TOPIC:
IP ADDRESSING AND SUBNETTING

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WHAT IS IP ADDRESSING?

“ AN IP ADDRESSING IS AN ADDRESS USED IN ORDER TO UNIQUELY IDENTIFY A DEVICE ON AN IP NETWORK.
THE ADDRESS IS MADE UP OF 32 BINARY BITS, WHICH CAN BE DIVISIBLE INTO A NETWORK PORTION AND HOST PORTION WITH THE HELP OF A SUBNET MASK. THE 32 BINARY BITS ARE BROKEN INTO FOUR OCTETS (1 OCTET = 8 BITS) ”

Internet Address

- What is an IP Address?
  - An **IP address** (**Internet Protocol address**) is a number that *uniquely identifies each computer or device connected to the Internet*.

- Why does an IP Address exist?
  - It exists as *the Internet relies on an addressing system* much like the postal service *to send data and information to a computer at a specific destination*.

<u>*Note*</u>: No two machine have the same IP address.

- **Address -** The unique number ID assigned to one host or interface in a network.
- **Subnet -** A portion of a network that shares a particular subnet address.
- **Subnet mask -** A 32-bit combination used to describe which portion of an address refers to the subnet and which part refers to the host.
- **Interface -** A network connection.

Lets understand IP (Internet Protocol) Addresses :

8 8 8 8

00000000.00000000.00000000.00000000(binary representation)

Example:

172.16.81.100(Class 2 IP address)

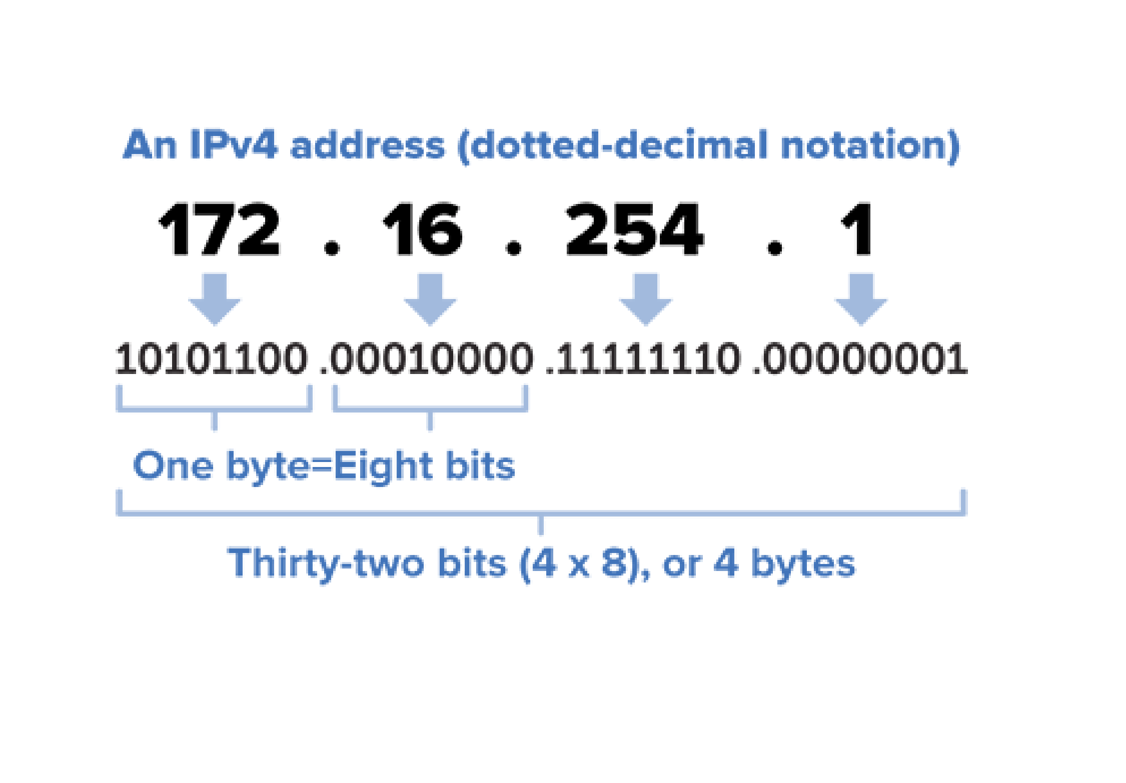
Range:

The value in each octet ranges from 0 to 255 decimal, or 00000000 - 11111111 binary.

Here is how binary octets convert to decimal:

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

(128+64+32+16+8+4+2+1=255)


An IPv4 address (dotted-decimal notation)
172 . 16 . 254 . 1
10101100 .00010000 .11111110 .00000001
One byte=Eight bits
Thirty-two bits (4 x 8), or 4 bytes

Here is a sample octet conversion when not all of the bits are set to 1.

0 1 0 0 0 0 0 1

0 64 0 0 0 0 0 1

(0+64+0+0+0+0+0+1=65)

And this sample shows an IP address represented in both binary and decimal.

10. 1. 23. 19 (decimal) 00001010.00000001.00010111.00010011 (binary)

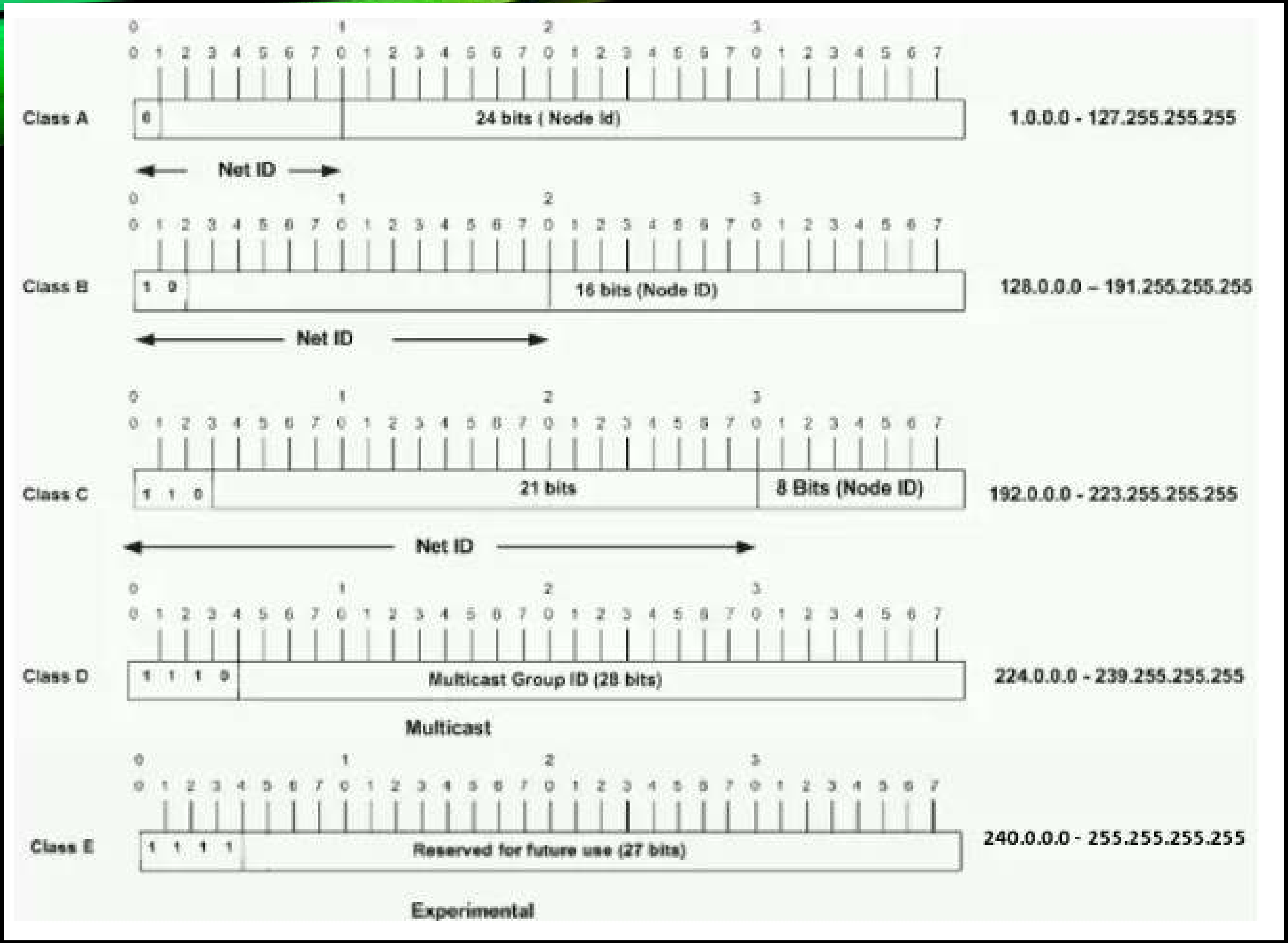
Classful Addressing

The 32 bit IP address is divided into five sub-classes. These are:

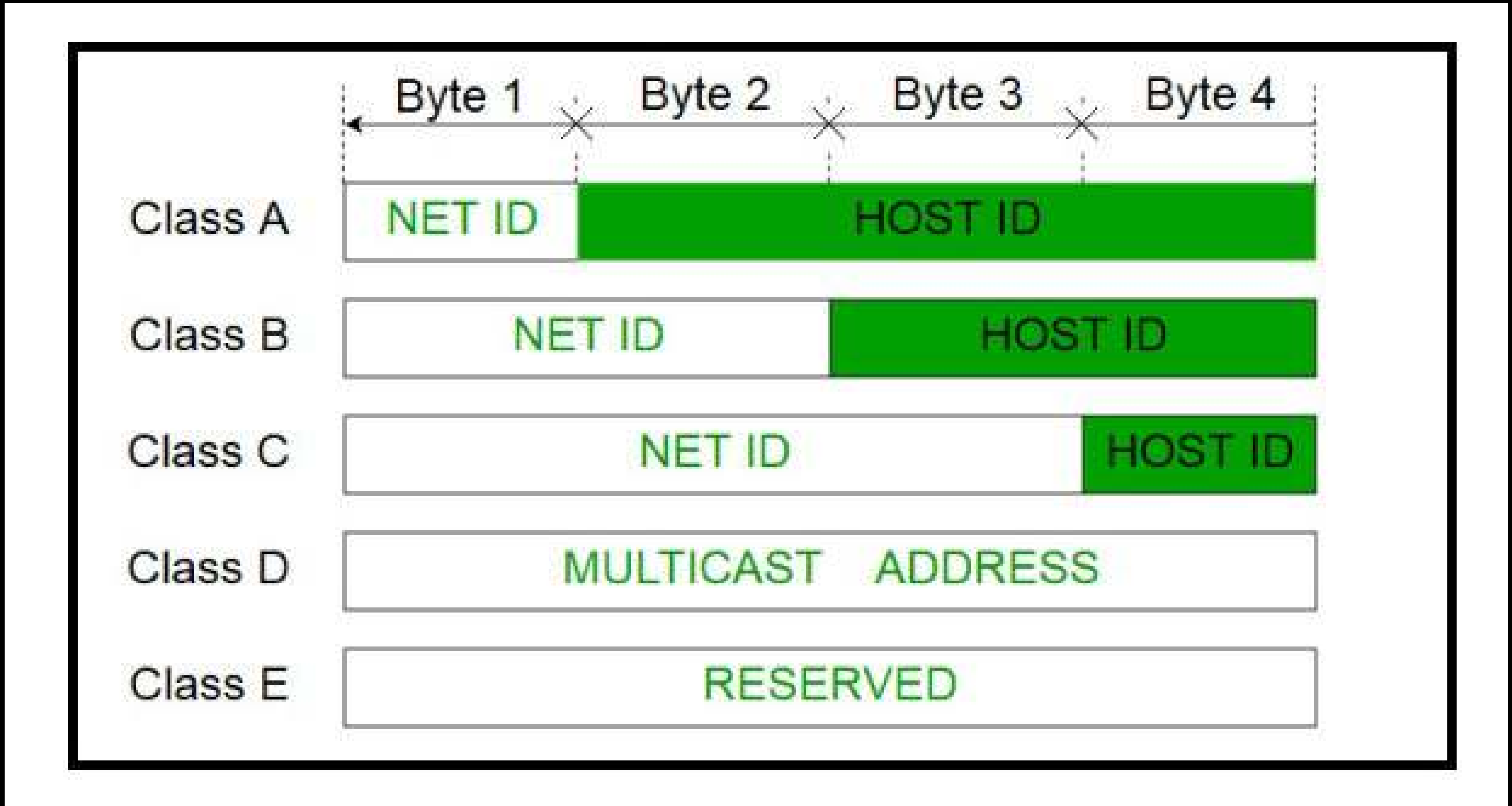
- Class A (0-126) “127 is special address and reserved for local host”
- Class B(128-191)
- Class C(192-223)
- Class D(224-239)
- Class E(240-255)

Each of these classes has a valid range of IP addresses. Classes D and E are reserved for multicast and experimental purposes respectively.The order of bits in the first octet determine the classes of IP address.
IPv4 address is divided into two parts:

- **Network ID**
- **Host ID**



Class A
0
24 bits (Node Id)
1.0.0.0 - 127.255.255.255
Net ID
Class B
1 0
16 bits (Node ID)
128.0.0.0 – 191.255.255.255
Net ID
Class C
1 1 0
21 bits
8 Bits (Node ID)
192.0.0.0 - 223.255.255.255
Net ID
Class D
1 1 1 0
Multicast Group ID (28 bits)
224.0.0.0 - 239.255.255.255
Multicast
Class E
1 1 1 1
Reserved for future use (27 bits)
240.0.0.0 - 255.255.255.255
Experimental


Byte 1
Byte 2
Byte 3
Byte 4
Class A
NET ID
HOST ID
Class B
NET ID
HOST ID
Class C
NET ID
HOST ID
Class D
MULTICAST ADDRESS
Class E
RESERVED

CLASS A:

- In a Class A address, the first octet is the network portion. Octets 2, 3, and 4 (the next 24 bits) are for the host portion.

N . H . H . H

First address in the network is Network address for example:

1.0.0.0

Last address in the network is reserved for broadcast for example:

1.0.0.255

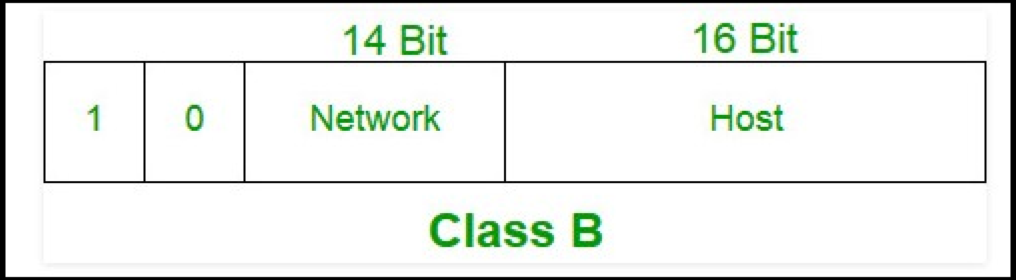
First usable address is 1.0.0.1 and last usable address 1.0.0.254

CLASS B:

- In a Class B address, the first two octets are the network portion. Octets 3, and 4 (the next 16 bits) are for the host portion.

N . N . H . H

- The network ID is 16 bits long.
- The host ID is 16 bits long.



First address in the network is Network address for example:

128.12.10.0

Last address in the network is reserved for broadcast for example:

128.12.10.255

First usable address is 128.12.10.1 and last usable address 128.12.10.254

CLASS C:

- In a Class C address, the first three octets are the network portion. Octets 4 (the last 8 bits) are for the host portion.

  N . N . N . H

- The network ID is 24 bits long.
- The host ID is 8 bits long.

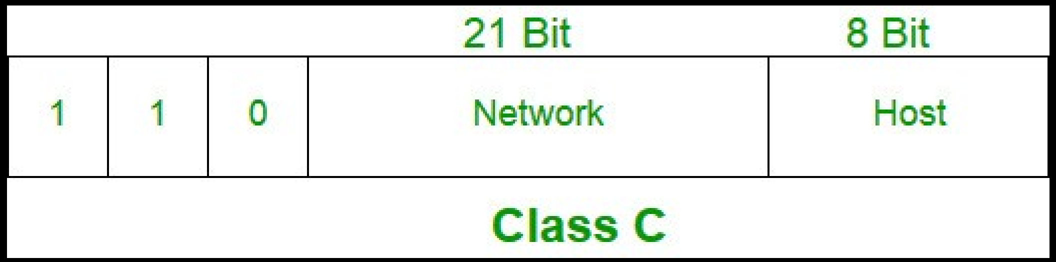
First address in the network is Network address for example:

192.168.1.0

Last address in the network is reserved for broadcast for example:

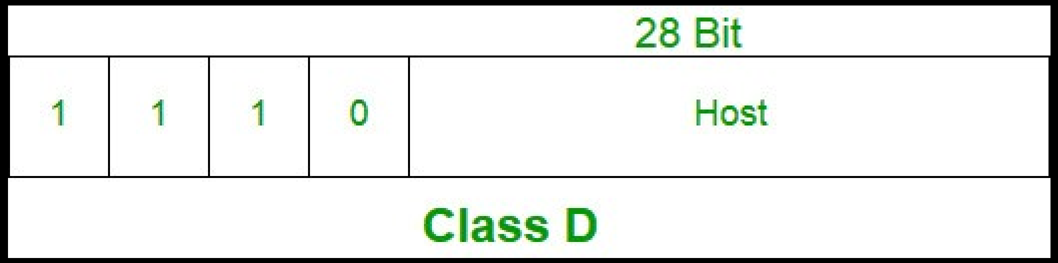
192.168.1.255

First usable address is 192.168.1.1 and last usable address is 192.168.1.254



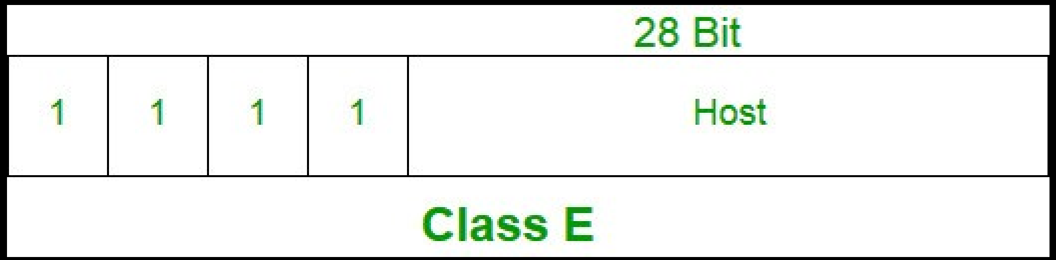
CLASS D:

- IP address belonging to class D are reserved for multi-casting. The higher order bits of the first octet of IP addresses belonging to class D are always set to 1110. The remaining bits are for the address that interested hosts recognize.
- Class D does not posses any sub-net mask. IP addresses belonging to class D ranges from 224.0.0.0 – 239.255.255.255.



CLASS E:

- IP addresses belonging to class E are reserved for experimental and research purposes. IP addresses of class E ranges from 240.0.0.0 – 255.255.255.254. This class doesn't have any sub-net mask. The higher order bits of first octet of class E are always set to 1111.



CLASS	LEADING BITS	NET ID BITS	HOST ID BITS	NO. OF NETWORKS	ADDRESSES PER NETWORK	START ADDRESS	END ADDRESS
CLASS A	0	8	24	2^7 (128)	2^{24} (16,777,216)	0.0.0.0	127.255.255.255
CLASS B	10	16	16	2^{14} (16,384)	2^{16} (65,536)	128.0.0.0	191.255.255.255
CLASS C	110	24	8	2^{21} (2,097,152)	2^8 (256)	192.0.0.0	223.255.255.255
CLASS D	1110	NOT DEFINED	NOT DEFINED	NOT DEFINED	NOT DEFINED	224.0.0.0	239.255.255.255
CLASS E	1111	NOT DEFINED	NOT DEFINED	NOT DEFINED	NOT DEFINED	240.0.0.0	255.255.255.255

CLASSES AND BLOCKS

CLASS A BLOCK:

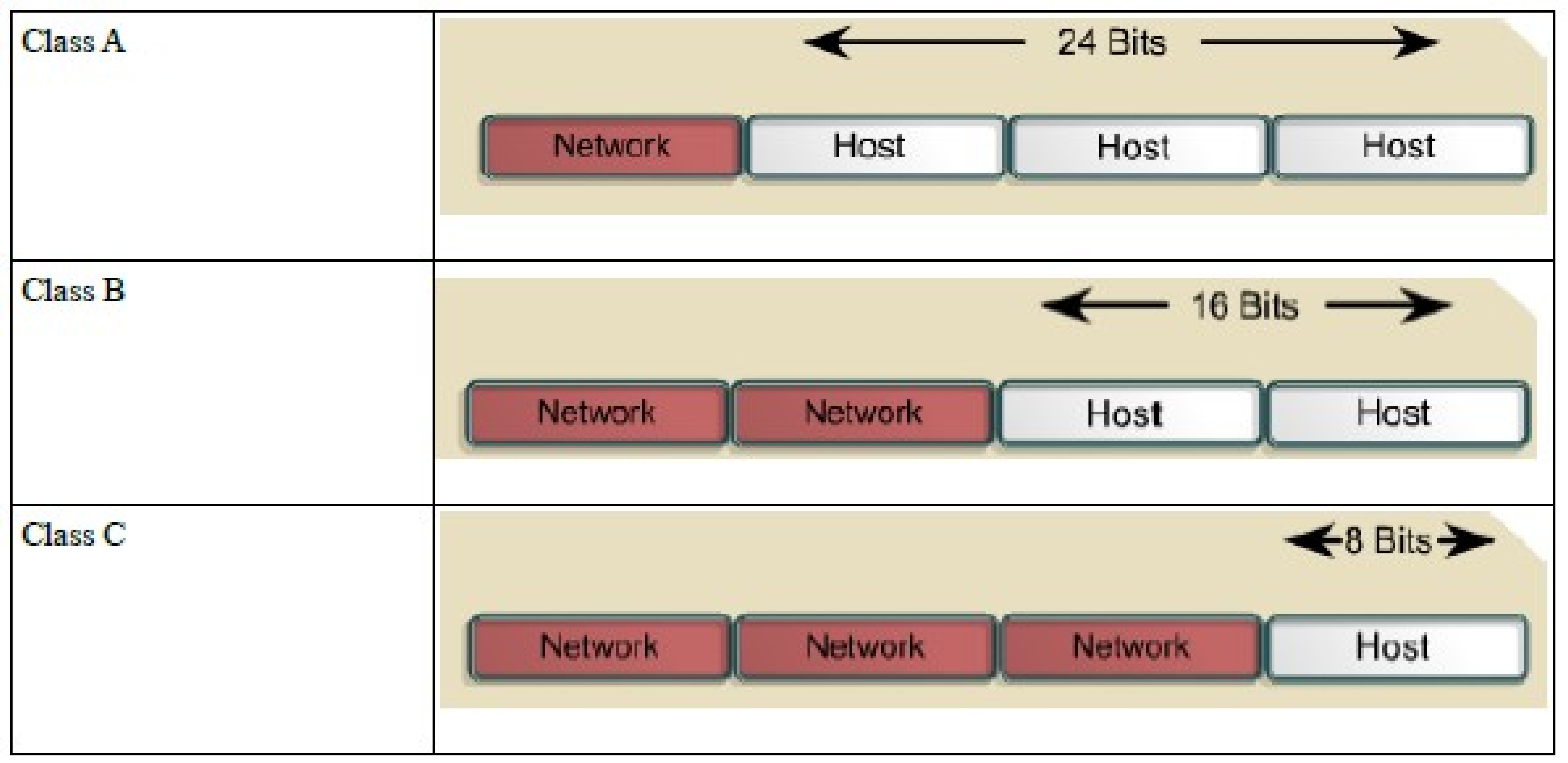
- In class A, one byte define the netid and 3 bytes defines the hostid.
- The first bit of a Class A address is always 0. With that first bit a 0, the lowest number that can be represented is00000000, decimal 0. The highest number that can be represented is 01111111, decimal 127. The numbers 0 and127 are reserved and cannot be used as network addresses. Any address that starts with a value between 1 and26 in the first octet is a Class A address.
- No of Class A Network: 27
- No. of Usable Host address per Network: 224-2 (Minus 2 because 2 addresses are reserved for network and broadcast address)
- In class A, one byte define the netid and 3 bytes defines the hostid.
- for A
  number of blocks = 2^7 as 1 bit is reserved for class identification. (0)
  block size = 2^24

CLASS B BLOCK:

- In class B, two bytes define the netid and 2 bytes defines the hostid.
- The first two bits of the first octet of a Class B address are always 10. The remaining six bits may be populated with either 1s or 0s. Therefore, the lowest number that can be represented with a Class B address is 10000000, decimal 128. The highest number that can be represented is 10111111, decimal 191. Any address that starts with a value in the range of 128 to 191 in the first octet is a Class B address.
- No of Class B Network: 214
- No. of Usable Host address per Network: 216-2
- for B
  number of blocks = 2^14 as 2 bits are reserved for class identification. (10)
  block size = 2^16

CLASS C BLOCK:

- In class C, three bytes define the netid and 1 byte defines the hostid.
- Class C address blocks used a /24 prefix. This meant that a class C network used only the last octet as host addresses with the three high-order octets used to indicate the network address.
- A Class C address begins with binary 110. Therefore, the lowest number that can be represented is 11000000, decimal 192. The highest number that can be represented is 11011111, decimal 223. If an address contains a number in the range of 192 to 223 in the first octet, it is a Class C address.
- No of Class C Network: 221
- No. of Usable Host address per Network: 28-2
- for C
  number of blocks = 2^21 as 3 bits are reserved for class identification. (110)
  block size = 2^8


Class A
24 Bits
Network
Host
Host
Host
Class B
16 Bits
Network
Network
Host
Host
Class C
8 Bits
Network
Network
Network
Host

CLASS D BLOCK:

- The Class D address class was created to enable multicasting in an IP address. A multicast address is a unique network address that directs packets with that destination address to predefined groups of IP addresses. Therefore, a single station can simultaneously transmit a single stream of data to multiple recipients.
- The Class D address space, much like the other address spaces, is mathematically constrained. The first four bits of a Class D address must be 1110. Therefore, the first octet range for Class D addresses is 11100000 to 11101111, or 224 to 239. An IP address that starts with a value in the range of 224 to 239 in the first octet is a Class D address.
- (The system of netid and blockid is not applicable to class D and class E.)

CLASS E BLOCK:

- A Class E address has been defined. However, the Internet Engineering Task Force (IETF) reserves these addresses for its own research. Therefore, no Class E addresses have been released for use in the Internet. The first four bits of a Class E address are always set to 1s. Therefore, the first octet range for Class E addresses is 11110000 to 11111111, or 240 to 255.

NETWORK MASKS

A network mask helps you know which portion of the address identifies the network and which portion of the address identifies the node. Class A, B, and C networks have default masks, also known as natural masks, as shown here:

Class A: 255.0.0.0

Class B: 255.255.0.0

Class C: 255.255.255.0

- An IP address on a Class A network that has not been subnetted would have an address/mask pair similar to: 8.20.15.1 255.0.0.0. In order to see how the mask helps you identify the network and node parts of the address, convert the address and mask to binary numbers.
- 8.20.15.1 = 00001000.00010100.00001111.00000001
- 255.0.0.0 = 11111111.00000000.00000000.00000000

Once you have the address and the mask represented in binary, then identification of the network and host ID is easier. Any address bits which have corresponding mask bits set to 1 represent the network ID. Any address bits that have corresponding mask bits set to 0 represent the node ID.

8.20.15.1 = 00001000.00010100.00001111.00000001 255.0.0.0 = 11111111.00000000.00000000.00000000

--------------------------------net id | host id

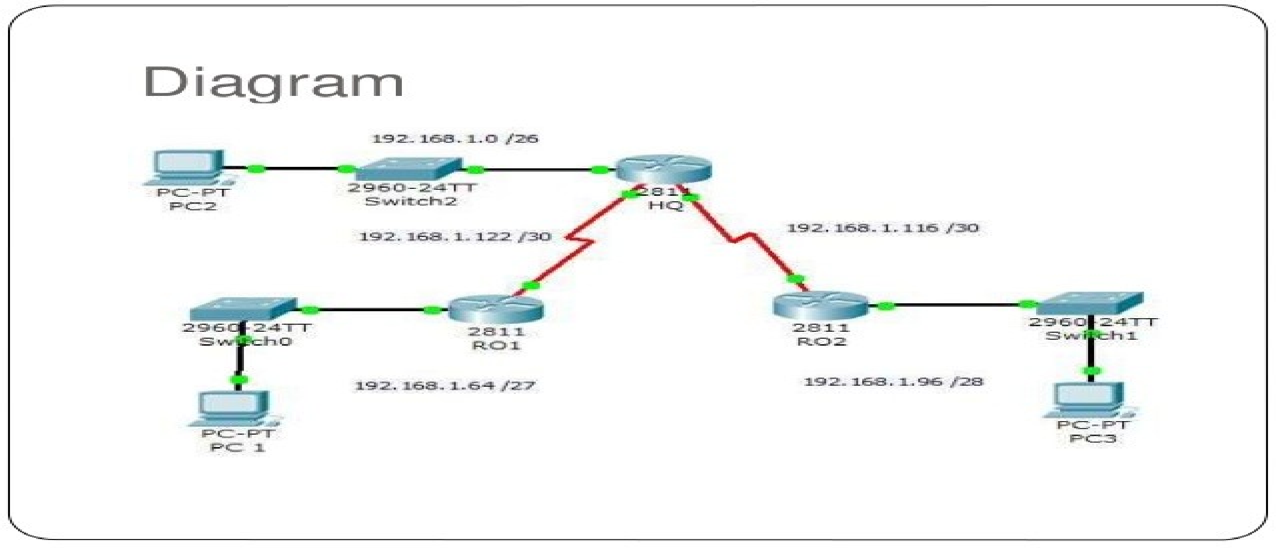
netid = 00001000 = 8

hostid = 00010100.00001111.00000001 = 20.15.1

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

SUB NETTING

- Subnetting allows creating multiple network from a single address block. Subnetting is a processs of beaking large network in a small networks known as subnetting.



WHY AND HOW?

- Maximize addressing efficiency.
- Extend the life of 4.
- Easy to mange.
- It can reduce network traffic by removing broadcast traffic.

HOW?

CIDR [Classless inter Domain Routing]

CIDR	Decimal	binary
/25	128	10000000
/26	192	11000000
/27	224	11100000

RULES FOR CREATING CIDR BLOCK

- H= number of host bits
- N= number of host bit use in network bit
- Number of new network resulting from the sub netting: =2^n
- Number of hosts per new network: =2^h-2 (one is network another is broadcasting)
- The size of the block must be presentable as power of 2.
- Size of the block is the total number of IP Addresses contained in the block.
- Size of any CIDR block will always be in the form 2^1, 2^2, 2^3, 2^4, 2^5 and so on.

EXAMPLE

Example:-1

- Subnet base address

192	168	1	0/24
11111111	11111111	11111111	00000000
N	N	N	H

  - New CIDR length /25

    →255.255.255.128(Subnet Mask)

192	168	1	0/25
11111111	11111111	11111111	10000000

- n = 1 [Number of host bit used in network] n
- h = 7 [Remaining host bits]

EXAMPLE

Example:-1

- Total subnets (2^n) :- 2^1 = 2.
- Block size (256 - subnet mask) :- 256 - 128 = 128
- Valid subnets 0,128
- Valid host per subnets (2^h-2)=2^7-2=126

Subnets	Subnet 1	Subnet 2
Network ID	192.168.1.0	192.168.1.128
First host	192.168.1.1	192.168.1.129
Last host	192.168.1.126	192.168.1.254
Broadcast ID	192.168.1.127	192.168.1.255

SUBNET MASK

- Sub net mask is 32 bits long addresss used to distinguish between network address and host address in IP address. Subnnet maskmis always used with ip address. Sub net mask has only one purpose, to identify which part of an ip address is network address and which part is host adess.

ip	192	168	1	1
Sub net mask	255	255	255	255

CLASSLESS ADDRESSING

- CIDR or Class Inter-Domain Routing was introduced in 1993 to replace classfull addressing. It allows the user to use VLSM or Variable Length Subnet Masks.
- **CIDR notation:**
  In CIDR subnet masks are denoted by /X. For example a subnet of 255.255.255.0 would be denoted by /24. To work a subnet mask in CIDR, we have to first convert each octet into its respective binary value. For example, if the subnet is of 255.255.255.0.

CLASSLESS INTER-DOMAIN ROUTING

- First Octet:
- 255 has 8 binary 1's when converted to binary
- Second Octet:
- 255 has 8 binary 1's when converted to binary
- Third Octet:
- 255 has 8 binary 1's when converted to binary
- Fourth Octet:
- 0 has 0 binary 1's when converted to binary

CLASSLESS ADDRESSING

- here are 24 binary 1’s, so the subnet mask is /24.
- While creating a network in CIDR, a person has to make sure that the masks are contagious, i.e. a subnet mask like 10111111.X.X.X can’t exist.
- t is not necessary that the divider between the network and the host portions is at an octet boundary. For example, in CIDR a subnet mask like 255.224.0.0 or 11111111.11100000.00000000.00000000 can exist.

VARIABLE-LENGTH SUBNETTING WITH IP NETWORKS

- The process of subnetting large networks is often restricted by the network mask (netmask) employed. Quite often, we are required to create several subnetworks, each with a different number of host computers (workstations). Problems like this are often solved using variable-length subnetting. With variable-length subnetting, the administrator uses two or more subnet masks and each mask is a different length.
- When variable-length subnetting is employed, the router is supplied with two subnet masks. These masks are applied one after the other. In this situation, the administrator first creates four subnets using the mask 255.255.255.192. The original subnet mask is 255.255.255.0, written in binary as:
  11111111.11111111.11111111.00000000 = 255.255.255.0
- and the original network IP address was 192.168.3.0, written in binary as:
  11000000.10101000.00000011.00000000 = 192.168.3.0

EXAMPLE:

192.168.15.0/26

1. Find subnet mask.
2. Find the total number of network can be created.
3. Find the total number of IP address on each network.
4. Find total number of host on each network.

Class C

N . N . N . H = 24 bits for network and 8 bits for host

CIDR: CIDR stand for classes inter domain routing . It is the total number of network bits.

CIDR value = /26

We have 24 bits we need 26 so we borrow 2 bits from host portion.

So our <u>subnet mask will be 255.255.255.192 </u>(2^7+2^6=192)

- **Number of networks :**
- 2^n (here n indicates total number of bits borrowed from host)
- So n=2 => 2^2 = 4
- So we can create 4 networks
- **Number of IP address :**
- 2^n (here n indicates total number of remaining host bits)
- So n = 6 => 2^6 = 64
- Total number of IP addresses 64.
- **Num of host in each network** :
- 2^n – 2 = 2 ^ 6 – 2 = 62 available hosts (here n indicates total number of remaining host bits)

Network ID	Host IP address	Broadcast address
1. 192.168.15.0	192.15.15.1-192.168.1.62	192.168.15.63
2. 192.168.15.64	192.15.15.65-192.168.1.126	192.168.15.127
3. 192.168.15.128.	192.15.15.129-192.168.1.190	192.168.15.191
4. 192.168.15.192	192.15.15.193-192.168.1.254	192.168.15.255


T1 H4 A1 N1 K5 S1