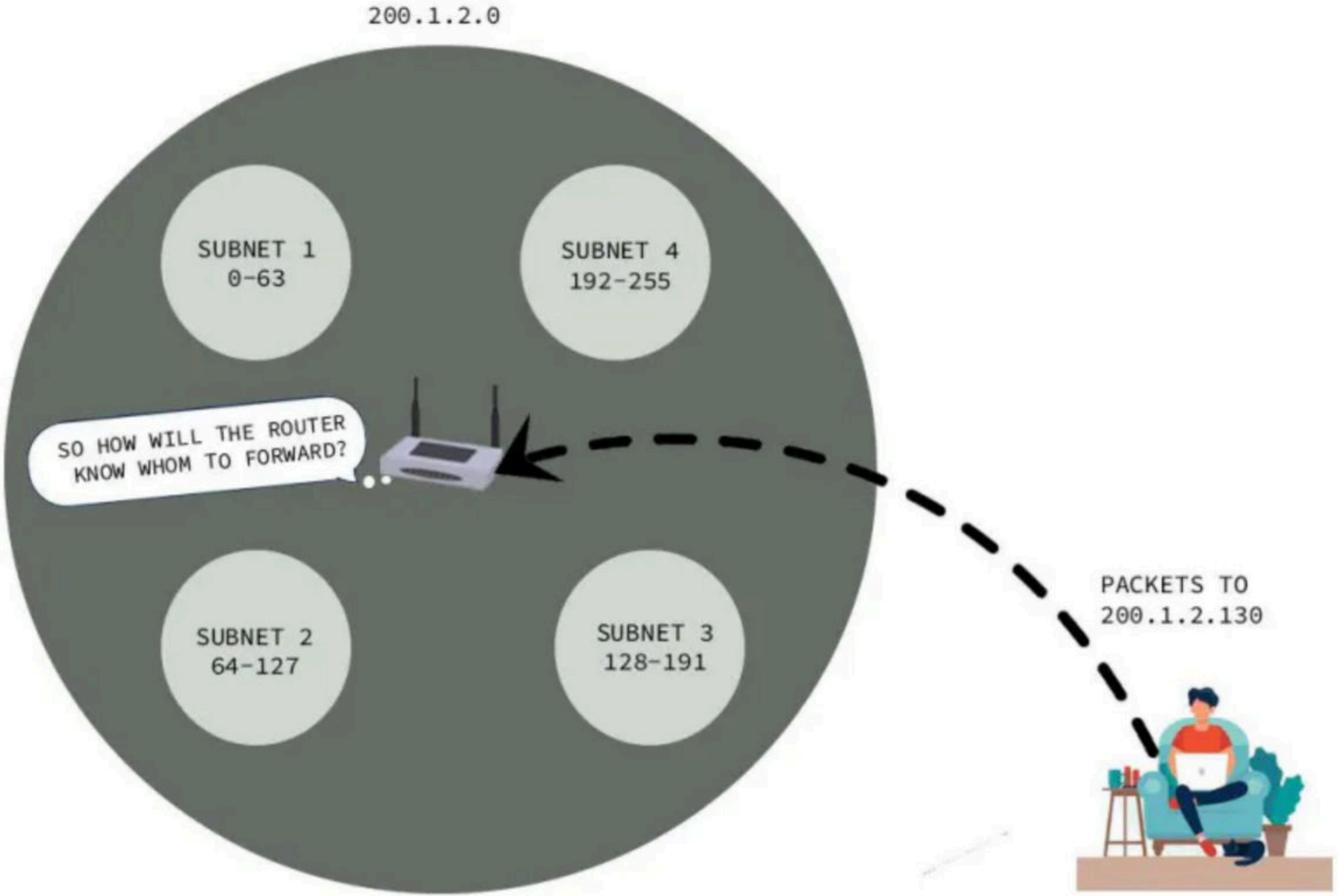
For 3rd Subnet-

- IP Address of the subnet = 200.1.2.128
- Total number of IP Addresses = 2^6 = 64
- Total number of hosts that can be configured = 64 – 2 = 62
- Range of IP Addresses = [200.1.2.**10**000000, 200.1.2.**10**111111] = [200.1.2.128, 200.1.2.191]
- Direct Broadcast Address = 200.1.2.**10**111111 = 200.1.2.191
- Limited Broadcast Address = 255.255.255.255

For 4th Subnet-

- IP Address of the subnet = 200.1.2.192
- Total number of IP Addresses = 2^6 = 64
- Total number of hosts that can be configured = 64 – 2 = 62
- Range of IP Addresses = [200.1.2.**11**000000, 200.1.2.**11**111111] = [200.1.2.192, 200.1.2.255]
- Direct Broadcast Address = 200.1.2.**11**111111 = 200.1.2.255
- Limited Broadcast Address = 255.255.255.255

Let us see a scenario,



Subnet mask

Subnet mask is a 32 bit number which is a sequence of 1's followed by a sequence of 0's where-

NID + SID = NUMBER OF 1'S

HID = NUMBER OF 0'S

Previous example
was of Class C network where
NID = 24 bits and HID =8 bits
after subnetting
NID+SID = 26 bits and HID = 6 bits

Therefore,

Subnet mask = 11111111.11111111.11111111.11000000

NID+SID HID

=> 255.255.255.192

SUBNET MASK
AND
IP ADDRESS

=

NID TO WHICH
THE IP BELONGS

EXAMPLE

IP ADDRESS = 200.1.2.130

SUBNET MASK = 255.255.255.192

SUBNET MASK: 11111111.11111111.11111111.11000000

IP: 11001000.00000001.00000010.10000010

11001000.00000001.00000010.10000000

200.1.2.128

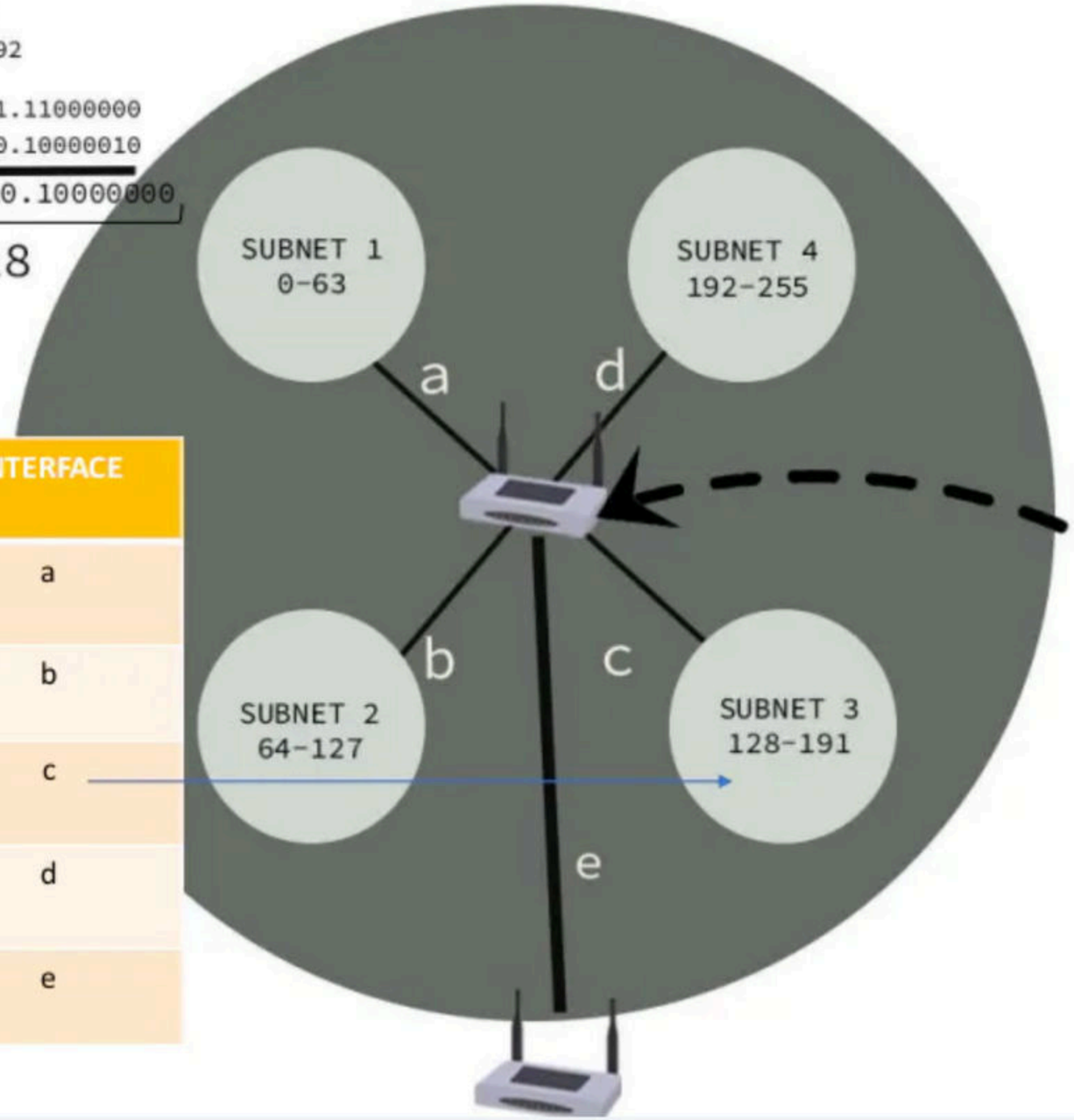
IP ADDRESS = 200.1.2.130
SUBNET MASK = 255.255.255.192

SUBNET MASK: 11111111.11111111.11111111.11000000
IP: 11001000.00000001.00000010.10000010

11001000.00000001.00000010.10000000

200.1.2.128

200.1.2.0



PACKETS TO
200.1.2.130

ROUTING TABLE

NID	SUBNET MASK	INTERFACE
200.1.2.0	255.255.255.192	a
200.1.2.64	255.255.255.192	b
200.1.2.128	255.255.255.192	c
200.1.2.192	255.255.255.192	d
0.0.0.0	0.0.0.0	e

SM → NID + SID → 1's
HID → 0's

SM: 255.255.255.128 ✓

IP's → N/W 255.255.255.10000000 ✓
2^7 = IP's

S/N → ?

1's = 25 = NID + SID
25 = 24 + SID
SID = 1 ⇒ 2^1 = 2 ✓

CC: ✓

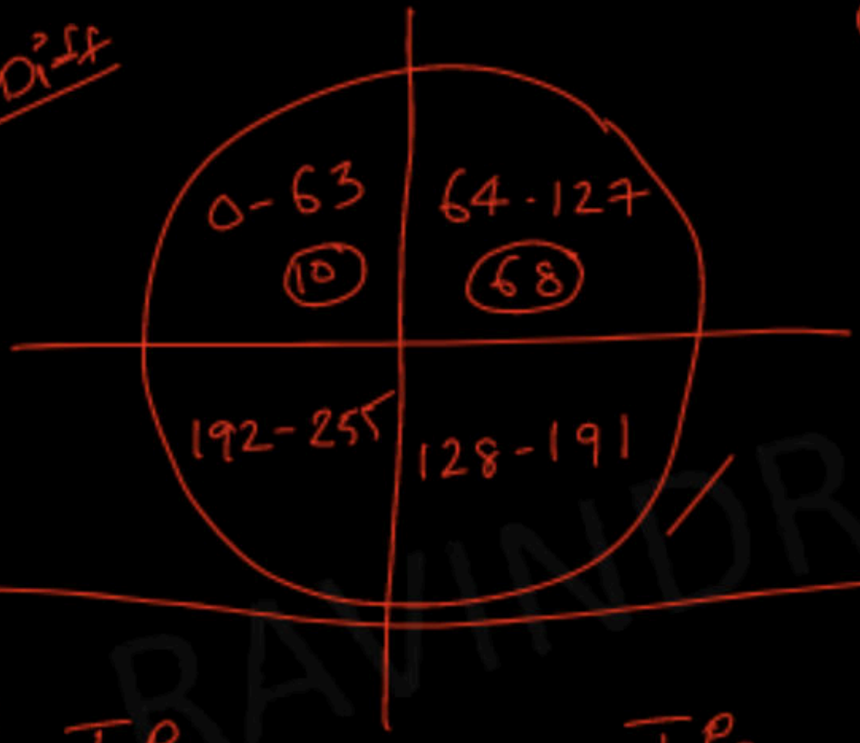
CB:
25 = NID + SID
25 = 16 + SID
SID = 9 ⇒ N/W = 2^9 = 215

CA:
1's = 25 = NID + SID
25 = 8 + SID
⇒ SID = 17
S/N = 2^{17}

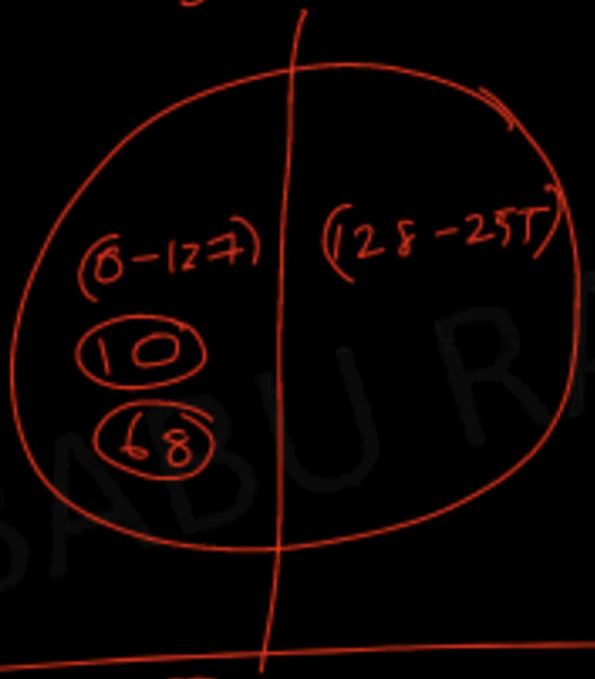
✓ IP_A : 200.1.2.10 }
✓ SM_A : 255.255.255.192 ✓

✓ IP_B : 200.1.2.68 }
✓ SM_B = 255.255.255.128 } Same

Diff



m I



A → diff
B → Same

m II

A:

IP_A	IP_B
SM_A	SM_A
200.1.2.0 = $NIID_{AA}$	200.1.2.64 = $NIID_{BA}$

B

IP_B	IP_A
SM_B	SM_B
200.1.20 = $NIID_{BB}$	= 200.1.2.0 $NIID_{AB}$

GATE 2019

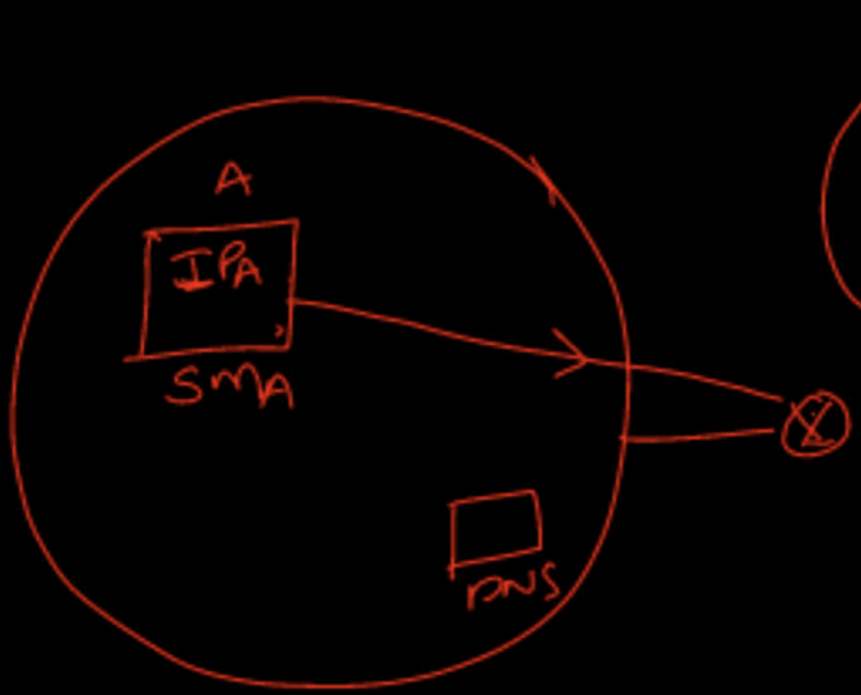
Consider three machines M, N, and P with IP addresses 100.10.5.2, 100.10.5.5, and 100.10.5.6 respectively. The subnet mask is set to 255.255.255.252 for all the three machines. Which one of the following is true?

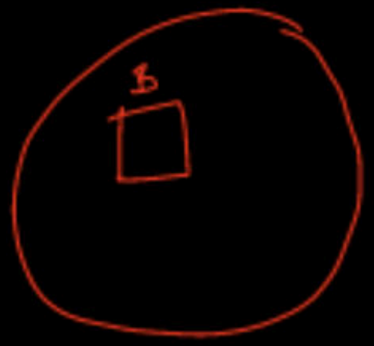
A.)M, N, and P all belong to the same subnet

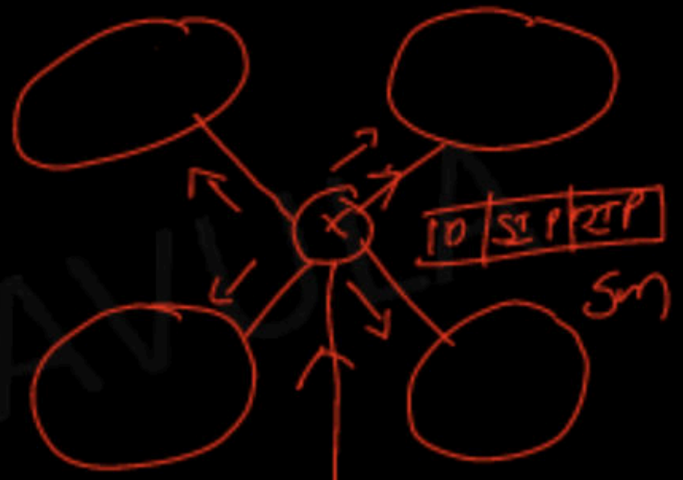
B.) Only M and N belong to the same subnet

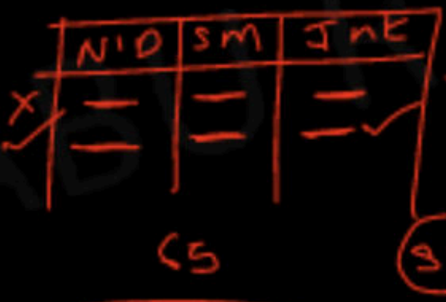
C.) M, N, and P belong to three different subnets

D.) Only N and P belong to the same subnet









Router

ISP

IP

DNS

DGW

SM

www.google.com → IP add.

	IP_A	IP_B
	SM_A	SM_A
	NID_{AA} ≠	NID_{BA}

Directly

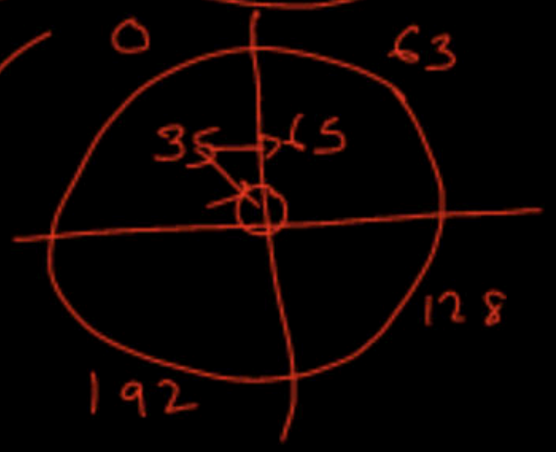
200.1.2.35 → D

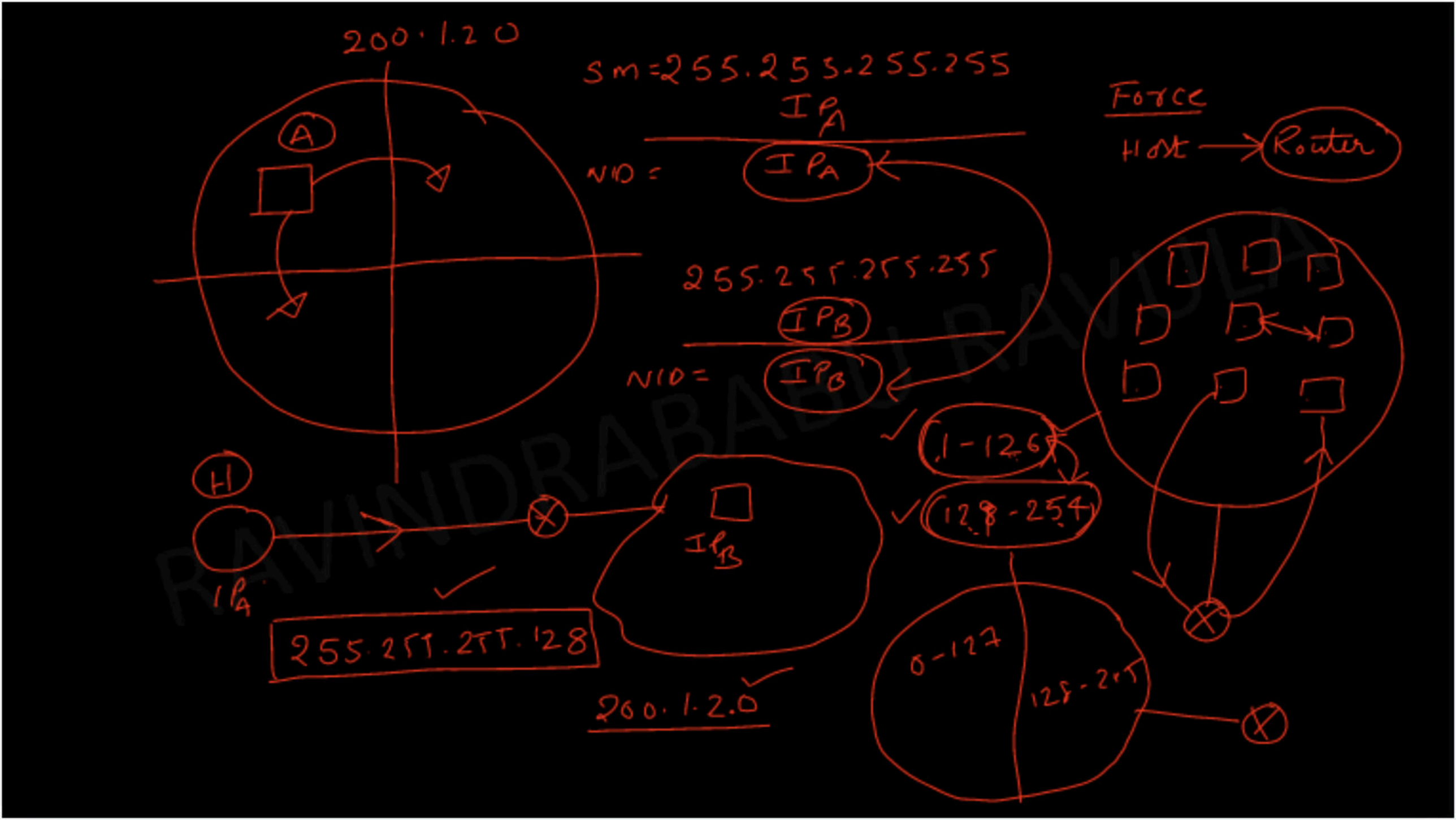
~~255.255.255.128~~

255.255.255.192

128

0




200.1.2.0
SM=255.255.255.255
IPA
NID=
IPA
Force
Host
Router
A
255.255.255.255
IPB
NID=
IPB
1-126
128-254
H
IPA
IPB
255.255.255.128
200.1.2.0
0-127
128-255

SOLUTION:

First, we will do bitwise AND between Subnet mask and given IP address one by one

For M: 100.10.5.2

Bitwise AND:

01100100.00001010.00000101.00000010 (100.10.5.2)

AND 11111111.11111111.11111111.11111100 (255.255.255.252)

= 01100100.00001010.00000101.00000000 (100.10.5.0)

For N: 100.10.5.5

Bitwise AND:

01100100.00001010.00000101.00000101 (100.10.5.5)

AND 11111111.11111111.11111111.11111100 (255.255.255.252)

= 01100100.00001010.00000101.00000100 (100.10.5.4)

For P: 100.10.5.6

Bitwise AND:

01100100.00001010.00000101.00000110 (100.10.5.6)

AND 11111111.11111111.11111111.11111100 (255.255.255.252)

= 01100100.00001010.00000101.00000100 (100.10.5.4)

It is sure from the above computation that N and P belong to the same network (i.e., 100.10.5.4), while M can belong to the same network or it can be from any other network.

So, option (D) is correct.

Advantages

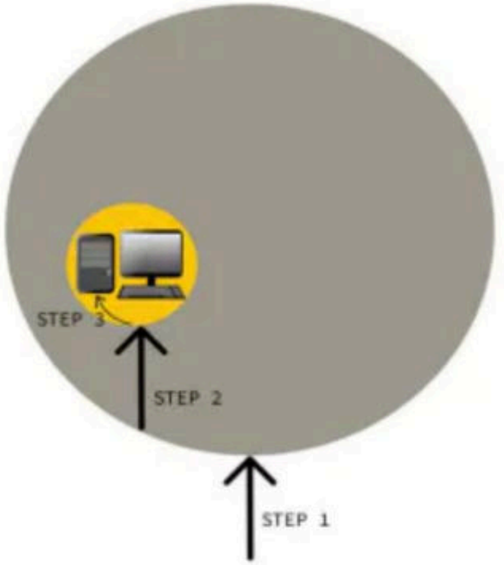
- It improves the security.
- The maintenance of subnets is easy.

Disadvantages

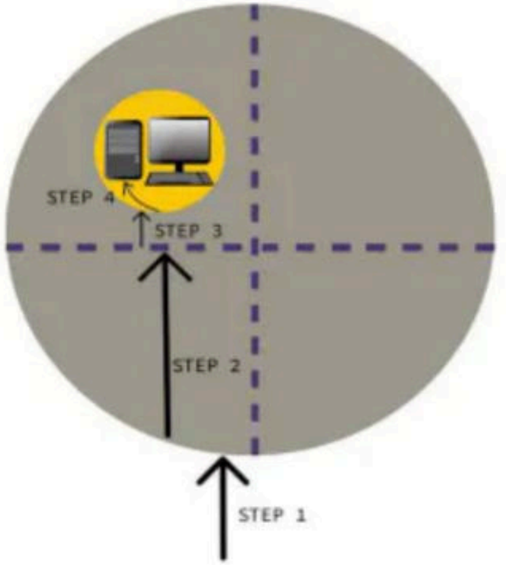
After subnetting, the communication process becomes complex involving the following 4 steps-

- Identifying the network
- Identifying the sub network
- Identifying the host
- Identifying the process

REACHING A HOST WITHOUT SUBNETTING



REACHING A HOST WITH SUBNETTING



Computer Networks

Subnet Masking question

SUBNET MASK	NO OF HOSTS	SUBNETS IN CLASS A	SUBNETS IN CLASS B	SUBNETS IN CLASS C
255.0.0.0				
255.128.0.0				
255.192.0.0				
255.240.0.0				
255.255.0.0				
255.255.255.0				
255.255.254.0				
255.255.255.224				
255.255.255.240				

SUBNET MASK	NO OF HOSTS	SUBNETS IN CLASS A	SUBNETS IN CLASS B	SUBNETS IN CLASS C
255.0.0.0	2^{24}- 2	1	-	-
255.128.0.0				
255.192.0.0				
255.240.0.0				
255.255.0.0				
255.255.255.0				
255.255.254.0				
255.255.255.224				
255.255.255.240				

SUBNET MASK	NO OF HOSTS	SUBNETS IN CLASS A	SUBNETS IN CLASS B	SUBNETS IN CLASS C
255.0.0.0	2^{24}- 2	1	-	-
255.128.0.0	2^{23}- 2	2	-	-
255.192.0.0				
255.240.0.0				
255.255.0.0				
255.255.255.0				
255.255.254.0				
255.255.255.224				
255.255.255.240				

SUBNET MASK	NO OF HOSTS	SUBNETS IN CLASS A	SUBNETS IN CLASS B	SUBNETS IN CLASS C
255.0.0.0	2^{24}- 2	1	-	-
255.128.0.0	2^{23}- 2	2	-	-
255.192.0.0	2^{22}- 2	2^2	-	-
255.240.0.0				
255.255.0.0				
255.255.255.0				
255.255.254.0				
255.255.255.224				
255.255.255.240				

SUBNET MASK	NO OF HOSTS	SUBNETS IN CLASS A	SUBNETS IN CLASS B	SUBNETS IN CLASS C
255.0.0.0	2^{24}- 2	1	-	-
255.128.0.0	2^{23}- 2	2	-	-
255.192.0.0	2^{22}- 2	2^2	-	-
255.240.0.0	2^{20}- 2	2^4	-	-
255.255.0.0				
255.255.255.0				
255.255.254.0				
255.255.255.224				
255.255.255.240				

SUBNET MASK	NO OF HOSTS	SUBNETS IN CLASS A	SUBNETS IN CLASS B	SUBNETS IN CLASS C
255.0.0.0	2^{24}- 2	1	-	-
255.128.0.0	2^{23}- 2	2	-	-
255.192.0.0	2^{22}- 2	2^2	-	-
255.240.0.0	2^{20}- 2	2^4	-	-
255.255.0.0	2^{16}- 2	2^8	1	-
255.255.255.0				
255.255.254.0				
255.255.255.224				
255.255.255.240				

SUBNET MASK	NO OF HOSTS	SUBNETS IN CLASS A	SUBNETS IN CLASS B	SUBNETS IN CLASS C
255.0.0.0	2^{24}- 2	1	-	-
255.128.0.0	2^{23}- 2	2	-	-
255.192.0.0	2^{22}- 2	2^2	-	-
255.240.0.0	2^{20}- 2	2^4	-	-
255.255.0.0	2^{16}- 2	2^8	1	-
255.255.255.0	2^8- 2	2^{16}	2^8	1
255.255.254.0				
255.255.255.224				
255.255.255.240				

SUBNET MASK	NO OF HOSTS	SUBNETS IN CLASS A	SUBNETS IN CLASS B	SUBNETS IN CLASS C
255.0.0.0	2^{24}- 2	1	-	-
255.128.0.0	2^{23}- 2	2	-	-
255.192.0.0	2^{22}- 2	2^{2}	-	-
255.240.0.0	2^{20}- 2	2^{4}	-	-
255.255.0.0	2^{16}- 2	2^{8}	1	-
255.255.255.0	2^{8}- 2	2^{16}	2^{8}	1
255.255.254.0	2^{9}- 2	2^{15}	2^{7}	-
255.255.255.224				
255.255.255.240				

SUBNET MASK	NO OF HOSTS	SUBNETS IN CLASS A	SUBNETS IN CLASS B	SUBNETS IN CLASS C
255.0.0.0	2^{24}- 2	1	-	-
255.128.0.0	2^{23}- 2	2	-	-
255.192.0.0	2^{22}- 2	2^{2}	-	-
255.240.0.0	2^{20}- 2	2^{4}	-	-
255.255.0.0	2^{16}- 2	2^{8}	1	-
255.255.255.0	2^{8}- 2	2^{16}	2^{8}	1
255.255.254.0	2^{9}- 2	2^{15}	2^{7}	-
255.255.255.224	2^{5}- 2	2^{19}	2^{11}	2^{3}
255.255.255.240				

SUBNET MASK	NO OF HOSTS	SUBNETS IN CLASS A	SUBNETS IN CLASS B	SUBNETS IN CLASS C
255.0.0.0	2^{24}- 2	1	-	-
255.128.0.0	2^{23}- 2	2	-	-
255.192.0.0	2^{22}- 2	2^{2}	-	-
255.240.0.0	2^{20}- 2	2^{4}	-	-
255.255.0.0	2^{16}- 2	2^{8}	1	-
255.255.255.0	2^{8}- 2	2^{16}	2^{8}	1
255.255.254.0	2^{9}- 2	2^{15}	2^{7}	-
255.255.255.224	2^{5}- 2	2^{19}	2^{11}	2^{3}
255.255.255.240	2^{4}- 2	2^{20}	2^{12}	2^{4}

When any host connects to the internet, ISP provides following 4 things to the host-

1. IP Address-

ISP assigns an IP Address to the host so that it can be uniquely identified on the Internet.

2. Default Gateway-

Default router connected to the network in which the host is present is the default gateway for the host.

3. Subnet Mask-

Subnet mask is a 32 bit number that is assigned to the host.
It is used to determine to which network the given IP Address belongs to.

4. Domain Name Service (DNS)-

Domain Name Service (DNS) is used to translate the domain name into an IP Address.

Subnet mask is used to determine to which network the given IP Address belongs to.

Host use its subnet mask to determine whether the other host it wants to communicate with is present within the same network or not.
If the destination host is present within the same network, then source host sends the packet directly to the destination host.
If the destination host is present in some other network, then source host routes the packet to the default gateway (router).
Router then sends the packet to the destination host.

To determine whether destination host is present within the same network or not, source host follows the following steps-

To answer this Follow the following steps:

Step-01:

Source host computes its own network address using its own IP Address and subnet mask.

After computation, source host obtains its network address with respect to itself.

Step-02:

Source host computes the network address of destination host using destination IP Address and its own subnet mask.

After computation, source host obtains the network address of destination host with respect to itself.

Step-03:

Source host compares the two results obtained in the above steps. There are 2 cases:

Case-1:

If the results are same,

Source host assumes that the destination host is present within the same network.

Source host sends the packet directly to the destination host.

Case-2:

If the results are different,

Source host assumes that the destination host is present in some other network.

Source host sends the packet via router to the destination host.

Example 1:

A:

Ia = 200.1.2.10

Sa = 255.255.255.128

B:

Ib = 200.1.2.69

Sb = 255.255.255.192

Determine Whether host B is present within the same network of A or not.

What they think about their positions.

Example 1:

A:

Ia = 200.1.2.10

Sa = 255.255.255.128

B:

Ib = 200.1.2.69

Sb = 255.255.255.192

Determine Whether host B is present within the same network of A or not.

What they think about their positions.

Solution:

Ia :	11001000.00000001.00000010.00001010	Ib :	11001000.00000001.00000010.01000101
Sa:	11111111.11111111.11111111.10000000	Sa:	11111111.11111111.11111111.10000000
NIDaa :	11001000.00000001.00000010.00000000	NIDba :	11001000.00000001.00000010.00000000
	200.1.2.0		**200.1.2.0**

According to A they are in same network

Example 1:

A:

Ia = 200.1.2.10

Sa = 255.255.255.128

B:

Ib = 200.1.2.69

Sb = 255.255.255.192

Determine Whether host B is present within the same network of A or not.

What they think about their positions.

Solution:

Ib :	11001000.00000001.00000010.01000101	Ia :	11001000.00000001.00000010.00001010
Sb:	11111111.11111111.11111111.11000000	Sb:	11111111.11111111.11111111.11000000
NIDba :	11001000.00000001.00000010.01000000	NIDaa :	11001000.00000001.00000010.00000000
	200.1.2.64		200.1.2.0

According to B they are in different network

Example 2:
SM : 255.255.255.255
IP = 200.1.2.3
What is NID?

Example 2:
SM : 255.255.255.255
IP = 200.1.2.3
What is NID?

Solution:

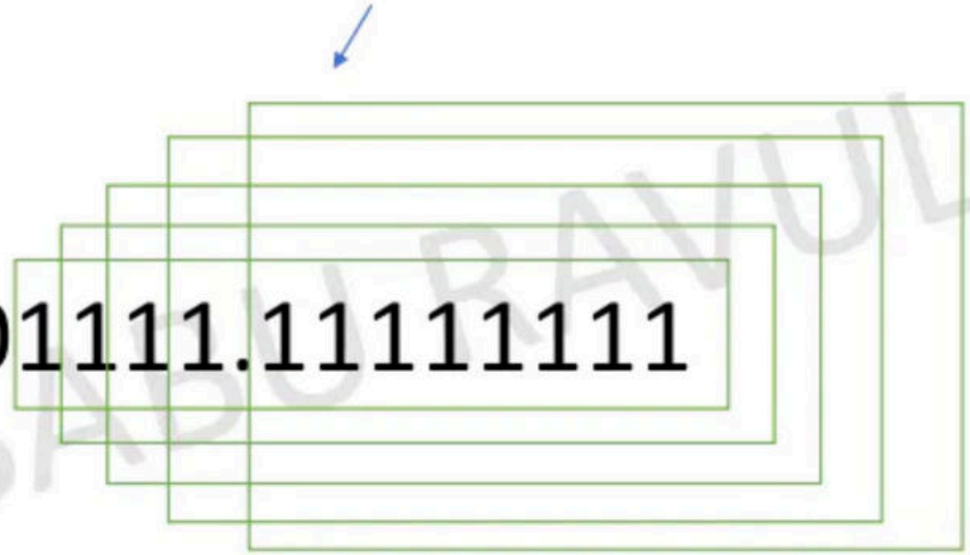
```
    11001000.00000001.00000010.01000101
AND 11111111.11111111.11111111.11111111
    11001000.00000001.00000010.01000101
```

IP address AND SM – 255.255.255.255 = IP address

Example 3:
If DBA = 200.1.15.255 which is a Classless IP
What is the Size of the NID ?

Example 3:
If DBA = 200.1.15.255 which is a Classless IP
What is the Size of the NID ?

There could be many possibilities
Since DBA contains all 1's in HID



11001000.00000001.00001111.11111111

Answer : NID = 20 or 21 or 22 or .....so on

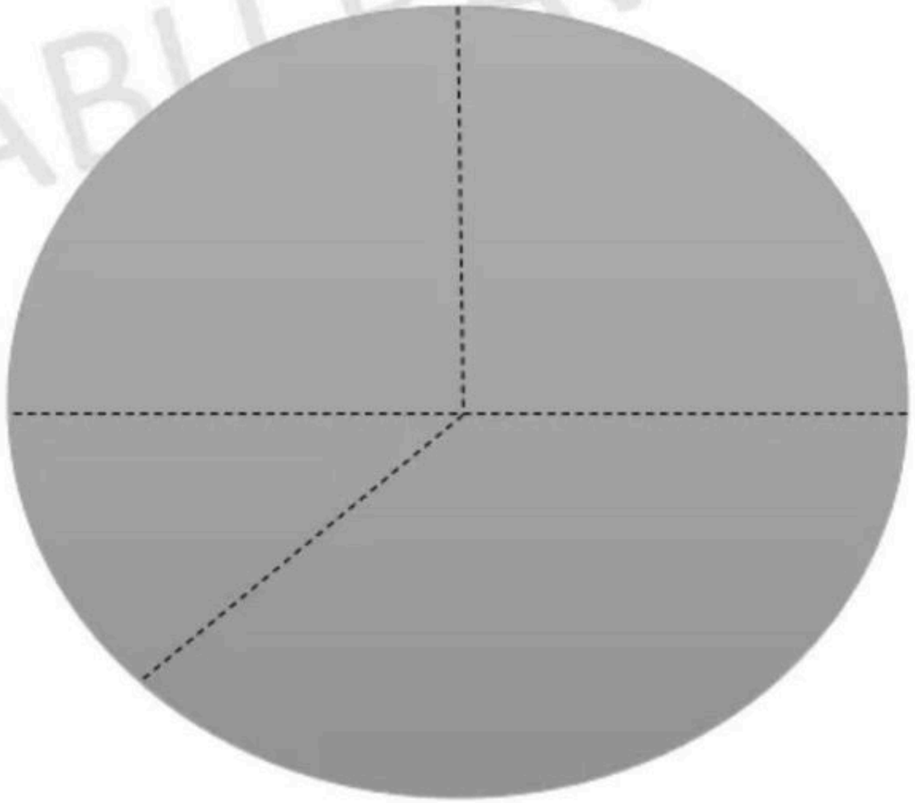
Computer Networks

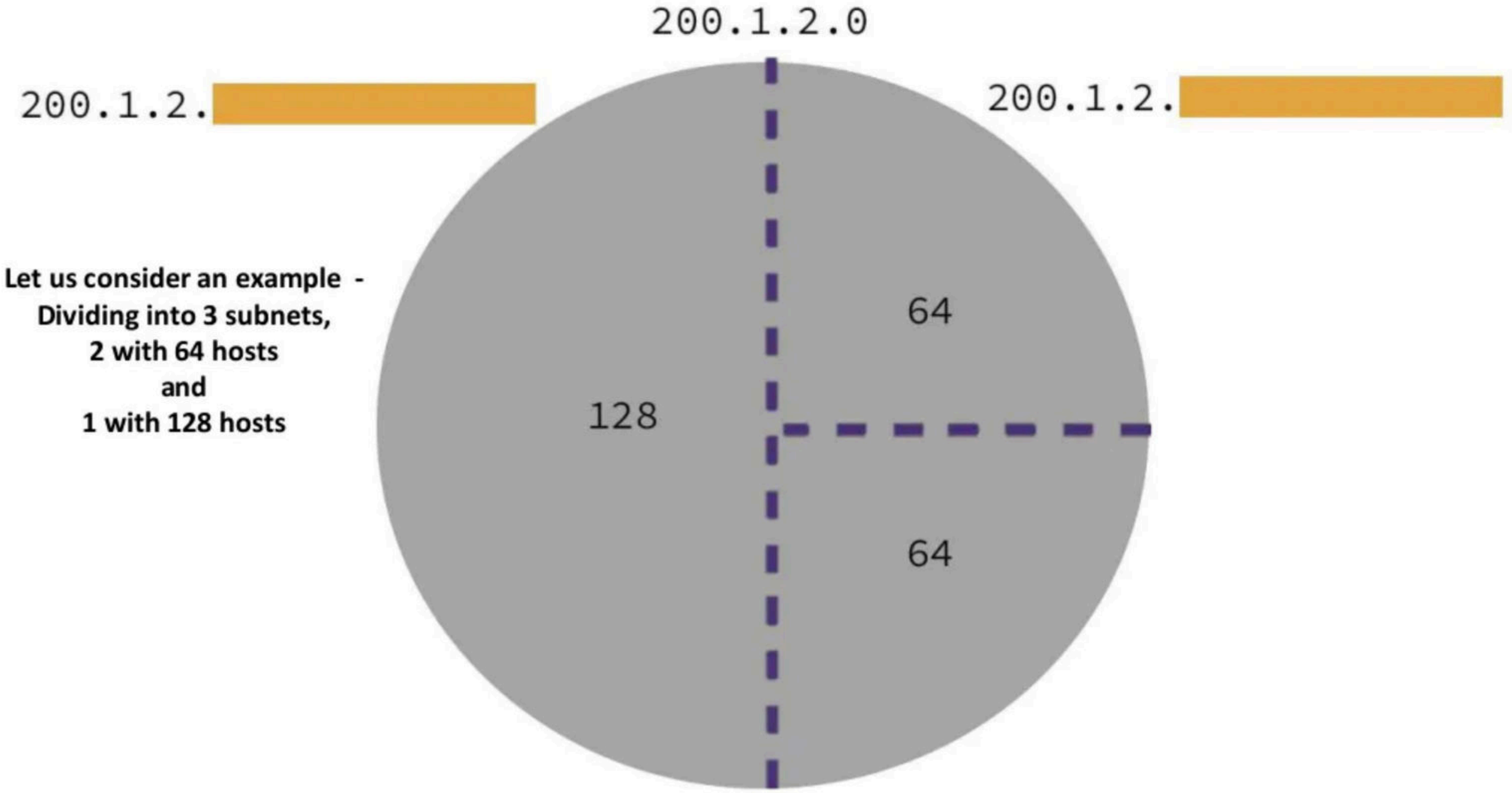
Variable Length Subnet Masking

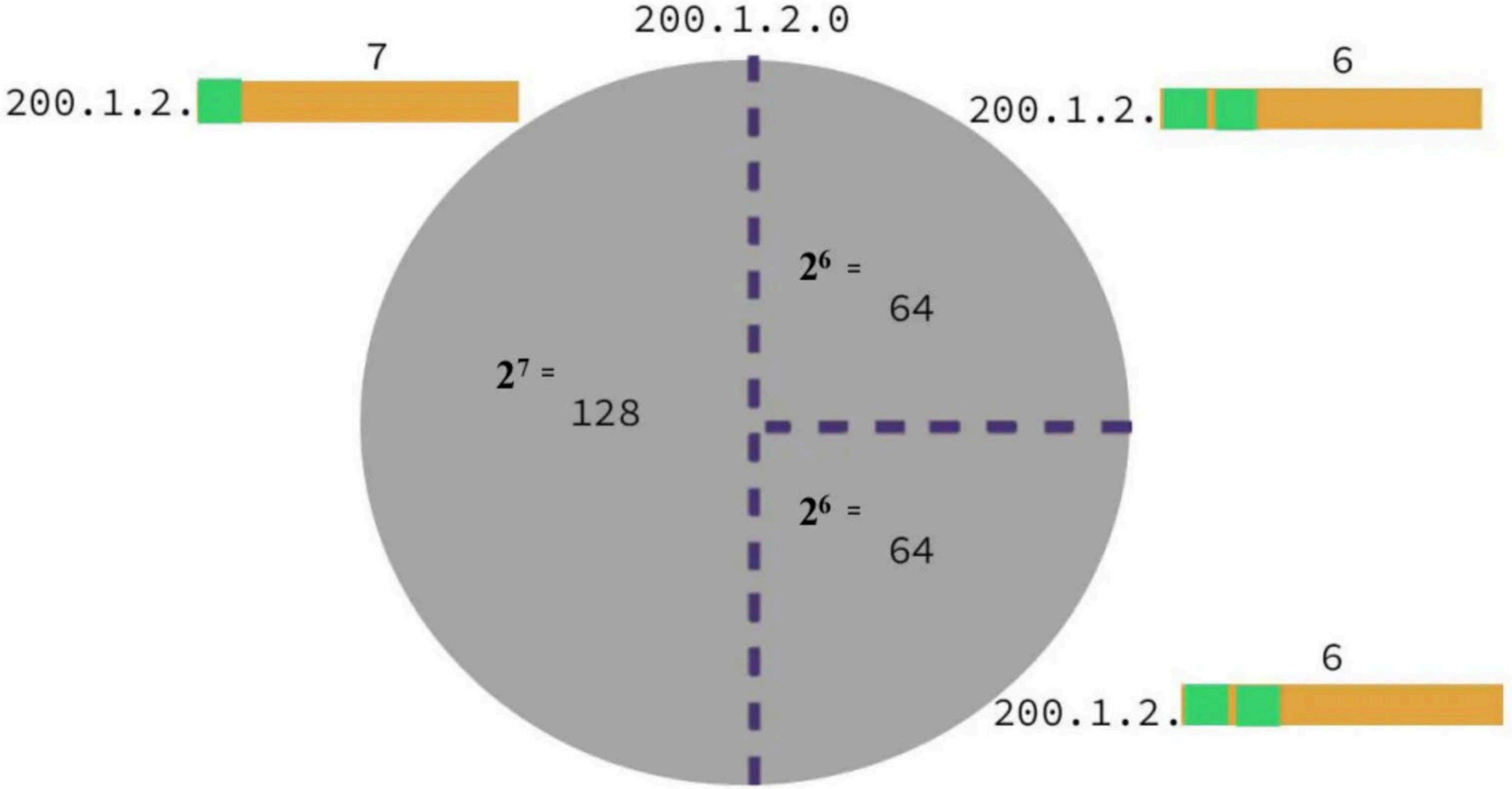
Variable Length Subnetting

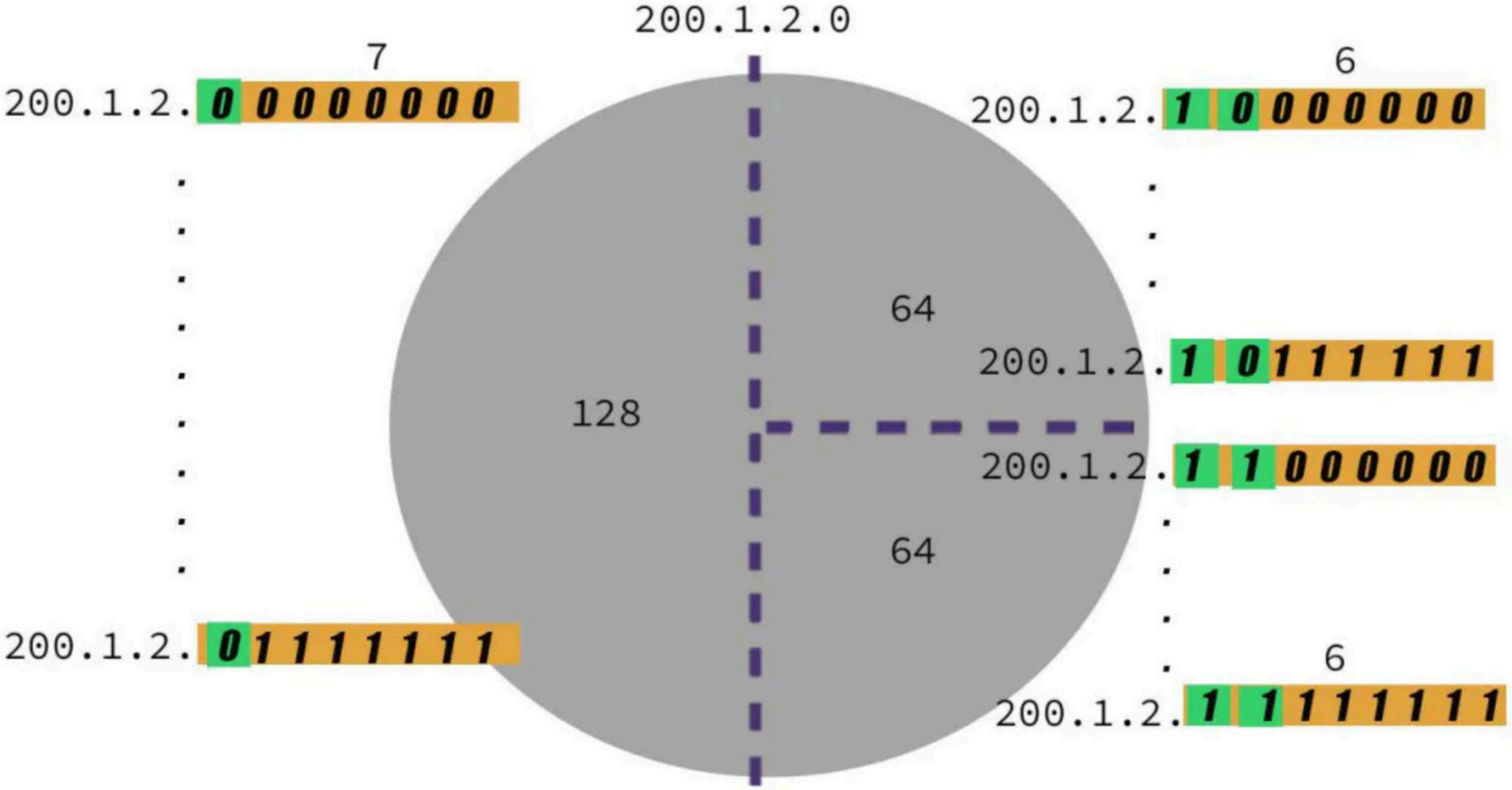
Variable length subnetting also called as classless subnetting divides the network into subnets where-

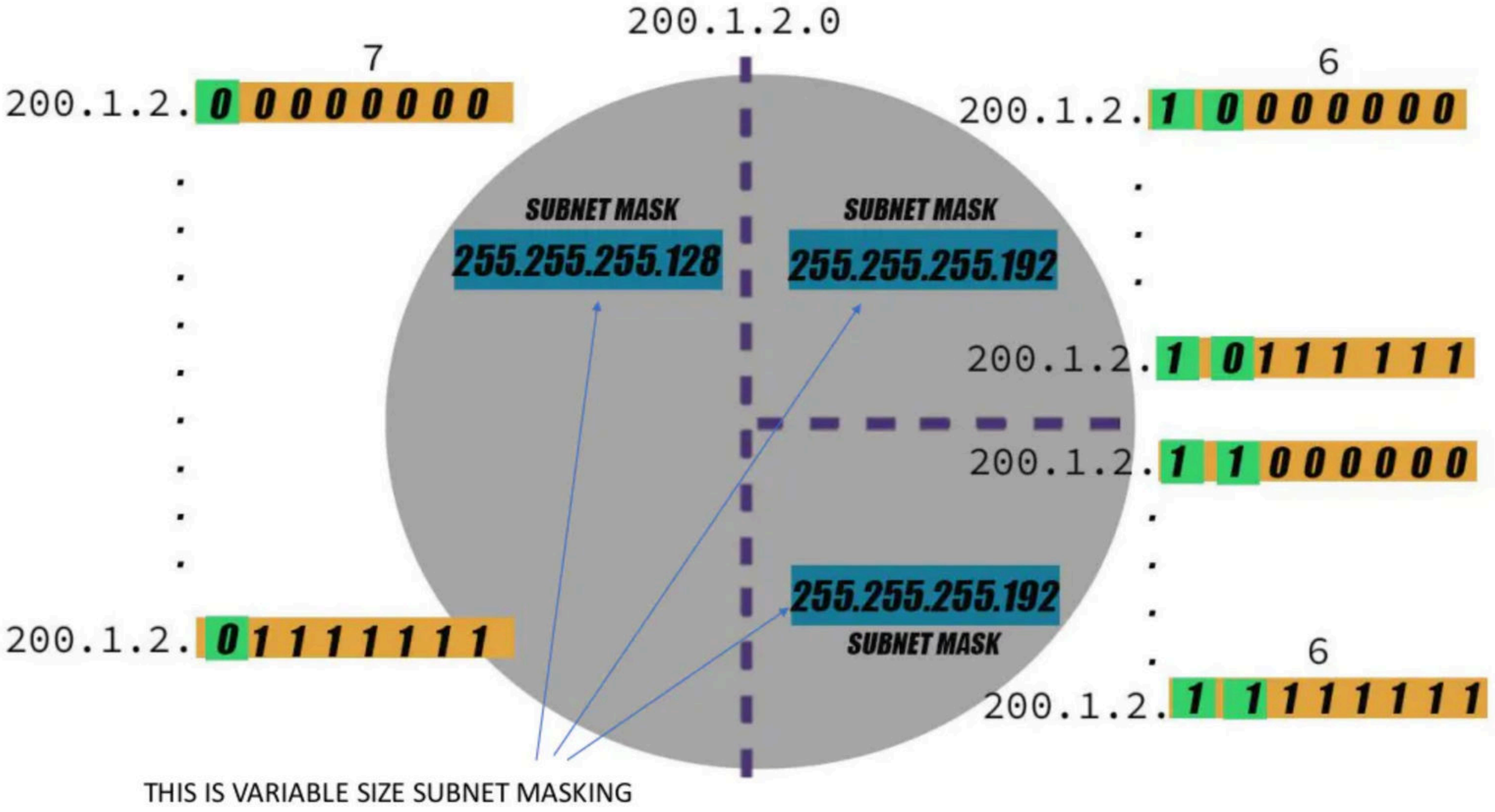
All the subnets are not of same size.
All the subnets do not have equal number of hosts.
All the subnets do not have same subnet mask.
Let us take an Example



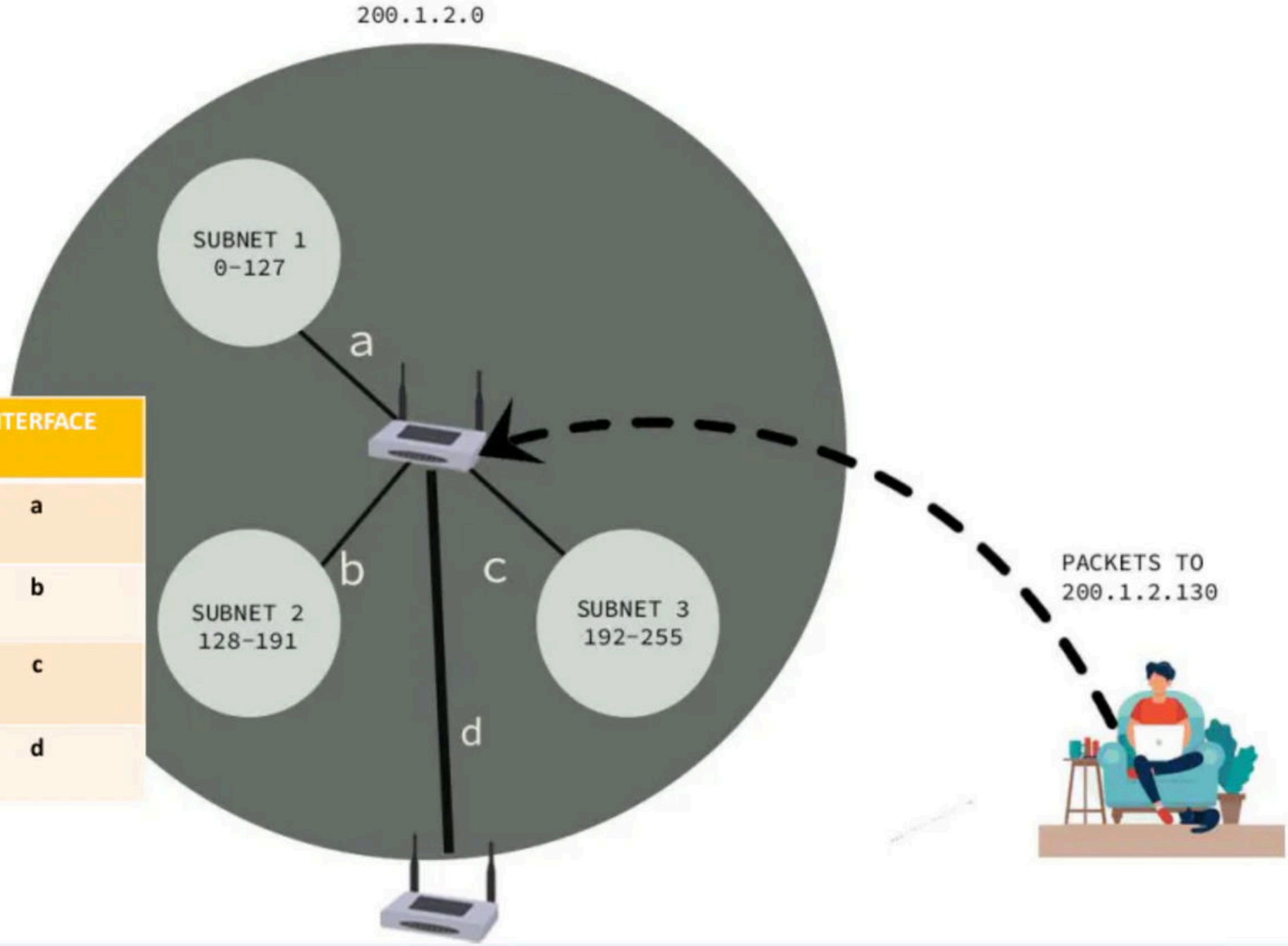

200.1.2.0
200.1.2.
200.1.2.
Let us consider an example -
Dividing into 3 subnets,
2 with 64 hosts
and
1 with 128 hosts
64
128
64


200.1.2.0
7
200.1.2.
6
200.1.2.
2^6 =
64
2^7 =
128
2^6 =
64
6
200.1.2.


200.1.2.0
7
200.1.2.0 0000000
200.1.2.0 1111111
6
200.1.2.1 0000000
200.1.2.1 0111111
200.1.2.1 1000000
200.1.2.1 1111111
64
128
64
6


200.1.2.0
7
200.1.2.0 0000000
200.1.2.0 1111111
SUBNET MASK
255.255.255.128
6
200.1.2.1 0000000
200.1.2.1 0111111
200.1.2.1 1000000
200.1.2.1 1111111
SUBNET MASK
255.255.255.192
SUBNET MASK
255.255.255.192
6
THIS IS VARIABLE SIZE SUBNET MASKING

NID	SUBNET MASK	INTERFACE
200.1.2.0	255.255.255.128	a
200.1.2.128	255.255.255.192	b
200.1.2.192	255.255.255.192	c
0.0.0.0	0.0.0.0	d



NOTE:

In order to find out the SID (Subnet id) or No of subnets, we must know either the Class of that network or NID

We can find out the HID even if The class of the network is not known

For example:
If Subnet mask = 255.255.255.192, And it known to be of Class A then,

We know that,
NID + SID = No of 1's
HID = No of 0's

No of 1's = 26
NID In class A = 8 bits
8 + SID = 26
SID = 18
No of subnets = 2^{18}

No of 0's = 6
HID = 6
IP/network = 2^6
Hosts/subnet=2^6-2

QUESTION:

If the subnet mask 255.255.255.128 belongs to class C, find-
1.Number of subnets
2.Number of hosts in each subnet

SOLUTION:

Given subnet mask= 255.255.255.128

= 11111111.11111111.11111111.10000000

Since 25 bits contain the value 1 and 7 bits contain the value 0, so-

- Number of NID bits + Number of Subnet ID bits = 25
- Number of HID bits = 7

Now,

- It is given that subnet mask belongs to class C.
- So, Number of NID bits = 24.

Substituting in the above equation, we get-

Number of Subnet ID bits

= 25 – 24

= 1

Number of subnets = $2^1 = 2$

Since number of HID bits = 7, so-

Number of hosts per subnet = $2^7 - 2 = 126$

GATE 2008

If a class B network on the Internet has a subnet mask of 255.255.248.0, what is the maximum number of hosts per subnet?

(A) 1022
(B) 1023
(C) 2046
(D) 2047

Answer (C)

The binary representation of subnet mask is
11111111.11111111.11111000.00000000.
There are 21 bits set in subnet.
So 11 bits are left for host ids.
Total possible values of host ids is 2^11 = 2048.

Out of these 2048 values, 2 addresses are reserved.
The address with all bits as 1 is reserved as broadcast address and address with all host id bits as 0 is used as network address of subnet.

In general, the number of addresses usable for addressing specific hosts in each network is always 2^N – 2 where N is the number of bits for host id.

Therefore, maximum no of hosts per subnet = 2048 -2 = 2046