

Internet Protocol (IP) Address – Subnetting and Supernetting

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ABSTRACT

In order for systems to locate each other in a distributed environment, nodes are given explicit addresses that uniquely identify the particular network the system is on and uniquely identify the system to that particular network. When these two identifiers are combined, the result is a globally-unique address. This address, known as IP addresses, as IP number, or merely as IP is a code made up of numbers separated by three dots that identifies a particular computer on the Internet. These addresses are actually 32-bit binary numbers. In this paper we will explain the IP address and their classification, subnetting and super netting and also explain the method of subnetting and super netting with the help of suitable examples. We can secure our network and enhance the performance of the network with the help of Subnetting and Super netting. [1]

1. IP ADDRESSES

The original Internet Protocol, IPv4, was developed in the early 1980s and served the global Internet community for more than three decades. IPv4 had a capacity of just over four billion IP addresses, which was enough for the experiment that the Internet started as in the 1980s. But IPv4 is a finite space, and after years of rapid Internet expansion, the pool of available unallocated addresses for IPv4 has been fully allocated to Internet services providers (ISPs) and users. Only 3.7 billion IPv4 addresses are usable by ordinary Internet access devices. The others are used for special protocols, like IP Multicasting. Today, none of those 3.7 billion IPv4 addresses remain unallocated. [2]

Every machine on a network has a unique identifier. Just as you would address a letter to send in the mail, computers use the unique identifier to send data to specific computers on a network. Most networks today, including all computers on the Internet, use the TCP/IP protocol as the standard for how to communicate on the network. In the TCP/IP protocol, the unique identifier for a computer is called its IP address.

IPv4 uses 32 binary bits to create a single unique address on the network. An IPv4 address is expressed by four numbers separated by dots. Each number is the decimal (base-10). For example: 192.168.1.100. It is actually 32-bit binary (base-2) numbers.

Binary representation of 192.168.1.100
= 11000000.10101000.00000001.01100100

The binary number is important because that will determine which class of network the IP address belongs to. The Class of the address determines which part belongs to the network address and which part belongs to the node.

2. ASSIGNING IP ADDRESS

We can assign the IP address to computer with the help of two methods

1. Static IP (Manually)
2. Dynamic IP (Automatically with the help of DHCP Server)

2.1 IP ADDRESS CLASSIFICATION

IP addresses are divided into 5 classes

Class A	} These Classes are used in LAN & WAN
Class B	
Class C	
Class D	} Reserved for Multicasting
Class E	} Reserved for Research & Development

2.2 FIND THE RANGE OF CLASS

To find the range of each Class a bit called priority bit is used. Priority bit is the left most bit of the first octet.

Table- 1: IP Class and their respective Priority bit

Class	Priority bit
A	0
B	10
C	110
D	1110
E	1111

Table-2 Range of IP address

Class	Binary Number	Range of IP Address	
		Startin g Value	Ending Value
A	00000000	0	126
B	10000000	128	191
C	11000000	192	223
D	11100000	224	239
E	11110000	240	255

Note: 127.0.0.1 is the loopback Internet protocol (IP) address also referred to as the “localhost.” The address is used to establish an IP connection to the same machine or computer being used by the end-user.[3]

2.3 SUBNET MASK

Class A - 255.0.0.0

NNNNNNNN.HHHHHHHH.HHHHHHHH.HHHHHHHH

11111111.00000000.00000000.00000000

Class B - 255.255.0.0

NNNNNNNN.NNNNNNNN.HHHHHHHH.HHHHHHHH

11111111.11111111.00000000.00000000

Class C - 255.255.255.0

NNNNNNNN.NNNNNNNN.NNNNNNNN.HHHHHHHH

11111111.11111111.11111111.00000000

Here 'N' represents the Network bit

and 'H' represents the Host bit

Table 3 Shows number of Network and Host bits of Class A, B, C

Class	No. of Network bits	No. of Host bits
A	8	24
B	16	16
C	24	8

There is a set pattern of static leading bits for each class

Class A leading bits=0

Class B leading Bits=10

Class C leading bits=110

By static, we mean that the bits cannot vary - and as a result they cannot add any address combinations, and must be subtracted to find the true value for n. The following table shows the number of leading bits, and we call that number, m. You must also subtract off the two special cases of all 1'(11111111) and all 0's (00000000).[4]

Maximum No. of possible networks = $2^{n-m} - 2$

Where n = No. of Network bits

m = No. of Static Leading bits

Maximum number of possible hosts = $2^n - 2$

Table 4 shows the number of leading bits

Class	Leading Bits (m bits)	Decimal Range of First Byte	Network Bits (n bits)	Host Bits (n bits)	Max. No. of Valid Networks $2^{n-m} - 2$	Maximum No. of Valid Hosts $2^n - 2$
A	0 (m=1)	1 to 126	8	24	$2^{8-1} - 2 = 126$	$2^{24} - 2 = 16,777,214$
B	10 (m=2)	128 to 191	16	16	$2^{16-2} - 2 = 16,384$	$2^{16} - 2 = 65,534$
C	110 (m=3)	192 to 223	24	8	$2^{24-3} - 2 = 2,097,152$	$2^8 - 2 = 254$

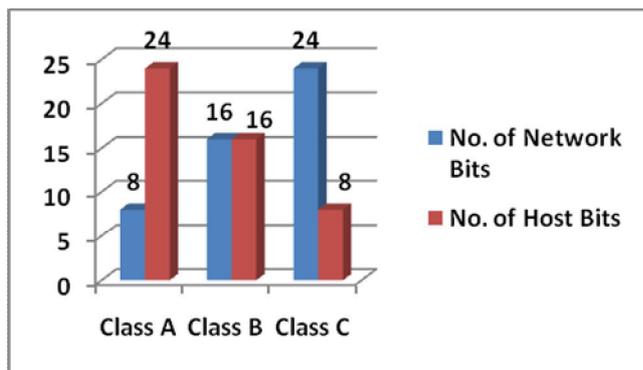


Chart -1 show the No. of network and host bits

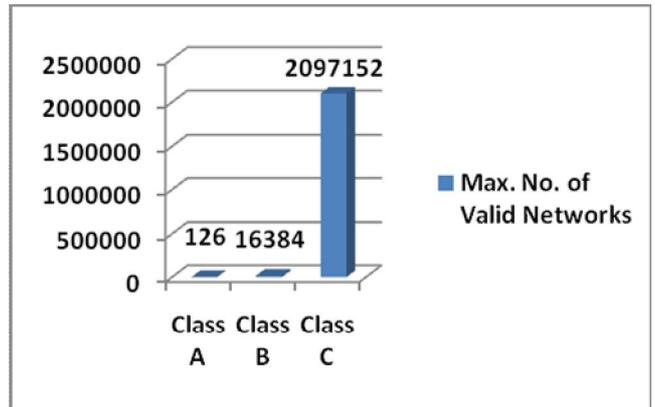


Chart -2 shows the Max. No. of valid networks

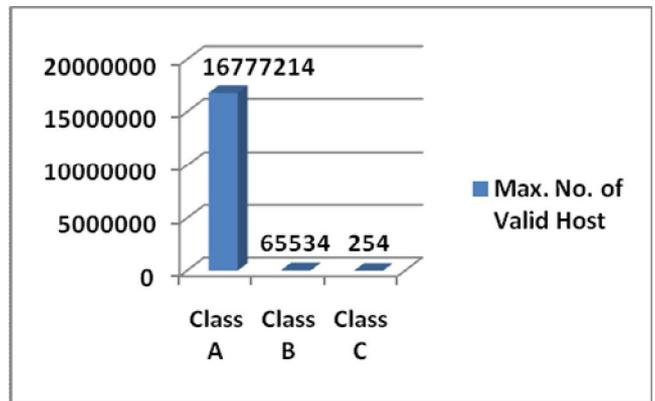


Chart -3 shows the max. No. of valid hosts

3. TYPES OF IP ADDRESS

Internet Protocol (IP) addresses is usually of two types: **Public and Private**.

3.1 PUBLIC IP ADDRESSES

A computer on the Internet is identified by its IP address. In order to avoid address conflicts, IP addresses are publicly registered with the Network Information Centre (NIC) [5]. A public IP address is assigned to every computer that connects to the Internet where each IP is unique. In this case, there cannot exist two computers with the same public IP address all over the Internet. This addressing scheme makes it possible for the computers to "find each other" online and exchange information. User has no control over the public IP address that is assigned to the computer. The public IP address is assigned to the computer by the Internet Service Provider as soon as the computer is connected to the Internet gateway.

A public IP address can be either static or dynamic. A static public IP address does not change and is used primarily for hosting web pages or services on the Internet. On the other hand, a dynamic public IP address is chosen from a pool of available addresses and changes each time one connects to the Internet.

Most Internet users will only have a dynamic IP assigned to their computer which goes off when the computer is disconnected from the Internet. Thus when it is re-connected it gets a new IP.

3.2 PRIVATE IP ADDRESSES

An IP address is considered private if the IP number falls within one of the IP address ranges reserved for private networks such as a Local Area Network (LAN). The Internet Assigned Numbers Authority (IANA) has reserved the following three blocks of the IP address space for private networks (local networks):

10.0.0.0 – 10.255.255.255 (Total Addresses: 16,777,216)

172.16.0.0 – 172.31.255.255 (Total Addresses: 1,048,576)

192.168.0.0 – 192.168.255.255 (Total Addresses: 65,536)

11111111.11111111.11111111.00000000

Private IP addresses are used for numbering the computers in a private network including home, school and business LANs in airports and hotels which makes it possible for the computers in the network to communicate with each other.

Say for example, if a **network X** consists of 10 computers, each of them can be given an IP starting from **192.168.1.1** to **192.168.1.10**. Unlike the public IP, the administrator of the private network is free to assign an IP address of his own choice.[6]

4. SUBNETTING

Conversion of host bits to network bits. Subnetting is the strategy used to partition a single physical network into more than one smaller logical sub-network, called subnets. An IP address includes a network segment and a host segment. Subnets are designed by accepting bits from the IP address's host part and using these bits to assign a number of smaller sub-networks inside the original network. Subnets were initially designed for solving the shortage of IP addresses over the Internet. The subnetting process allows the administrator to divide a single Class A, Class B, or Class C network number into smaller portions. The subnets can be subnetted again into sub-subnets.

Dividing the network into a number of subnets provides the following benefits:

- Reduces the network traffic by reducing the volume of broadcasts
- Helps to exceed the constraints in a local area network (LAN), for example, the maximum number of permitted hosts.
- Enables users to access a work network from their homes; there is no need to open the complete network.[7]

Variable Length Subnet Mask (VLSM) is a process of dividing an IP space into the subnets of different sizes without wasting IP addresses. When we perform subnetting, all subnets have the same number of hosts, this is known as FLSM (Fixed length subnet mask).

4.1 METHOD

Example: we want to divide 192.168.1.0/24 into 4 smaller networks.

With the help of following formula:

$$2^n \geq \text{requirements}$$

$$2^n \geq 4$$

$$2^2 \geq 4$$

$$4 \geq 4$$

$$\text{Number of networks: } 2^2 = 4$$

Now two host bits will be converted in network bits

Default subnet mask:

255.255.255.0

Customize subnet mask will be

11111111.11111111.11111111.11000000

255.255.255.192

No. of valid host

$$2^6 - 2 = 64 - 2 = 62$$

The 4 networks will be as followed

192.168.1.0 To 192.168.1.63

192.168.1.64 To 192.168.1.127

192.168.1.128 To 192.168.1.191

192.168.1.192 To 192.168.1.255

Network ID will be 0, 64, 128, 192

Broadcast ID will be 63,127,191,255

5. SUPERNETTING

The inverse of subnetting is supernetting. Instead of moving mask bits to the right of the default mask for subnetting, we move mask bits to the left for supernetting. With subnetting we create more network address at the host expense of host address. With supernetting we create more host address at the expenses of network addresses.

Supernetting is not for users, it is only for Internet Service Providers who are attempting to obtain the most efficient allocation of IP address using the A,B,C class scheme. In this method networks bits are convert into host bits. [8]

5.1 METHOD

Example: Suppose we want to connect 1000 computer in Class C network.

As we know that we can connect 254 computers in Class C network. For connecting 1000 computers we will have to convert network bits into host bits.

IP address = 192.68.1.1

Default Subnet mask = 255.255.255.0

$$2^h - 2 \geq \text{requirements}$$

$$2^h - 2 \geq 1000$$

$$2^{10} - 2 \geq 1000$$

$$1024 - 2 \geq 1000$$

$$1022 \geq 1000 \text{ (Condition is true)}$$

Natural Subnet mask

11111111.11111111.11111111.00000000
11111111.11111111.11111100.00000000 (conversion of network bits into host bits)

255.255.252.0 (Classless subnet mask)

- 192 168 0 0 to 192 168 3 255
- 192 168 4 0 to 192 168 7 255
- 192 168 8 0 to 192 168 11 255
- 192 168 12 0 to 192 168 15 255
- 192 168 16 0 to 192 168 19 255
- 192 168 20 0 to 192 168 23 255
- 192 168 24 0 to 192 168 27 255
- 192 168 28 0 to 192 168 31 255
- 192 168 32 0 to 192 168 35 255
- 192 168 36 0 to 192 168 39 255
- 192 168 40 0 to 192 168 43 255
- 192 168 44 0 to 192 168 47 255
- 192 168 48 0 to 192 168 51 255
- 192 168 52 0 to 192 168 55 255

and so on. The effective network will be 64

CIDR: stands for Classless Inter-Domain Routing. CIDR was developed in the 1990s as a standard scheme for routing network traffic across the Internet.

Why Use CIDR?

Before CIDR technology was developed, Internet routers managed network traffic based on the class of IP addresses. In this system, the value of an IP address determines its sub-network for the purposes of routing.

CIDR is an alternative to traditional IP subnetting that organizes IP addresses into sub-networks independent of the value of the addresses themselves.

CIDR is also known as supernetting as it effectively allows multiple subnets to be grouped together for network routing.

CIDR Notation

CIDR specifies an IP address range using a combination of an IP address and its associated network mask. CIDR notation uses the following format –

xxx . xxx . xxx . xxx /n

Where n is the number of (leftmost) '1' bits in the mask.[9]

6. CONCLUSION

Though a 32 bits IP address offers a tremendously large number of addresses the A, B, C class structure does not make efficient use of network ID and Host ID assignments. Subnetting improves the situation by allowing a better split between network and host assignments while improving the performance and maintainability of large network.

With the help of subnetting and supernetting we can secure our network as well as we can reduce the cost.

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Dr. Singh has 15 years experience in Academic and Research. He is a Post Graduate in Computer Science and an MCA. He has received the Ph.D. degree in Information Technology from Mahatama Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot in 2012. He has to his credit several research papers published in National and International journals and conferences. Presently he is working in Jagran Institute of Management, Kanpur as Associate Professor.