Chapter 4

IP Addresses: Classful Addressing

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- INTRODUCTION
- CLASSFUL ADDRESSING
- OTHER ISSUES
- A SAMPLE INTERNET

4.1

INTRODUCTION

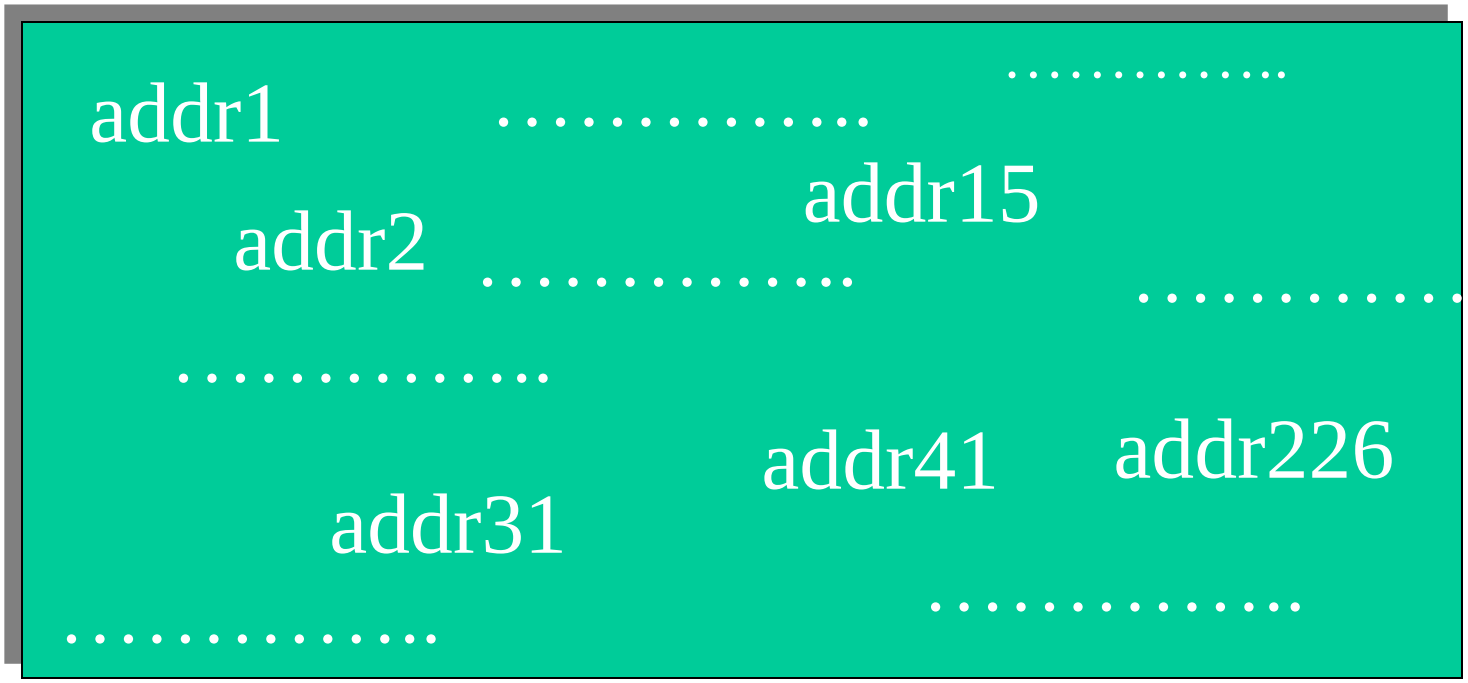
Note

An IP address is a 32-bit address.

Note

The IP addresses are unique.

Address Space



RULE:

If a protocol uses *N* bits to define an address, the address space is 2^N because each bit can have two different values (0 and 1) and *N* bits can have 2^N values.

Note

The address space of IPv4 is

$$2^{32}$$

or

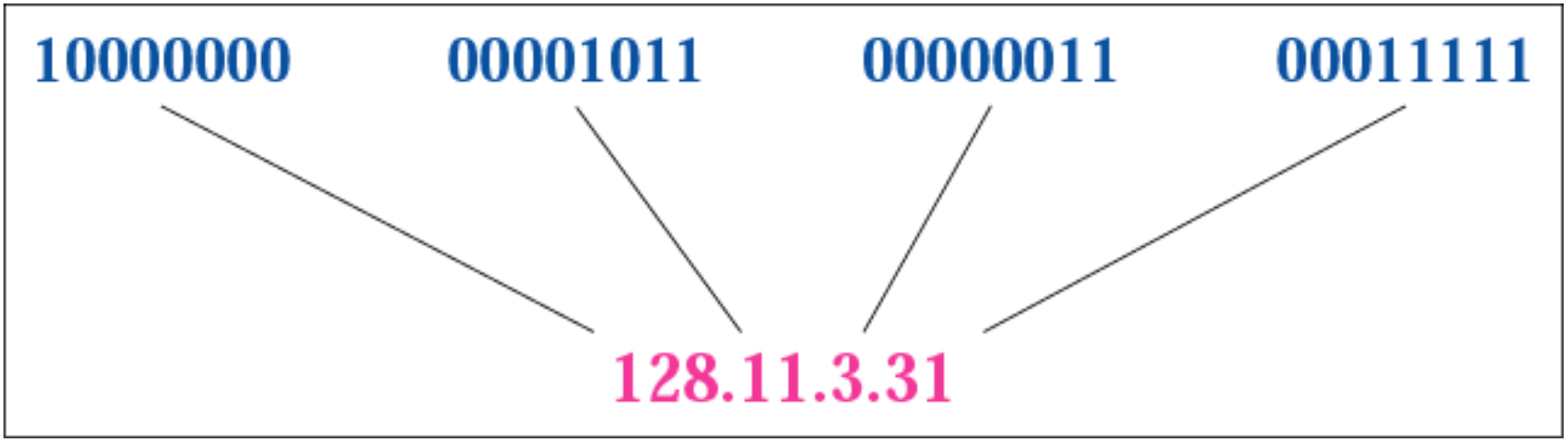
4,294,967,296.

Binary Notation

01110101 10010101 00011101 11101010

Figure 4-1

Dotted-decimal notation



Hexadecimal Notation

0111 0101 1001 0101 0001 1101 1110 1010

75 95 1D EA

0x75951DEA

Example 1

Change the following IP address from binary notation to dotted-decimal notation.

10000001 00001011 00001011 11101111

Solution

129.11.11.239

Example 2

Change the following IP address from dotted-decimal notation to binary notation.

111.56.45.78

Solution

01101111 00111000 00101101 01001110

Example 3

Find the error, if any, in the following IP address:

111.56.045.78

Solution

There are no leading zeroes in dotted-decimal notation (045).

Example 3 (continued)

Find the error, if any, in the following IP address:

75.45.301.14

Solution

In dotted-decimal notation, each number is less than or equal to 255; 301 is outside this range.

Example 4

Change the following IP addresses from binary notation to hexadecimal notation.

10000001 00001011 00001011 11101111

Solution

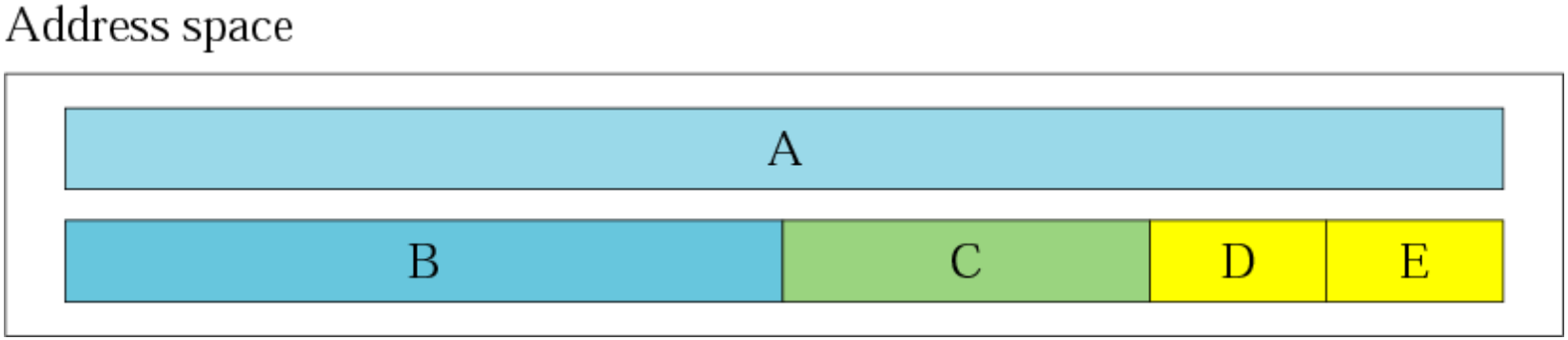
0X810B0BEF or $810B0BEF_{16}$

4.2

CLASSFUL ADDRESSING

Figure 4-2

Occupation of the address space



Note

In classful addressing, the address space is divided into five classes: A, B, C, D, and E.

Figure 4-3

Finding the class in binary notation

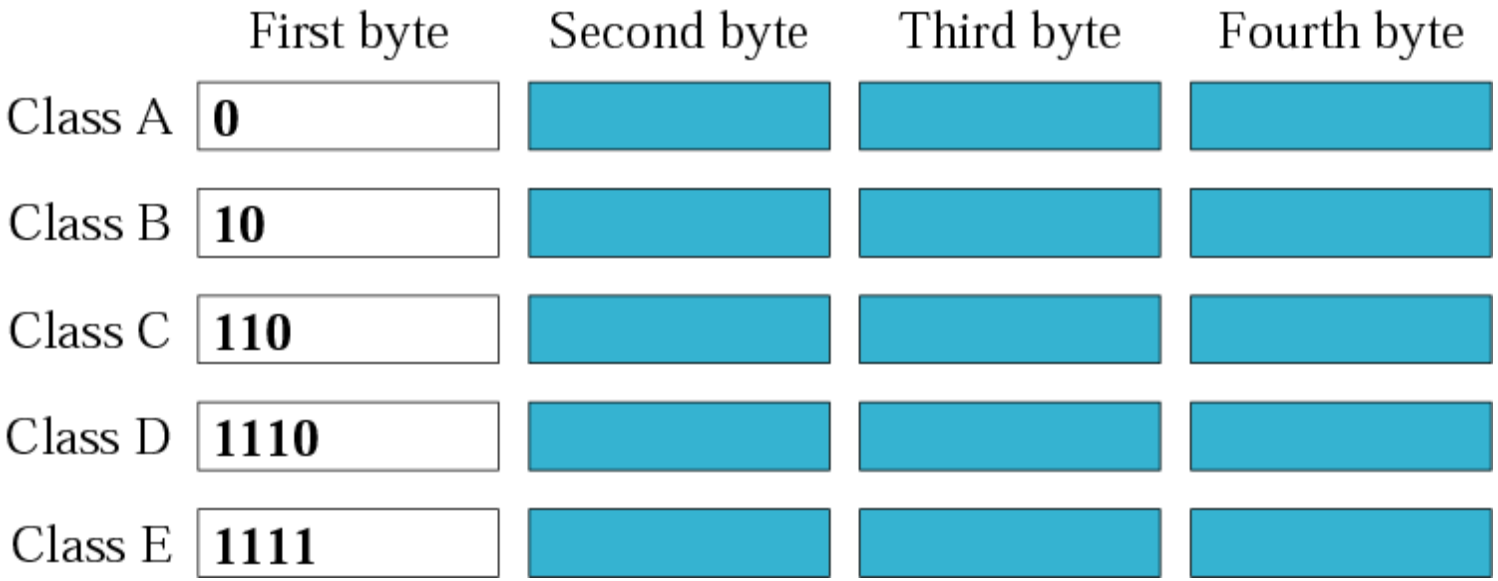
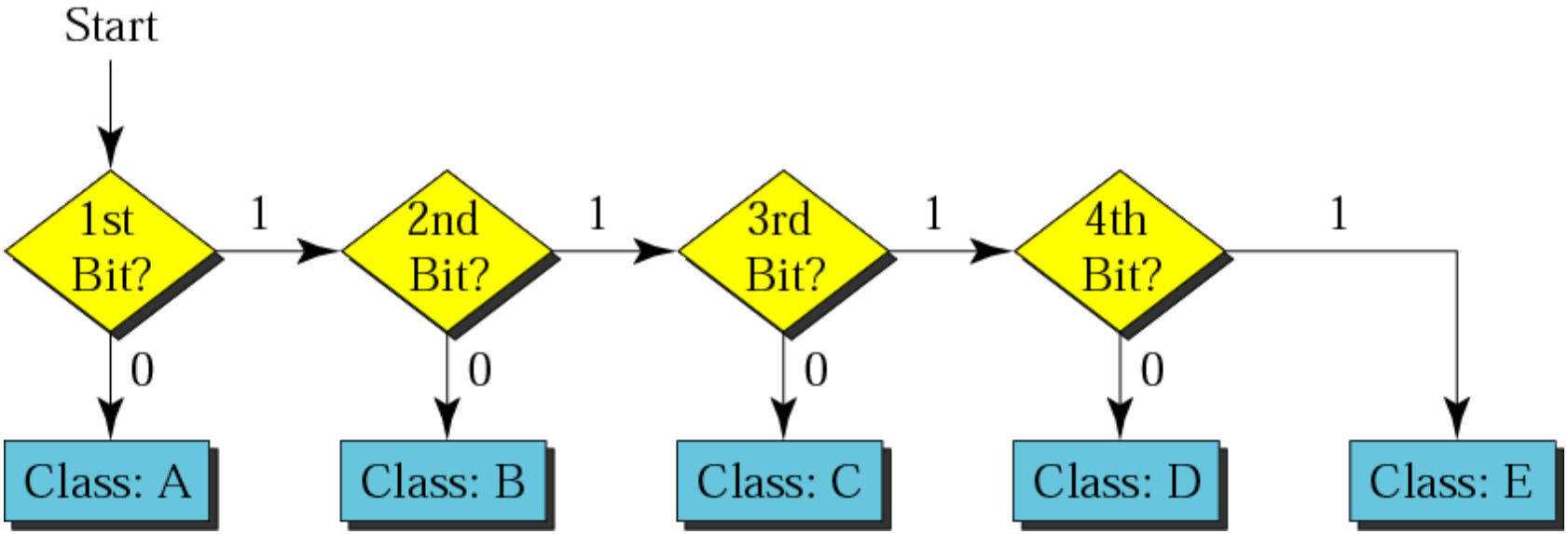


Figure 4-4

Finding the address class



Example 5

How can we prove that we have 2,147,483,648 addresses in class A?

Solution

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.

Example 6

Find the class of the address:

00000001 00001011 00001011 11101111

Solution

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

Example 6 (Continued)

Find the class of the address:

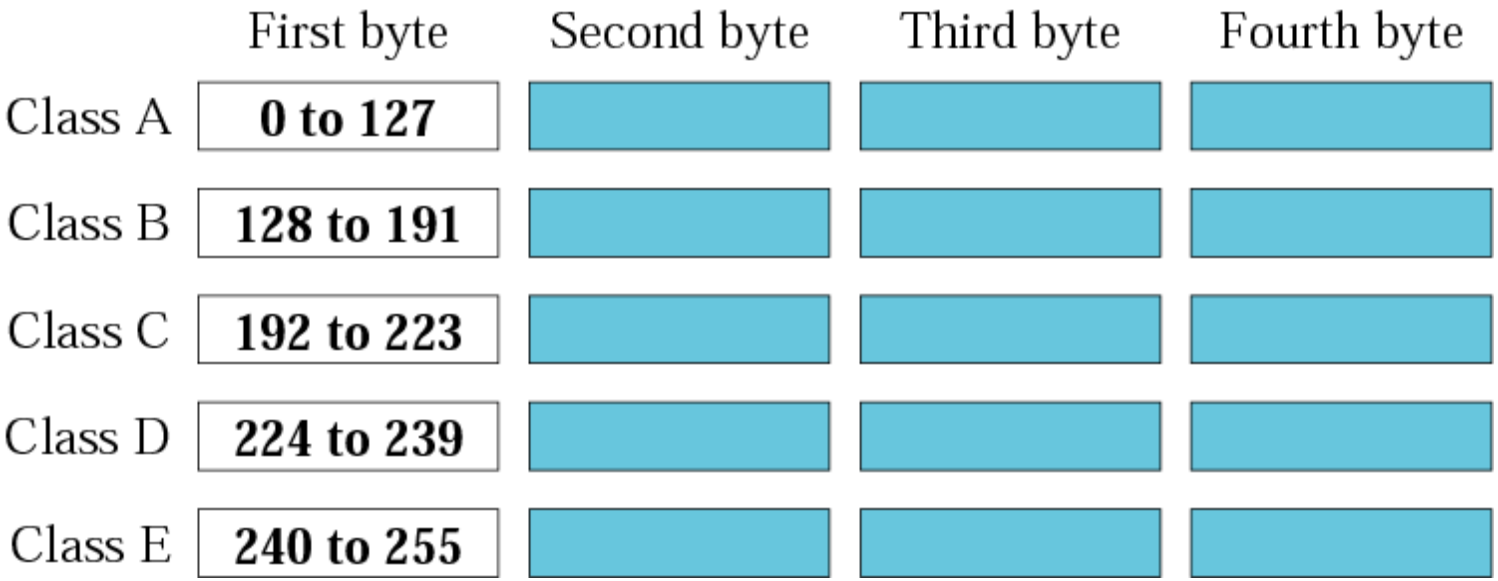
11000001 10000011 00011011 11111111

Solution

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

Figure 4-5

Finding the class in decimal notation



Example 7

Find the class of the address:

227.12.14.87

Solution

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

Example 7 (Continued)

Find the class of the address:

193.14.56.22

Solution

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

Example 8

In Example 4 we showed that class A has 2^{31} (2,147,483,648) addresses. How can we prove this same fact using dotted-decimal notation?

Solution

The addresses in class A range from 0.0.0.0 to 127.255.255.255. We notice that we are dealing with base 256 numbers here.

Solution (Continued)

Each byte in the notation has a weight. The weights are as follows:

256^3 , 256^2, 256^1, 256^0

Last address: $127 \times 256^3 + 255 \times 256^2 + 255 \times 256^1 + 255 \times 256^0 = 2{,}147{,}483{,}647$

First address: = 0

If we subtract the first from the last and add 1, we get 2,147,483,648.

Figure 4-6

Netid and hostid

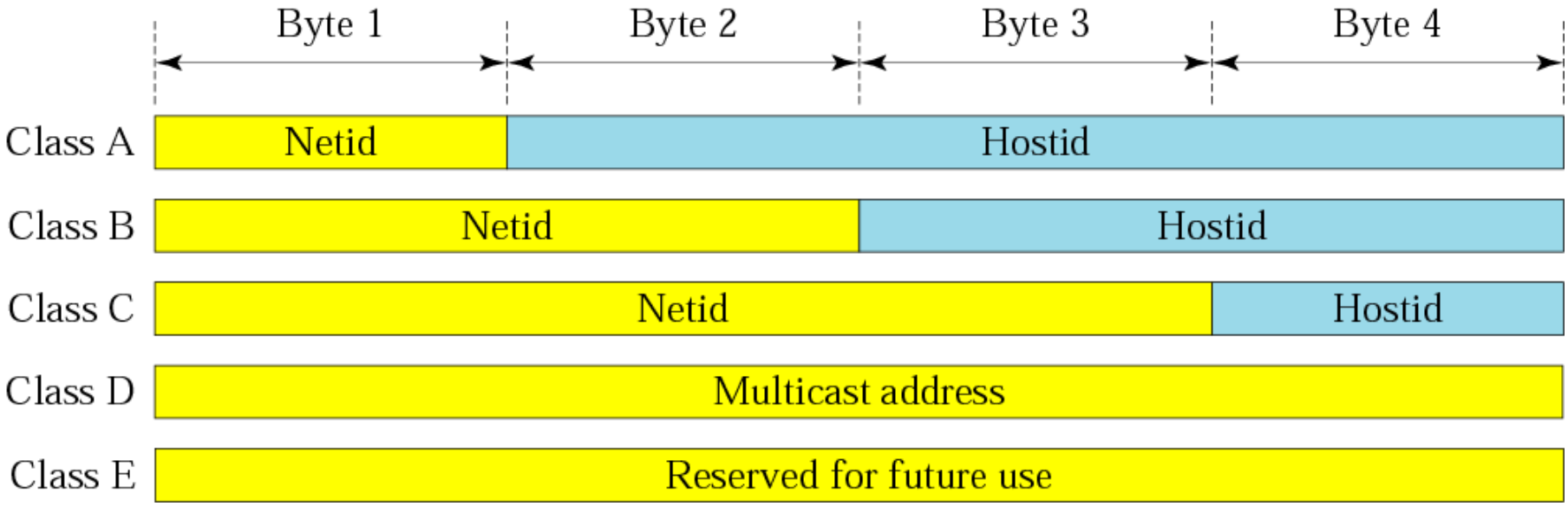
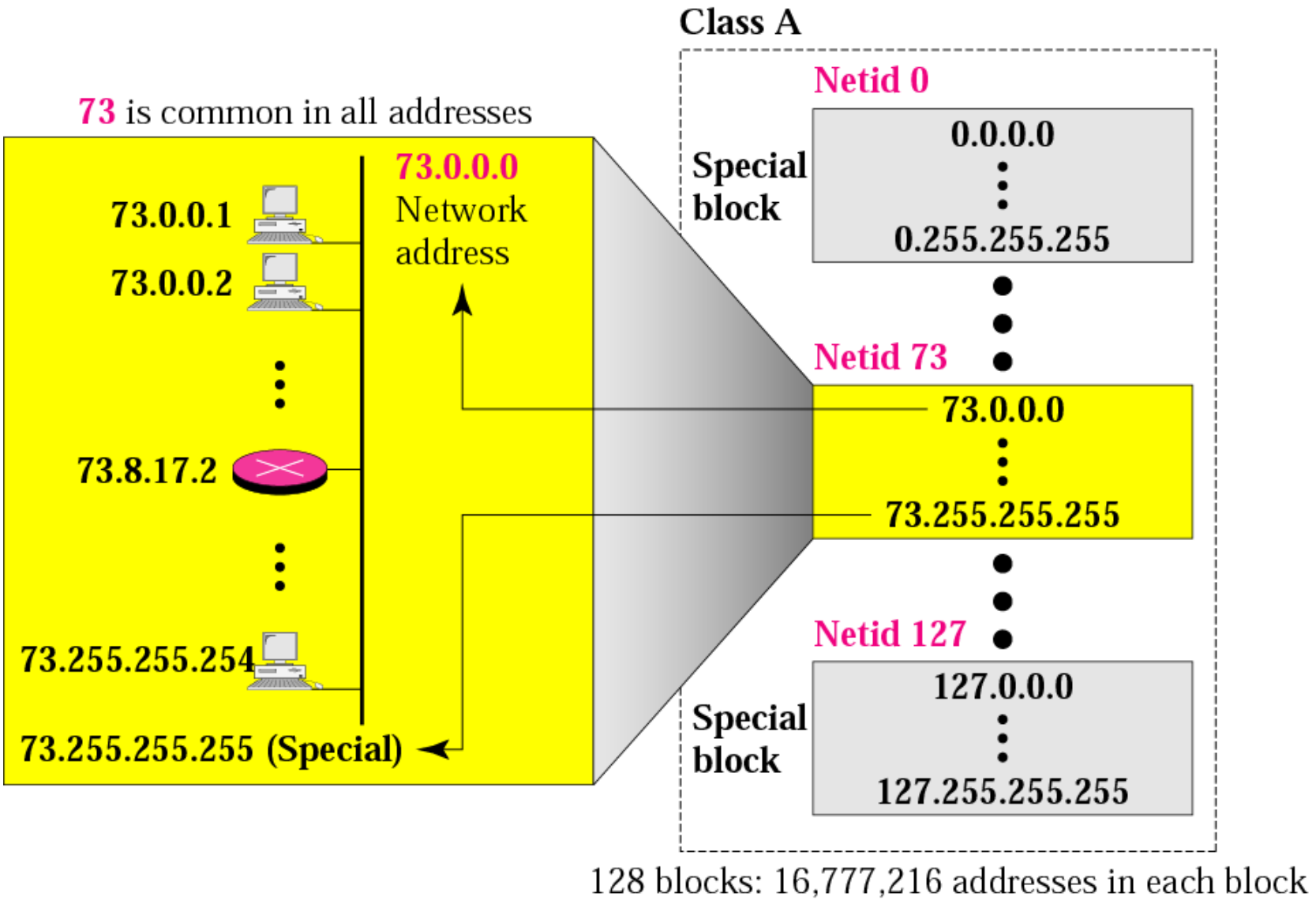


Figure 4-7

Blocks in class A

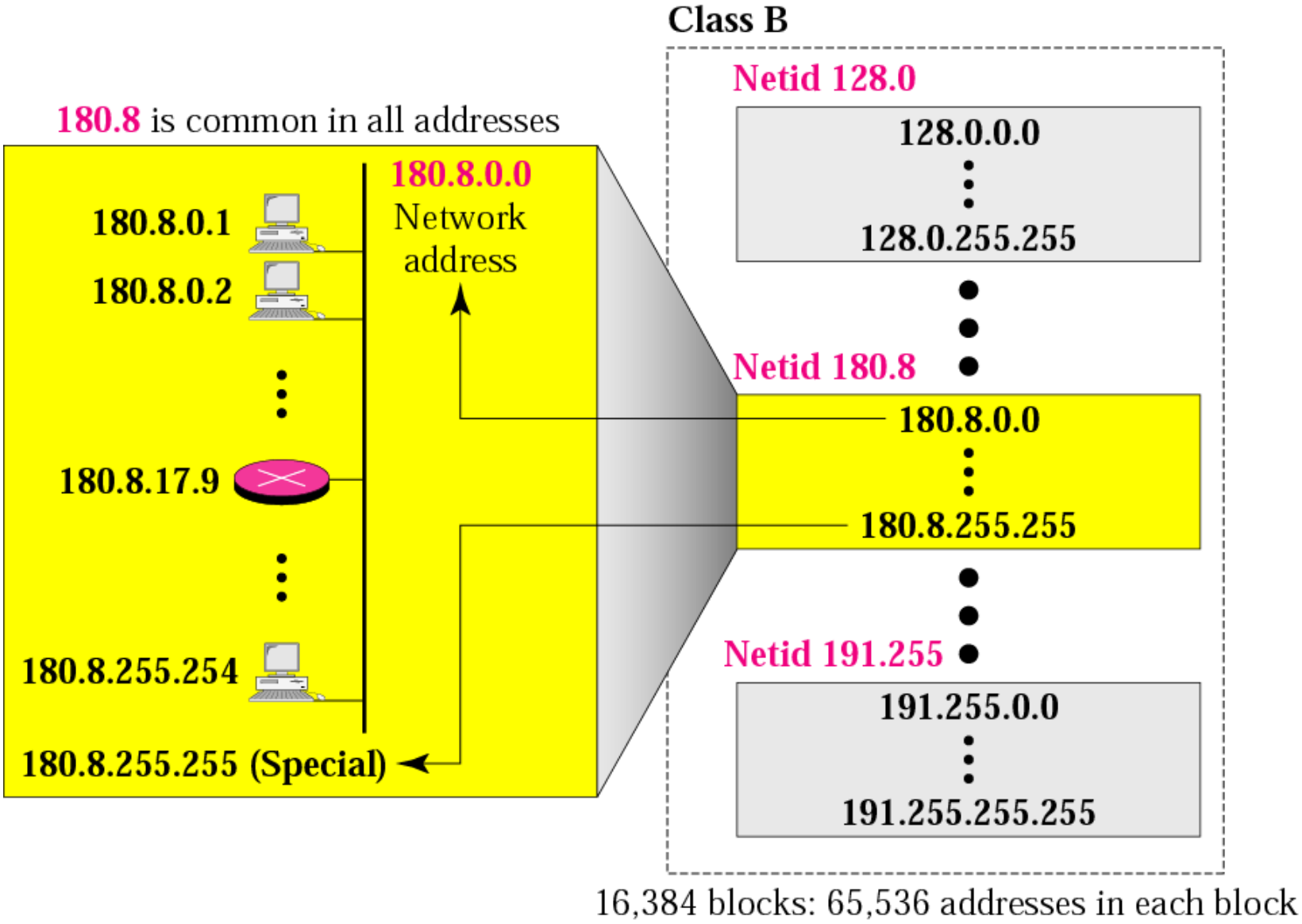


Note

Millions of class A addresses are wasted.

Figure 4-8

Blocks in class B

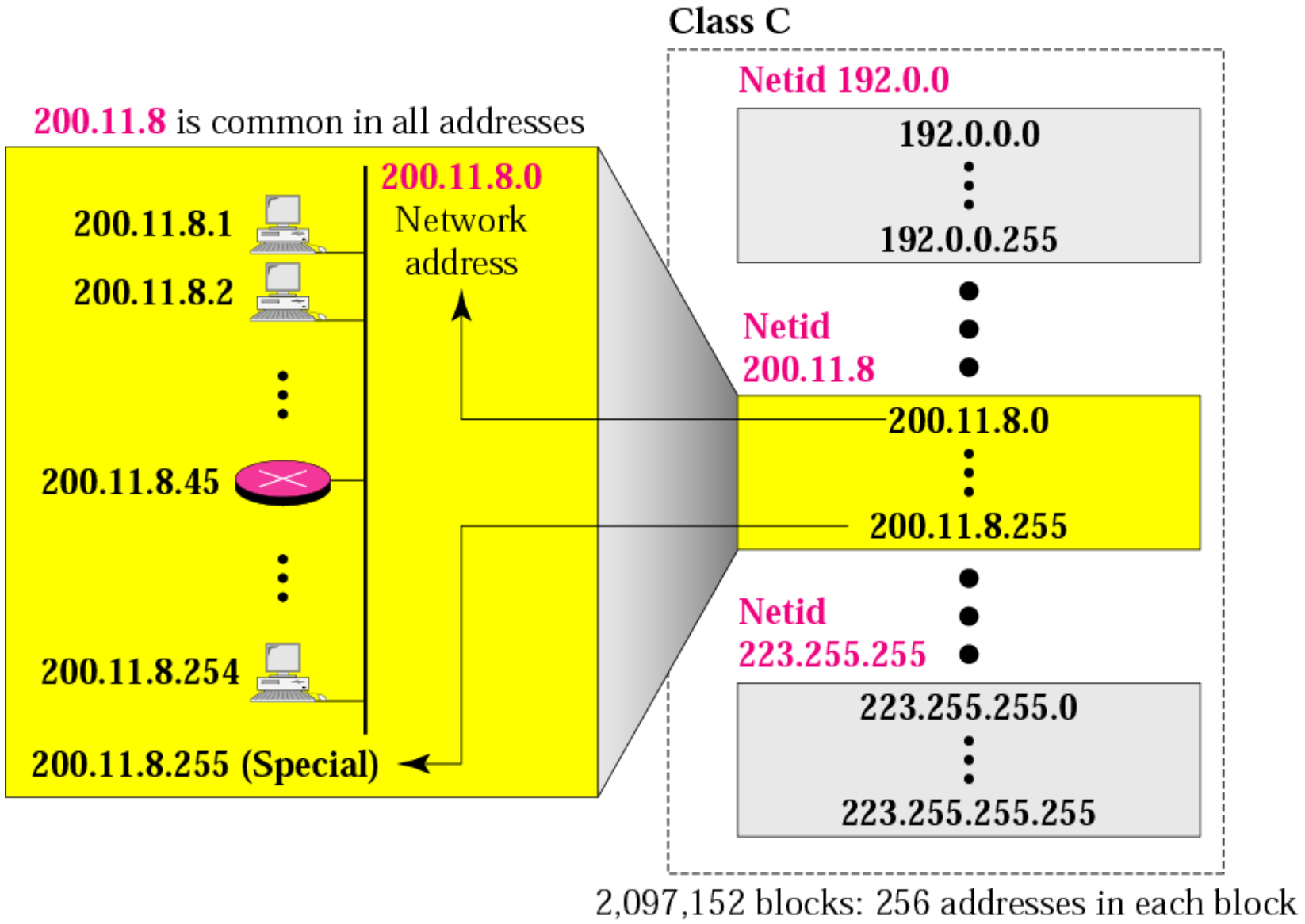


Note

Many class B addresses are wasted.

Figure 4-9

Blocks in class C



Note

The number of addresses in a class C block is smaller than the needs of most organizations.

Note

Class D addresses are used for multicasting; there is only one block in this class.

Note

Class E addresses are reserved for special purposes; most of the block is wasted.

Network Addresses

The network address is the first address.

The network address defines the network to the rest of the Internet.

Given the network address, we can find the class of the address, the block, and the range of the addresses in the block

Note

In classful addressing, the network address (the first address in the block) is the one that is assigned to the organization.

Example 9

Given the network address 17.0.0.0, find the class, the block, and the range of the addresses.

Solution

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.

Example 10

Given the network address 132.21.0.0, find the class, the block, and the range of the addresses.

Solution

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.

Example 11

Given the network address 220.34.76.0, find the class, the block, and the range of the addresses.

Solution

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.

Mask

A mask is a 32-bit binary number that gives the first address in the block (the network address) when bitwise ANDed with an address in the block.

Figure 4-10

Masking concept

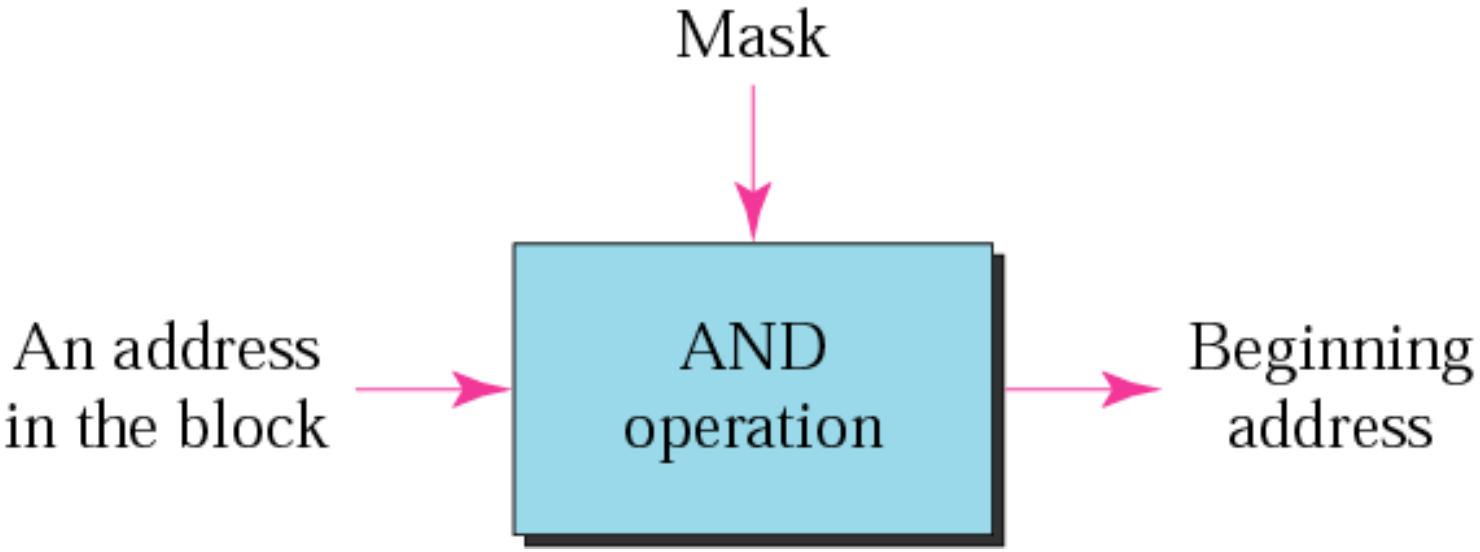
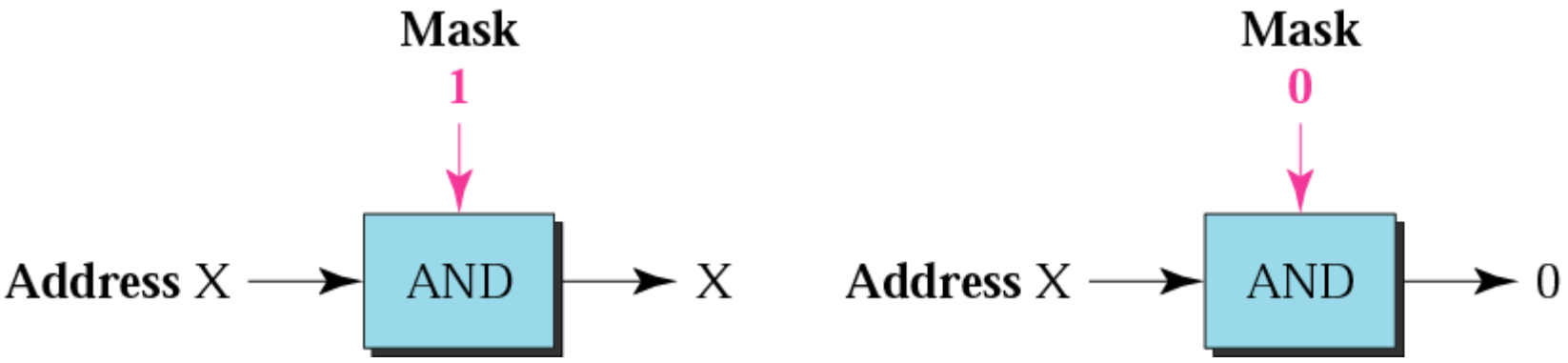


Figure 4-11

AND operation



Note

The network address is the beginning address of each block. It can be found by applying the default mask to any of the addresses in the block (including itself). It retains the netid of the block and sets the hostid to zero.

Example 12

Given the address 23.56.7.91 and the default class A mask, find the beginning address (network address).

Solution

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.

Example 13

Given the address 132.6.17.85 and the default class B mask, find the beginning address (network address).

Solution

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.

Example 14

Given the address 201.180.56.5 and the class C default mask, find the beginning address (network address).

Solution

The default mask is 255.255.255.0, which means that the first 3 bytes are preserved and the last byte is set to 0. The network address is 201.180.56.0.

Note

We must not apply the default mask of one class to an address belonging to another class.

4.13

OTHER ISSUES

Figure 4-12

Multihomed devices

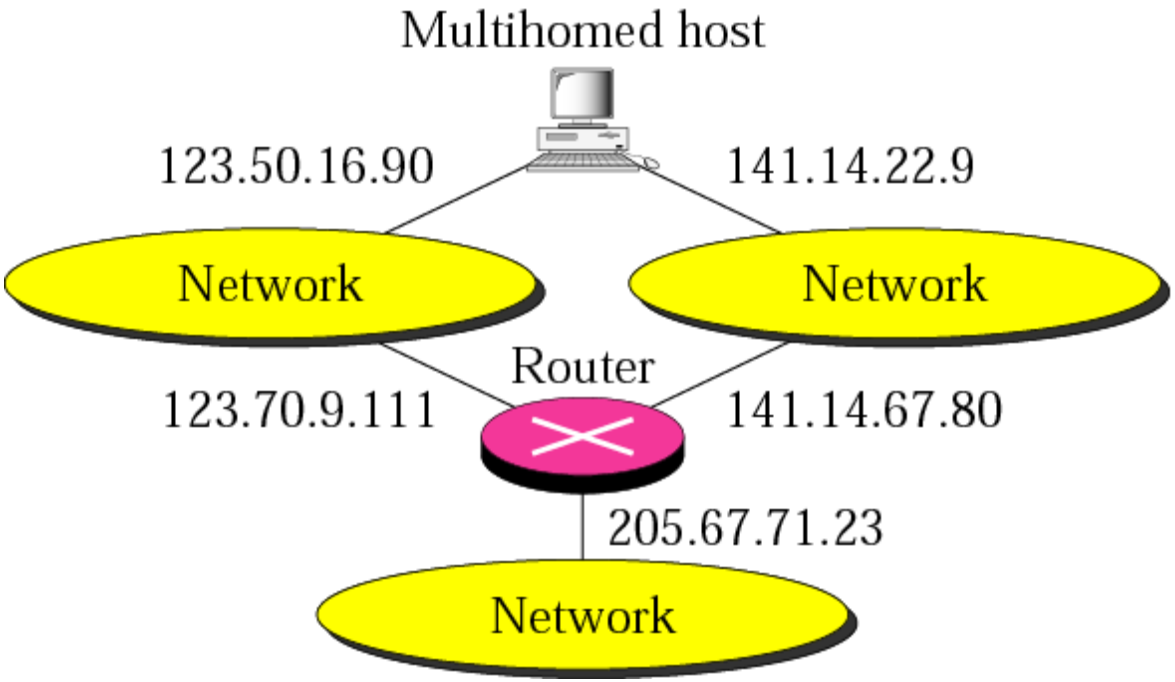


Figure 4-13

Network addresses

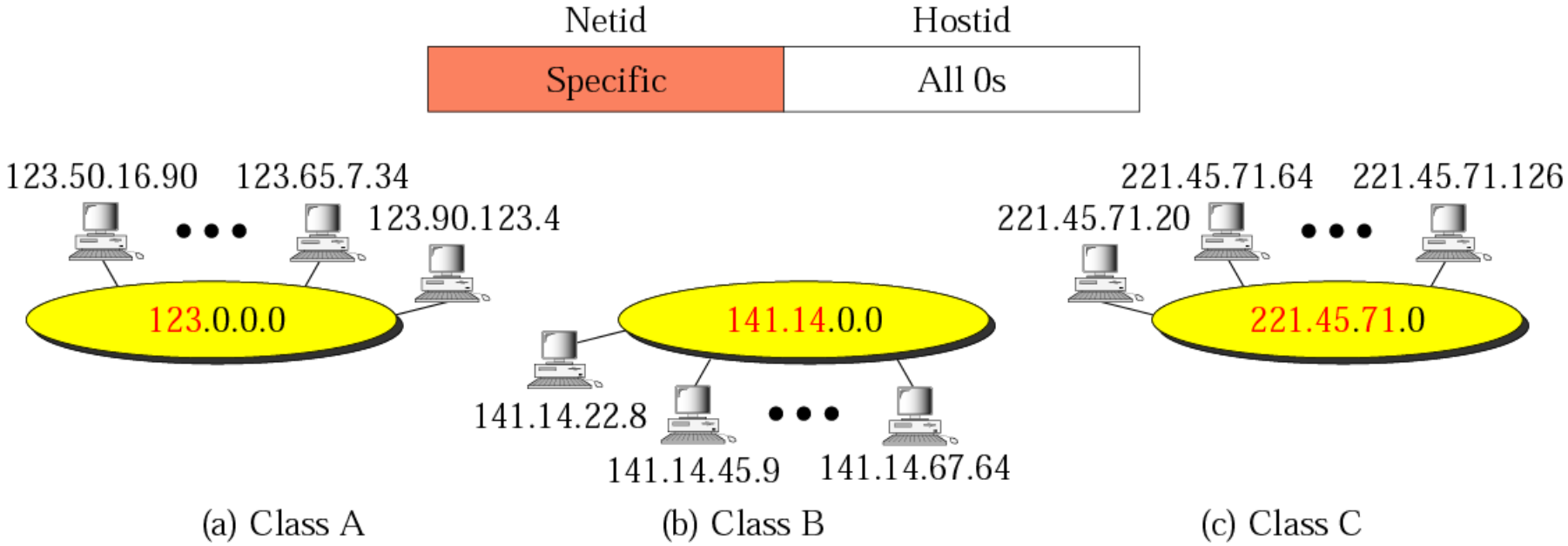
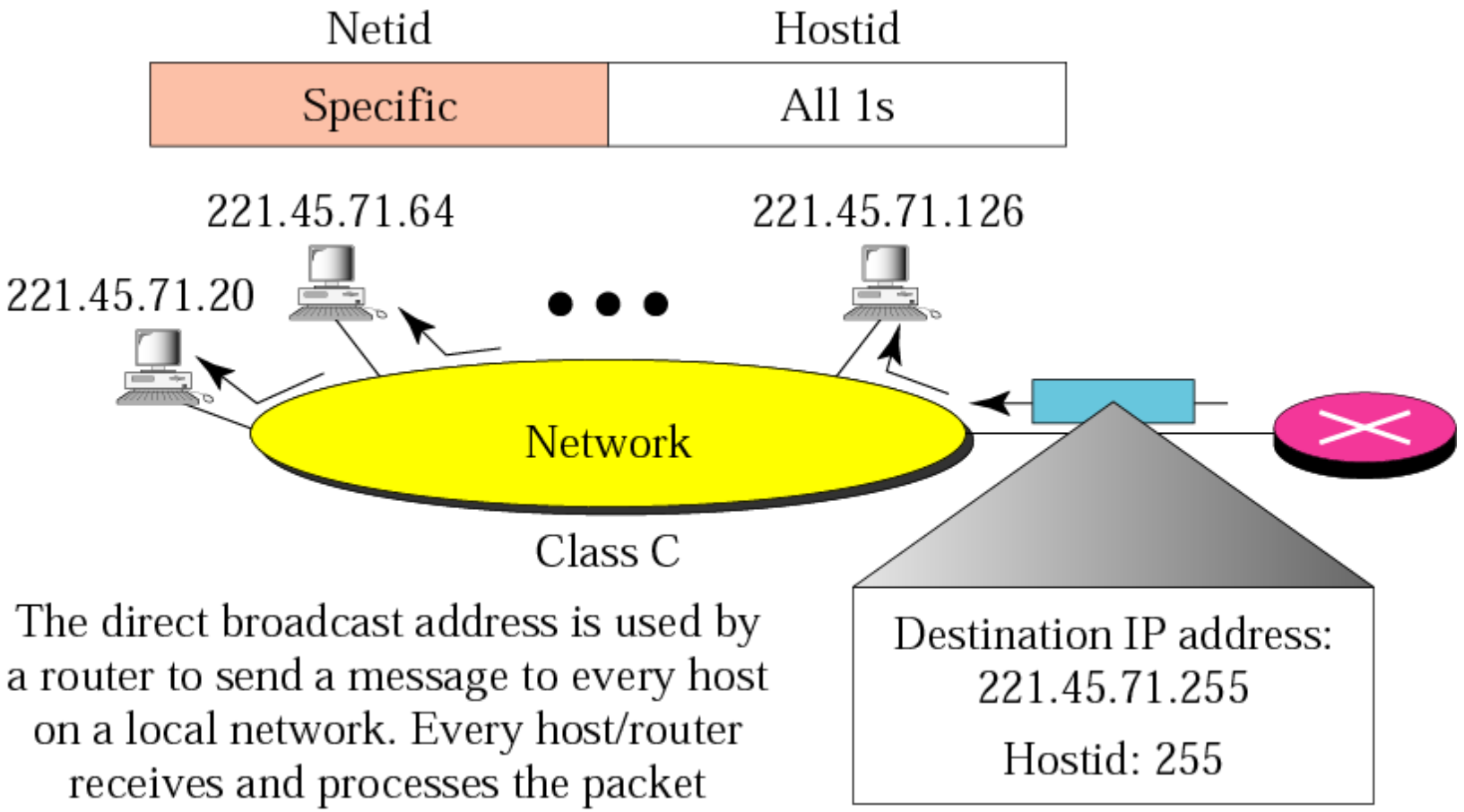


Figure 4-14

Example of direct broadcast address



The direct broadcast address is used by a router to send a message to every host on a local network. Every host/router receives and processes the packet with a direct broadcast address.

Figure 4-15

Example of limited broadcast address

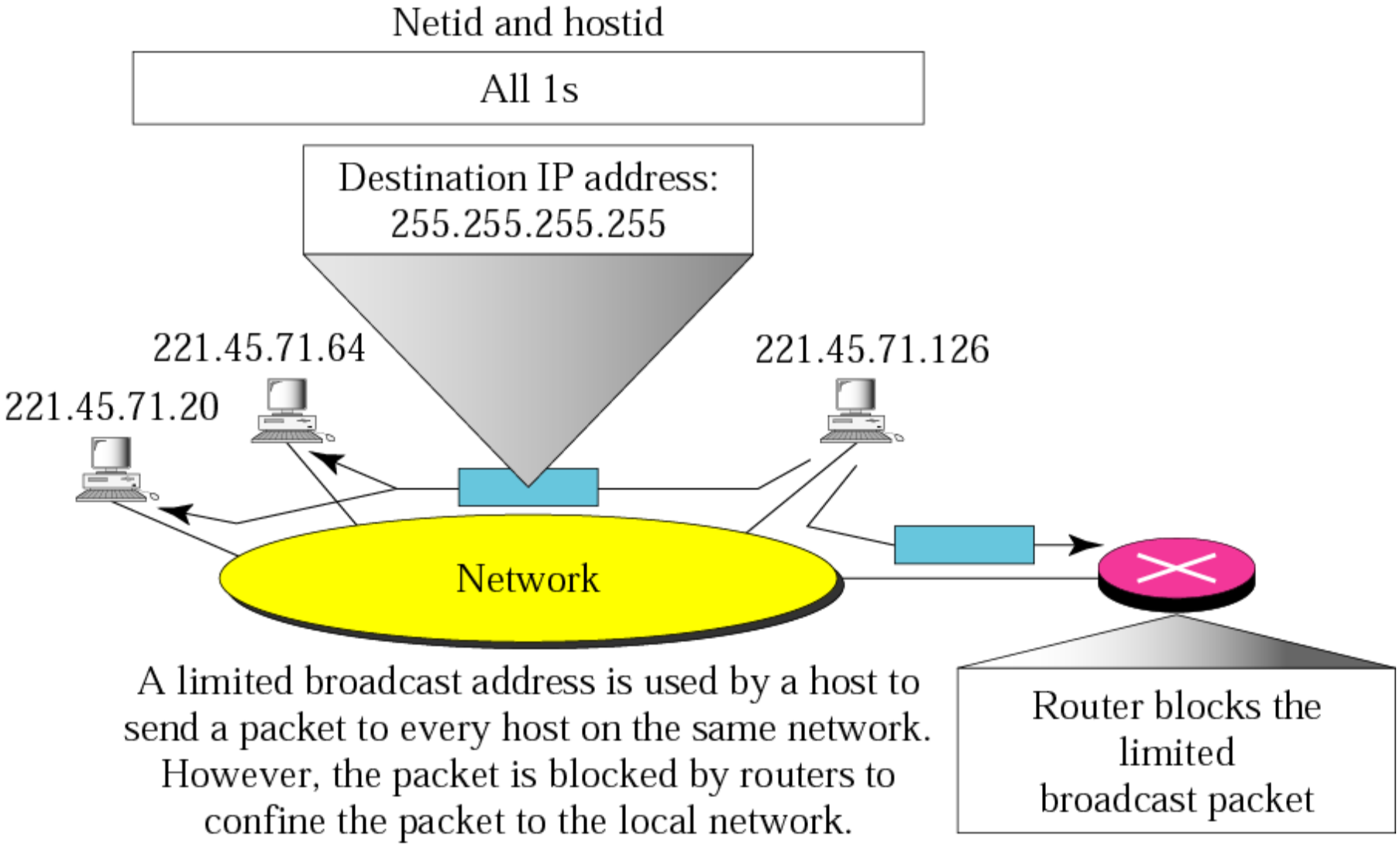
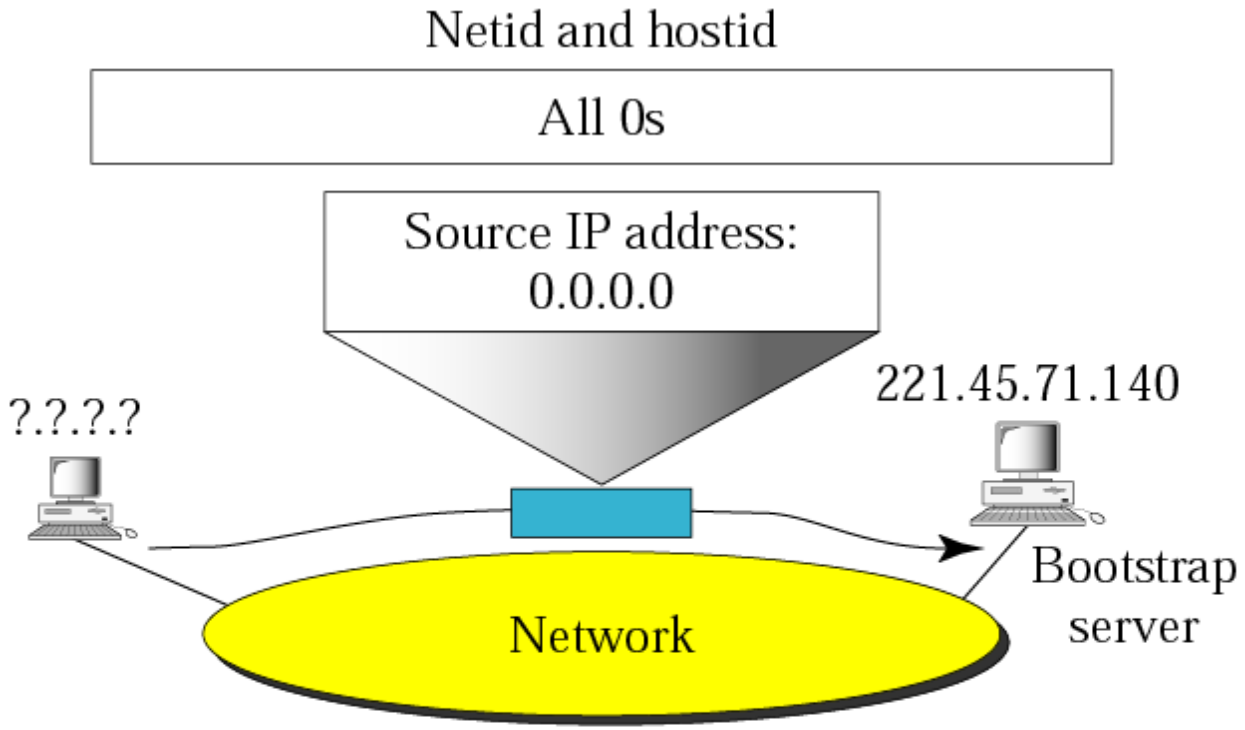


Figure 4-16

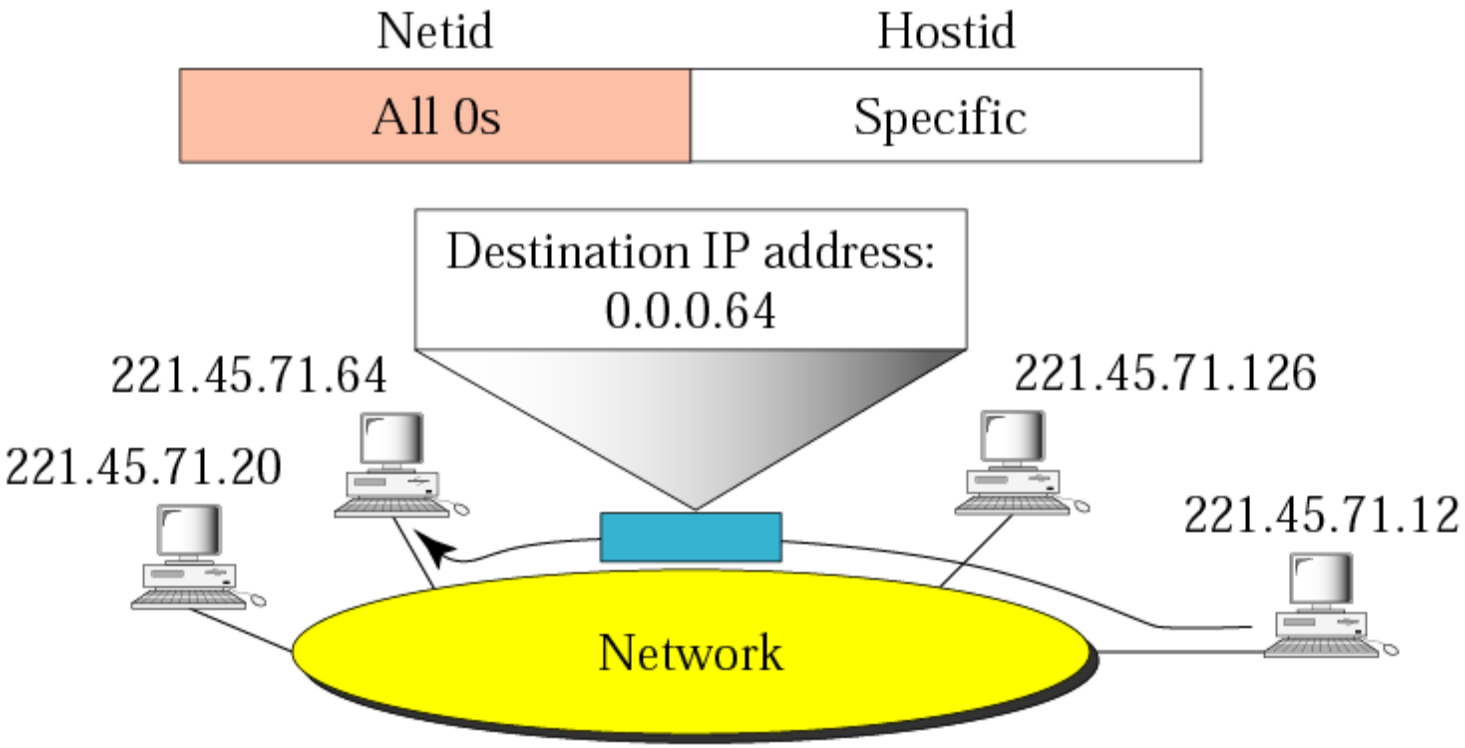
Example of *this* host on *this* address



A host that does not know its IP address uses the IP address 0.0.0.0 as the source address and 255.255.255.255 as the destination address to send a message to a bootstrap server.

Figure 4-17

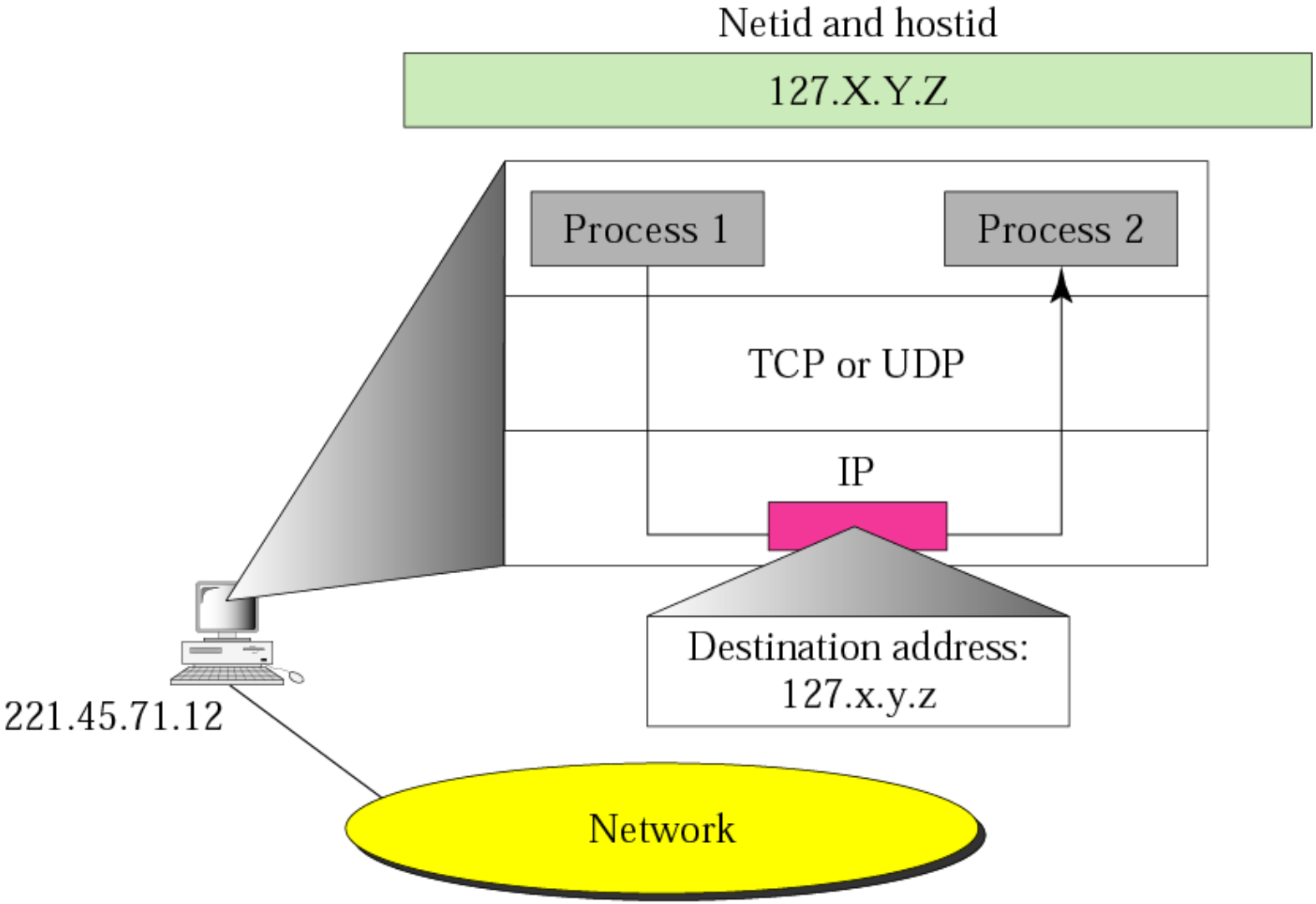
Example of specific host on *this* network



This address is used by a router or host
to send a message to a specific host on the same network.

Figure 4-18

Example of loopback address



A packet with a loopback address will not reach the network.

Private Addresses

A number of blocks in each class are assigned for private use. They are not recognized globally. These blocks are depicted in Table 4.4

Unicast, Multicast, and Broadcast Addresses

Unicast communication is *one-to-one*.

Multicast communication is *one-to-many*.

Broadcast communication is *one-to-all*.

4.4

A SAMPLE INTERNET WITH CLASSFUL ADDRESSES

Figure 4-19

Sample internet