Network Subnetting

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1 Classful Addressing

1.1 Classification of Classful Addressing

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

- Class A
- Class B
- Class C
- Class D
- Class E

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 determines the classes of the IP address. The IPv4 address is divided into two parts:

- Network ID
- Host ID

The class of IP address is used to determine the bits used for network ID and host ID and the number of total networks and hosts possible in that particular class.

1.2 Class A

Table 1: Class A

Name	**Decimal Notation**
Network ID	8 bits
Host ID	24 bits
Public IP Range	1.0.0.0 to 127.0.0.0
Private IP Range	10.0.0.0 to 10.255.255.255
No of Networks	$\mathbf{2^7}$**-2** = 126
No of Hosts Per Network	$\mathbf{2^{24}}$**-2** = 16,777,214

1.3 Class B

Table 2: Class B

Name	**Decimal Notation**
Network ID	16 bits
Host ID	16 bits
Public IP Range	128.0.0.0 - 191.255.0.0
Private IP Range	172.16.0.0 to 172.31.255.255
No of Networks	$\mathbf{2^{14}}$**-2** = 16,382
No of Hosts Per Network	$\mathbf{2^{16}}$**-2** = 65,534

1.4 Class C

1.5 Important Note

IP addresses are globally managed by Internet Assigned Numbers Authority(IANA) and regional Internet registries(RIR). While finding the total number of host IP addresses, 2 IP addresses are not counted and are therefore, decreased from the total count because the first IP address of any network is the network number and whereas the last IP address is reserved for broadcast IP.

Table 3: Class C

Name	Decimal Notation
Network ID	24 bits
Host ID	8 bits
Public IP Range	192.0.0.0 - 223.255.255.0
Private IP Range	192.168.0.0 - 192.168.255.255
Special IP Range	127.0.0.1 - 127.255.255.255
No of Networks	$\mathbf{2^{21}-2}$ = 2,097,150
No of Hosts Per Network	$\mathbf{2^{8}-2}$ = 254

1.6 Question Answer Bank

1. How can we prove that we have2,147,483,648 addresses in class A?
Ans: In class A, only 1 bit defines the class. The remaining 31 bits are available for the address. With 31 bits, we can have 2^{31} or 2,147,483,648 addresses

2. Given the network address 17.0.0.0, find the class, the block, and the range of the addresses.
Ans: The class is A because the first byte is between 0 and 127. The block has a netid of 17. The addresses range from 17.0.0.0 to 17.255.255.255

3. Given the network address 132.21.0.0, find the class, the block, and the range of the addresses.
Ans: The class is B because the first byte is between 128 and 191. The block has a netid of 132.21. The addresses range from 132.21.0.0 to 132.21.255.255

4. Given the network address 220.34.76.0, find the class, the block, and the range of the addresses.
Ans: The class is C because the first byte is between 192 and 223. The block has a netid of 220.34.76. The addresses range from 220.34.76.0 to 220.34.76.255

5. Given the address 23.56.7.91 and the default class A mask, find the beginning address (network address) Ans: The default mask is 255.0.0.0, which means that only the first byte is preserved and the other 3 bytes are set to 0s. The network address is 23.0.0.0

6. Given the address 132.6.17.85 and the default class B mask, find the beginning address (network address)) Ans: The default mask is 255.255.0.0, which means that the first 2 bytes are preserved and the other 2 bytes are set to 0s. The network address is 132.6.0.0

1.7 A SAMPLE INTERNET WITH CLASSFUL ADDRESSES

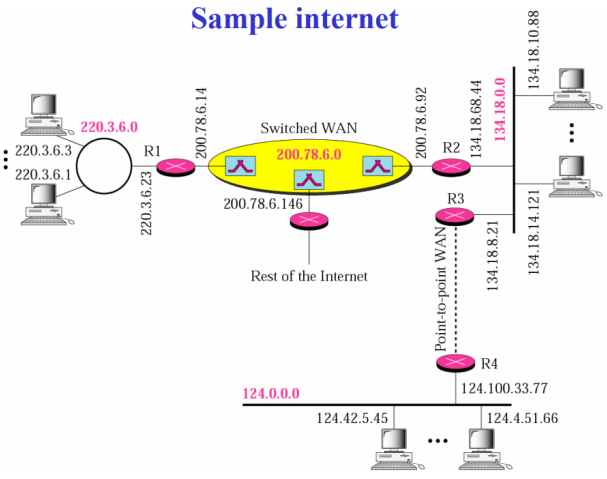

Figure 1: A Sample Internet with Classful Address

2 Classless Addressing

2.1 Classless Addressing

Classless addressing, also called Classless Inter-Domain Routing (CIDR), is an improved IP addressing system. It increases the effectiveness of IP address allocation because of the absence of class distribution.

2.2 Structure of Classless Addressing

The CIDR block comprises two parts. These are as follows:

Block id is used for the network identification, but the number of bits is not pre-defined as it is in the classful IP addressing scheme. Host id is used to identify the host part of the network.

- Block ID - Block id is used for the network identification, but the number of bits is not pre-defined as it is in the classful IP addressing scheme.
- Host ID - Host id is used to identify the host part of the network.

2.3 Notation of Classless Addressing

CIDR IP addresses look as follows:

w . x . y . z/n

In the example above, w,x,y,z each defines an 8-bit binary number, while n tells us about the number of bits used to identify the network and is called an IP network prefix or mask.

2.4 Advantages of Classless Addressing

IP addressing includes two types: Classful and Classless. Classless addressing offers a more effective method of allocating IP addresses than Classful addressing, which is the main difference between the two. To put it briefly, Classless addressing prevents the issue of IP address loss that can occur with Classful addressing.

2.4.1 Example of Classless Addressing

If we loop an example, if we need 1000 IP addresses, for an organization tells us a /23 block is much more efficient than a Class B allocation. /22 gives us 1022 usable host addresses. That means by switching to classless addressing, we've avoided wasting over 65,000 addresses.

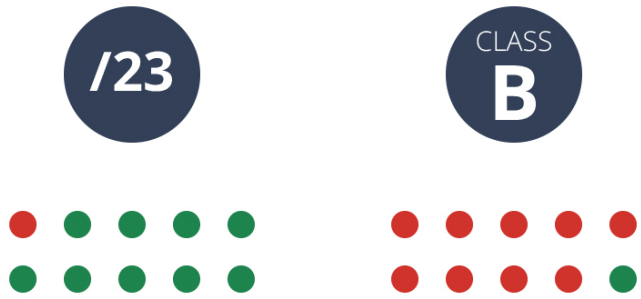

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Figure 2: With a /23, almost all IPs are used. With a Class B, 90% of IPs will be wasted.

3 Classless Address Subnetting

3.1 Subnetting Mathematical Examples

3.1.1 Practice Example 1

Find out the following things of this IP 19.23.21.78/29?

1. Block Size?
2. Number of Subnets
3. Total Number of Usable Hosts in every network?
4. Number of Usable Hosts in this network?
5. Find out Network Address?
6. Find out Usable Host IP Range
7. Find Out First Valid Host
8. Find Out Last Valid Host
9. Find Out Broadcast Address
10. Find Out Network Mask
11. Network Class Type?

3.1.2 Answer of Practice Example 1

Here, CIDR Notation has given. It is 29. And, this IP belongs to class A. So, Network ID is 8 bit and Host id is 24 Bit. As, CIDR is 29 so, we use last octet. So, Binary representation will for Subnet Mask:

1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 0 0 0

The last octet belongs to Host ID and there have 5 1s and 3 Os, that will work When we'll figure out no of Subnet ID and No of Hosts.

1. Block Size = 256-248 = 8
2. No of Subnets = $\mathbf{2}^5$ = **32**, here, power 5 means, the 5 1s of last octet in Host ID
3. Total No of Hosts Usage in every network=$\mathbf{2}^{24}$**-2** = 16,777,214 Hosts
4. Total No of Hosts in this network=$\mathbf{2}^3$**-2** = 6 Hosts Only, here, power 3 means, the 3 0s of last octet in Host ID
5. Netowrk Address = 19.23.21.72
6. First Valid Host = 19.23.21.73
7. Last Valid Host = 19.23.21.79
8. Broadcast Address = 19.23.21.80
9. Network Mask = 255.255.255.248
10. Class = A

3.1.3 Practice Example 2

Find out the following things of this IP 122.57.120.79/22?

1. Block Size?
2. Number of Subnets
3. Total Number of Usable Hosts in every network?
4. Number of Usable Hosts in this network?
5. Find out Network Address?
6. Find out Usable Host IP Range
7. Find Out First Valid Host
8. Find Out Last Valid Host
9. Find Out Broadcast Address
10. Find Out Network Mask
11. Network Class Type?

3.1.4 Answer of Practice Example 2

Here, CIDR Notation has given. It is 22. And, this IP belongs to class A. So, Network ID is 8 bit and Host id is 24 Bit. As, CIDR is 22 so, we use last 2 octets. So, Binary representation will for Subnet Mask:

1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 0 0 . 0 0 0 0 0 0 0 0

The last octet belongs to Host ID and there have 0 1s and 8 Os, that will work When we'll figure out no of Subnet ID and No of Hosts.

1. Block Size = 256-252 = 4
2. No of Subnets = $\mathbf{2^6}$ = **64**
3. Total No of Hosts Usage in every network=$\mathbf{2^{24}-2}$ = 16,777,214 Hosts
4. Total No of Hosts in this network=$\mathbf{2^{10}-2}$ = 1022 Hosts Only
5. Network Address = 122.57.120.0
6. First Valid Host = 122.57.120.1
7. Last Valid Host = 122.57.120.254
8. Broadcast Address = 122.57.120.255
9. Network Mask = 255.255.252.0
10. Class = A

3.1.5 Practice Example 3

Find out the following things of this IP 103.197.153.104/20?

1. Block Size?
2. Number of Subnets
3. Total Number of Usable Hosts in every network?
4. Number of Usable Hosts in this network?
5. Find out Network Address?
6. Find out Usable Host IP Range
7. Find Out First Valid Host
8. Find Out Last Valid Host
9. Find Out Broadcast Address
10. Find Out Network Mask
11. Network Class Type?

3.1.6 Answer of Practice Example 3

Here, CIDR Notation has given. It is 20. And, this IP belongs to class A. So, Network ID is 8 bit and Host id is 24 Bit. As, CIDR is 20 so, we use last 2 octets. So, Binary representation will for Subnet Mask:

1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 0 0 0 0 . 0 0 0 0 0 0 0 0

1. Block Size = 256-240 = 16
2. No of Subnets = $\mathbf{2^4}$ = **16**
3. Total No of Hosts Usage in every network=$\mathbf{2^{24}-2}$ = 16,777,214 Hosts
4. Total No of Hosts in this network=$\mathbf{2^{12}-2}$ = 4094 Hosts Only
5. Network Address = 103.197.144.0
6. First Valid Host = 103.197.144.1
7. Last Valid Host = 103.197.159.254
8. Broadcast Address = 103.197.159.255
9. Network Mask = 255.255.240.0
10. Class = A

3.1.7 Practice Example 4

Find out the following things of this IP 128.197.153.104/27?

1. Block Size?
2. Number of Subnets
3. Total Number of Usable Hosts in every network?
4. Number of Usable Hosts in this network?
5. Find out Network Address?
6. Find out Usable Host IP Range
7. Find Out First Valid Host
8. Find Out Last Valid Host
9. Find Out Broadcast Address
10. Find Out Network Mask
11. Network Class Type?

3.1.8 Answer of Practice Example 4

Here, CIDR Notation has given. It is 27. And, this IP belongs to class B. So, Network ID is 16 bit and Host id is 16 Bit. As, CIDR is 27 so, we use last octet. So, Binary representation will for Subnet Mask:

1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 0 0 0 0 0

1. Block Size = 256-224 = 32
2. No of Subnets = $\mathbf{2^3}$ = **8**
3. Total No of Hosts Usage in every network=$\mathbf{2^{16}-2}$ = 65, 534 Hosts
4. Total No of Hosts in this network=$\mathbf{2^5-2}$ = 30 Hosts Only
5. Network Address = 128.197.153.96
6. First Valid Host = 128.197.153.97
7. Last Valid Host = 128.197.153.126
8. Broadcast Address = 128.197.153.127
9. Network Mask = 255.255.255.224
10. Class = B

3.1.9 Practice Example 5

Find out the following things of this IP 219.73.128.29/10?

1. Block Size?
2. Number of Subnets
3. Total Number of Usable Hosts in every network?
4. Number of Usable Hosts in this network?
5. Find out Network Address?
6. Find out Usable Host IP Range
7. Find Out First Valid Host
8. Find Out Last Valid Host
9. Find Out Broadcast Address
10. Find Out Network Mask
11. Network Class Type?

3.1.10 Answer of Practice Example 5

Here, CIDR Notation has given. It is 10. And, this IP belongs to class C. So, Network ID is 24 bit and Host id is 8 Bit. As, CIDR is 10 so, we use last three octets. So, Binary representation will for Subnet Mask:

1 1 1 1 1 1 1 1 . 1 1 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0

1. Block Size = 256-192 = 64
2. No of Subnets = $\mathbf{2^2 = 4}$
3. Total No of Hosts Usage in every network=$\mathbf{2^8-2}$ = 254 hosts per network
4. Total No of Hosts in this network=$\mathbf{2^{22}-2}$ = 4194302 Hosts Only
5. Network Address = 219.64.0.0
6. First Valid Host = 219.64.0.1
7. Last Valid Host = 19.127.255.254
8. Broadcast Address = 19.127.255.255
9. Network Mask = 255.192.0.0
10. Class = C