

# ISO/OSI Stack

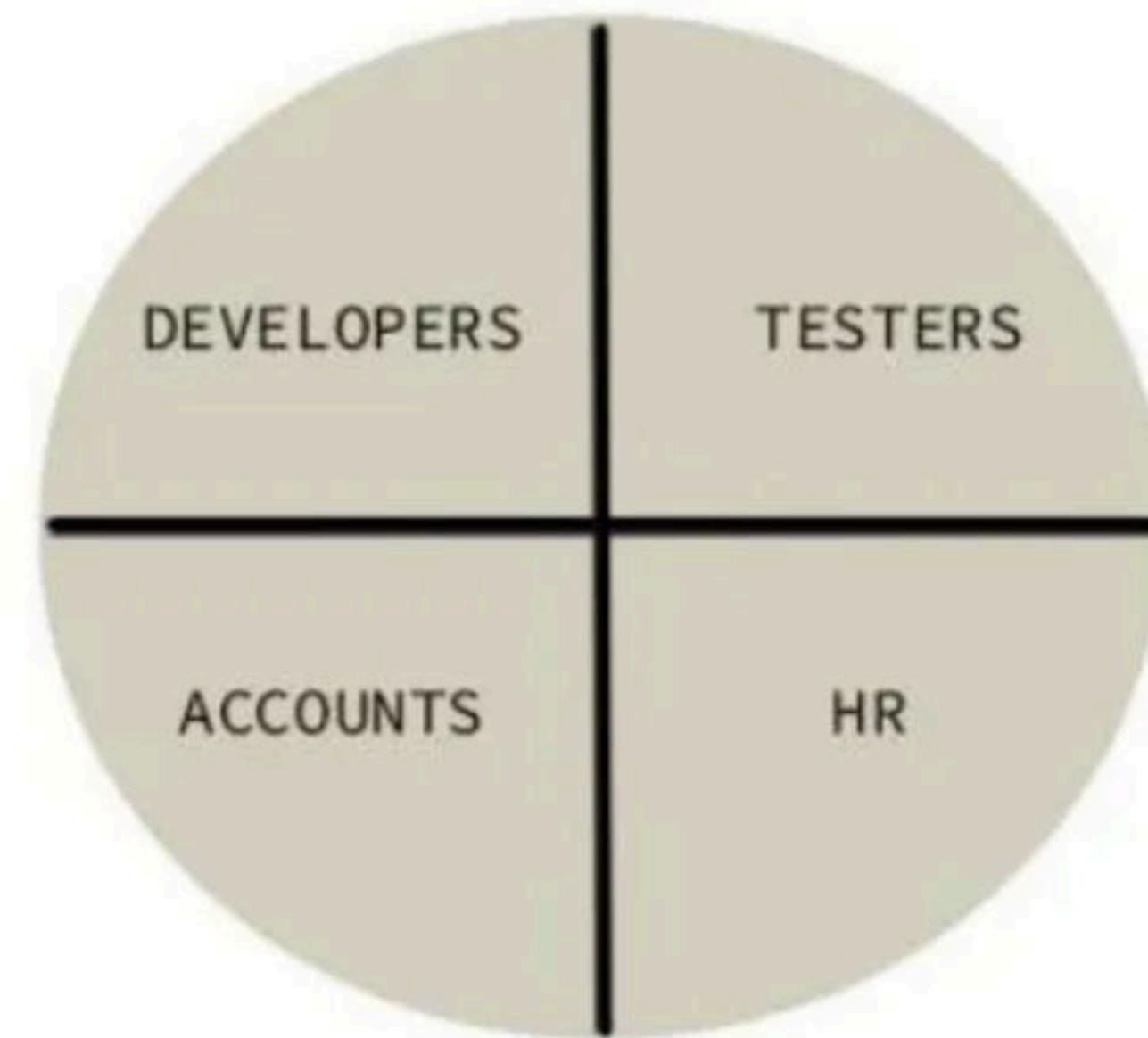
Complete Course on Computer Networks - Part I

Ravindrababu Ravula • Lesson 5 • Jan 22, 2021

# Computer Networks

Subnet, Subnet Mask, Routing

## UNDERSTANDING SUBNETTING WITH AN EXAMPLE

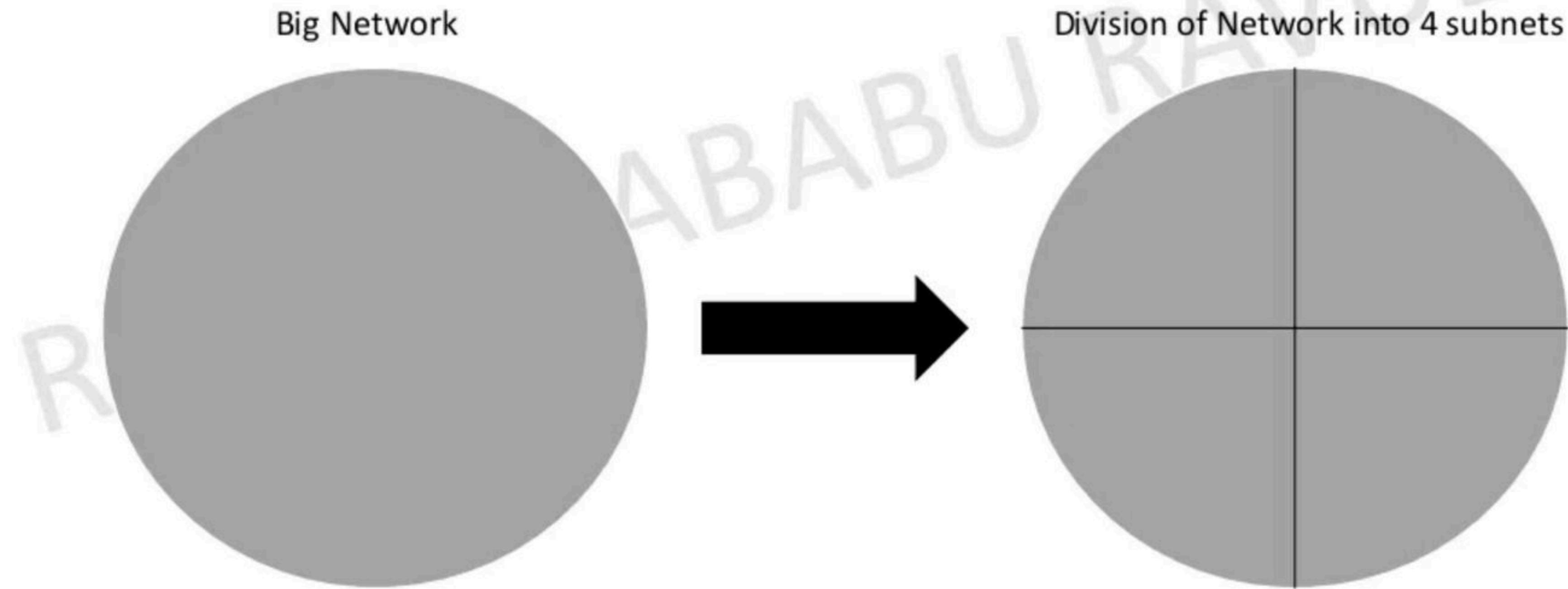


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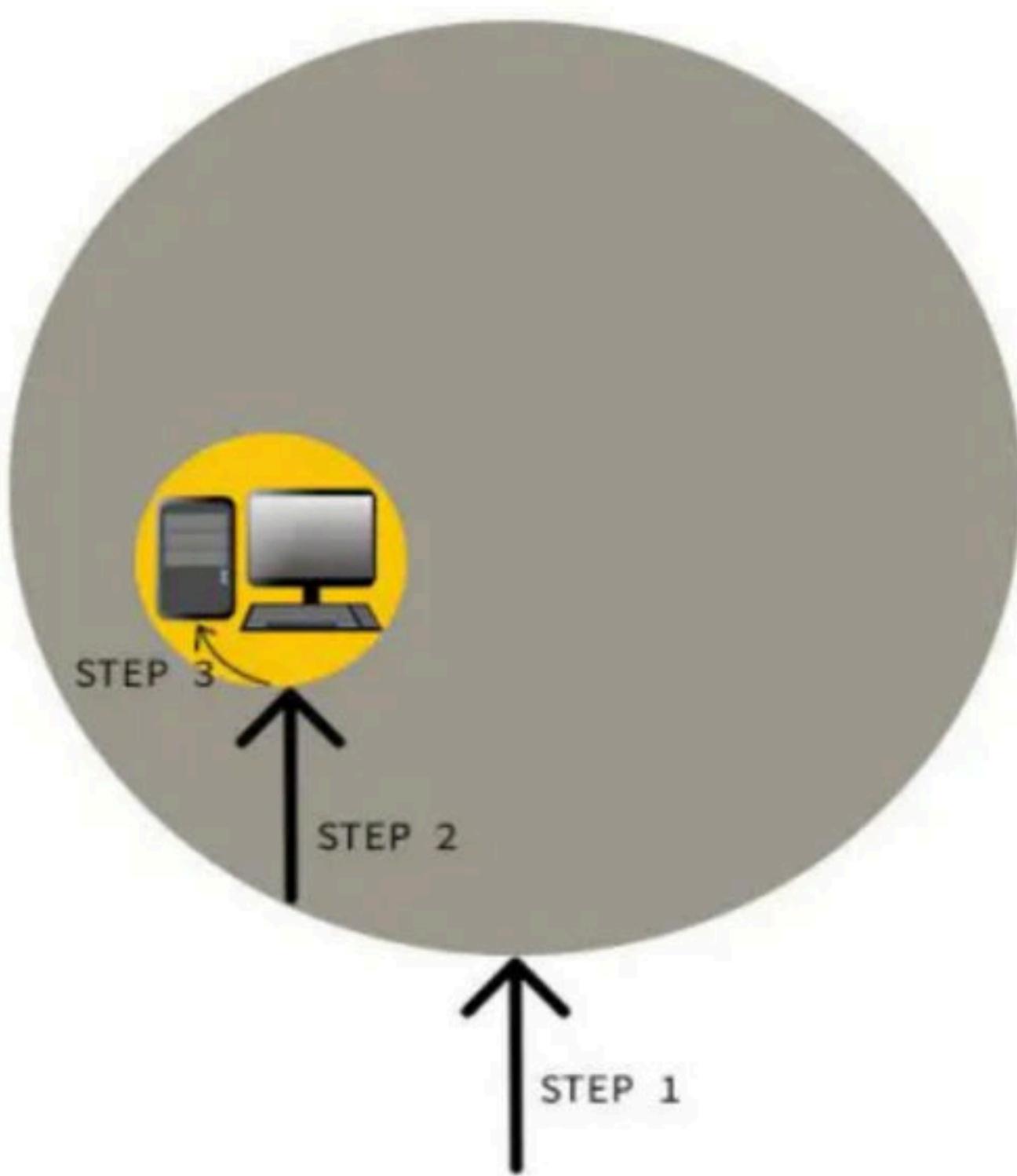
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## Subnetting

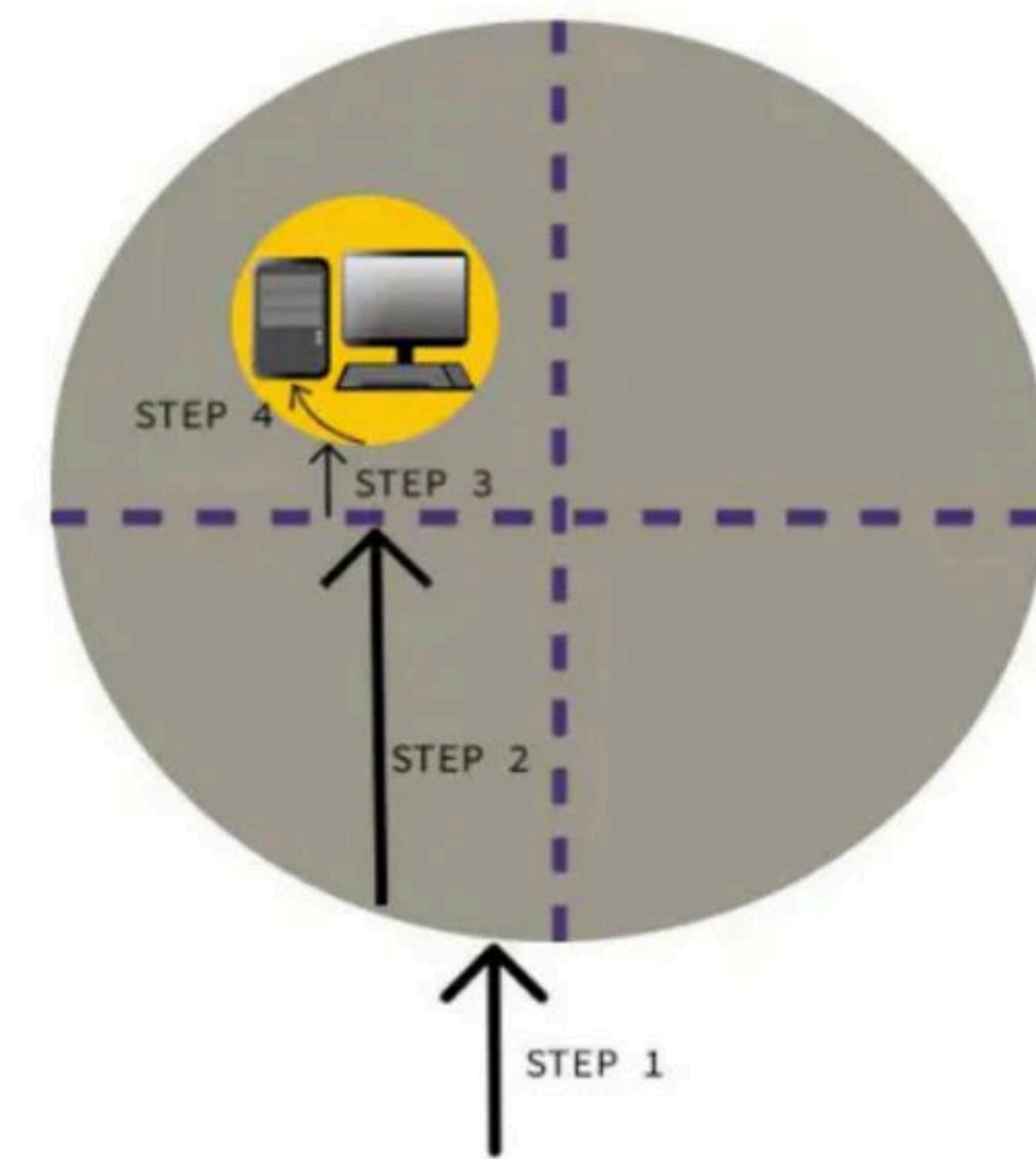
The process of dividing a single network into multiple sub networks is called as subnetting.  
The sub networks so created are called as subnets.



REACHING A HOST WITHOUT SUBNETTING



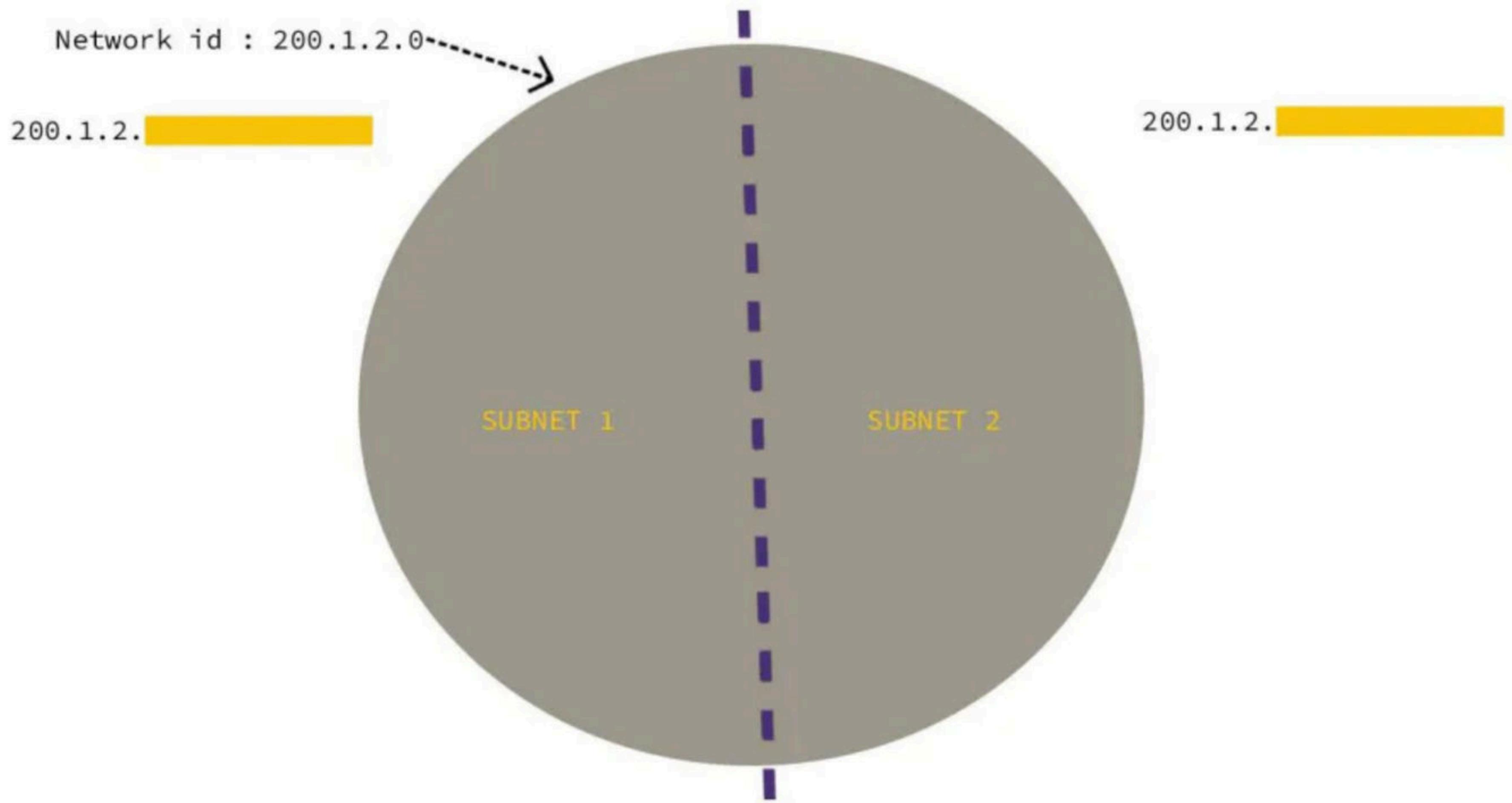
REACHING A HOST WITH SUBNETTING



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## Dividing the Network into 2 subnets

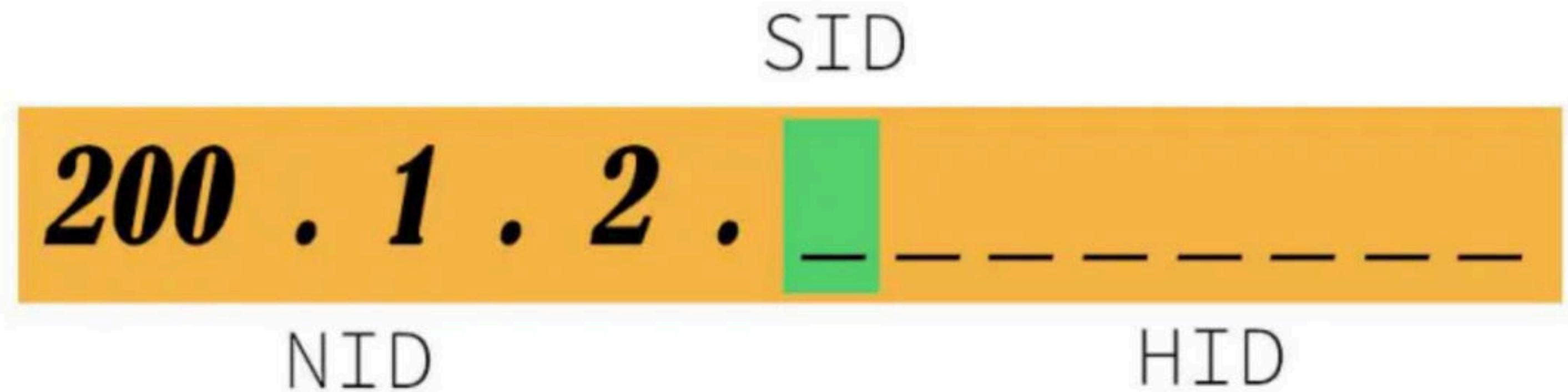


For creating two subnets and to represent their subnet IDs, we require 1 bit.

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

200.1.2.0ooooooooo

200.1.2.0ooooooo01

200.1.2.0oooooo10

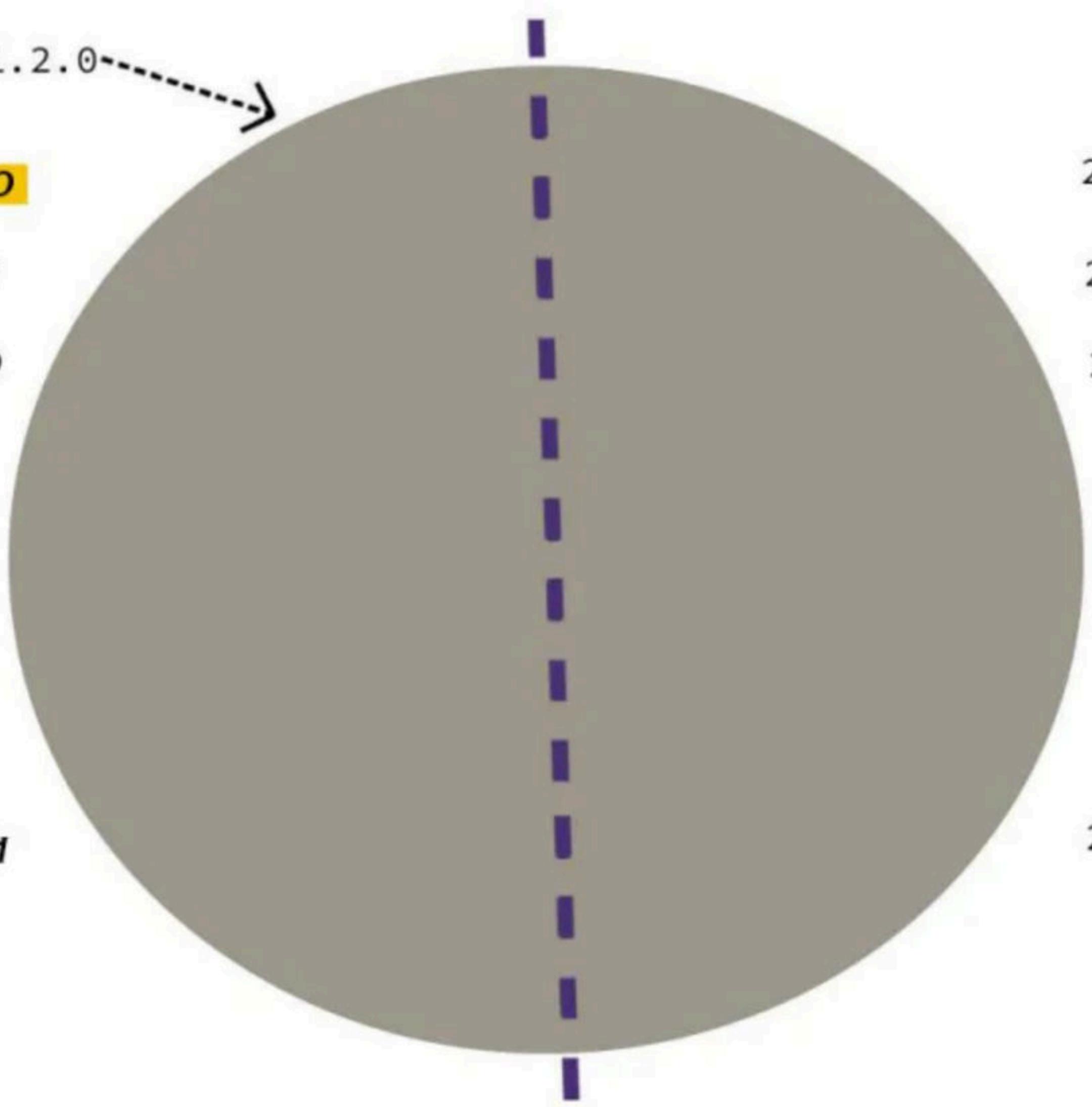
200.1.2.01111111

200.1.2.1ooooooooo

200.1.2.1ooooooo01

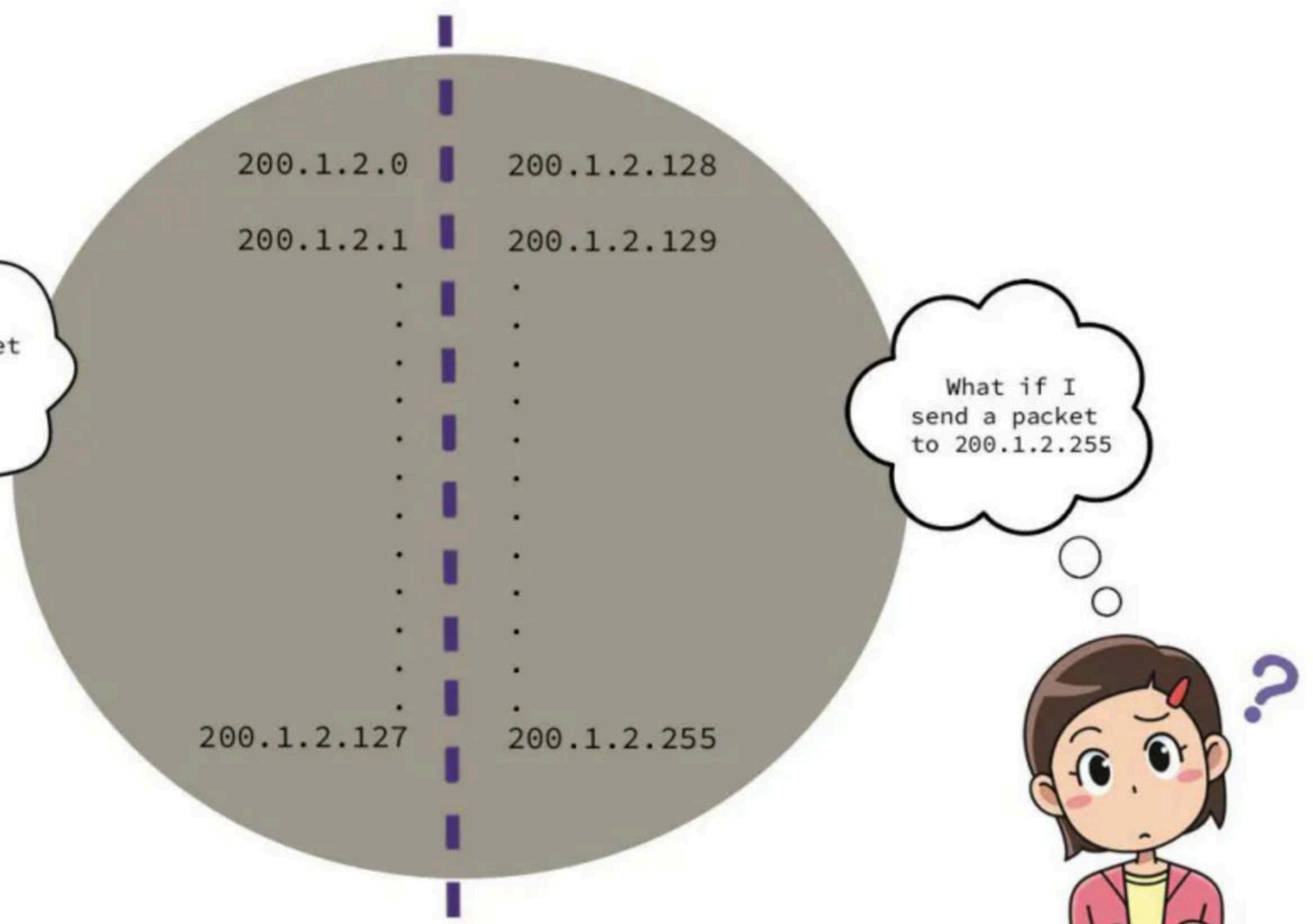
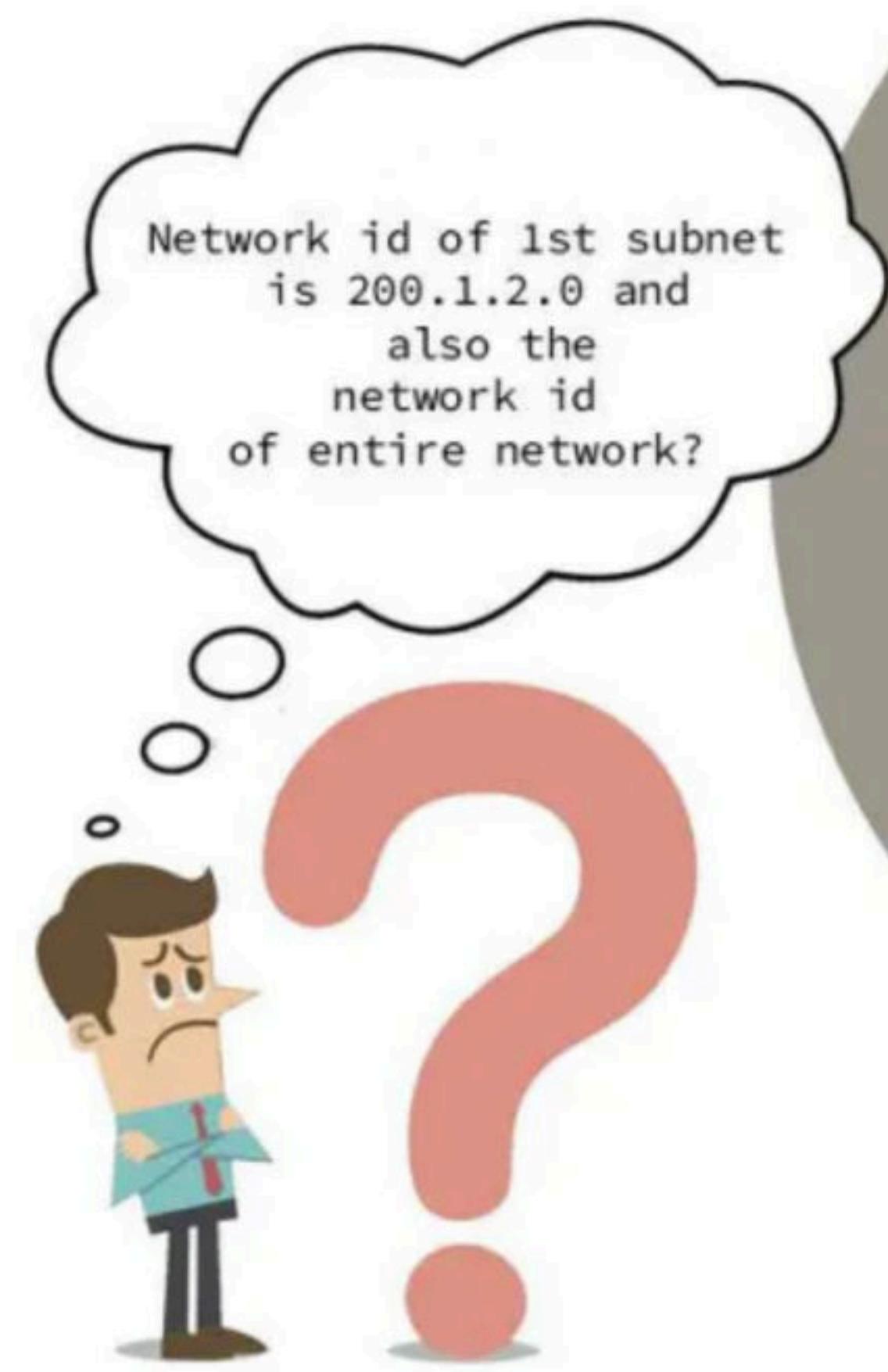
200.1.2.1ooooooo01

200.1.2.11111111



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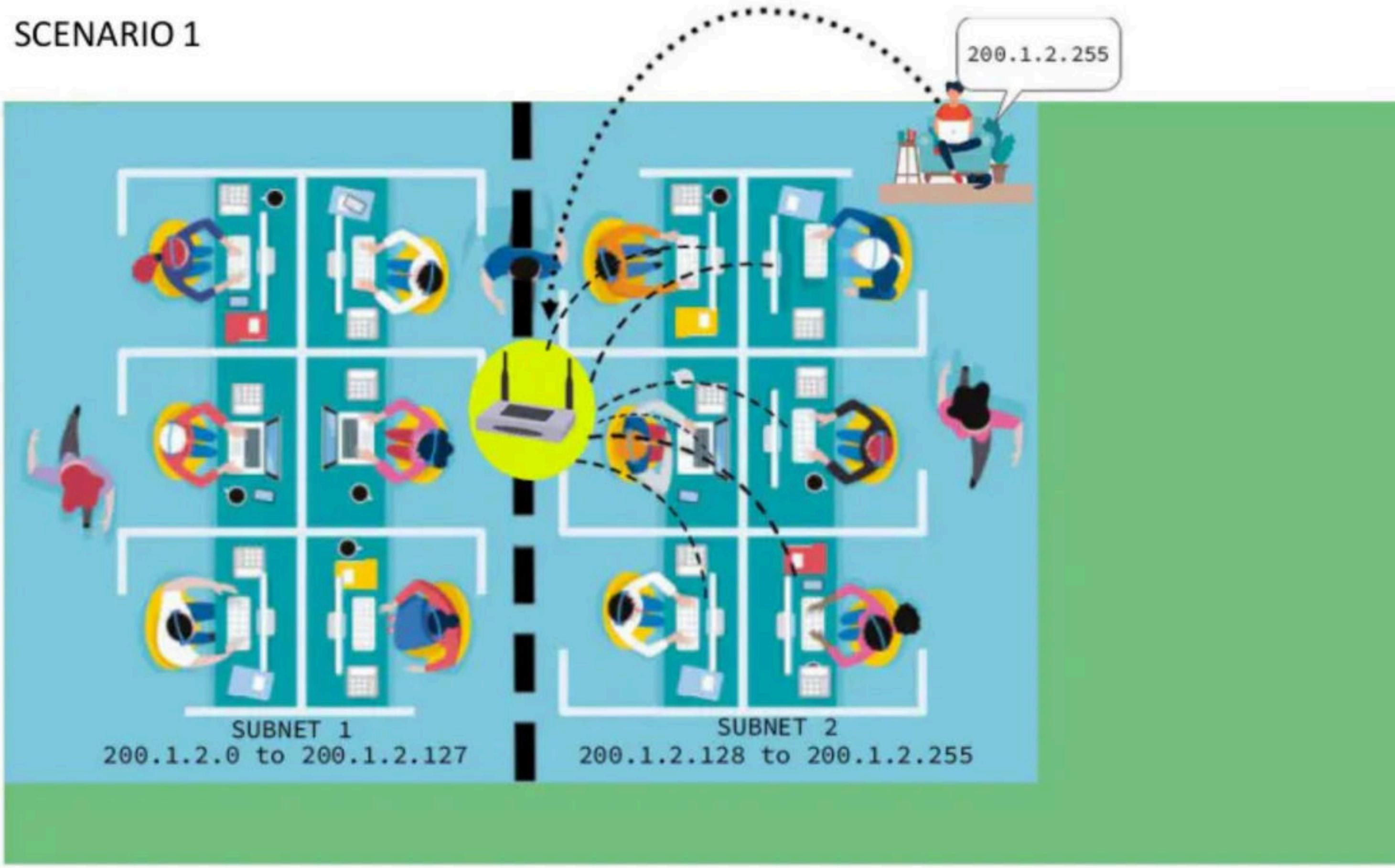
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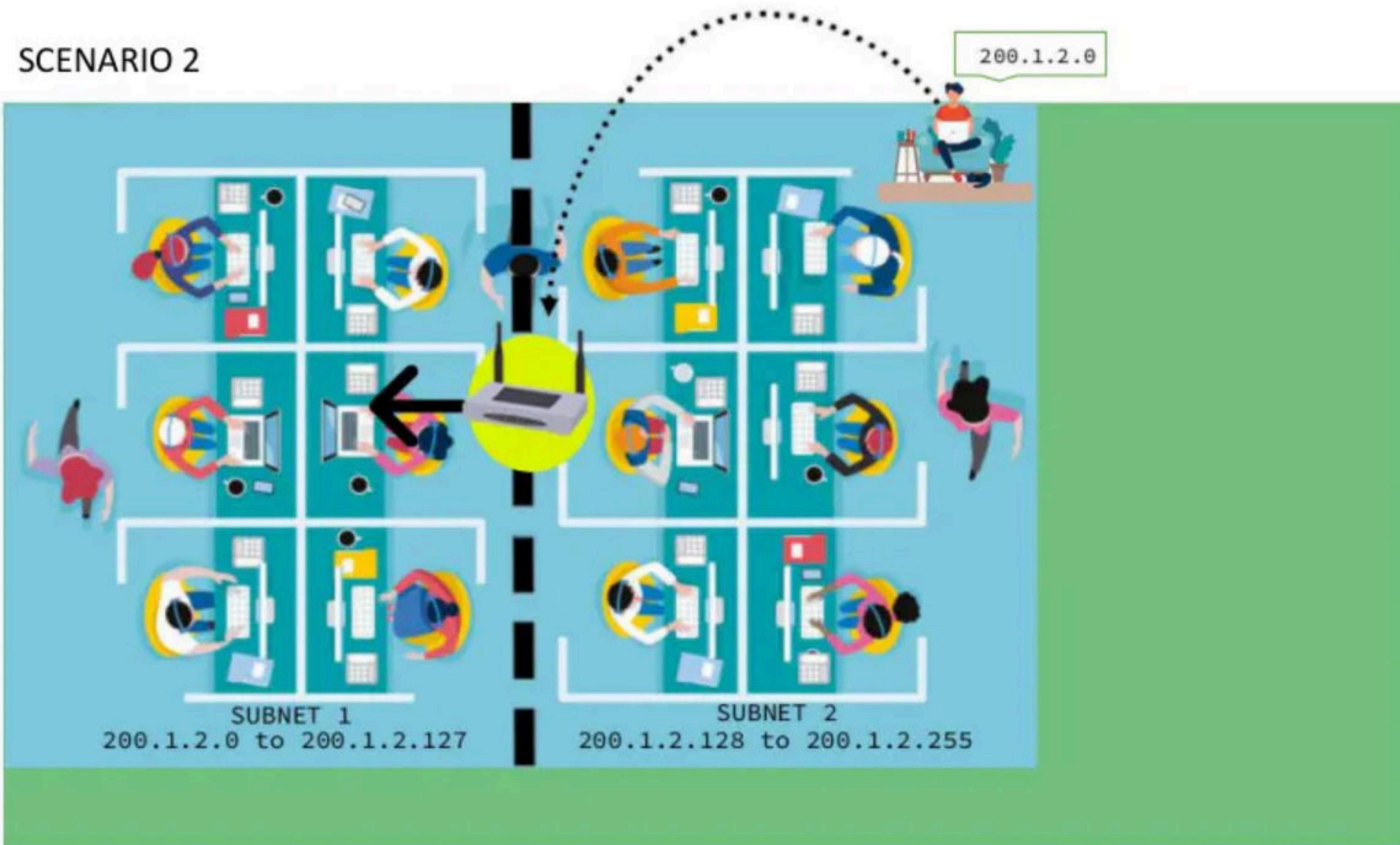
## SCENARIO 1



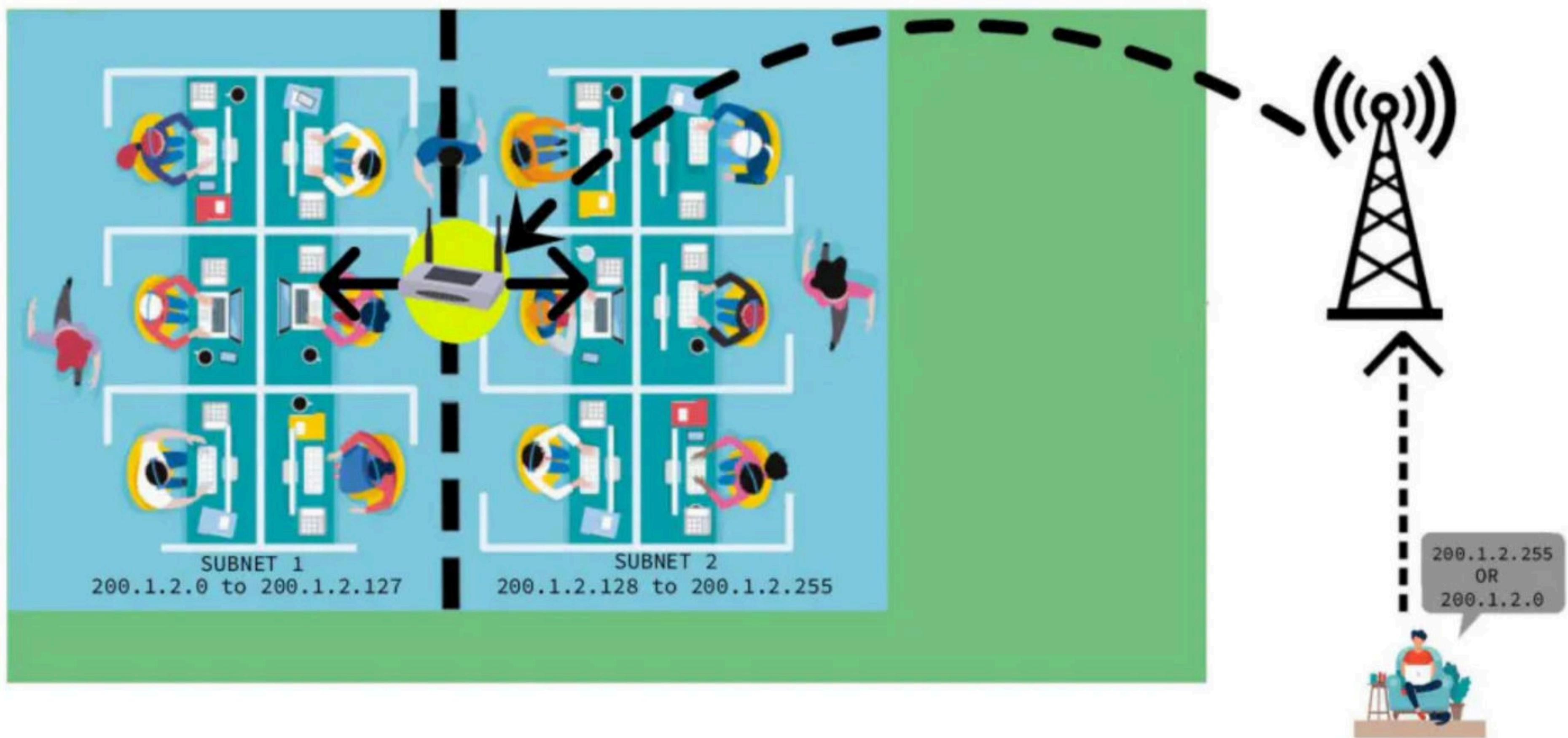
A

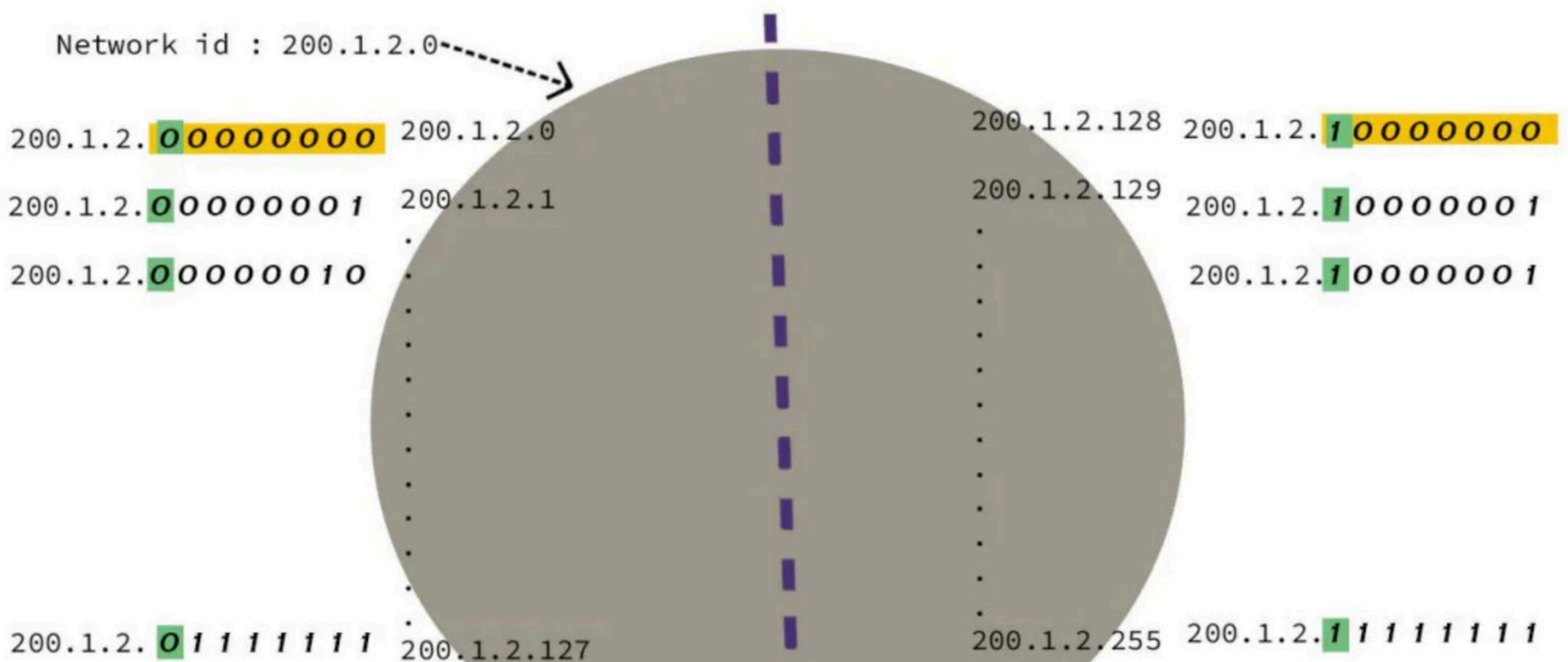
F

## SCENARIO 2



### SCENARIO 3





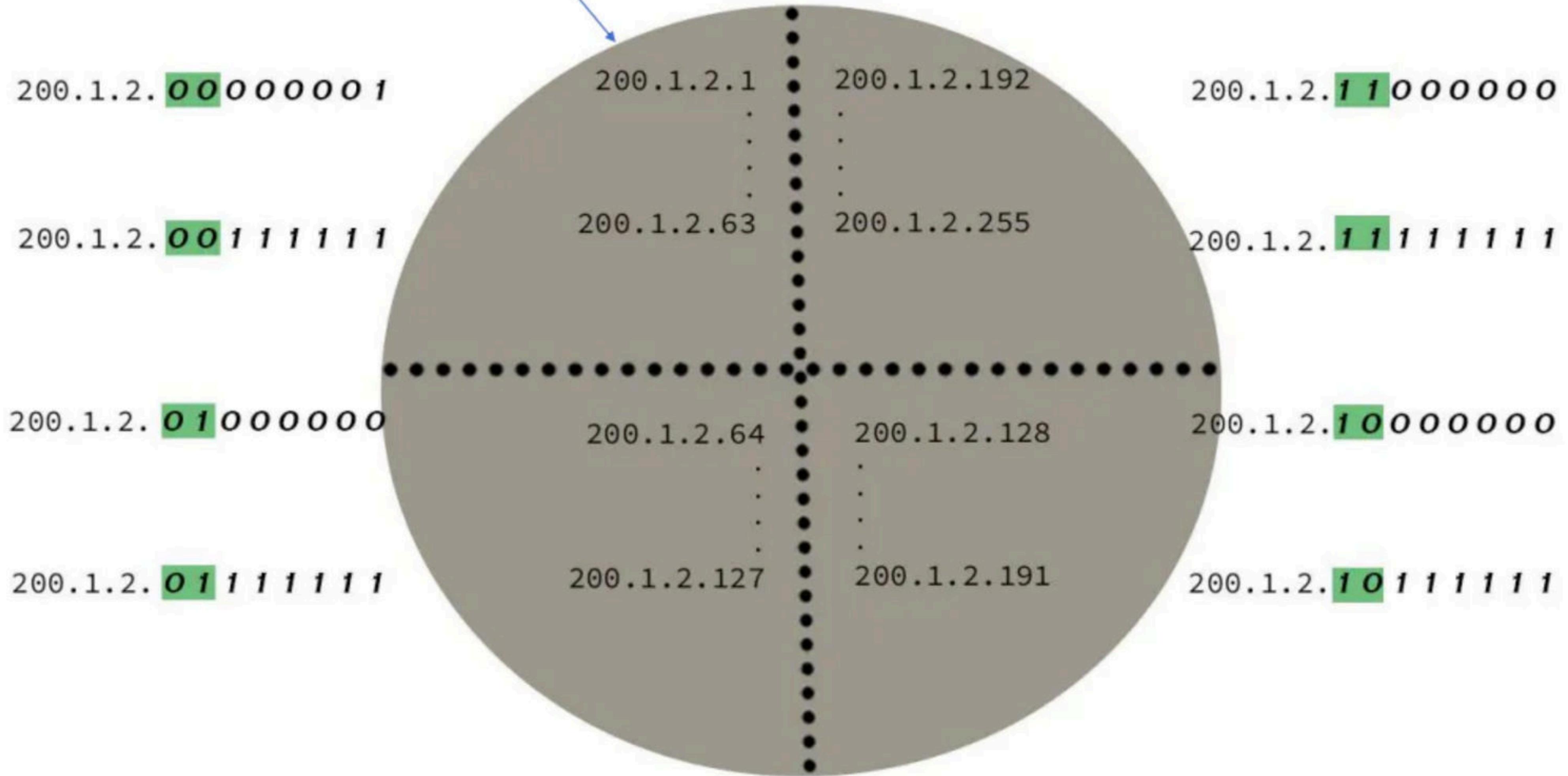
- IP Address of the subnet = 200.1.2.0
- Total number of IP Addresses =  $2^7 = 128$
- Total number of hosts that can be configured =  $128 - 2 = 126$
- Range of IP Addresses = [200.1.2.00000000, 200.1.2.01111111] = [200.1.2.0, 200.1.2.127]
- Direct Broadcast Address = 200.1.2.01111111 = 200.1.2.127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

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DIVIDING INTO 4 SUBNETS: NID : 200.1.2.0



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IP Address of the four subnets are-

- 200.1.2.**00000000** = 200.1.2.0
- 200.1.2.**01000000** = 200.1.2.64
- 200.1.2.**10000000** = 200.1.2.128
- 200.1.2.**11000000** = 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.**00000000**, 200.1.2.**00111111**] = [200.1.2.0, 200.1.2.63]
- Direct Broadcast Address = 200.1.2.**00111111** = 200.1.2.63
- 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.**11000000**, 200.1.2.**11111111**] = [200.1.2.192, 200.1.2.255]
- Direct Broadcast Address = 200.1.2.**11111111** = 200.1.2.255
- 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.**01000000**, 200.1.2.**01111111**] = [200.1.2.64, 200.1.2.127]
- Direct Broadcast Address = 200.1.2.**01111111** = 200.1.2.127
- Limited Broadcast Address = 255.255.255.255

#### For 3rd Subnet-

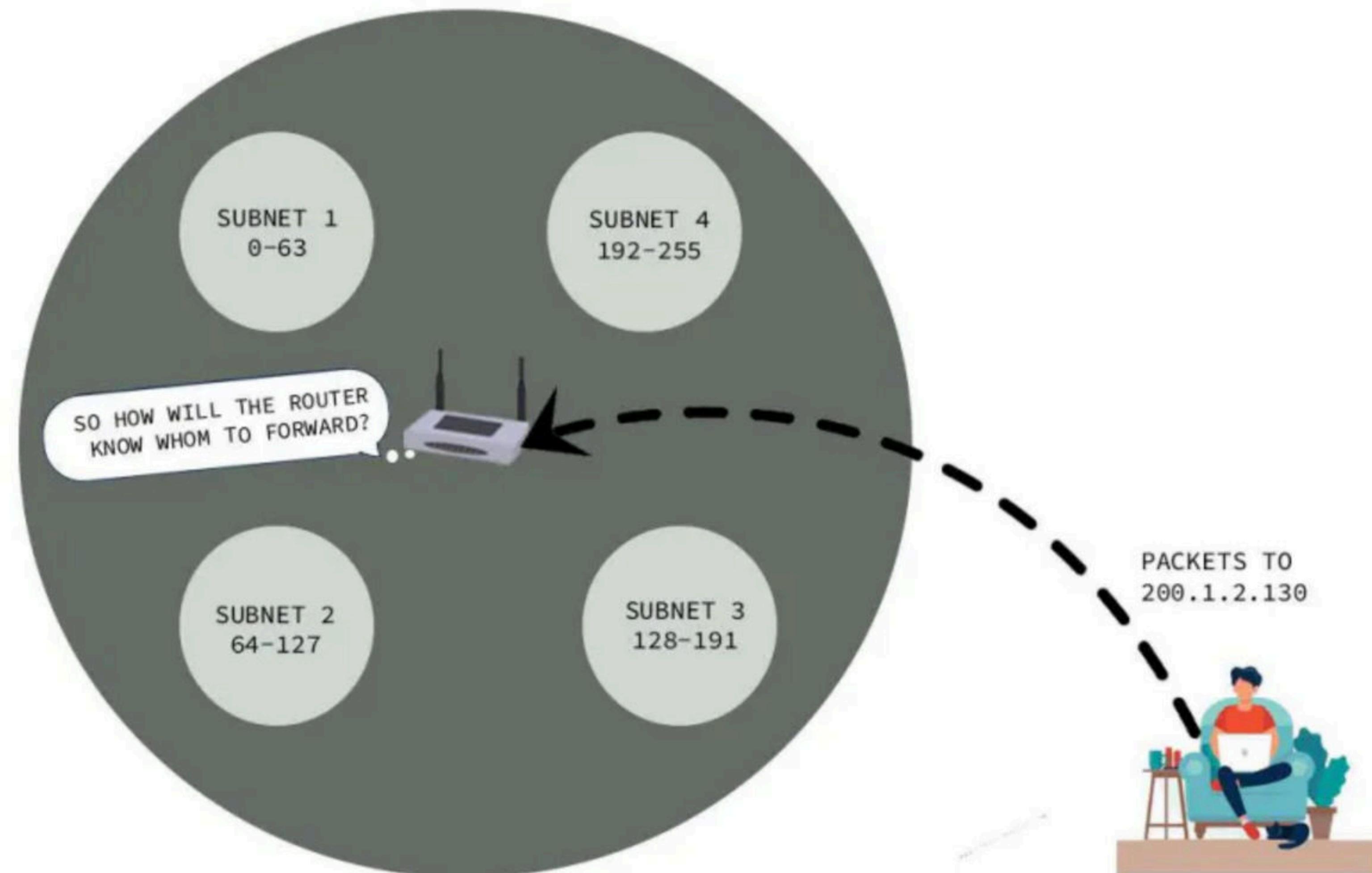
- IP Address of the subnet = 200.1.2.128
- Total number of IP Addresses =  $2^6 = 64$
- Total number of hosts that can be configured =  $64 - 2 = 62$
- Range of IP Addresses = [200.1.2.**10000000**, 200.1.2.**10111111**] = [200.1.2.128, 200.1.2.191]
- Direct Broadcast Address = 200.1.2.**10111111** = 200.1.2.191
- Limited Broadcast Address = 255.255.255.255

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Let us see a scenario,

200.1.2.0



# Routing table

NID	SM	Interface
200.1.2.0	255.255.255.192	a ✓
200.1.2.4	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 ✓

D	SA	DA
	X	

SM } AND  
 X } AND  
NID

Size same  
 → Same sm

200.1.2.0

VLSM

S1

0-63

S2

64-127

128-191

192-255

120-1.2.0

100  
SM  
64

0.0.0.0  
0.0.0.0

VLSM

100  
SA  
200.1.2.30

X

32 bits number

1's  $\rightarrow$  NID + SID

0's  $\rightarrow$  IP

SM =

$$\begin{array}{cccc} \text{255} & \cdot & \text{255} & \cdot \\ \hline \text{11111111.11111111.11111111.11000000} & \checkmark & & \\ \hline \text{11001000.0000001.00000010.10000010} & & & \\ \hline \text{11001000.0000001.00000010.10000000} & & & \\ \hline (200 & \cdot & 1 & \cdot 2 \cdot 128) & & & \end{array}$$

SM:

$$\begin{array}{cccc} \text{255} & \cdot & \text{255} & \cdot \text{255} \cdot 192 = 11000000 \\ \hline \text{200} & \cdot & 1 & \cdot 2 \cdot 2^9 = 00010100 \\ \hline \text{200} & \cdot & 1 & \cdot 2 \cdot 8 & \end{array}$$

SM

$$\begin{array}{cccc} \text{255} & \cdot & \text{255} & \cdot \text{255} \cdot 192 = 11000000 \\ \hline \text{200} & \cdot & 1 & \cdot 2 \cdot 68 = 01000100 \\ \hline \text{200} & \cdot & 1 & \cdot 2 \cdot 64 & \end{array}$$

SM

200.1.2.0  $\rightarrow$  4 SN

NID  $\rightarrow$   $2^4$   
SID  $\rightarrow$  2

$2^6 \rightarrow 1's$

IP

200.1.2.130

130  $\rightarrow$  128 + 2

$$2^6 = \text{IP} = 64$$

bit wise AND

$$\begin{array}{r} 248 \\ \times 255 \\ \hline 10 \end{array}$$

$$200.1.2.20$$

SM

$$\begin{array}{l} 130 \rightarrow 128 \\ 20 \rightarrow 0 \\ 68 \rightarrow 64 \end{array}$$



## 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

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## 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

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IP ADDRESS = 200.1.2.130  
BNET MASK = 255.255.255.192

SUBNET MASK: 11111111.11111111.11111111.11000000

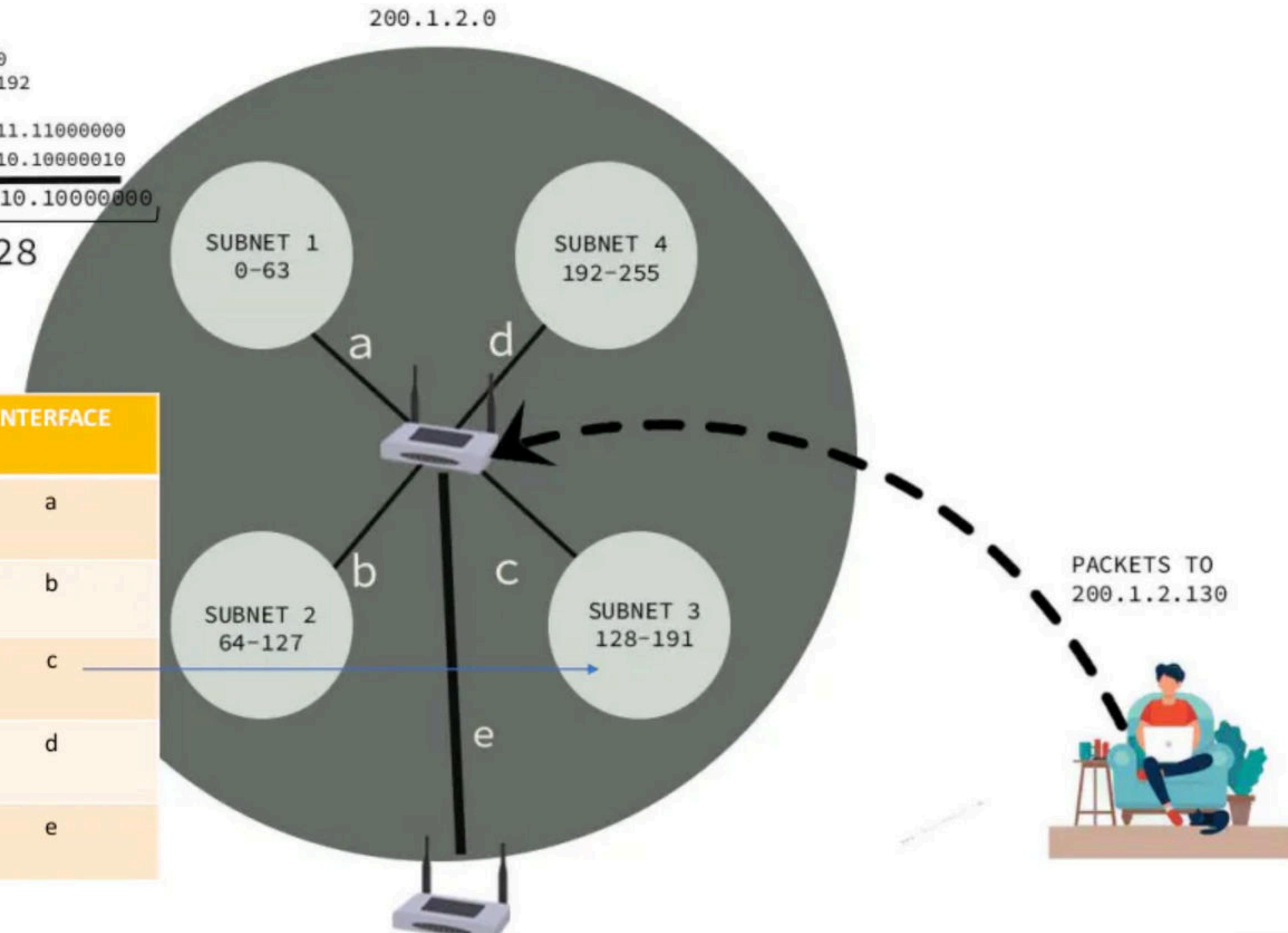
IP: 11001000.00000001.00000010.10000010

**11001000.0000001.00000010.10000000.**

200.1.2.128

## 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

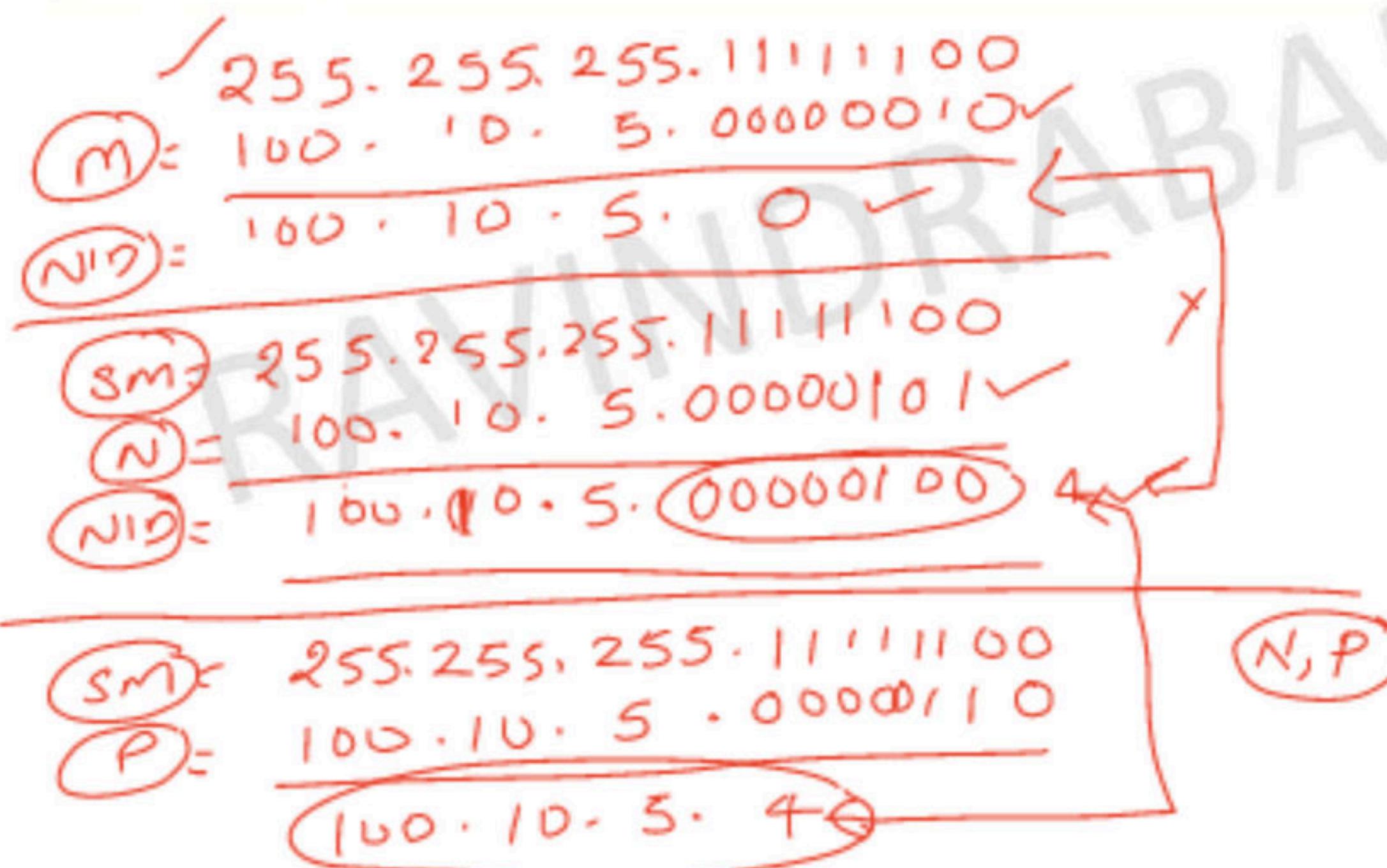


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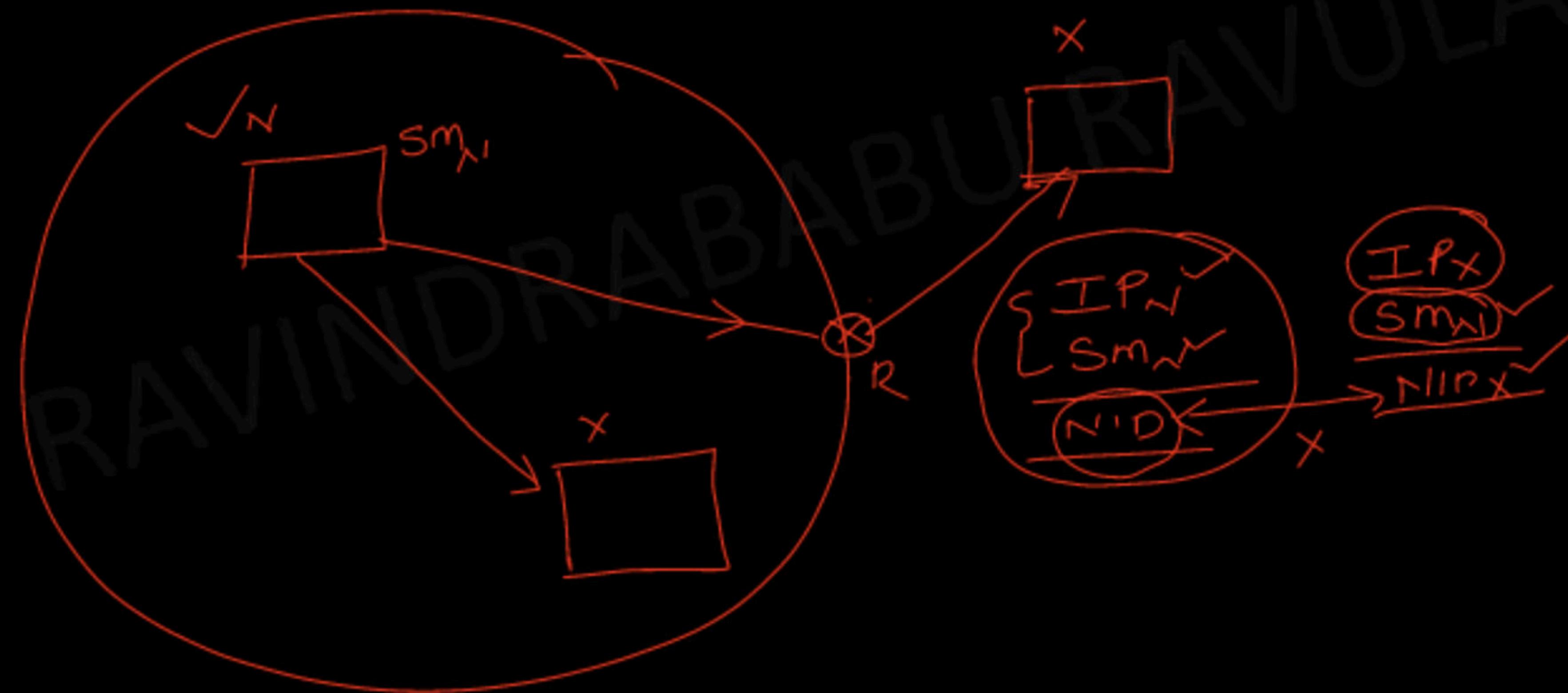
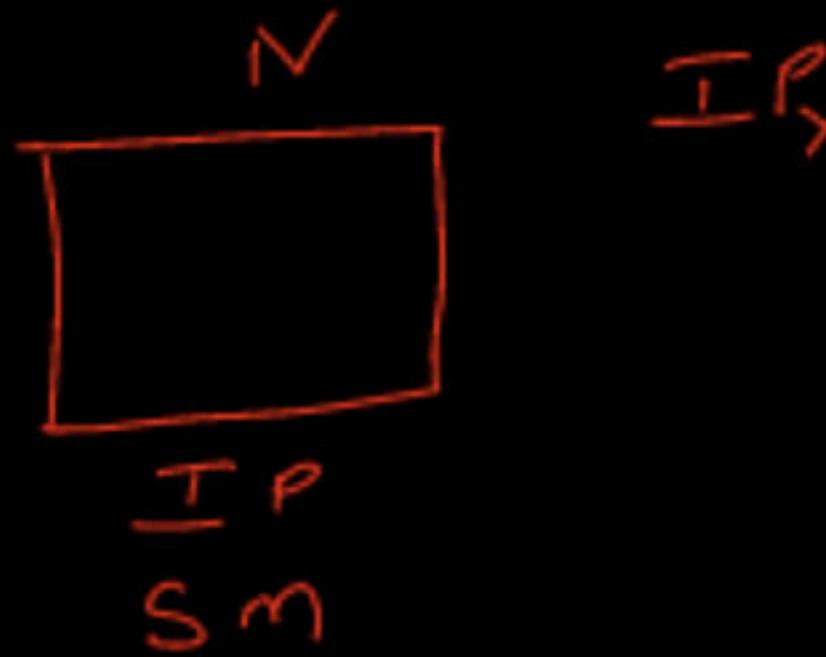
Consider three machines M, N, and P with IP addresses 100.10.5.2, 100.10.5.5, and 100.10.5.6 respectively. The subnet mask is set to 255.255.255.252 for all the three machines. Which one of the following is true?

- 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



128	- 1000000000
192	- 1100000000
224	- 1110000000
240	- 1111000000
248	- 1111100000
252	- 1111110000
254	- 1111111000
255	- 1111111100

$IP \rightarrow ISP$   
 $Sm \rightarrow ISP$   
 $DNS S \rightarrow ISP$   
 $DR \xrightarrow{?} ISP$



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**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.

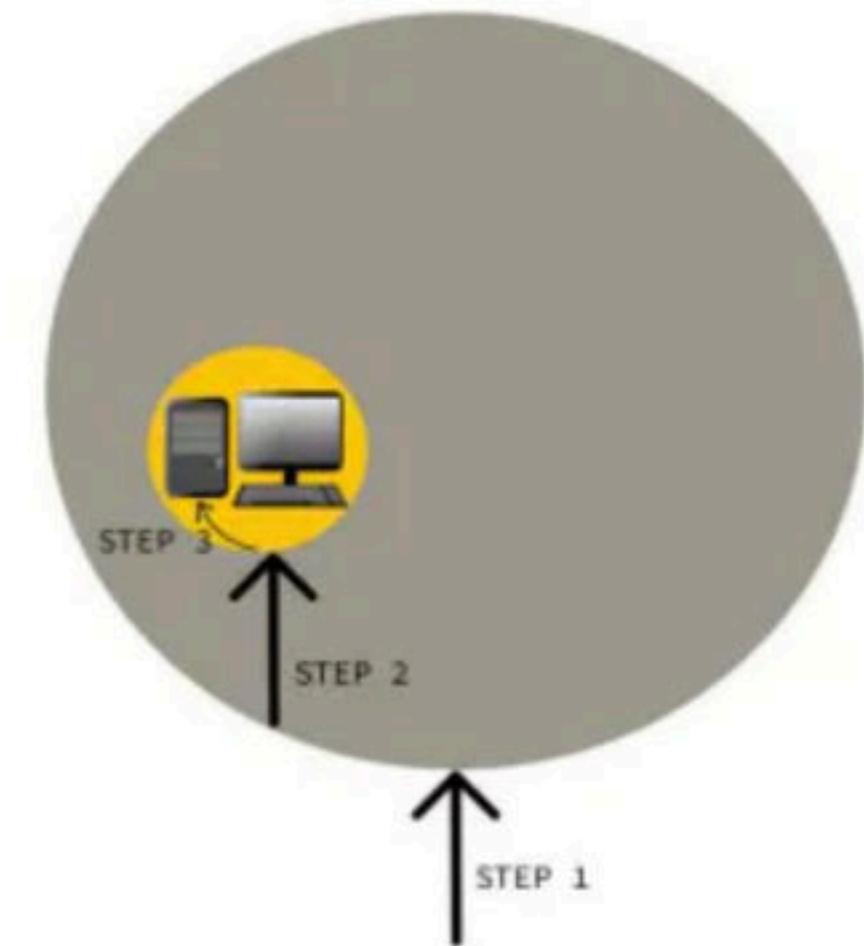
The maintenance of subnets is easy.

## Disadvantages

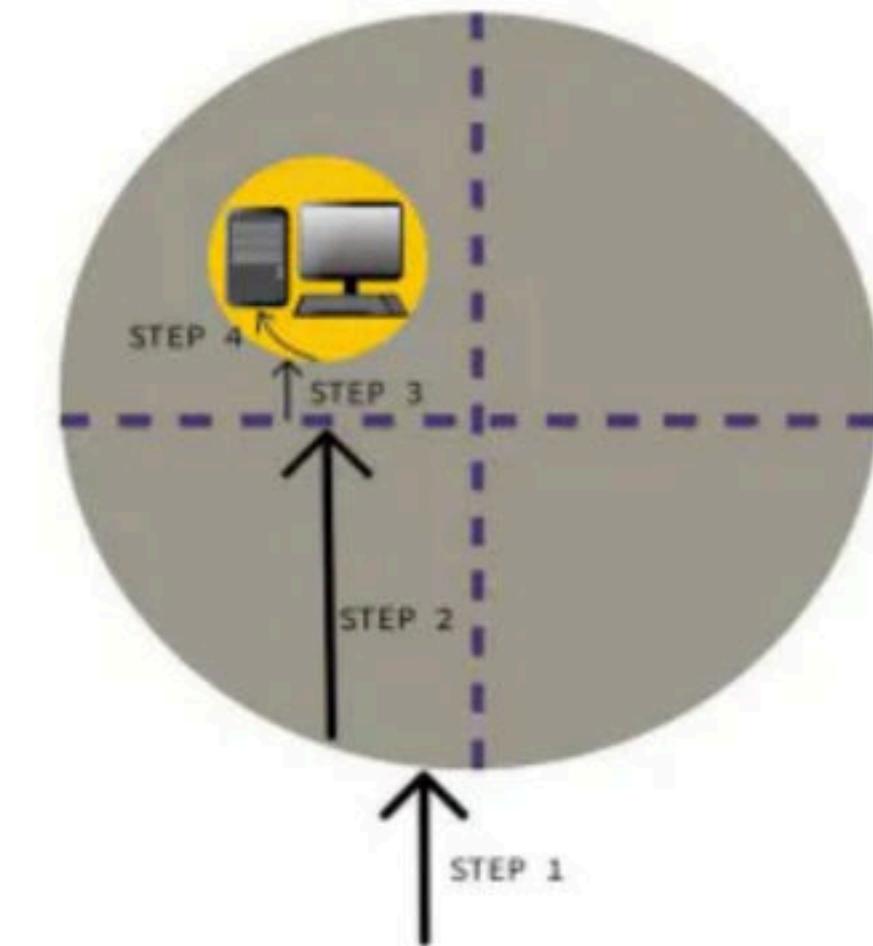
After subnetting, the communication process becomes complex involving the following 4 steps-

- 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	16777214			
255.128.0.0	254			
255.192.0.0	62			
255.240.0.0	14			
255.255.0.0	2			
255.255.255.0	1			
255.255.254.0	0			
255.255.255.224	0			
255.255.255.240	0			

<b>SUBNET MASK</b>	<b>NO OF HOSTS</b>	<b>SUBNETS IN CLASS A</b>	<b>SUBNETS IN CLASS B</b>	<b>SUBNETS IN CLASS C</b>
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				

<b>SUBNET MASK</b>	<b>NO OF HOSTS</b>	<b>SUBNETS IN CLASS A</b>	<b>SUBNETS IN CLASS B</b>	<b>SUBNETS IN CLASS C</b>
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.

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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:**

**I<sub>a</sub> = 200.1.2.10**

**S<sub>a</sub> = 255.255.255.128**

**B:**

**I<sub>b</sub> = 200.1.2.69**

**S<sub>b</sub> = 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

Sa: 11111111.11111111.11111111.10000000

---

NIDaa : 11001000.00000001.00000010.00000000

**200.1.2.0**

Ib : 11001000.00000001.00000010.01000101

Sa: 11111111.11111111.11111111.10000000

---

NIDba : 11001000.00000001.00000010.00000000

**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

Sb: 11111111.11111111.11111111.11000000

NIDba : 11001000.00000001.00000010.01000000

200.1.2.64

Ia : 11001000.00000001.00000010.00001010

Sb: 11111111.11111111.11111111.11000000

NIDaa : 11001000.00000001.00000010.00000000

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 ?**

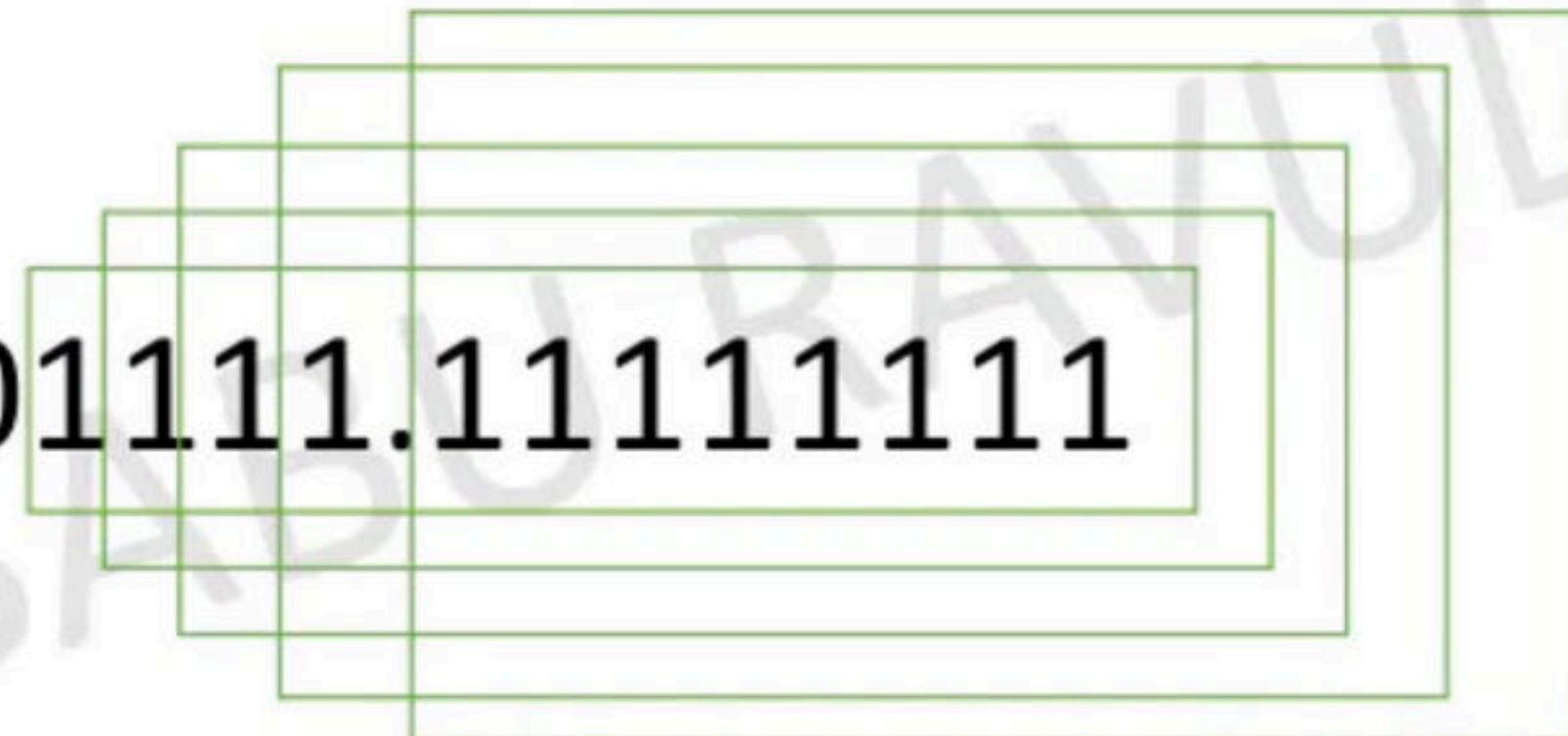
**Example 3:**

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

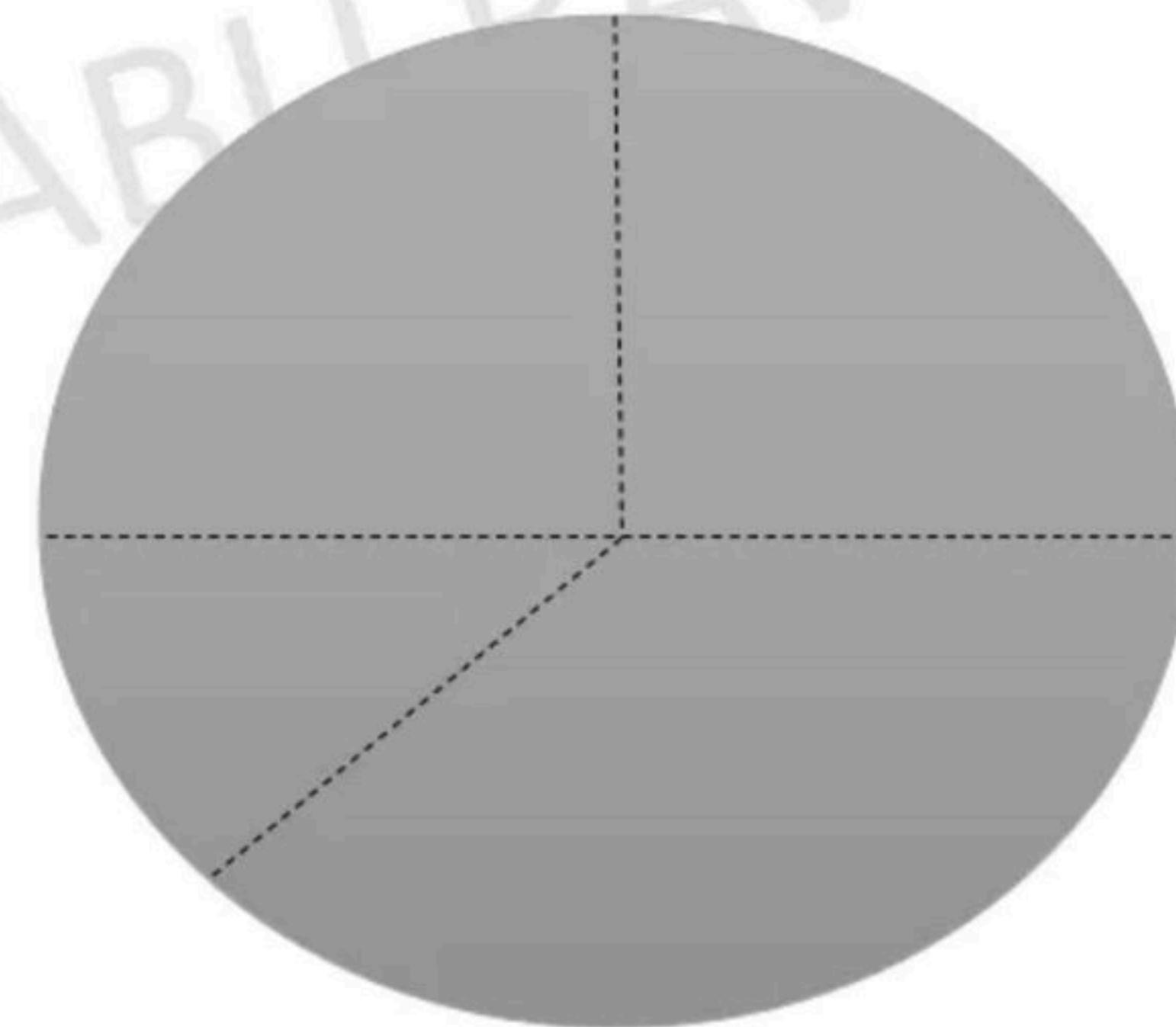
Variable Length Subnet Masking

## 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.

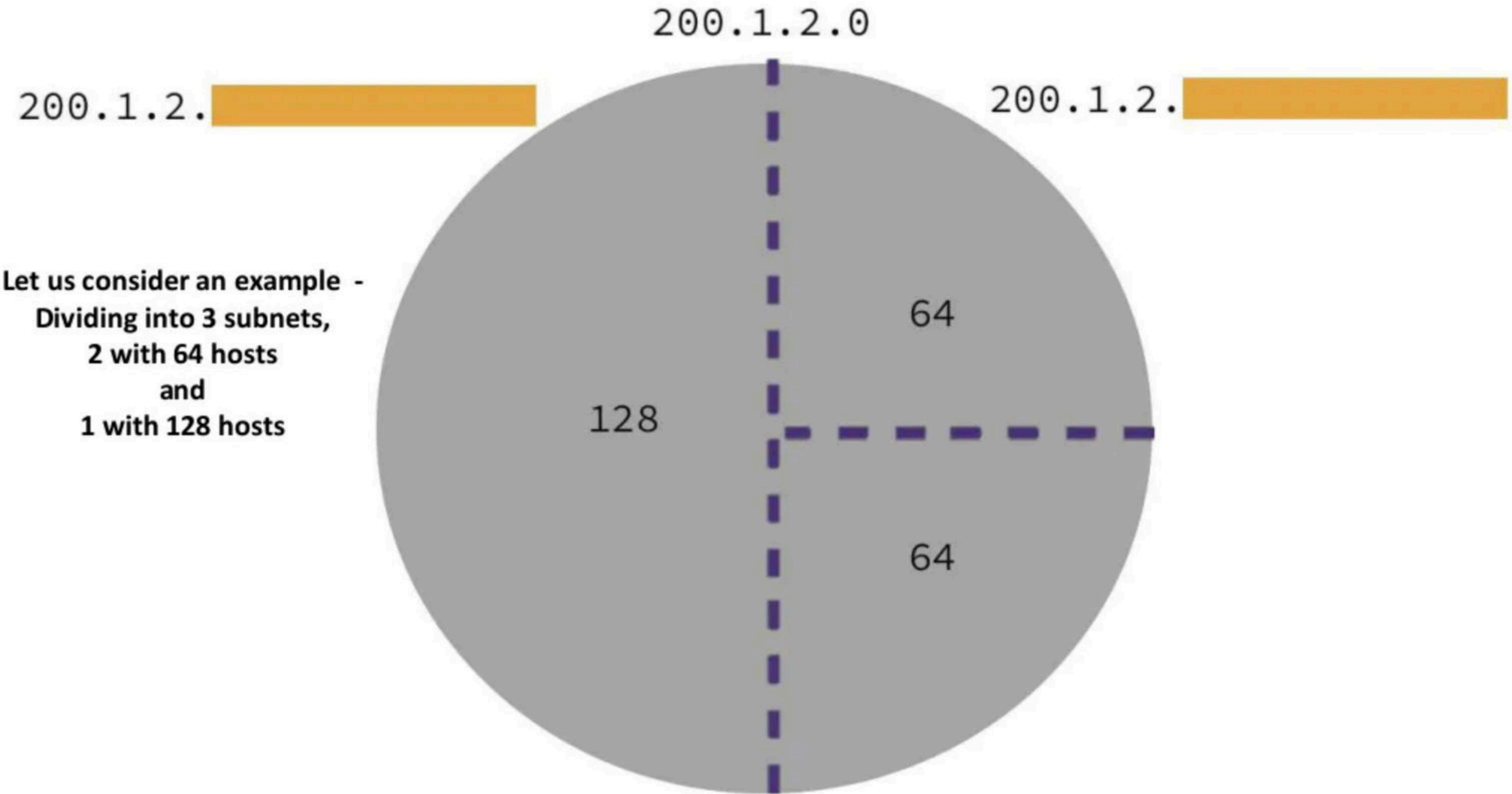
Let us take an Example



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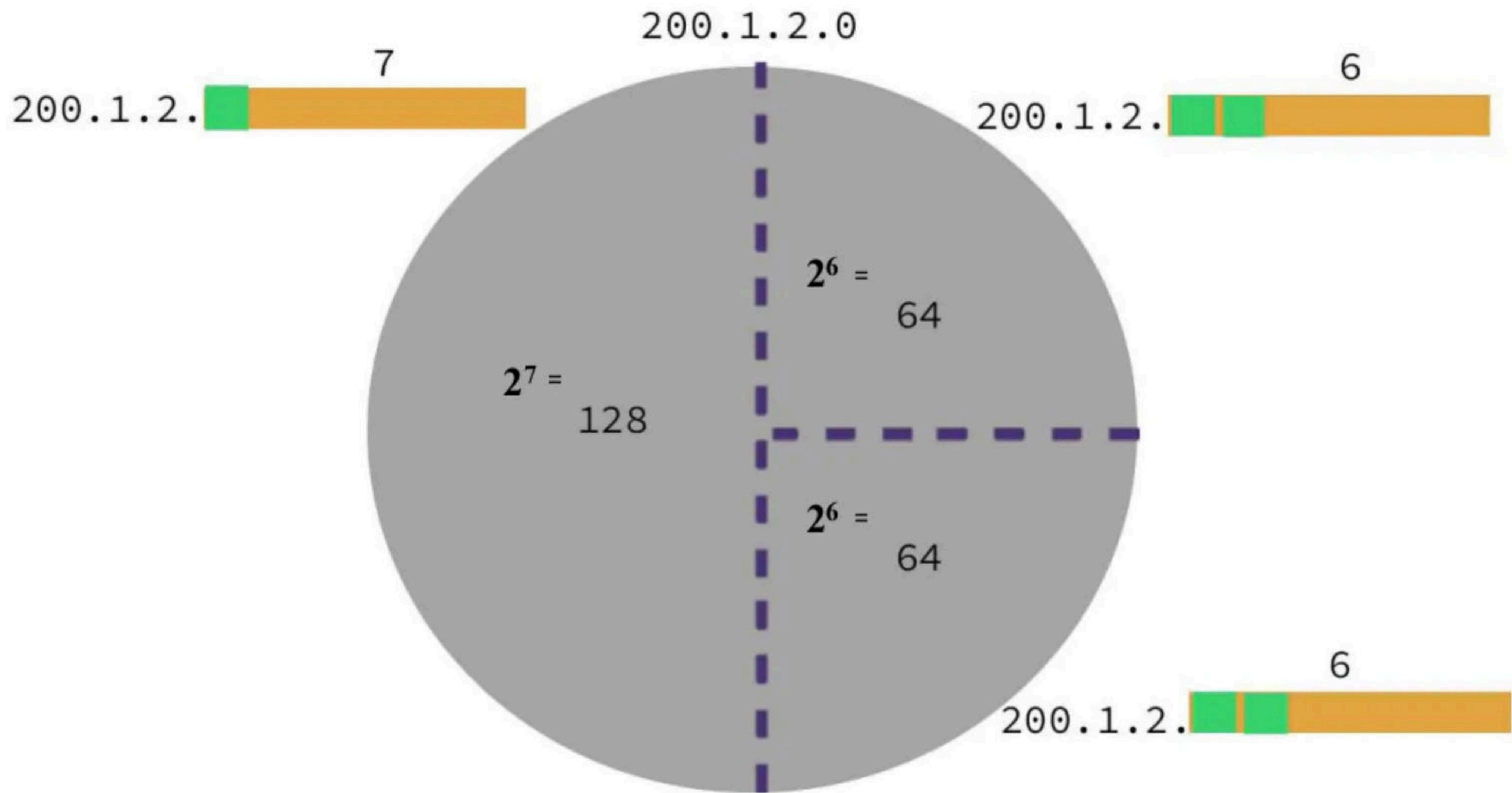
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**Let us consider an example -**  
**Dividing into 3 subnets,**  
**2 with 64 hosts**  
**and**  
**1 with 128 hosts**



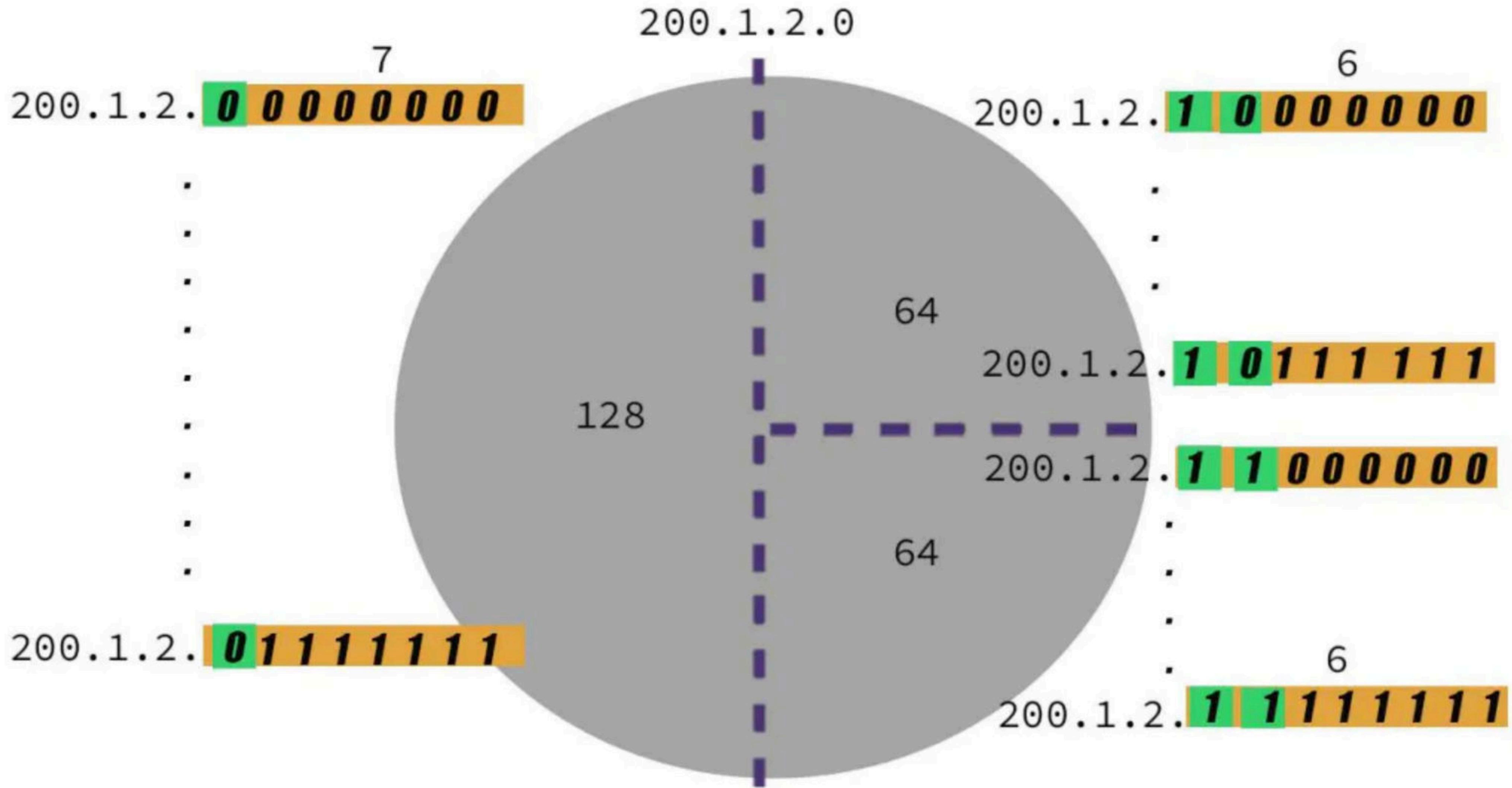
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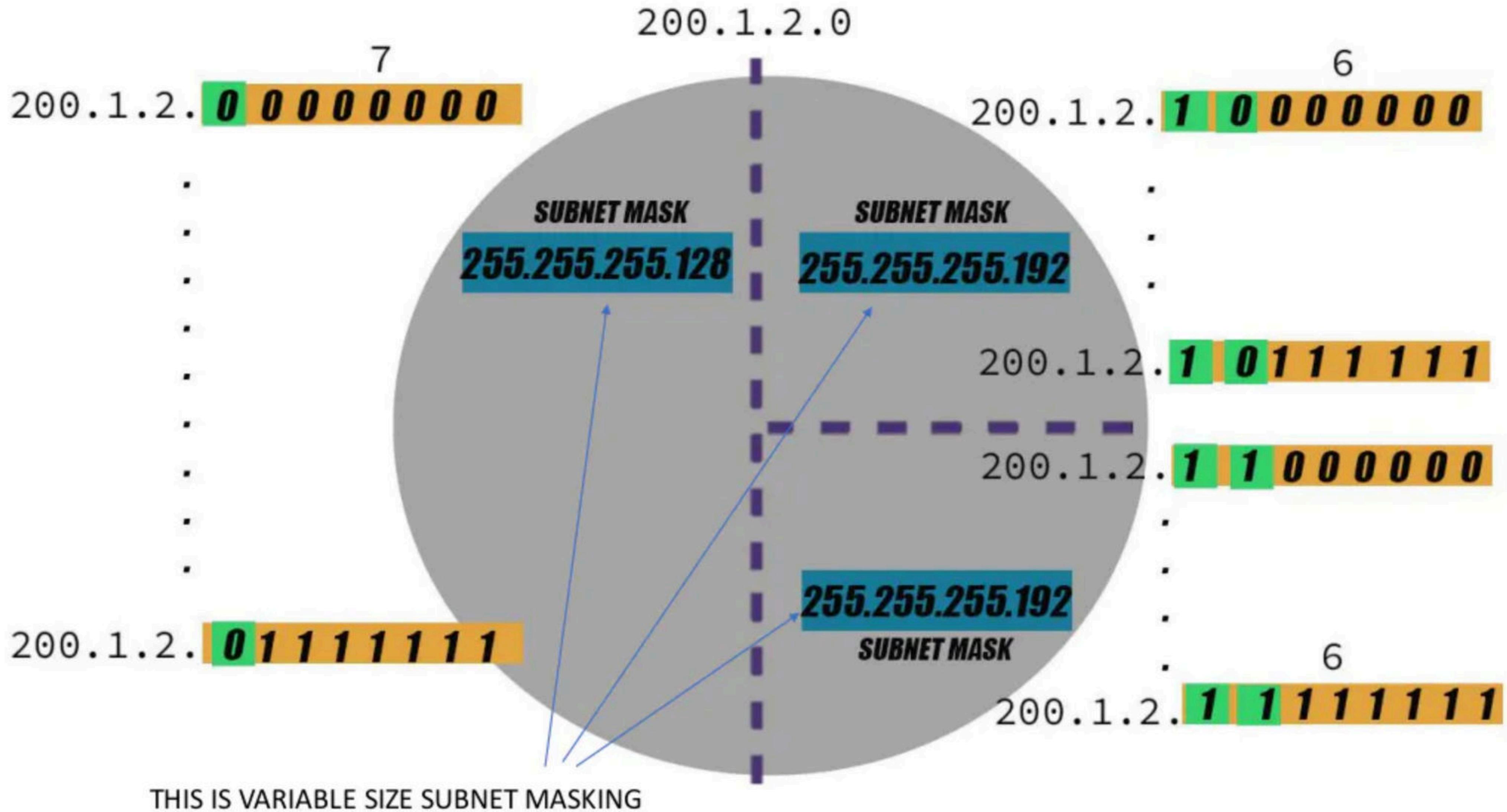
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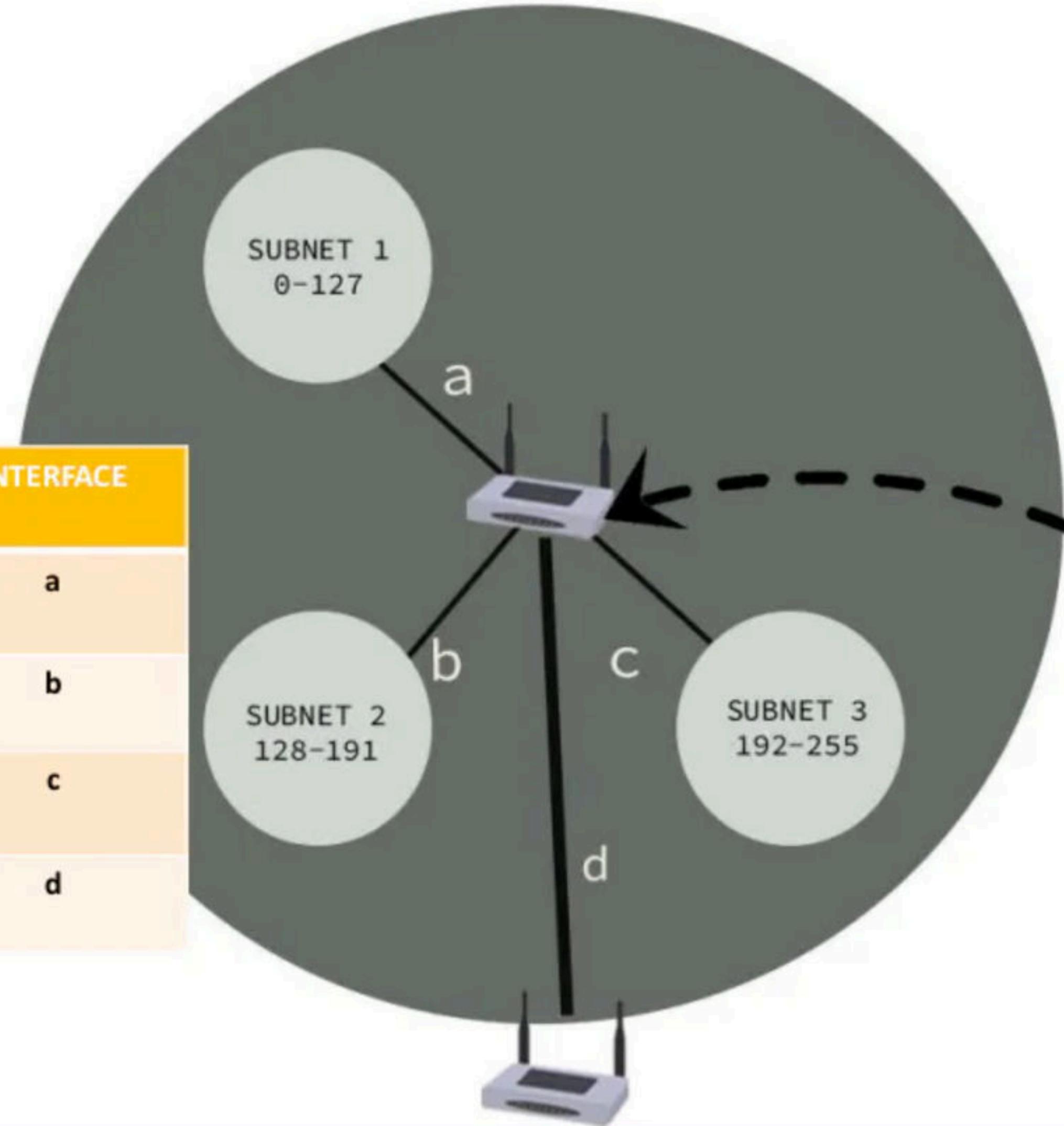
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200.1.2.0



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

PACKETS TO  
200.1.2.130



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## **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

$IP/network = 2^6$

$Hosts/subnet=2^6-2$

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**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  
11111111.11111111.1111000.00000000.

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 =  $2048 - 2 = 2046$