IPV4 ADDRESSES:

- An IPv4 address is a 32-bit address that uniquely and universally defines the connection of a host or a router to the Internet.
- The IP address is the address of the connection, not the host or the router, because if the device is moved to another network, the IP address may be changed.

Address Space:

- A protocol like IPv4 that defines addresses has an address space. An **address space** isthe total number of addresses used by the protocol.
- If a protocol uses *b* bits to define an address, the address space is 2^b.

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).
- In *binary notation,* an IPv4 address is displayed as 32 bits. To make the address more readable, one or more spaces are usually inserted between each octet (8 bits). Each octet is often referred to as a byte.
- To make the IPv4 address more compact and easier to read, it is usuallywritten in decimal form with a decimal point (dot) separating the bytes.
- This format isreferred to as *dotted-decimal notation*. each number in the dotted-decimal notation is between 0 and 255.
- IPv4 address in hexadecimal notation. Each hexadecimal digit is equivalent to four bits.This means that a 32-bit address has 8 hexadecimal digits. This notation is often used in network programming.

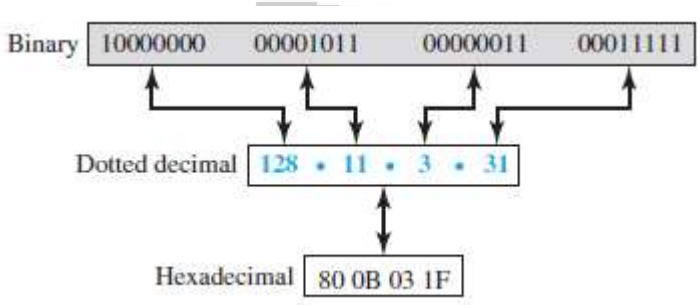


Fig: Three different notations in IPV4 addressing

- A 32-bit IPv4 address is also hierarchical, but divided only into two parts.

- The firstpart of the address, called the *prefix*, defines the network; the second part of the address, called the *suffix*, defines the node.

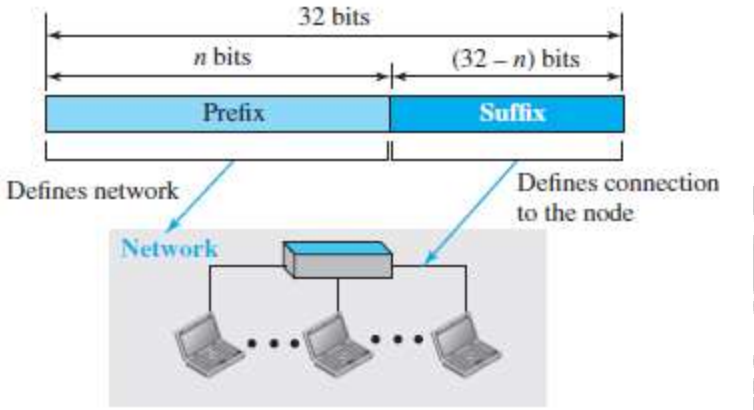
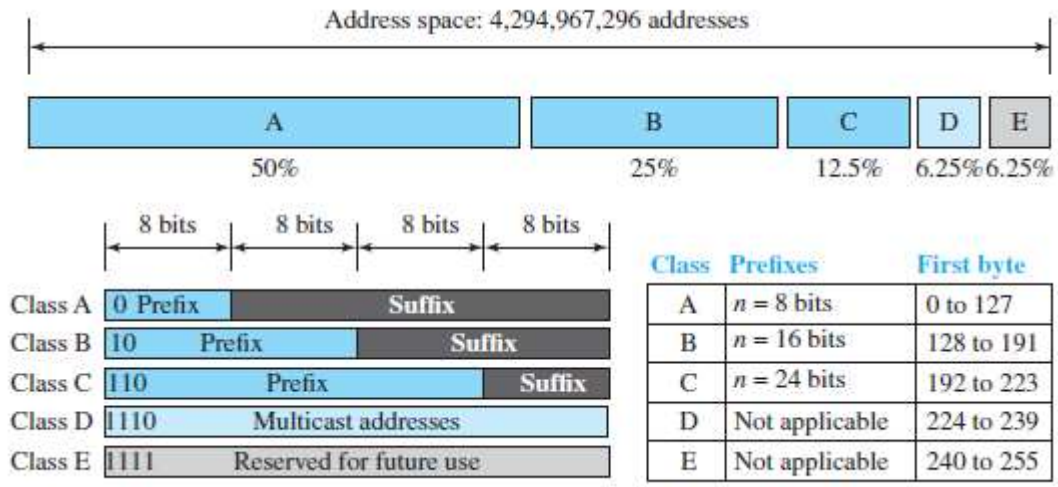


Fig: Hierarchy in addressing.

- IPv4 was first designed as a fixed-length prefix. This scheme, isreferred to as classful addressing. Classless addressing, uses a variable-length network prefix.

Classful Addressing:

- IPv4 address was designed with a fixed-length prefix, butto accommodate both small and large networks, three fixed-length prefixes were designed instead of one (n = 8, n = 16, and n = 24).
- The whole address space was divided into five classes (class A, B, C, D, and E), as shown in Fig This scheme is referred to as **classful addressing.** class A, the network length is 8 bits, the first bit, which is 0, 2^7 = 128.
- In class B, the network length is 16 bits, but since the first two bits, which are $(10)^2$, define the class, we can have only 14 bits as the network identifier. This means there are only 2^{14} = 16,384 networks in the world that can have a class B address. All addresses that start with $(110)^2$ belong to class C.
- In class C, the networklength is 24 bits, but since three bits define the class, we can have only 21 bits as the network identifier. This means there are 2^{21} = 2,097,152 networks in the world that can have a class C address.



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

Fig: Occupation of the address space in classful addressing.

- Class D is not divided into prefix and suffix. It is used for multicast addresses. Alladdresses that start with 1111 in binary belong to class E.
- As in Class D, Class E is not divided into prefix and suffix and is used as reserve.

Address Depletion:

- The reason that classful addressing has become obsolete is address depletion. Since theaddresses were not distributed properly, the Internet was faced with the problem of the addresses being rapidly used up, resulting in no more addresses available for organizations and individuals that needed to be connected to the Internet
- Class A can be assigned to only 128 organizations a single network. Class B addresses were designed for midsize organizations, but manyof the addresses in this class also remained unused.
- Class C the number of addresses that can be used in each network (256)was so small that most companies.

Subnetting and Supernetting:

- In subnetting, a class A or class B block isdivided into several subnets. if a network in class A is divided into four subnets,
- 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 more than the 256 addresses available in a class C block.

Advantage of Classful Addressing:

- **A**dvantage: 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.

Classless Addressing:

- **Classless addressing:**In classless addressing, variable-length blocks are used that belong to noclasses.
- 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 lengthblocks. The prefix in an address defines the block (network); the suffix defines the node (device).

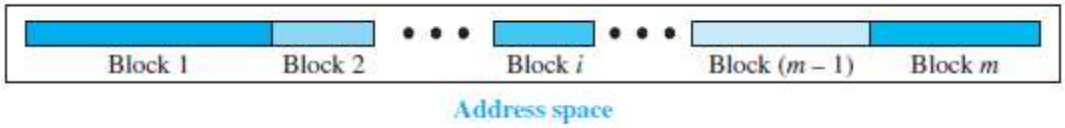


Fig: Variable- length blocks in classless addressing.

Unlike classful addressing, the prefix length in classless addressing is variable. We can have a prefix length that ranges from 0 to 32.

Prefix Length: Slash Notation:

- The notation is informally referred to as*slash notation* and formally as ***classless interdomain routing*** or ***CIDR.***

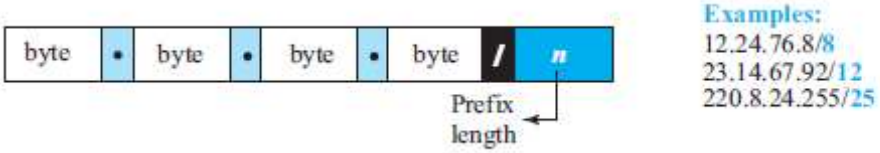


Fig: Slash notation (CIDR)

Extracting Information from an 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.

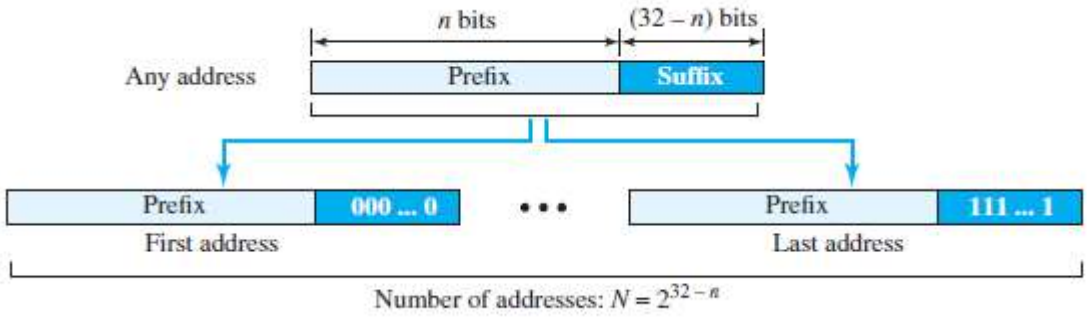


Fig: Information extraction in classes addressing.

Address Mask:

- Another way to find the first and last addresses in the block is to use the address mask.
- The address mask is a 32-bit number in which the *n* leftmost bits are set to 1s and the rest of the bits (32 − *n*) are set to 0s.
- The reason for defining a mask in this way is that it can be used by a computer program to extract the information in a block, using the three bit-wise operations NOT, AND, and OR.

1. The number of addresses in the block N = NOT(mask) + 1.
2. The first address in the block = (Any address in the block) AND(mask).
3. The last address in the block = (Any address in the block) OR[(NOT(mask)].