IPV4 ADDRESSING

An IPv4 address is a 32-bit address that uniquely and universally defines the connection of a host or a router to the Internet. IPv4 addresses are unique in the sense that each address defines one, and only one, connection to the Internet.IPv4 addresses are universal in the sense that the addressing system must be accepted by any host that wants to be connected to the Internet.

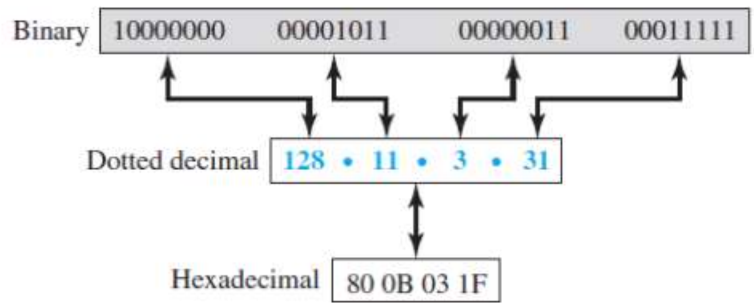
Address Space

An address space is the total number of addresses used by the protocol. If a protocol uses b bits to define an address, the address space is 2b because each bit can have two different values (0 or 1). IPv4 uses 32-bit addresses, which means that the address space is 232 or 4,294,967,296 (more than four billion). If there were no restrictions, more than 4 billion devices could be connected to the Internet.

Notation

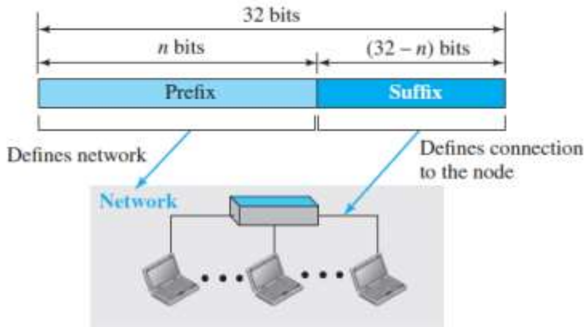
There are three common notations to show an IPv4 address: binary notation (base 2), dotted decimal notation (base 256), and hexadecimal notation (base 16).

Three different notations in IPv4 addressing

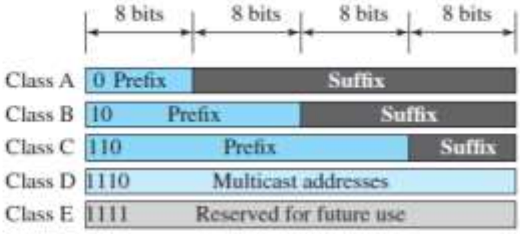


Hierarchy in Addressing A 32-bit IPv4 address is also hierarchical, but divided only into two parts. The first part of the address, called the prefix, defines the network; the second part of the address, called the suffix, defines the node (connection of a device to the Internet). The prefix length is n bits and the suffix length is (32-) bits.

Hierarchy in addressing



Classful Addressing:



Class	Prefixes	First byte
A	$n = 8$ bits	0 to 127
B	$n = 16$ bits	128 to 191
C	$n = 24$ bits	192 to 223
D	Not applicable	224 to 239
E	Not applicable	240 to 255

Address Depletion:

The reason that classful addressing has become obsolete is address depletion. To understand the problem, let us think about class A. This class can be assigned to only 128 organizations in the world, but each organization needs to have a single network with 16,777,216 nodes. Class B addresses were designed for midsize organizations, but many of the addresses in this class also remained unused. Class C addresses have a completely different flaw in design. The number of addresses that can be used in each network (256) was so small that most companies were not comfortable using a block in this address class.

- **Class A:** It uses an 8-bit network number whose first bit is always zero, as shown in the table. It is reserved for IP unicast addresses. If the number of hosts is huge on a network, this class is used. It uses only one octet to define prefix length. The numbers of the network, which can accommodate, are 2^8 or 128
- **Class B:** It facilitates 16 bits for both the network address and host address. The first two bits are continually 10. It is distant from IP unicast addresses. It uses 2 octets for a specific network, while the remaining two octets for host IDs. They are mainly used for medium to large-sized networks. The Class B addresses can be supported to 16,384 networks with up to 65,536 hosts per network.
- **Class C:** It is distant for IP unicast addresses. They are defined as small networks. The first 3 octets determine a specific network, and the last octet specifies host IDs. The Class C addresses can be used up to 2,097,152 networks with up to 254 hosts per network. Its first three bits are continually set to 110.
- **Class D:** It defines IP multicast addresses.
- **Class E:** These addresses were reserved for practical uses.

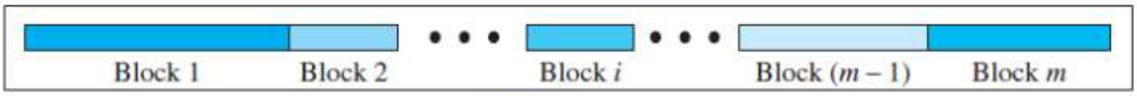
Subnetting and Supernetting

In subnetting, a class A or class B block is divided into several subnets. Each subnet has a larger prefix length than the original network. For example, if a network in class A is divided into four subnets, each subnet has a prefix of nsub = 10. At the same time, if all of the addresses in a network are not used, subnetting allows the addresses to be divided among several organizations. While subnetting was devised to divide a large block into smaller ones, supernetting was devised to combine several class C blocks into a larger block to be attractive to organizations that need addresses available in a class C block. This idea did not work either because it makes the routing of packets more difficult.

Advantage of Classful Addressing Given an address, we can easily find the class of the address and, since the prefix length for each class is fixed, we can find the prefix length immediately. In other words, the prefix length in classful addressing is inherent in the address; no extra information is needed to extract the prefix and the suffix.

Classless Addressing

In 1996, the Internet authorities announced a new architecture called classless addressing. In classless addressing, variable-length blocks are used that belong to no classes. We can have a block of 1 address, 2 addresses, 4 addresses, 128 addresses, and so on. In classless addressing, the whole address space is divided into variable length blocks. The prefix in an address defines the block (network); the suffix defines the node (device). Theoretically, we can have a block of 20 , 21 , 2 2 , . . . , 232 addresses.

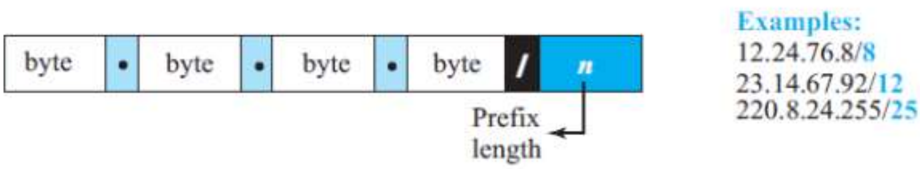


Address space

Unlike classful addressing, the prefix length in classless addressing is variable. We can have a prefix length that ranges from 0 to 32. The size of the network is inversely proportional to the length of the prefix. A small prefix means a larger network; a large prefix means a smaller network. the idea of classless addressing can be easily applied to classful addressing. An address in class A can be thought of as a classless address in which the prefix length is 8. An address in class B can be thought of as a classless address in which the prefix is 16, and so on. In other words, classful addressing is a special case of classless addressing.

Prefix Length: Slash Notation:

In this case, the prefix length, n is added to the address, separated by a slash. The notation is informally referred to as slash notation and formally as classless interdomain routing or CIDR (pronounced cider) strategy.



Extracting Information from an Address Three pieces of information about the block to which the address belongs: the number of addresses, the first address in the block, and the last address. 1. The number of addresses in the block is found as $N = 2^{(32-n)}$. 2. To find the first address, we keep the n leftmost bits and set the (32 − n) rightmost bits all to 0s. 3. To find the last address, we keep the n leftmost bits and set the (32 − n) rightmost bits all to 1s. Subnetting An organization (or an ISP) that is granted a range of addresses may divide the range into several subranges and assign each subrange to a subnetwork (or subnet). Note that nothing stops the organization from creating more levels. A subnetwork can be divided into several sub subnetworks. A sub-subnetwork can be divided into several sub-sub-subnetworks, and so on. Designing Subnets We assume the total number of addresses granted to the organization is N, the prefix length is n, the assigned number of addresses to each subnetwork is Nsub, and the prefix length for each subnetwork is nsub. Then the following steps need to be carefully followed to guarantee the proper operation of the subnetworks.

Example An organization is granted a block of addresses with the beginning address 14.24.74.0/24. The organization needs to have 3 subblocks of addresses to use in its three subnets: one subblock of 10 addresses, one subblock of 60 addresses, and one subblock of 120 addresses. Design the subblocks.

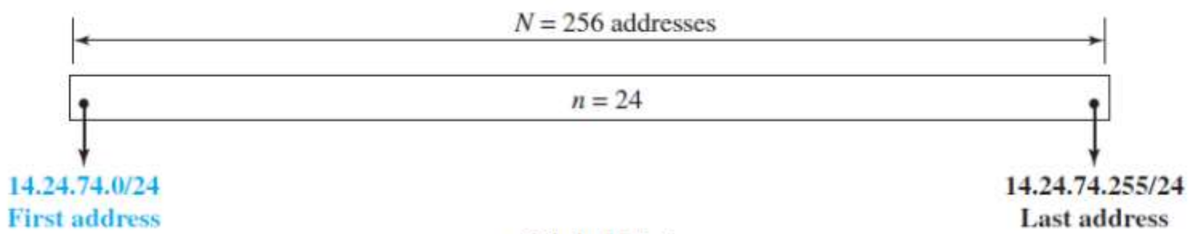
Solution

There are $2^{32-24} = 256$ addresses in this block. The first address is 14.24.74.0/24; the last address is 14.24.74.255/24. To satisfy the third requirement, we assign addresses to subblocks, starting with the largest and ending with the smallest one.

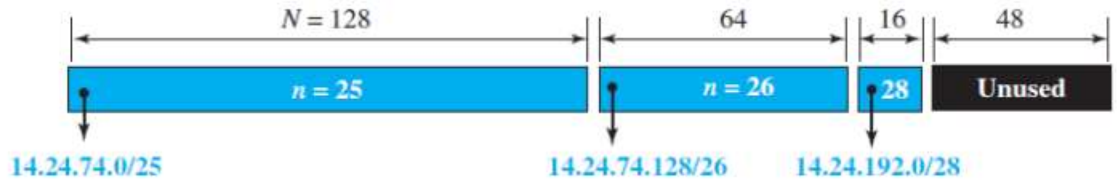
a. The number of addresses in the largest subblock, which requires 120 addresses, is not a power of 2. We allocate 128 addresses. The subnet mask for this subnet can be found as $n_1 = 32 - \log_2 128 = 25$. The first address in this block is 14.24.74.0/25; the last address is 14.24.74.127/25.

b. The number of addresses in the second largest subblock, which requires 60 addresses, is not a power of 2 either. We allocate 64 addresses. The subnet mask for this subnet can be found as $n_2 = 32 - \log_2 64 = 26$. The first address in this block is 14.24.74.128/26; the last address is 14.24.74.191/26.

c. The number of addresses in the smallest subblock, which requires 10 addresses, is not a power of 2 either. We allocate 16 addresses. The subnet mask for this subnet can be found as $n_3 = 32 - \log_2 16 = 28$. The first address in this block is 14.24.74.192/28; the last address is 14.24.74.207/28.



a. Original block



b. Subblocks