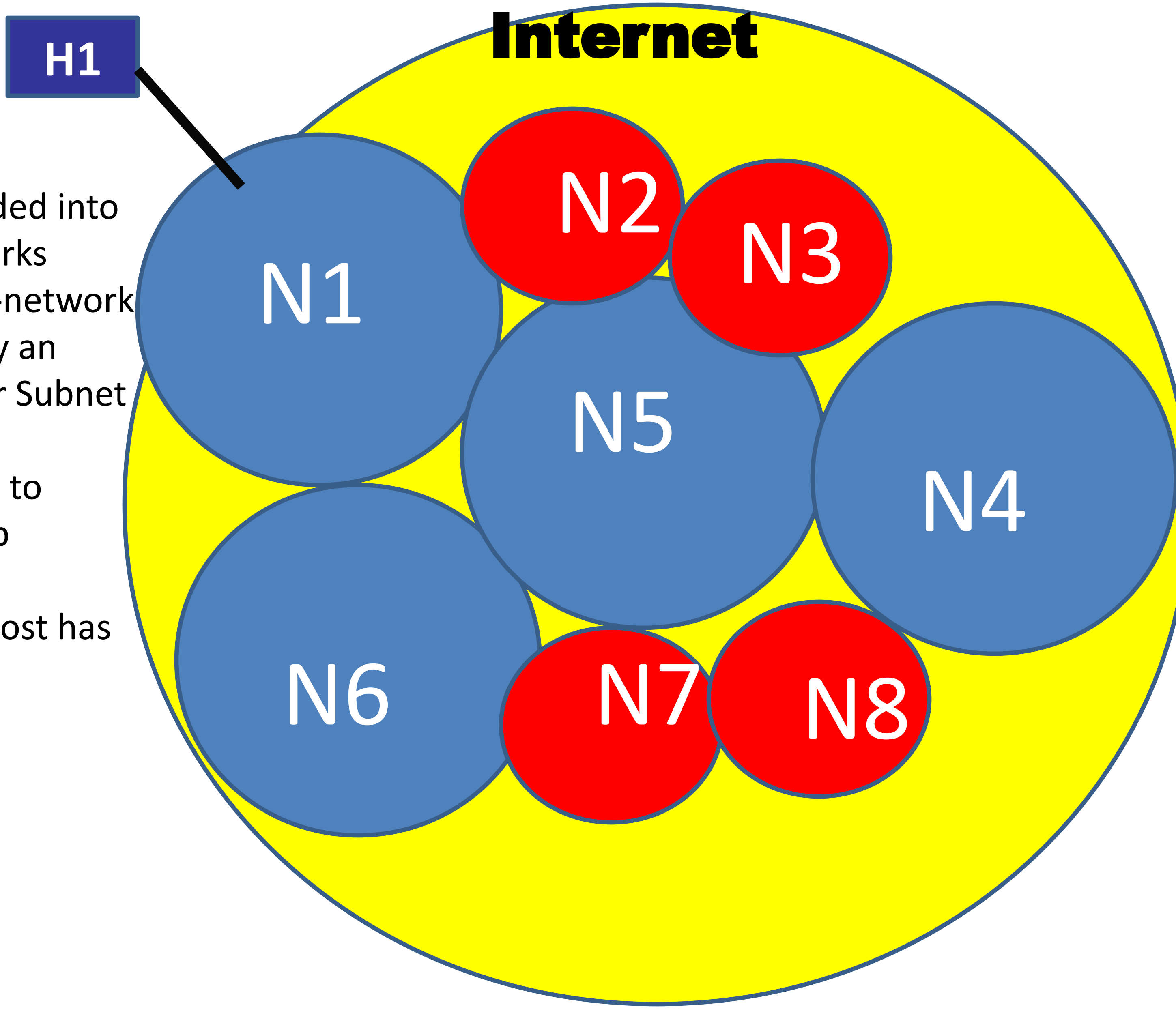
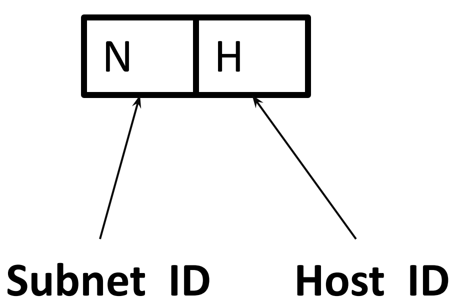
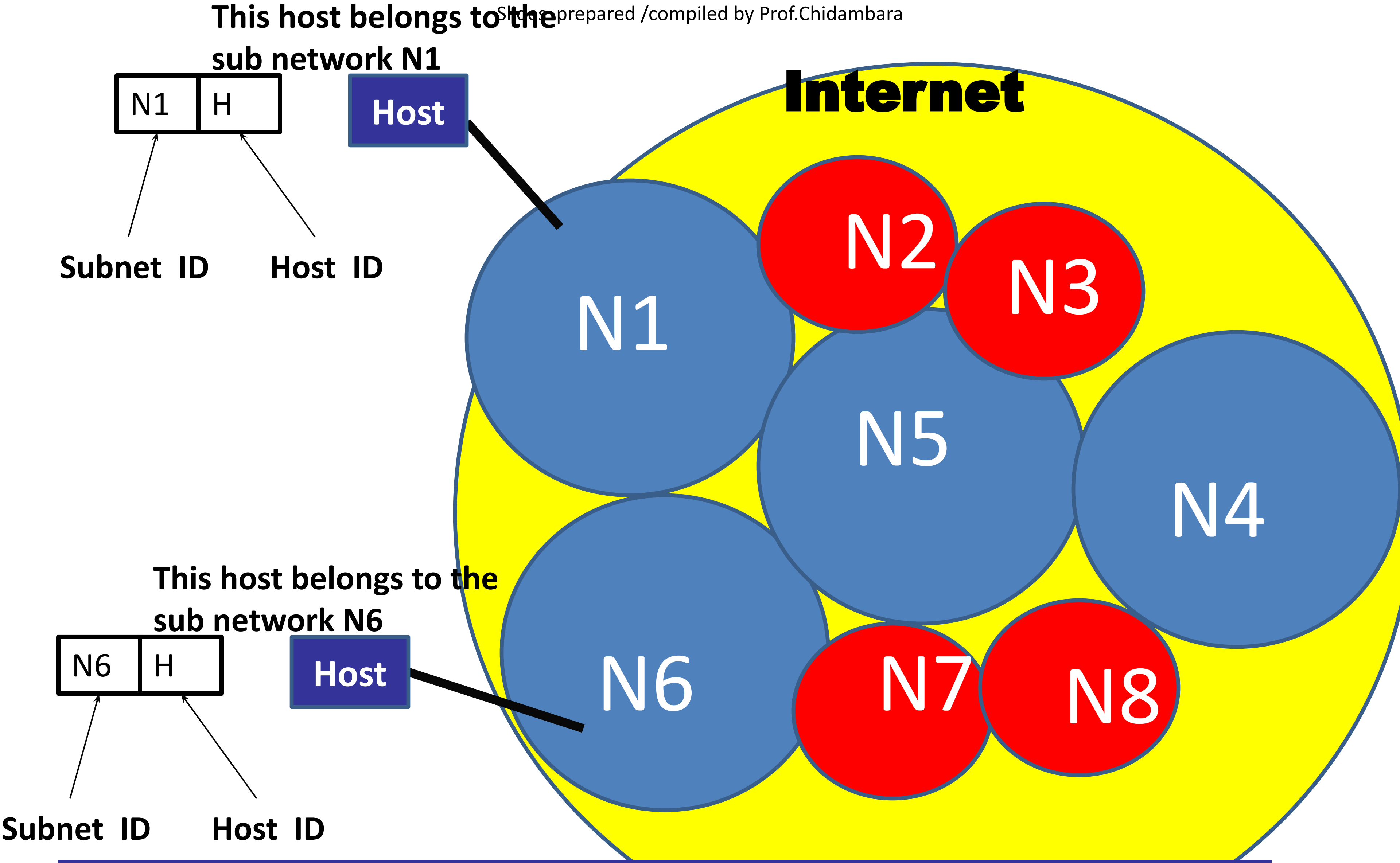
Network Layer: Logical Addressing (IP Addressing)

Every host / gadget connected to internet, must have an **unique IP address**,

- Internet is network of networks
- Global internet is divided into hundreds of sub-networks
- Each Network or Sub-network is uniquely identified by an address (Network ID or Subnet ID)
- every host connected to internet is part of a sub network.
- So , the address of a host has 2 parts





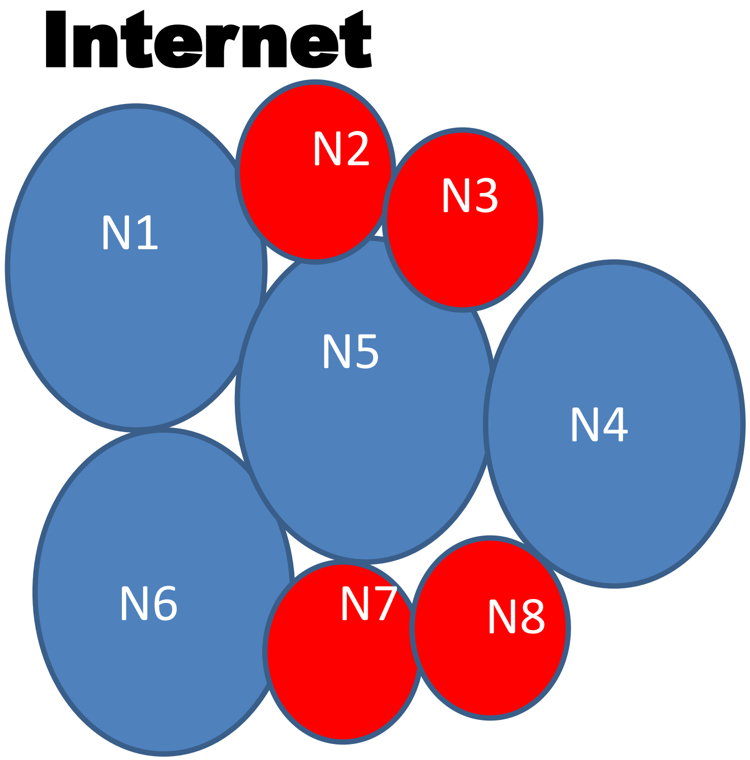


Example

If the IP address of a host connected to a sub network is 192.168.1.1/24, its sub net ID is 192.168.1.0 …..how…..details letter

So, the IP address, depends on the network to which it is connected.

The IP address ,when a client is connected at home is different from when it is connected at college campus.

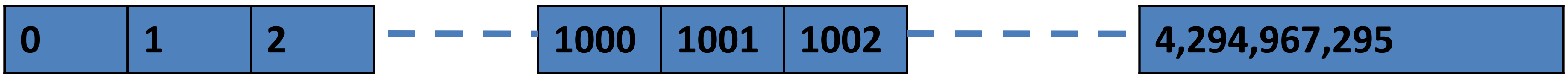


IPv4 ADDRESSES

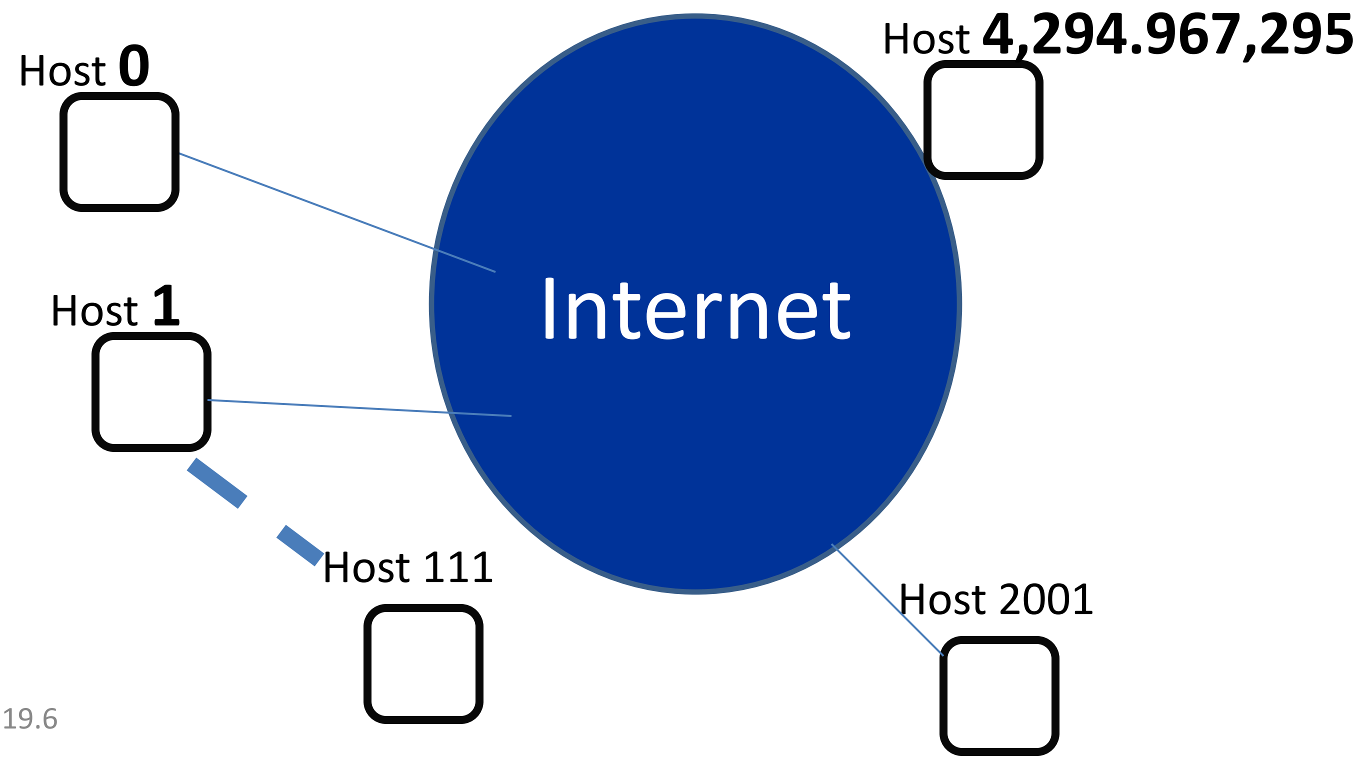
An IPv4 address is a 32-bit address that uniquely and universally defines the connection of a device (for example, a computer or a router) to the Internet.

The address space supported by IPv4 is :
2^{32} or 4,294,967,296.

Ideally, every smart device connected to internet should have an IP address in the following address space



Theoretically, from the addressing point of view, this is how it looks like

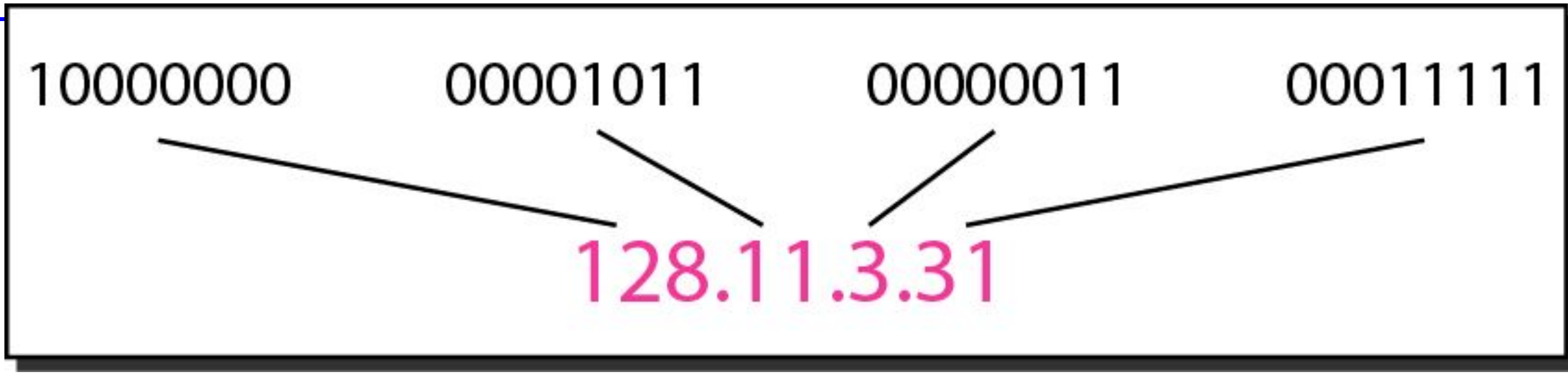


Since internet is a public network, address space has to be controlled by some authority

Who ?

Internet Corporation for Assigned Names and Numbers **(ICANN)**

Dotted-decimal notation and binary notation for an IPv4 address



First address	
Binary	Equivalent Dotted decimal notation
00000000 00000000 00000000 00000000	**0.0.0.0**
Intermediate address (Random)	
10000000 10000001 10000010 11111111	128.129.130.255
Last address	
11111111 11111111 11111111 11111111	**255.255.255.255**

Example 19.1

Change the following IPv4 addresses from binary notation to dotted-decimal notation.

a. 10000001 00001011 00001011 11101111

b. 11000001 10000011 00011011 11111111

Solution

We replace each group of 8 bits with its equivalent decimal number (see Appendix B) and add dots for separation.

a. 129.11.11.239

b. 193.131.27.255

Example 19.2

Change the following IPv4 addresses from dotted-decimal notation to binary notation.

a. 111.56.45.78

b. 221.34.7.82

Solution

We replace each decimal number with its binary equivalent (see Appendix B).

a. 01101111 00111000 00101101 01001110

b. 11011101 00100010 00000111 01010010

Example 19.3

Find the error, if any, in the following IPv4 addresses.

a. 111.56.045.78

b. 221.34.7.8.20

c. 75.45.301.14

d. 11100010.23.14.67

Solution

a. There must be no leading zero (045).

b. There can be no more than four numbers.

c. Each number needs to be less than or equal to 255.

d. A mixture of binary notation and dotted-decimal notation is not allowed.

In classful addressing, the address space is divided into five classes: A, B, C, D, and E.

This was the earlier version of IP address allocation ; Now has become obsolete.

However for learning purpose, knowing this is important

&

to appreciate the improved (current) version i.e. Classless address

Figure 19.2 *Finding the classes in binary and dotted-decimal notation*

	First byte	Second byte	Third byte	Fourth byte
Class A	0			
Class B	10			
Class C	110			
Class D	1110			
Class E	1111			

a. Binary notation

	First byte	Second byte	Third byte	Fourth byte
Class A	0–127			
Class B	128–191			
Class C	192–223			
Class D	224–239			
Class E	240–255			

b. Dotted-decimal notation

Number of blocks and block size in classful IPv4 addressing

Class	*Number of Blocks*	*Block Size*	*Application*
A	128	16,777,216	Unicast
B	16,384	65,536	Unicast
C	2,097,152	256	Unicast
D	1	268,435,456	Multicast
E	1	268,435,456	Reserved

Find the class of each address.

a. 00000001 00001011 00001011 11101111

b. 11000001 10000011 00011011 11111111

c. 14.23.120.8

d. 252.5.15.111

Solution

a. The first bit is 0. This is a class A address.

b. The first 2 bits are 1; the third bit is 0. This is a class C address.

c. The first byte is 14; the class is A.

d. The first byte is 252; the class is E.

Concept of Network Mask or Subnet Mask

Whenever a host connected to internet is to be identified or configured, 2 numbers are used

1. IP Address
2. Network mask or subnet mask

Table 19.2 *Default masks for classful addressing*

Class	*Binary*	*Dotted-Decimal*	*CIDR*
A	**11111111** 00000000 00000000 00000000	**255**.0.0.0	/8
B	**11111111 11111111** 00000000 00000000	**255.255**.0.0	/16
C	**11111111 11111111 11111111** 00000000	**255.255.255**.0	/24

Network mask or subnet mask is used to find out the network id or subnet id to which a host belongs to.

Disadvantage of traditional Classfull addressing

In classfull addressing, a large part of the available addresses were wasted.

Why ?

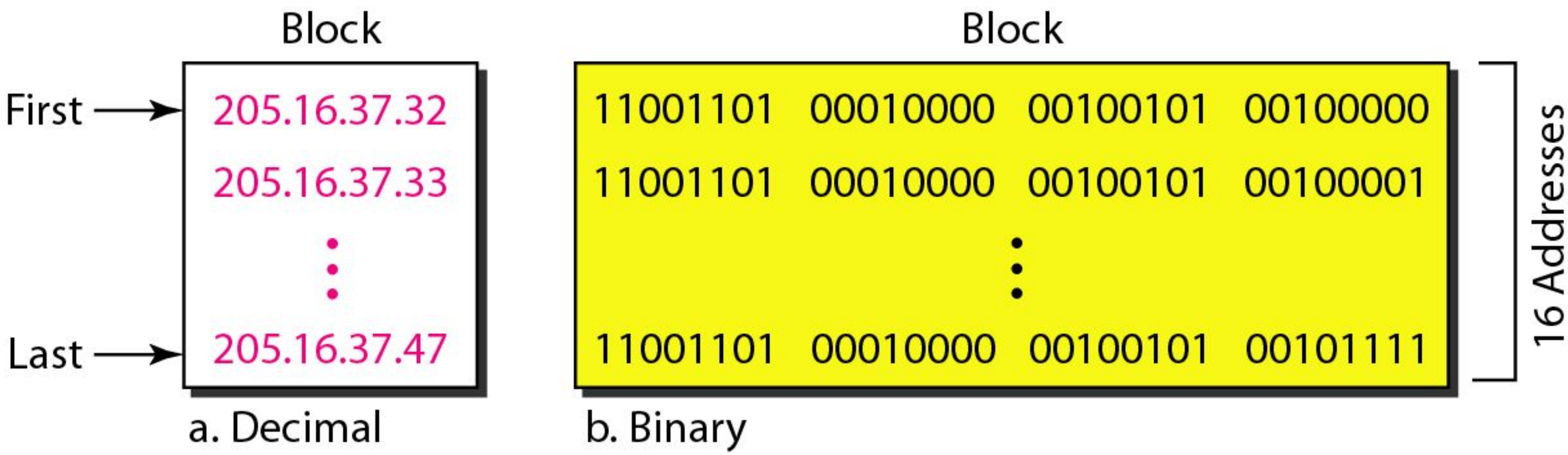
“ find out the answer “

Classless
(also called Classless Internet Domain Routing –CIDR) address mechanism is used in modern internet

In Classless addressing,
required block of addresses for a subnet can be allocated,
in order to
efficiently use the address space..

Classless address Concept

Example : A block of 16 addresses granted to a small organization



Note

In IPv4 classless addressing, a block of addresses can be defined as

x.y.z.t /*n*

in which x.y.z.t defines one of the addresses and the /*n* defines the mask.

Any sub network is characterized by the following 4 parameters :

1. Subnet ID
2. Total number of addresses in that subnet / block (Address space)
3. First usable address
4. Last usable address

x.y.z.t /*n*

Note

The number of addresses in the block can be found by using the formula

$$2^{32-n}.$$

Example 19.8

Find the number of addresses in Example 19.6.

Solution

The value of n is 28, which means that number of addresses is 2^{32-28} *or 16.*

x.y.z.t /*n*

The first address in the block can be found by setting the rightmost
$32 - n$ bits to 0s.

A block of addresses is granted to a small organization. We know that one of the addresses is 205.16.37.39/28. What is the first address in the block?

Solution

The binary representation of the given address is

11001101 00010000 00100101 00100111

If we set 32−28 rightmost bits to 0, we get

11001101 00010000 00100101 0010000

or

205.16.37.32.

x.y.z.t /*n*

Note

The last address in the block can be found by setting the rightmost
32 − n bits to 1s.

Example 19.7

Find the last address for the block in Example 19.6.

Solution

The binary representation of the given address is

11001101 00010000 00100101 00100111

If we set 32 − 28 rightmost bits to 1, we get

11001101 00010000 00100101 00101111

or

205.16.37.47

This is actually the block shown in Figure 19.3.

'Rules' of IP addressing

The **first address** in a block /subnet is normally **not assigned to any device** in the subnet; it is used as the **subnet ID** that represents the complete subnet to the rest of the world.

The **Last address** in a block is normally **not assigned to any device**; it is used as a special **address to broadcast** a packet to all the hosts in that subnet

So, total number of usable addresses in a subnet is always total number of addresses available – 2
For example in a clasfull addressing, in class C, only 254 addresses can be used to configure hosts.

Each address in the block can be considered as a two-level hierarchical structure:
the leftmost *n* bits (prefix) define the network;
the rightmost $32 - n$ bits define the host.

Role of subnet mask in IP address

Every IP address assigned to a host must be accompanied by another parameter called Subnet Mask

Example

IP address : 10. 20. 30. 4

Subnet mask : 255.255.255.0

Suffix

When subnet mask is ANDed with IP address following number is resulted:

10.20.30.0

Which is the subnet ID to which the respective host belongs to

Combination of IP address and Subnet mask can also be represented in following notation :

x.y.z.t /*n*

IP address : 10. 20. 30. 4

Subnet mask : 255.255.255.0

is also represented as

10.20.30.4/24

Suffix

Why 24 ?

Number of 1s in the subnet mask

One more example

IP address : 10. 20. 30. 4

Subnet mask : $\boxed{255.\ 255.}$ 0. 0

Suffix

Subnet ID : 10.20.0.0

x.y.z.t /*n notation*

IP address : 10. 20. 30. 4

Subnet mask : $\boxed{255.\ 255.}$ 0. 0

Suffix

Is equivalent to

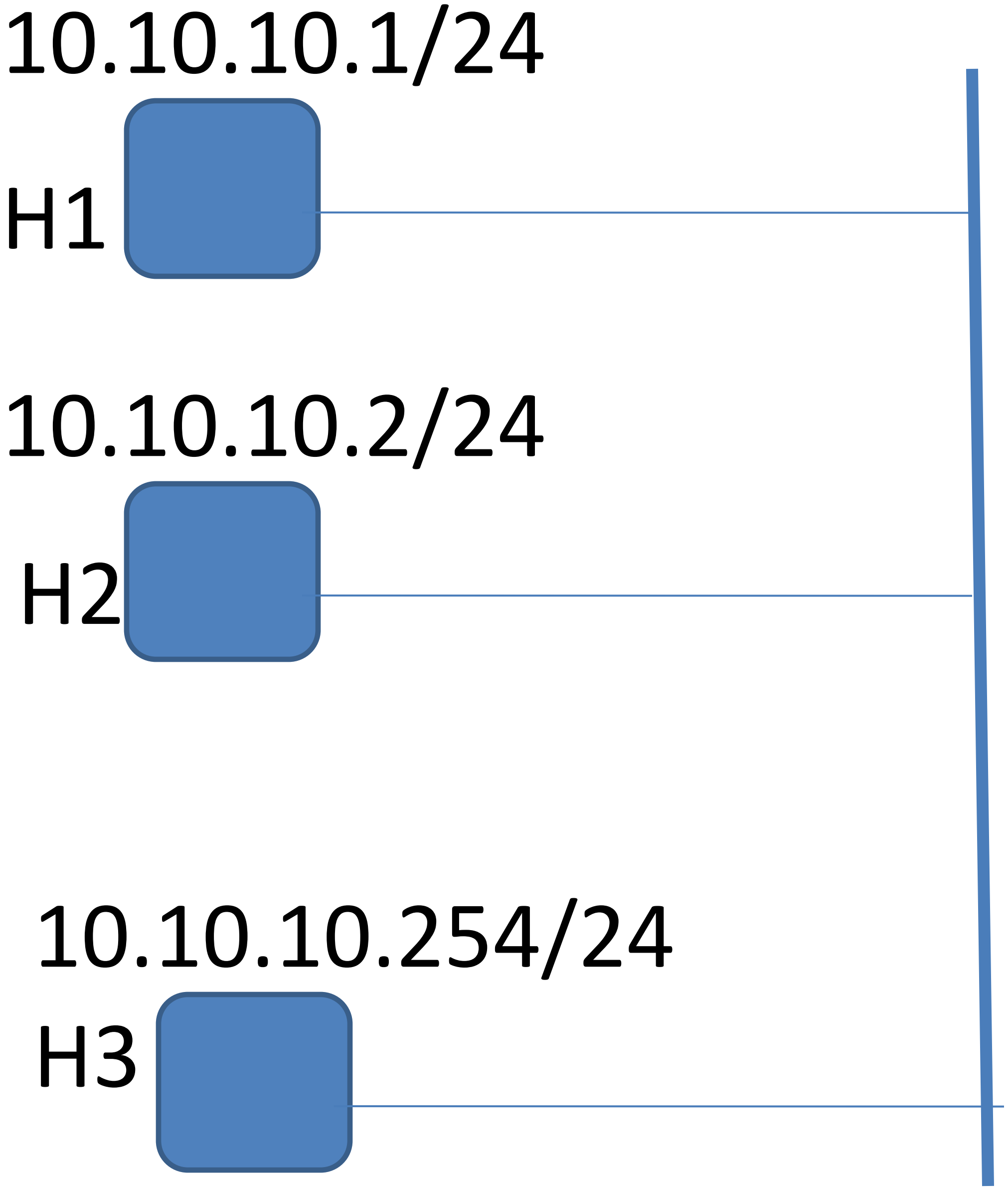
10.20.30.4/16

Why 16

Number of 1s in the subnet mask is 16

summary

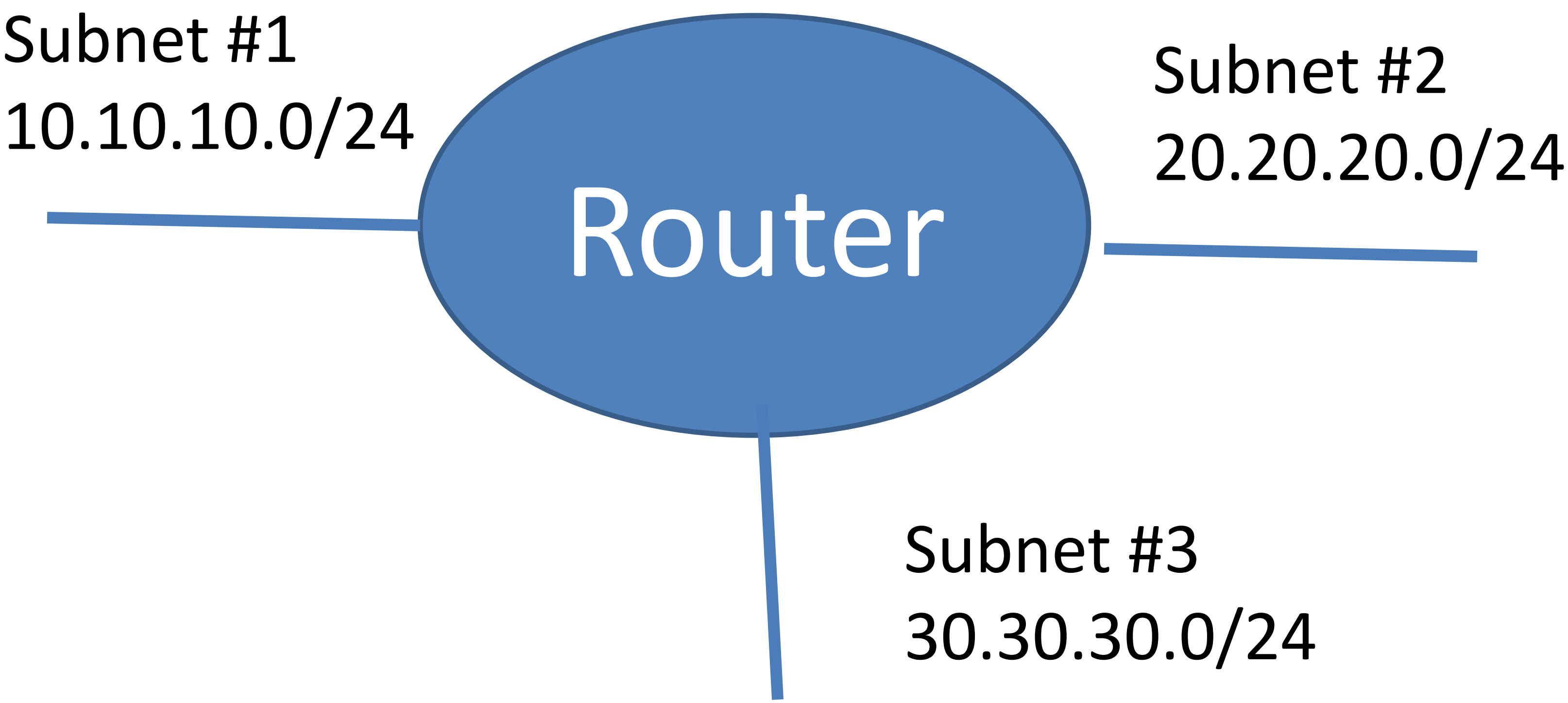
Purpose of
Subnet mask (or /suffix number)
is
to find out
to which subnet
the respective host belongs to



H1 , H2 & H3 belong to one subnet because subnet id of each of these addresses is 10.10.10.0

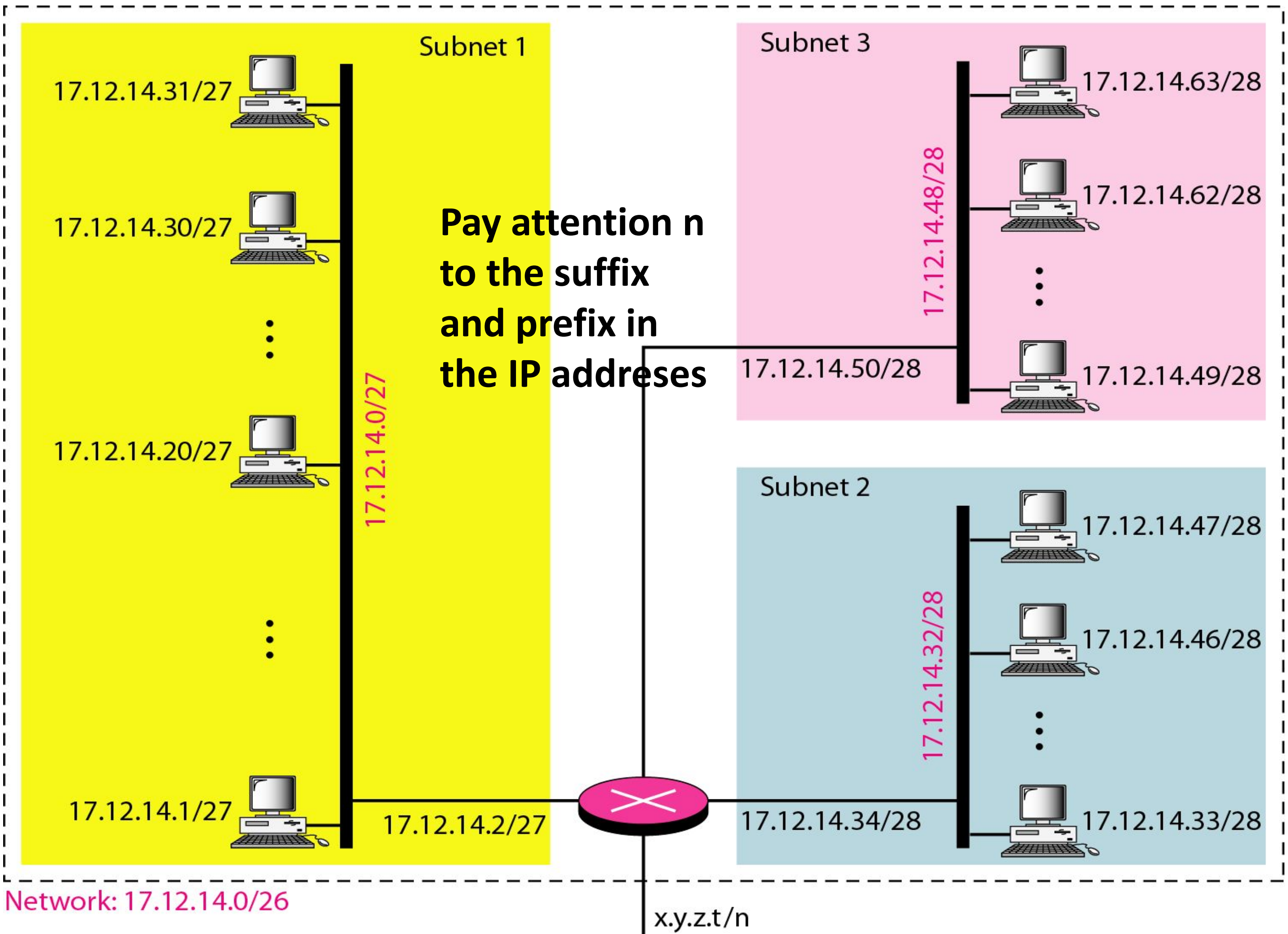
IF SUBNET ID IS SAME THEN THE HOSTS BELONG TO SAME SUBNET

Two or more subnets can be networked only using Routers not using Switch or Hub



Example :

*A*n network address space 17.12.14.0/26 is segmented in to 3 subnets



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IPV4 addressing - Major challenge for the technologists :

Only 4 billion addresses are available ; But number of hosts/gadgets to be connected is more than 4 billion.

Because of mobile revolution, users are exponentially growing.

How to manage the demand and supply problem ???

Demand (for more IP addresses)

Supply problem (limited IP addresses)

How to provide address for growing number of users ?

Temporary (Ad-hoc solutions)

1.Classless Addressing
2. DHCP
3.NAT

Permanent Solution

IPV6