IPv4 Addressing

- A host typically has only a single link into the network; when IP in the host wants to send a datagram, it does so over this link.
- The boundary between the host and the physical link is called an **interface**.
- A router thus has multiple interfaces, one for each of its links.
- Because every host and router is capable of sending and receiving IP datagrams, IP requires each host and router interface to have its own IP address.
- Thus, an IP address is technically associated with an interface.
- Each IP address is 32 bits long (equivalently, 4 bytes), and there are thus a total of 2^{32} possible IP addresses.

IPv4 Addressing

- The identifier used in the IP layer of the TCP/IP protocol suite to identify each device connected to the Internet is called **the Internet address or IP address.**

- An IPv4 address is a 32-bit address that uniquely and universally defines the connection of a host or a router to the Internet.

- An IP address is the address of the interface.

IPV4 Address Space

An IPv4 address is 32 bits long.

The address space of IPv4 is 2^{32} or 4,294,967,296.

The IPv4 addresses are unique and universal.

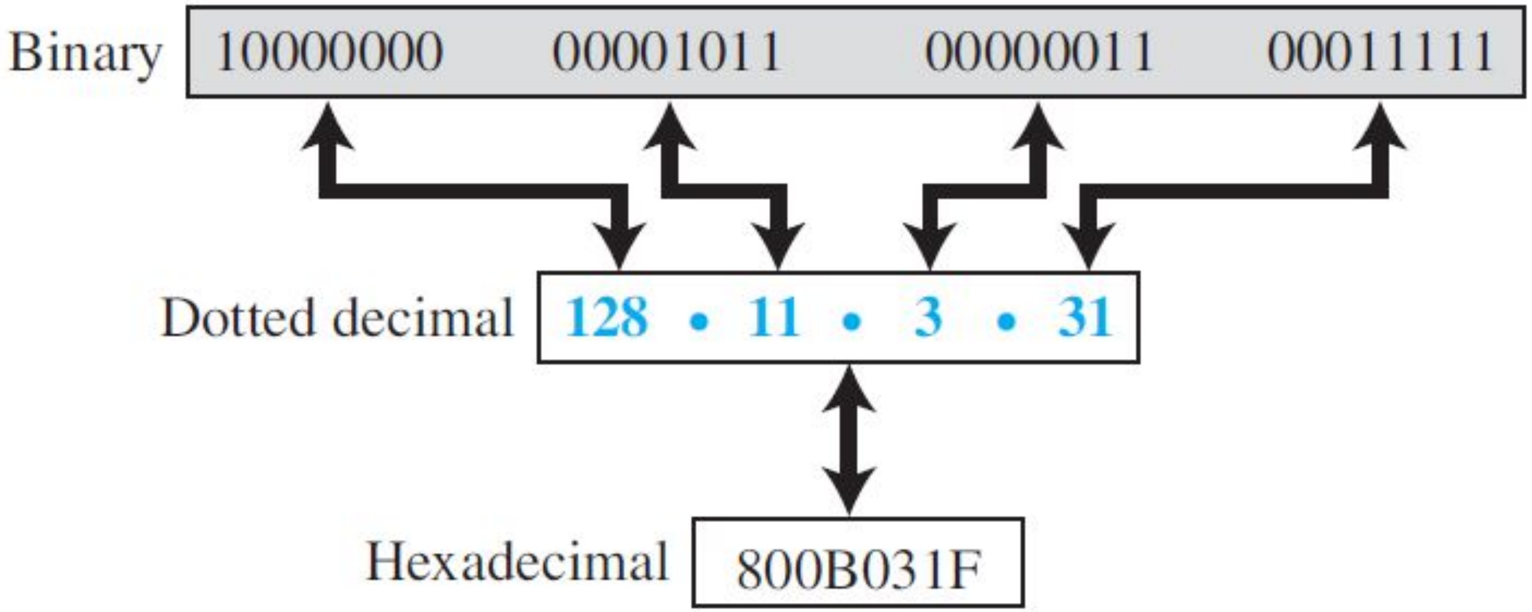
IP Address Notation

- There are three common notations to show an IPv4 address:

1. binary notation (base 2)
2. dotted-decimal notation (base 256)
3. hexadecimal notation (base 16).

The most prevalent, however, is base 256.

Figure 4.29 *Three different notations in IPv4 addressing*



IP Address Notation: **binary notation**

- In **binary notation, an IPv4 address is displayed as 32 bits.**

- To make the address more readable, one or more spaces is usually inserted between each octet (8 bits).

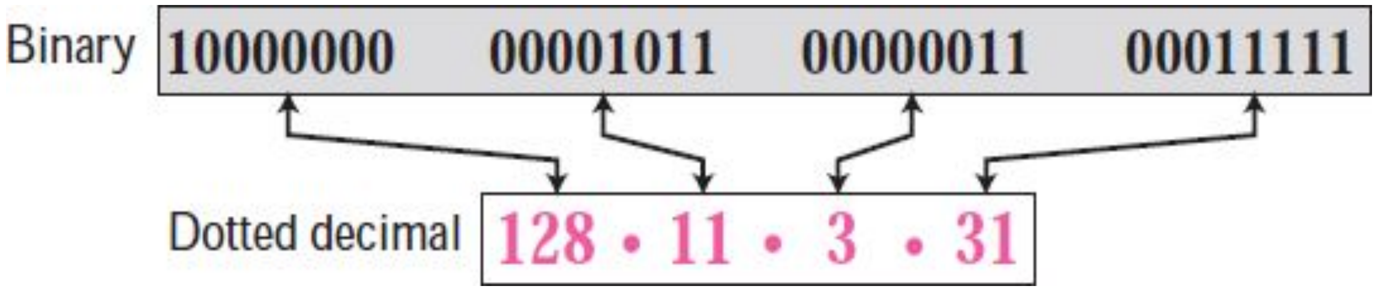
- Each octet is often referred to as a byte.

- **01110101 10010101 00011101 11101010**

Dotted-Decimal Notation: Base 256

- To make the IPv4 address more compact and easier to read, an IPv4 address is usually written in decimal form with a decimal point (dot) separating the bytes.

- This format is referred to as **dotted-decimal notation.**



Hexadecimal notation

- We sometimes see an IPv4 address in **hexadecimal notation.**
- **Each hexadecimal digit** is equivalent to four bits.

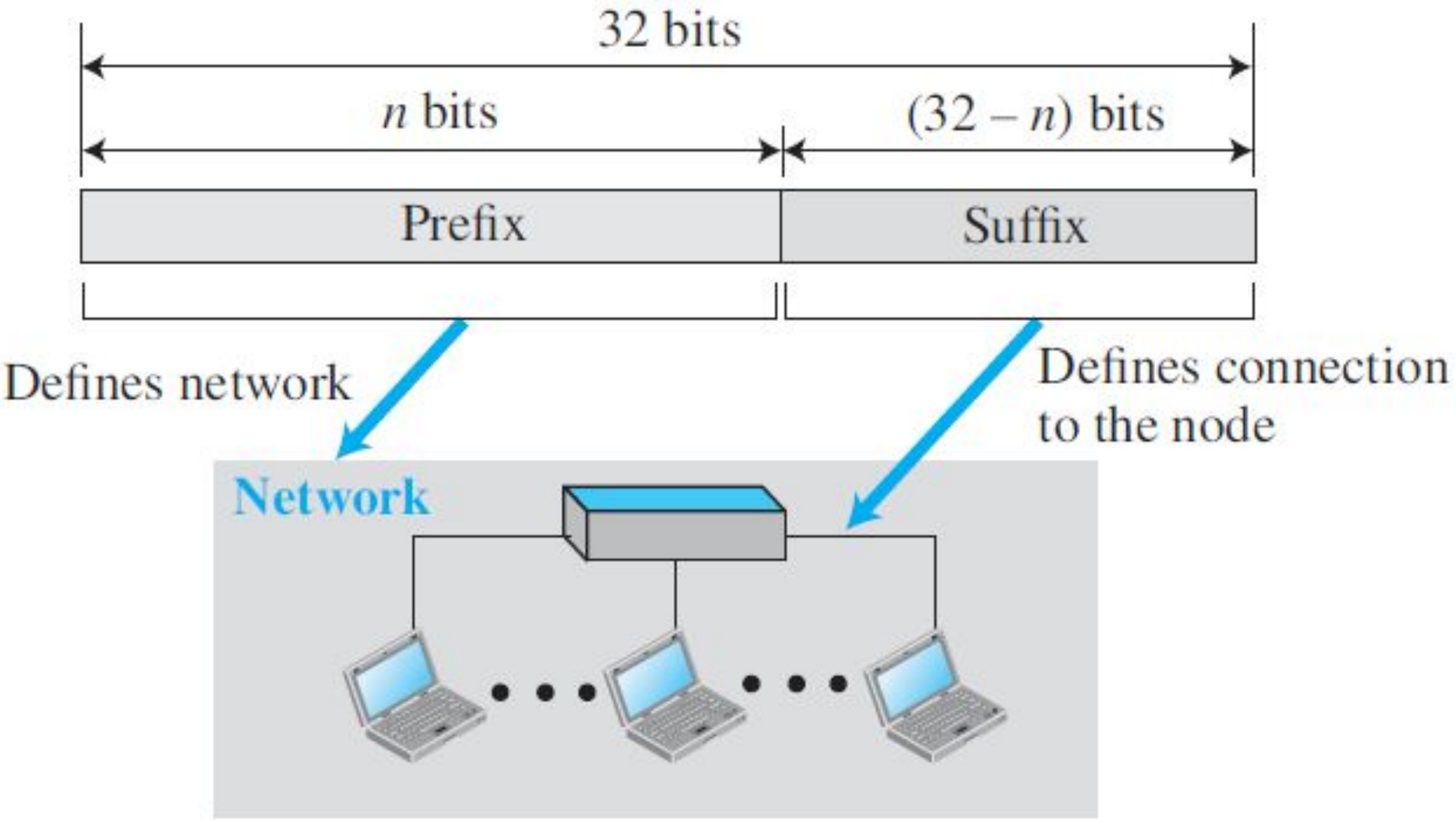
- This means that a 32-bit address has 8 hexadecimal digits.
- This notation is often used in network programming.

- **1000 0001 0000 1011 0000 1011 1110 1111**
- 0X810B0BEF or $810B0BEF_{16}$

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).
- Figure shows the prefix and suffix of a 32-bit IPv4 address.
- The prefix length is n bits and the suffix length is (32 − n) bits.
- A prefix can be fixed length or variable length.
- The network identifier in the IPv4 was first designed as a fixed-length prefix. This scheme, which is now obsolete, is referred to as classful addressing.
- The new scheme, which is referred to as classless addressing, uses a variable-length network prefix

Figure 4.30 *Hierarchy in addressing*



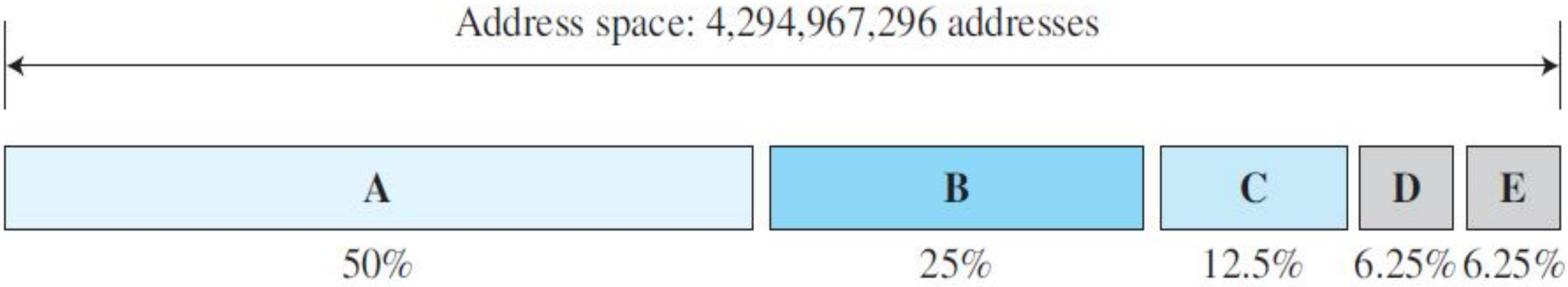
Classful addressing.

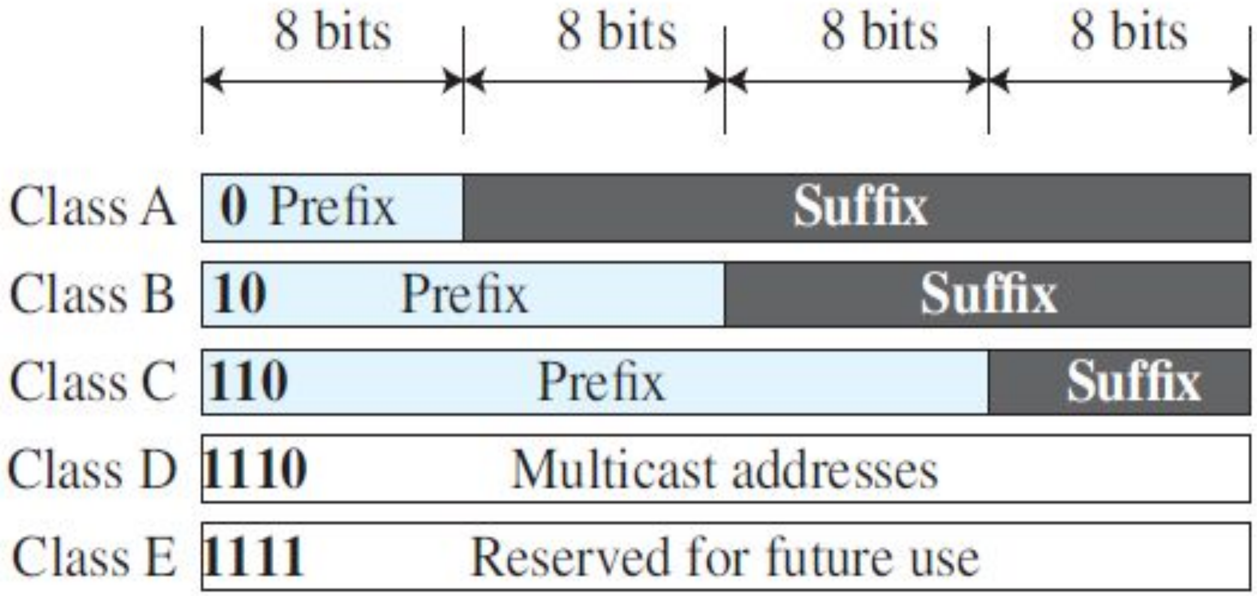
- When the Internet started, an IPv4 address was designed with a fixed-length prefix, but to accommodate both small and large networks, three fixed-length prefixes were designed instead of one (n = 8, n = 16, and n = 24).

- The whole address space was divided into five classes (class A, B, C, D, and E),

- This scheme is referred to as classful addressing.

Figure 4.31 *Occupation of the address space in 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

Finding Class of an IP Address

Find the class of each address:

a. 00000001 00001011 00001011 11101111

b. 11000001 10000011 00011011 11111111

c. 10100111 11011011 10001011 01101111

d. 11110011 10011011 11111011 00001111

a. The first bit is 0. This is a class A address.

b. The first 2 bits are 1; the third bit is 0. This is a class C address.

c. The first bit is 1; the second bit is 0. This is a class B address.

d. The first 4 bits are 1s. This is a class E address.

Finding Class of an IP Address

Find the class of each address:

a. 227.12.14.87

b. 193.14.56.22

c. 14.23.120.8

d. 252.5.15.111

Solution

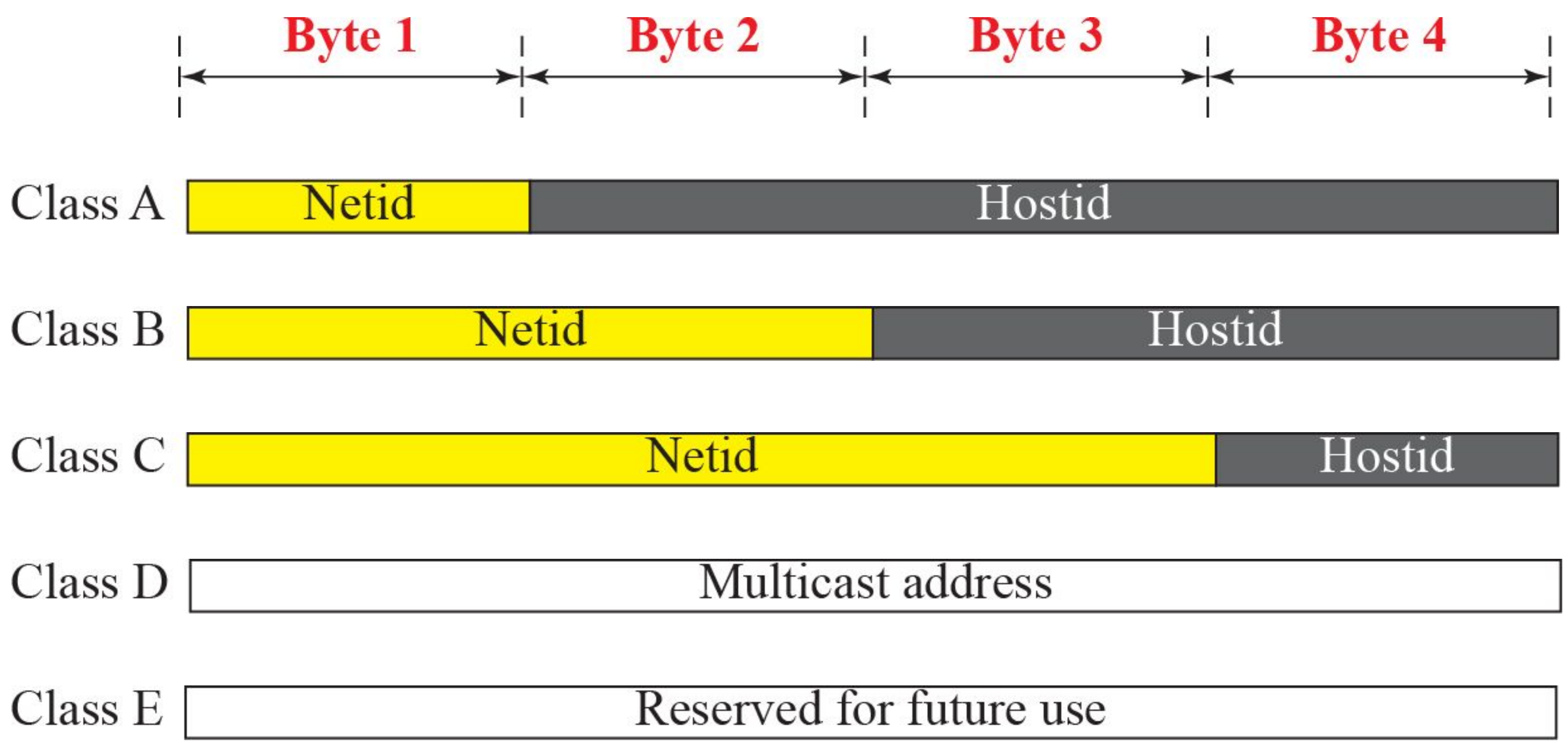
a. The first byte is 227 (between 224 and 239); the class is D.

b. The first byte is 193 (between 192 and 223); the class is C.

c. The first byte is 14 (between 0 and 127); the class is A.

d. The first byte is 252 (between 240 and 255); the class is E.

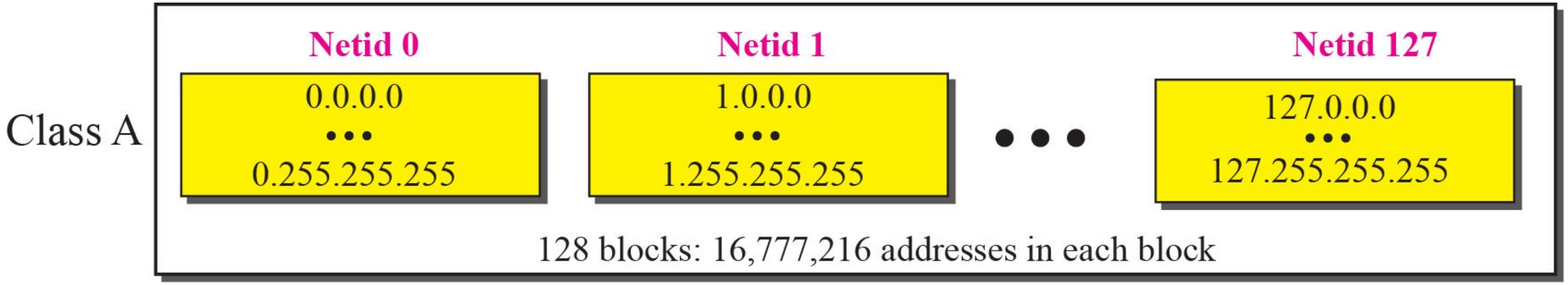
Netid and hostid



Classful Addressing :Classes and Blocks

- One problem with classful addressing is that each class is divided into a fixed number of blocks with each block having a fixed size.

Classful Addressing :Classes and Blocks



In class A, the network length is 8 bits, but since the first bit, which is 0, defines the class, we can have only seven bits as the network identifier.

This means there are only 2^7 = 128 networks/blocks in the world that can have a class A address.

Millions of class A addresses are wasted.

Classful Addressing :Classes and Blocks

- In class B, the network length is 16 bits, but since the first two bits, which are (10), define the class, we can have only 14 bits as the network identifier. This means there are only 2^14 = 16,384 networks/blocks 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 network length 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.

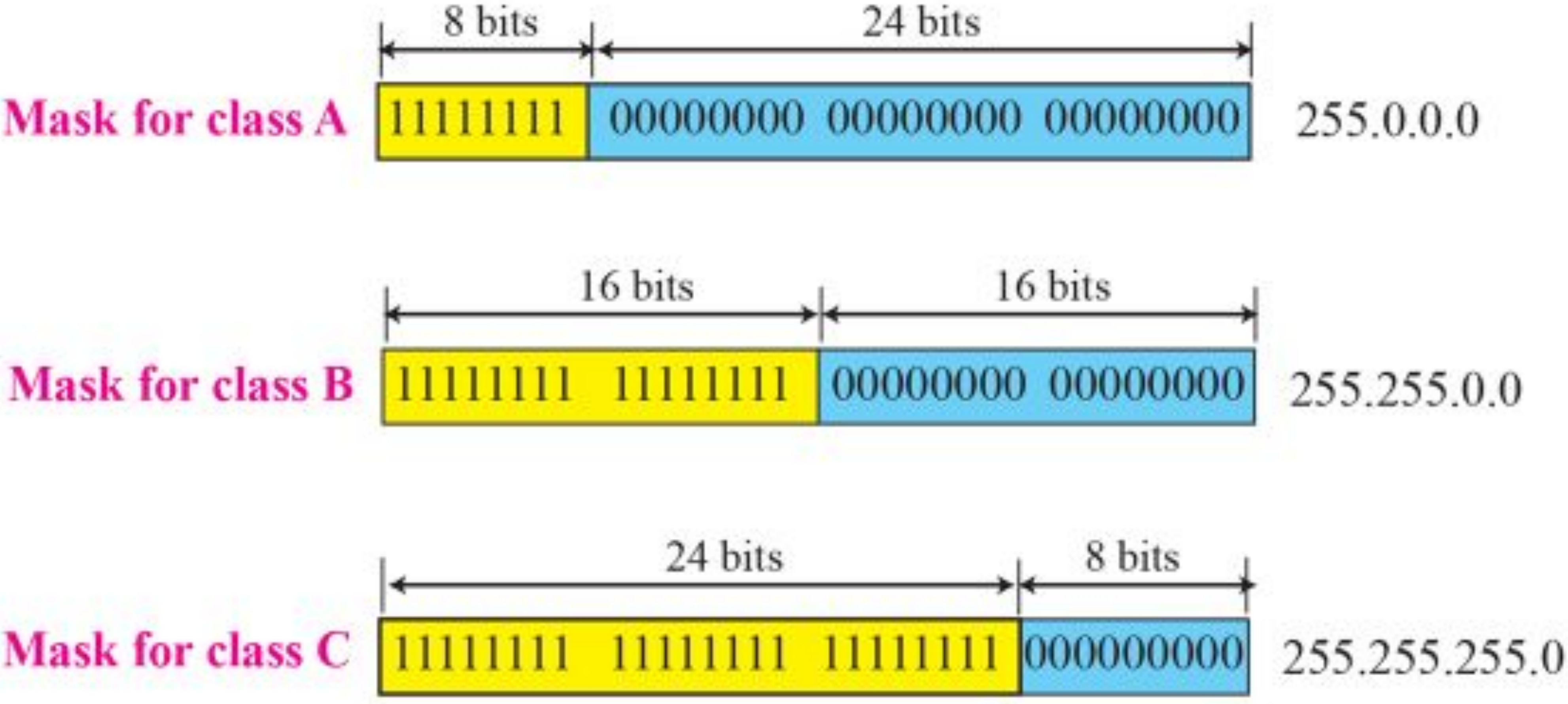
- Class D is not divided into prefix and suffix. It is used for multicast addresses. All addresses that start with 1111 in binary belong to class E. As in Class D, Class E is not divided into prefix and suffix and is used as reserve.

Class D addresses are made of one block, used for multicasting.

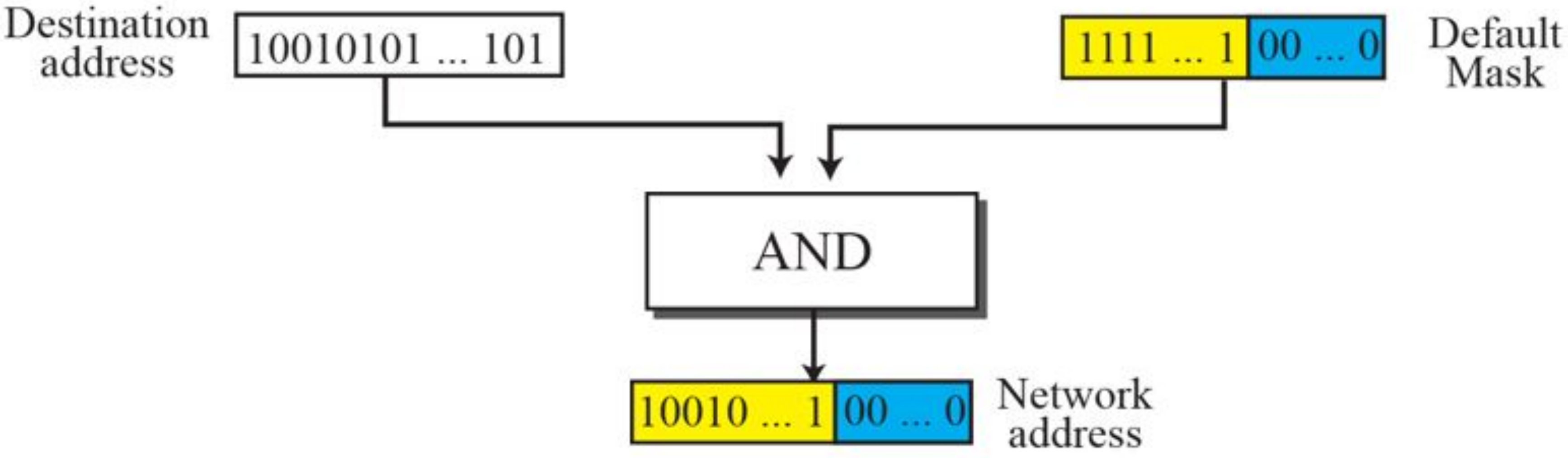
The only block of class E addresses was reserved for future purposes.

The range of addresses allocated to an organization in classful addressing was a block of addresses in Class A, B, or C.

Network mask : Classful Addressing



Finding a network address using the default mask



Classful Addressing : Address Depletion

- The reason that classful addressing has become obsolete is address depletion.

- Since the addresses 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.

Classful Addressing : Address Depletion

- Let us think about class A.
- This class can be assigned to only 128 organizations in the world, but each organization needs to have one single network (seen by the rest of the world) with 16,777,216 nodes (computers in this single network).
- Since there may be only a few organizations that are this large, most of the addresses in this class were wasted (unused).

Classful Addressing : Address Depletion

- Class B addresses were designed for midsize organization, 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 E addresses were almost never used, wasting the whole class.

Subnetting and Supernetting

- **To alleviate address depletion, two strategies were proposed and, to some extent, implemented: 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 address to be divided among several organizations.
- This idea did not work because most large organizations were not happy about dividing the block and giving some of the unused addresses to smaller organizations.

Subnetting and Supernetting

- 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.

- This idea did not work either because it makes the routing of packets more difficult.

Advantage of Classful Addressing

- Although classful addressing had several problems and became obsolete, it had one advantage:

- 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.

Three-Level Addressing: Subnetting

- The idea of splitting a block to smaller blocks is referred to as subnetting.
- In **subnetting, a network is divided into several smaller subnetworks (subnets)** with each subnetwork having its own subnetwork address.

Before Subnetting

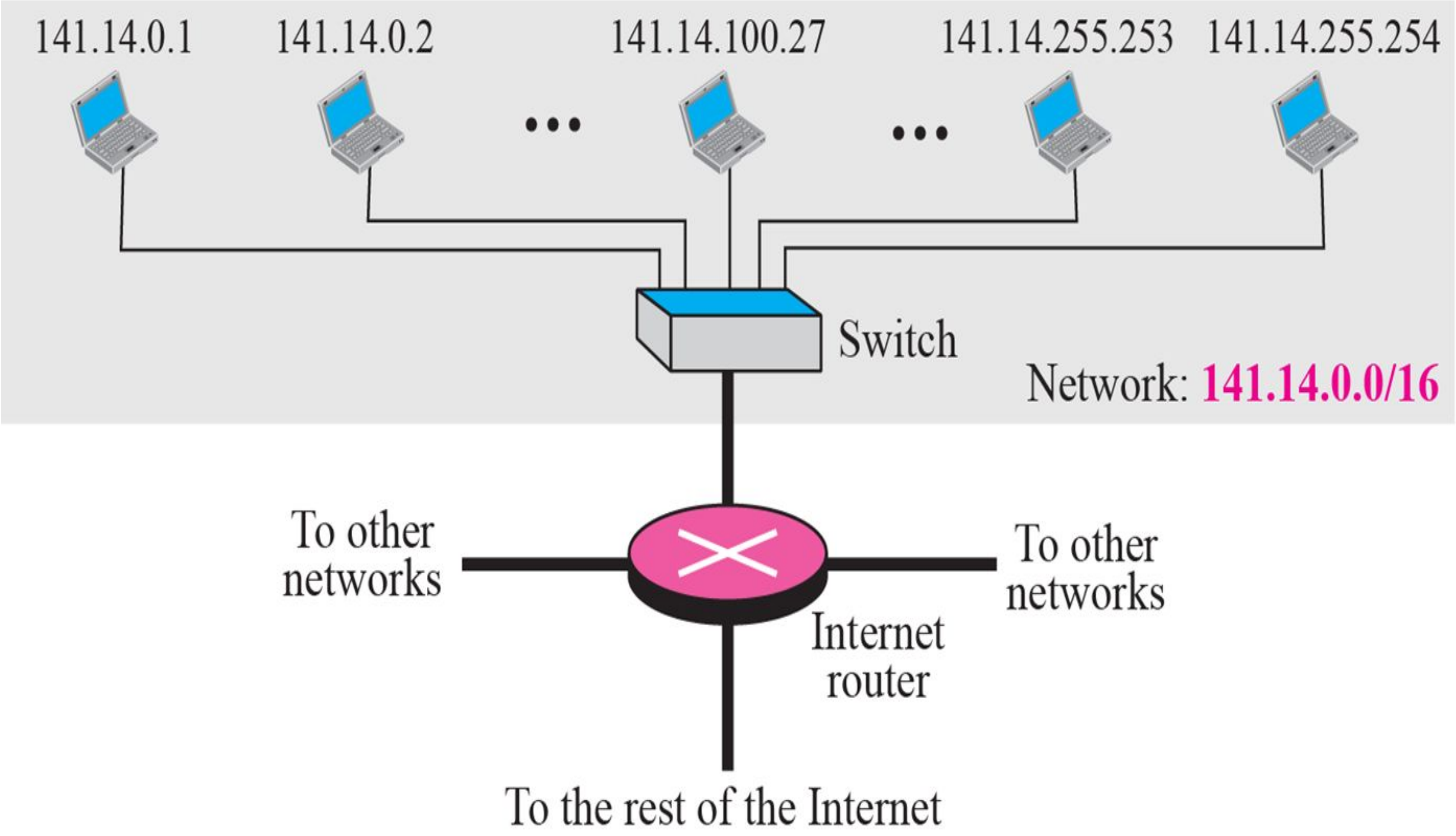


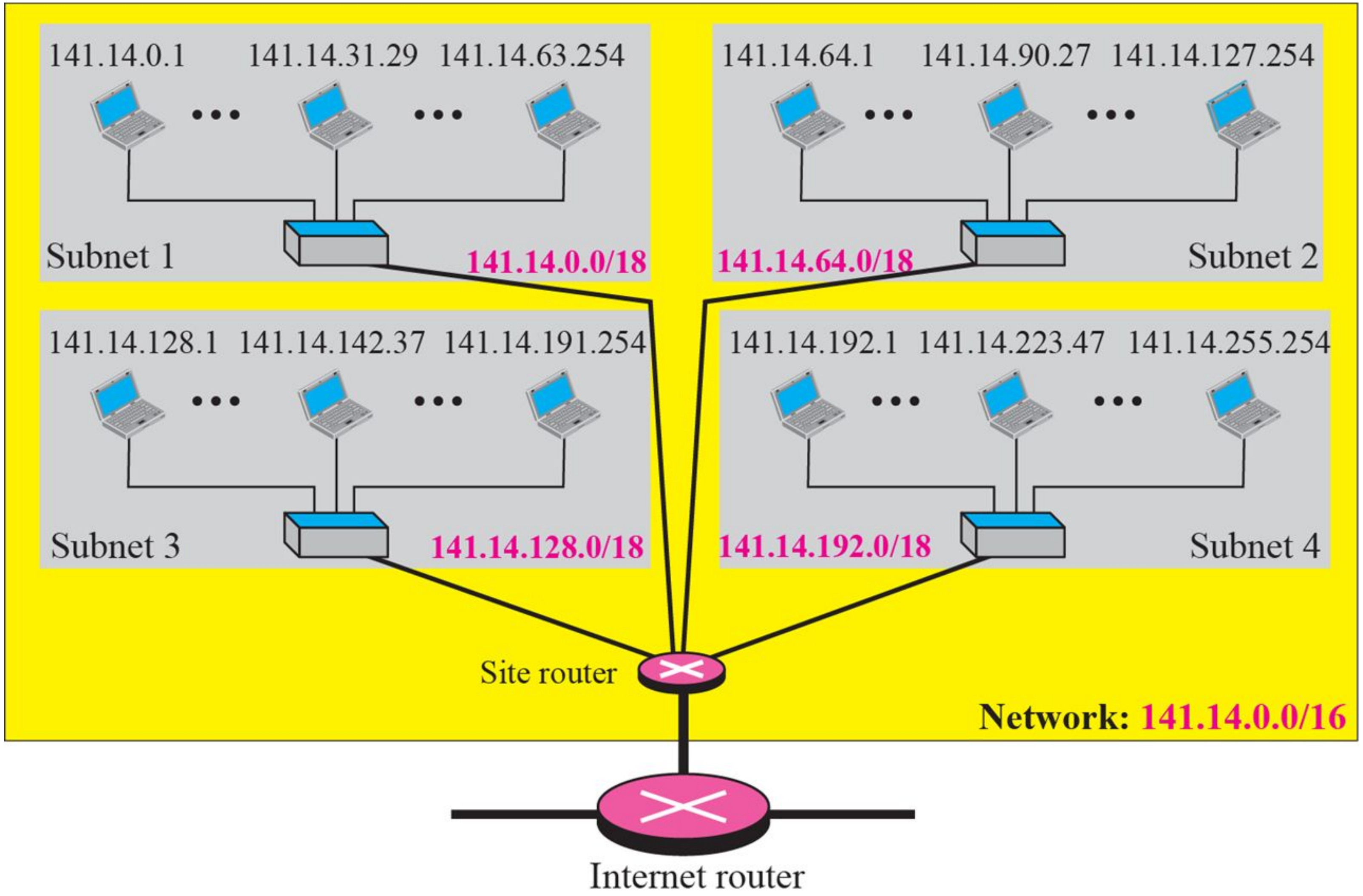
Figure shows a network using class B addresses before subnetting.

We have just one network with almost 2^{16} hosts.

The whole network is connected, through one single connection, to one of the routers in the Internet.

Note that we have shown /16 to show the length of the netid (class B).

After Subnetting



Network Mask and Subnetwork Mask