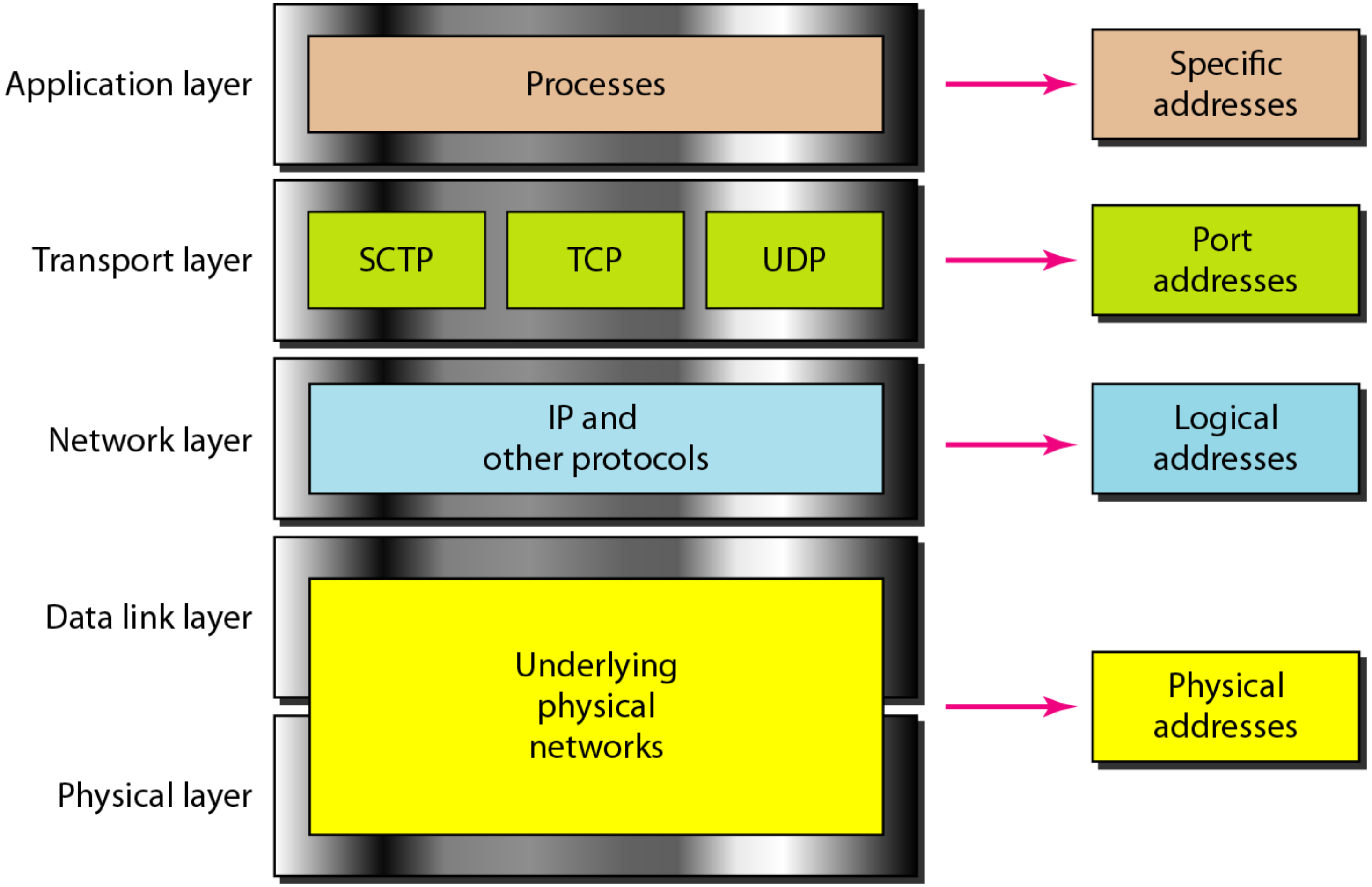
Chapter 4

Subletting and Super netting

Addressing

5 Addressing

Relationship of layers and addresses in TCP/IP

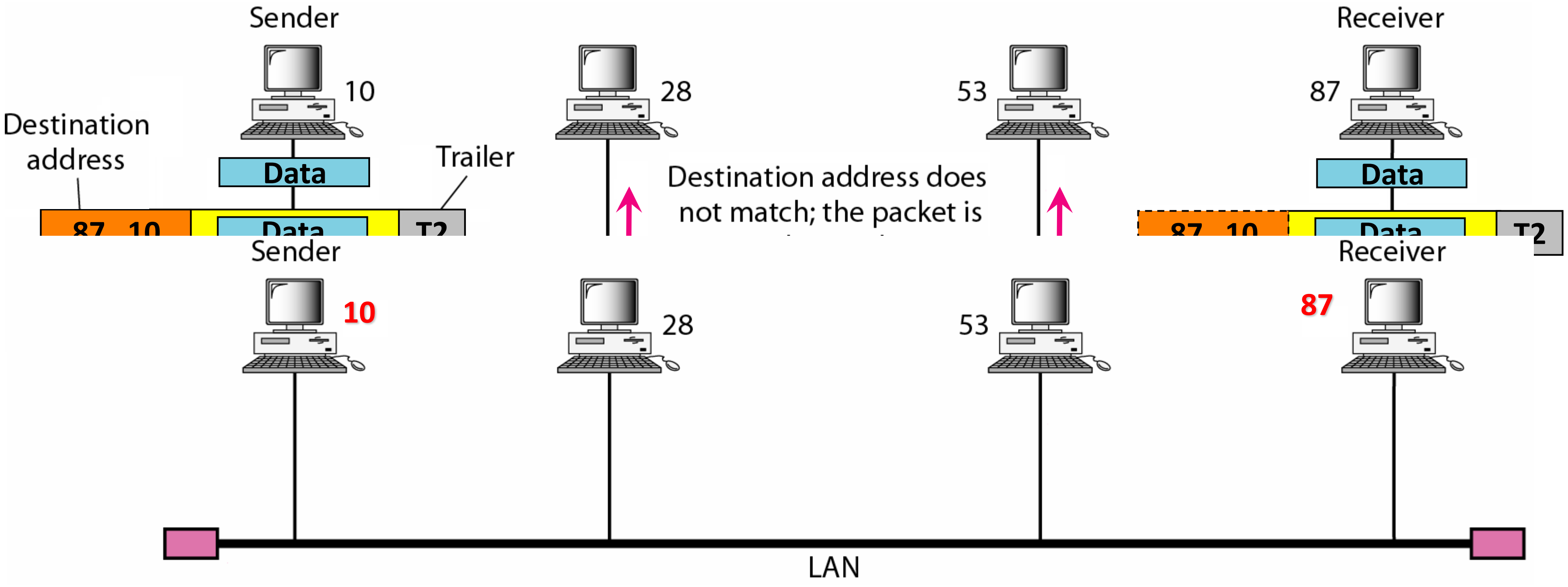


5 Addressing

- Physical Addresses (≡ Link address)
  - Address of a node as defined by its LAN or WAN
  - Included in the frame used by the data link layer
  - Lowest level address
  - Size and format depend on the network
    - Ethernet uses 6-byte physical address
    - LocalTalk uses 1-byte dynamic address

5 Addressing

- Example 1: A node with physical address 10 sends a frame to a node with physical address 87.



5 Addressing

- Example 2: LANs use 48- bit (6-byte) physical address written as 12 hexadecimal digits; every byte is separated by a colon.

07:01:02:01:2C:4B
A 6-byte (12 hexadecimal digits) physical address.

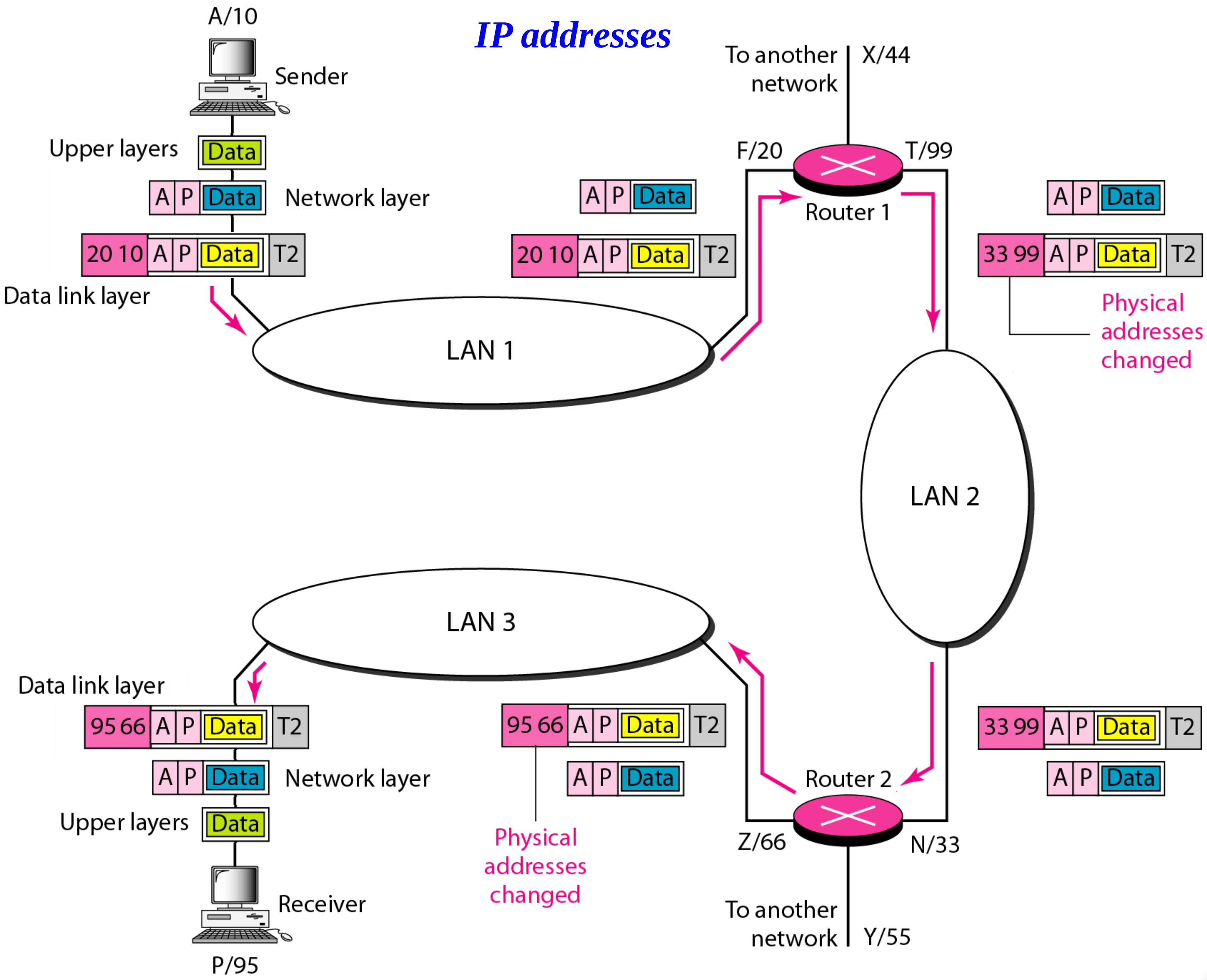
5 Addressing

- Logical Addresses
  - Necessary for universal communication that are independent of underlying physical networks
  - Physical addresses are not adequate in an internetwork environment where different networks can have different address formats
  - A universal addressing system is needed in which each host can be identified uniquely, regardless of the underlying physical network
  - Logical address in the Internet is currently a 32-bit address that can uniquely define a host connected to the internet
  - No two publicly addressed and visible hosts on the Internet can have the same IP address

5 Addressing

- Example
  - The following exhibit shows part of an internet with:
    - 3 LANs
    - 2 Routers
    - Each device has a pair of addresses (logical & physical)
    - Computer with logical/physical address A/10 needs to send a packet to the computer with address P/95

IP addresses



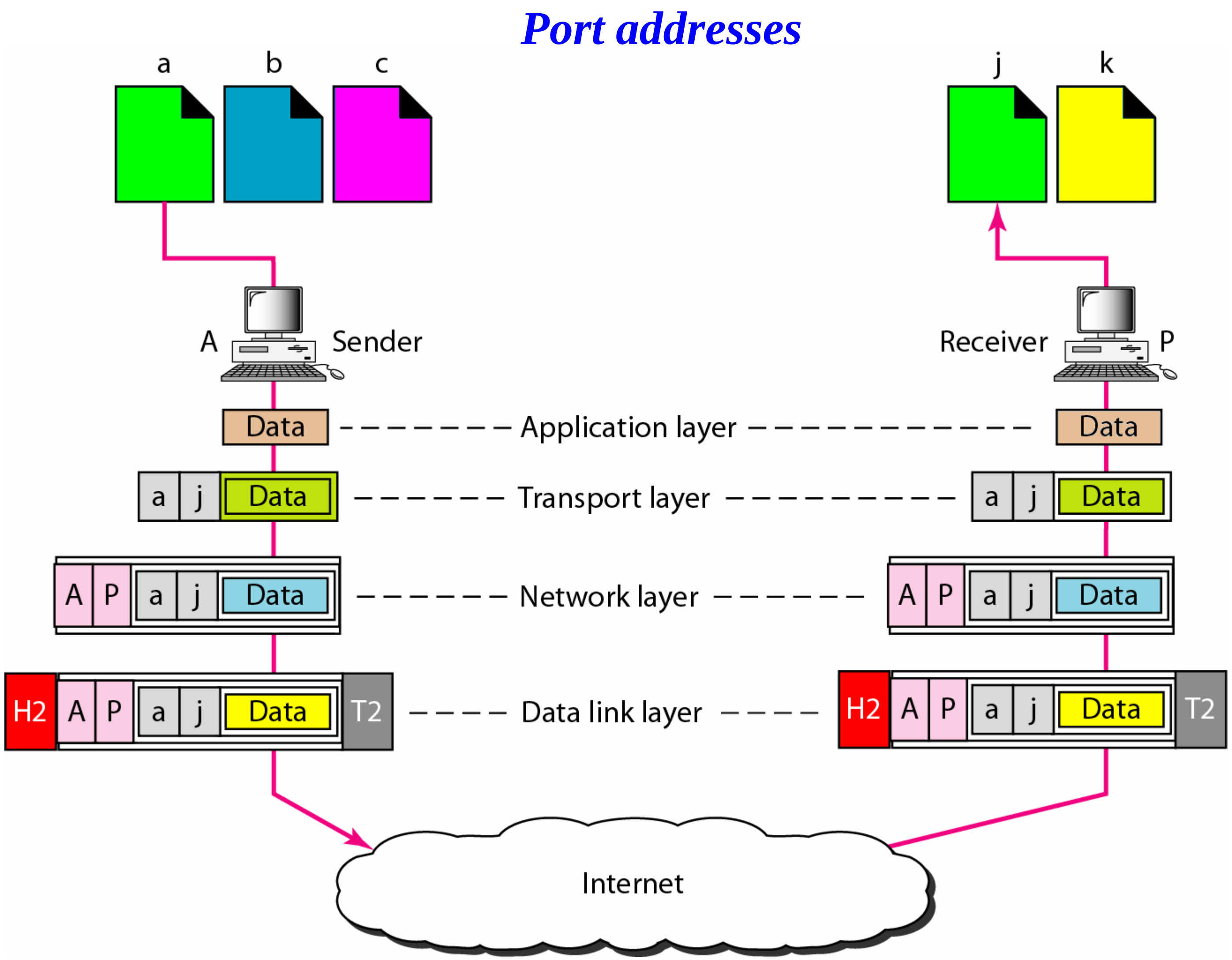
5 Addressing

The physical addresses will change from hop to hop, but the logical addresses usually remain the same.

5 Addressing

- Port Addresses
  - Arrival at the destination host is not the final objective of data communication on the Internet
  - A system that sends nothing but data from one computer to another is not complete
  - Today computers are devices that can run multiple processes at the same time
  - The end objective of Internet communication is a process communicating with another process
  - For processes to receive data simultaneously, a method to label the different processes is needed
  - In TCP/IP the label is called: port number (16-bit)

5 Addressing



5 Addressing

- Port Addresses

The physical addresses change from hop to hop,
but the logical and port addresses usually remain the same.

5 Addressing

- Port Addresses
  - Example: A port address is a 16-bit address represented by one decimal number

753

A 16-bit port address represented as one single number.

5 Addressing

- Specific Addresses
  - Some application have user-friendly addresses that are designed for that specific address
  - Example: e-mail address, URL, These addresses, however, get changed to the corresponding port and logical addresses by the sending computer

IP Addresses: Classful Addressing

Objectives

- ***Understand IPv4 addresses and classes***
- ***Identify the class of an IP address***
- ***Find the network address given an IP address***
- ***Understand masks and how to use them***
- ***Understand subnets and supernets***

4.1 INTRODUCTION

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 IP address is a 32-bit address that uniquely and universally defines the connection of a host or a router to the Internet. IP addresses are unique. They are unique in the sense that each address defines one, and only one, connection to the Internet. Two devices on the Internet can never have the same address.

The topics discussed in this section include:

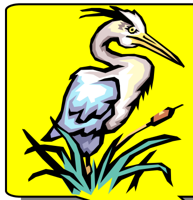
Address Space Notation

Note:

An IP address is a 32-bit address.

Note:

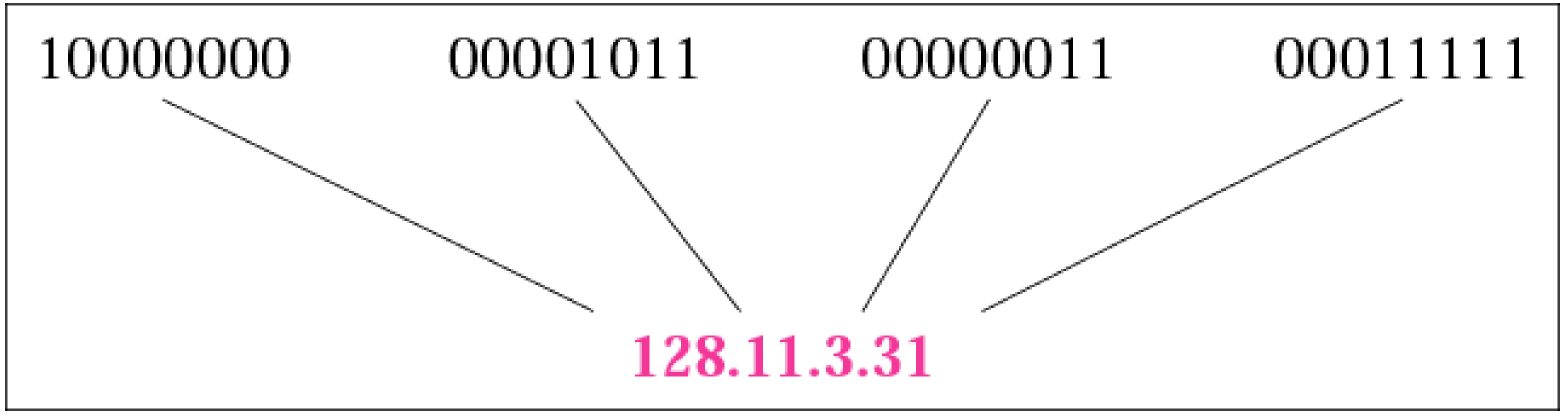
The IP addresses are unique.

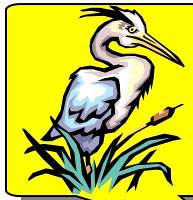


Note:

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

Figure 4.1 *Dotted-decimal notation*





Note:

The binary, decimal, and hexadecimal number systems are reviewed in Appendix B.

Example 1

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

a. 10000001 00001011 00001011 11101111
b. 11000001 10000011 00011011 11111111
c. 11100111 11011011 10001011 01101111
d. 11111001 10011011 11111011 00001111

Solution

We replace each group of 8 bits with its equivalent decimal number (see Appendix B) and add dots for separation:

a. 129.11.11.239 *b. 193.131.27.255*
c. 231.219.139.111 *d. 249.155.251.15*

EXAMPLE 2

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

a. 111.56.45.78 *b. 221.34.7.82*
c. 241.8.56.12 *d. 75.45.34.78*

Solution

We replace each decimal number with its binary equivalent:

a. 01101111 00111000 00101101 01001110
b. 11011101 00100010 00000111 01010010
c. 11110001 00001000 00111000 00001100
d. 01001011 00101101 00100010 01001110

EXAMPLE 3

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

a. 111.56.045.78

b. 221.34.7.8.20

c. 75.45.301.14

d. 11100010.23.14.67

Solution

a.

4.2 CLASSFUL ADDRESSING

IP addresses, when started a few decades ago, used the concept of classes. This architecture is called classful addressing. In the mid-1990s, a new architecture, called classless addressing, was introduced and will eventually supersede the original architecture. However, part of the Internet is still using classful addressing, but the migration is very fast.

The topics discussed in this section include:

Recognizing Classes
Netid and Hostid
Classes and Blocks
Network Addresses
Sufficient Information
Mask
CIDR Notation
Address Depletion

Figure 4.2 *Occupation of the address space*

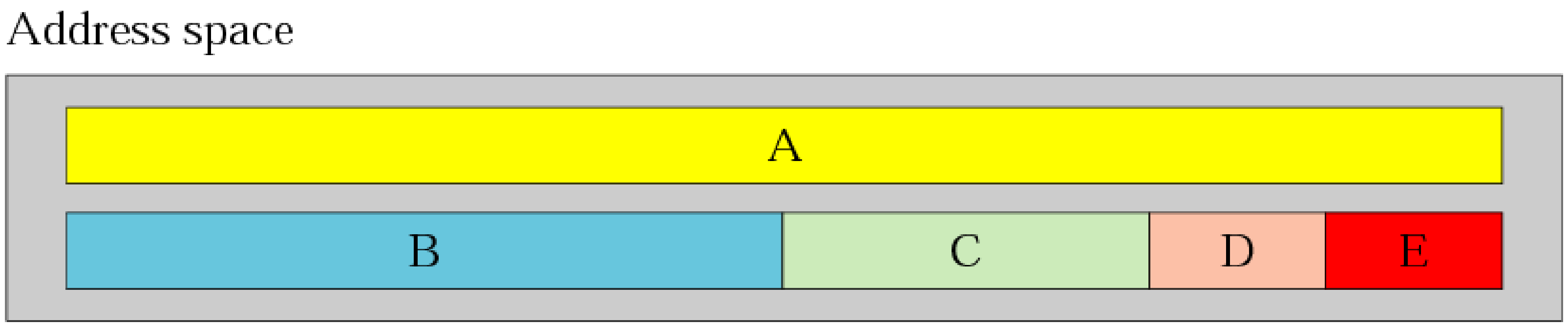


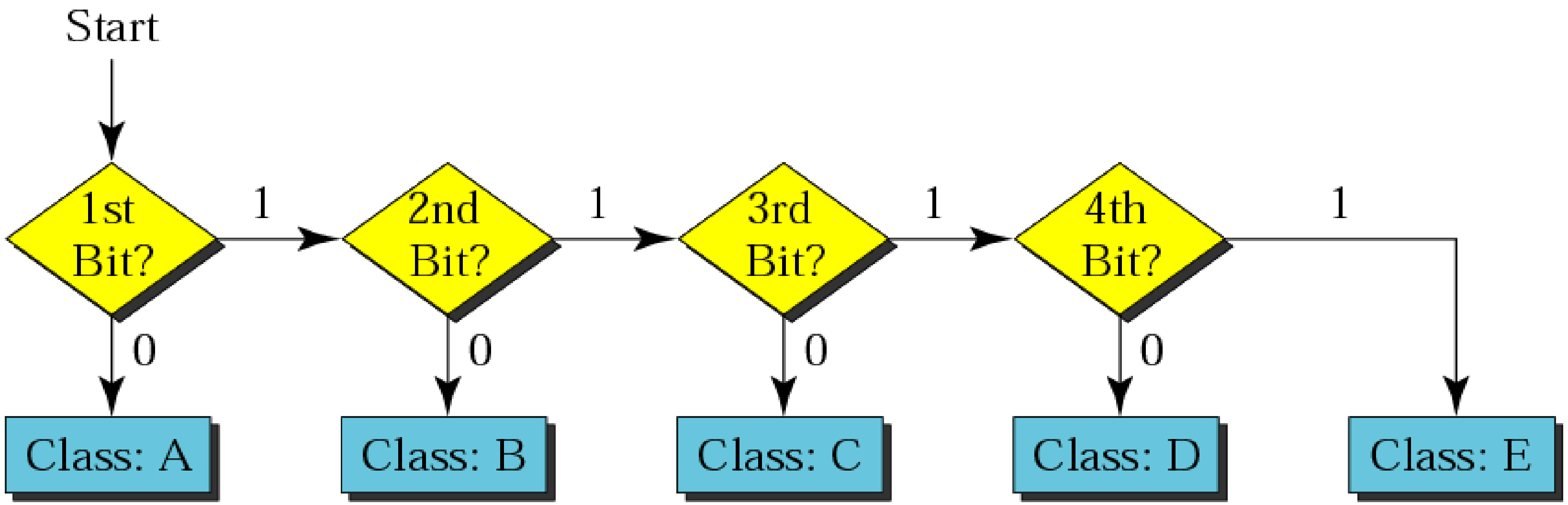
Table 4.1 Addresses per class

Class	*Number of Addresses*	*Percentage*
A	$2^{31} = 2,147,483,648$	50%
B	$2^{30} = 1,073,741,824$	25%
C	$2^{29} = 536,870,912$	12.5%
D	$2^{28} = 268,435,456$	6.25%
E	$2^{28} = 268,435,456$	6.25%

Figure 4.3 *Finding the class in binary notation*

	First byte	Second byte	Third byte	Fourth byte
Class A	**0**			
Class B	**10**			
Class C	**110**			
Class D	**1110**			
Class E	**1111**			

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 each address:

a. 00000001 00001011 00001011 11101111
b. 11000001 10000011 00011011 11111111
c. 10100111 11011011 10001011 01101111
d. 11110011 10011011 11111011 00001111

Solution

See the procedure in Figure 4.4.

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 0; the second bit is 1. This is a class B address.
d. The first 4 bits are 1s. This is a class E address..

Figure 4.5 *Finding the class in decimal notation*

	First byte	Second byte	Third byte	Fourth byte
Class A	**0 to 127**			
Class B	**128 to 191**			
Class C	**192 to 223**			
Class D	**224 to 239**			
Class E	**240 to 255**			

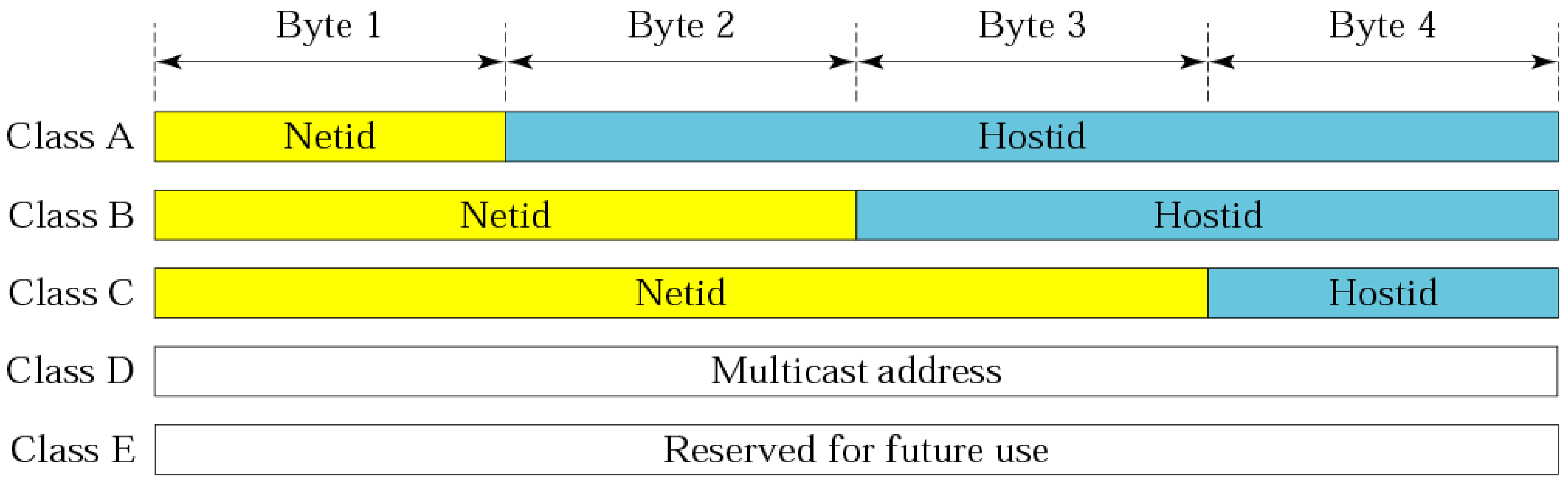
EXAMPLE 7

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 ***e.134.11.78.56***

Solution

Figure 4.6 *Netid and hostid*



Note:

Millions of class A addresses are wasted.

Figure 4.7 *Blocks in class A*

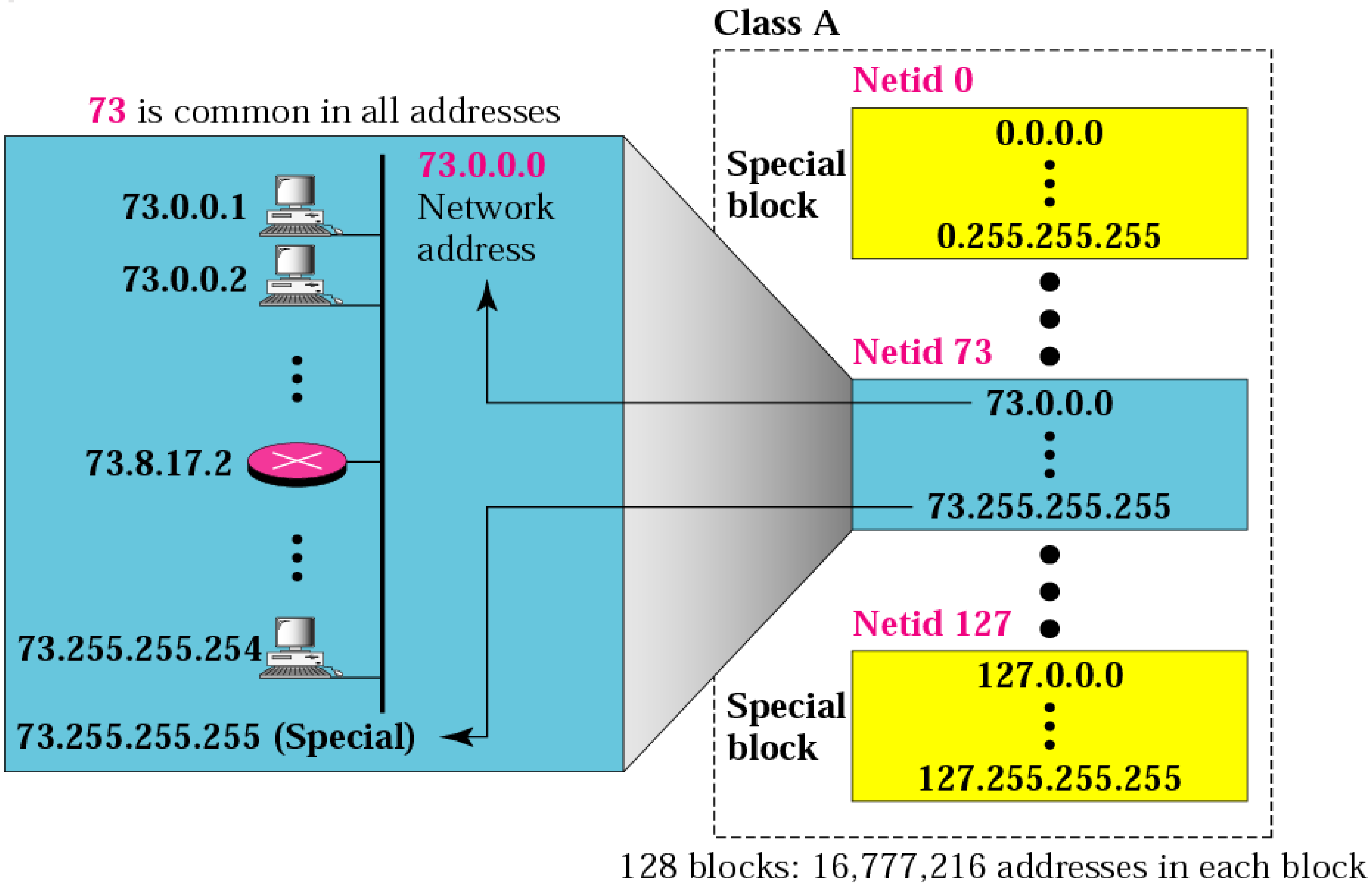
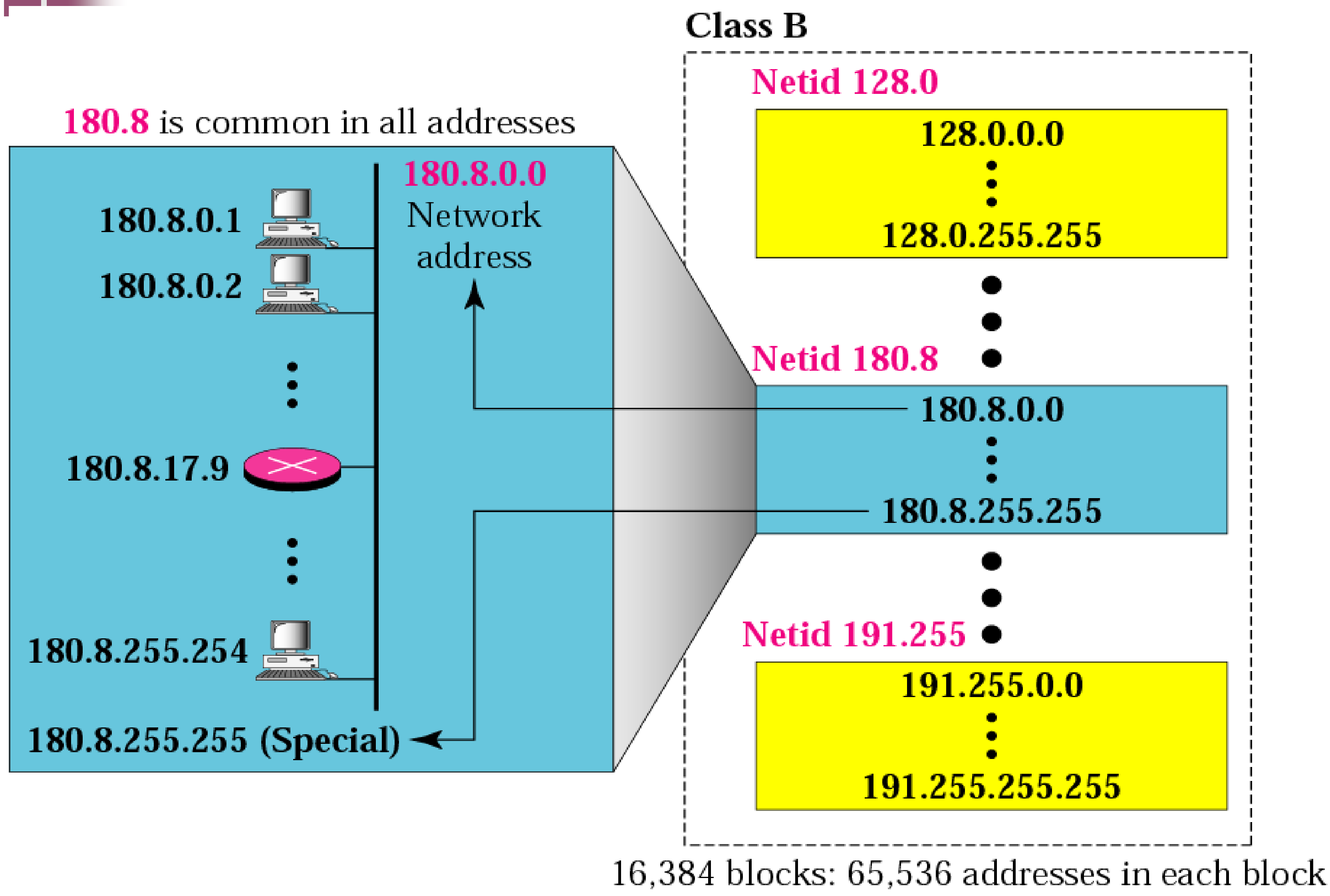
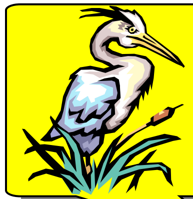


Figure 4.8 *Blocks in class B*

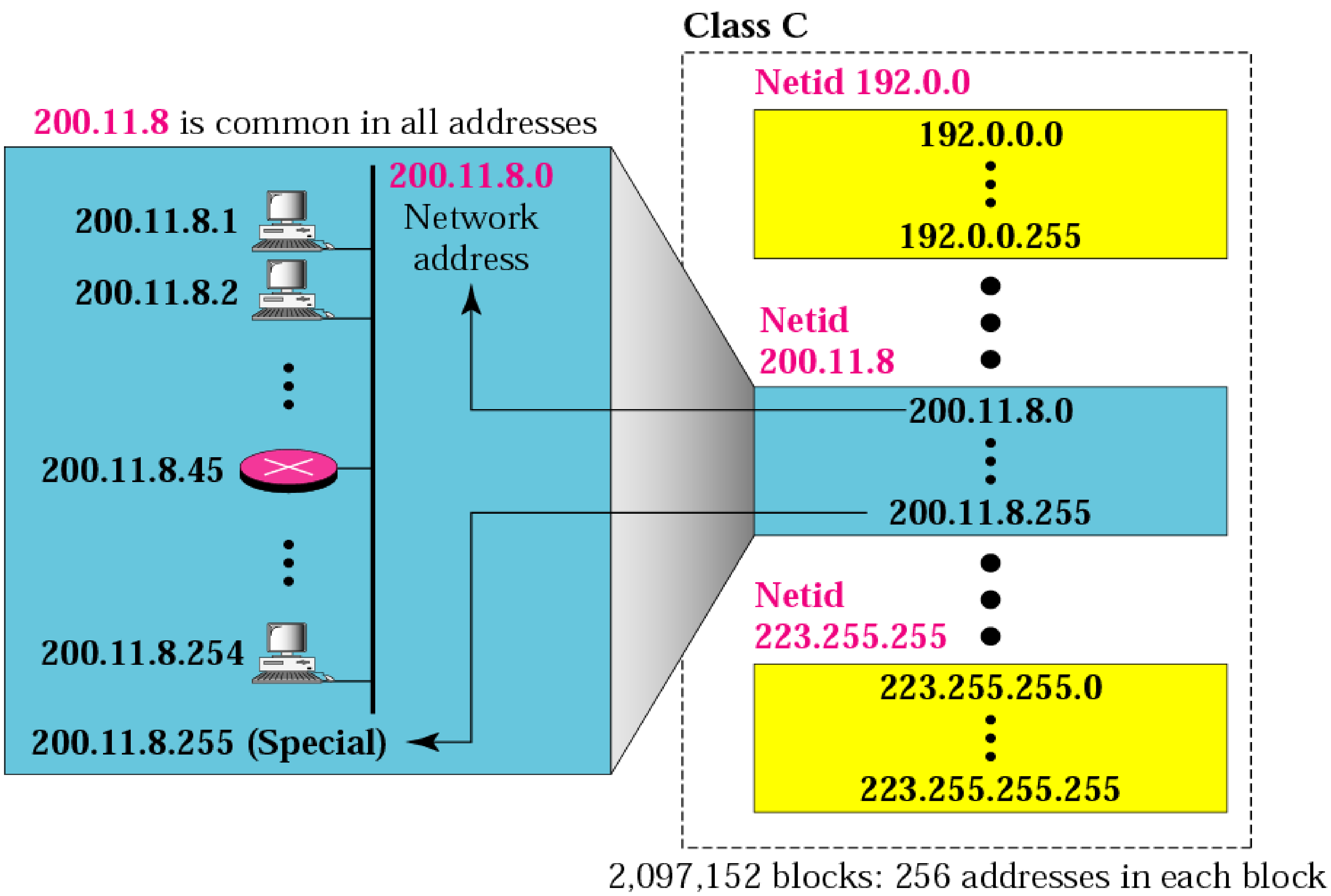


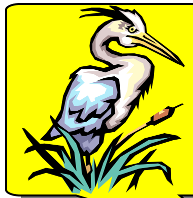


Note:

Many class B addresses are wasted.

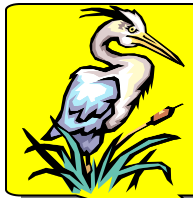
Figure 4.9 *Blocks in class C*





Note:

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

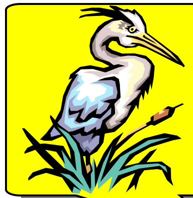


Note:

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

Note:

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



Note:

In classful addressing, the network address (the first address in the block) is the one that is assigned to the organization. The range of addresses can automatically be inferred from the network address.

EXAMPLE 9

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

Solution

EXAMPLE 10

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

Solution

EXAMPLE 11

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

Solution

Figure 4.10 *Masking concept*

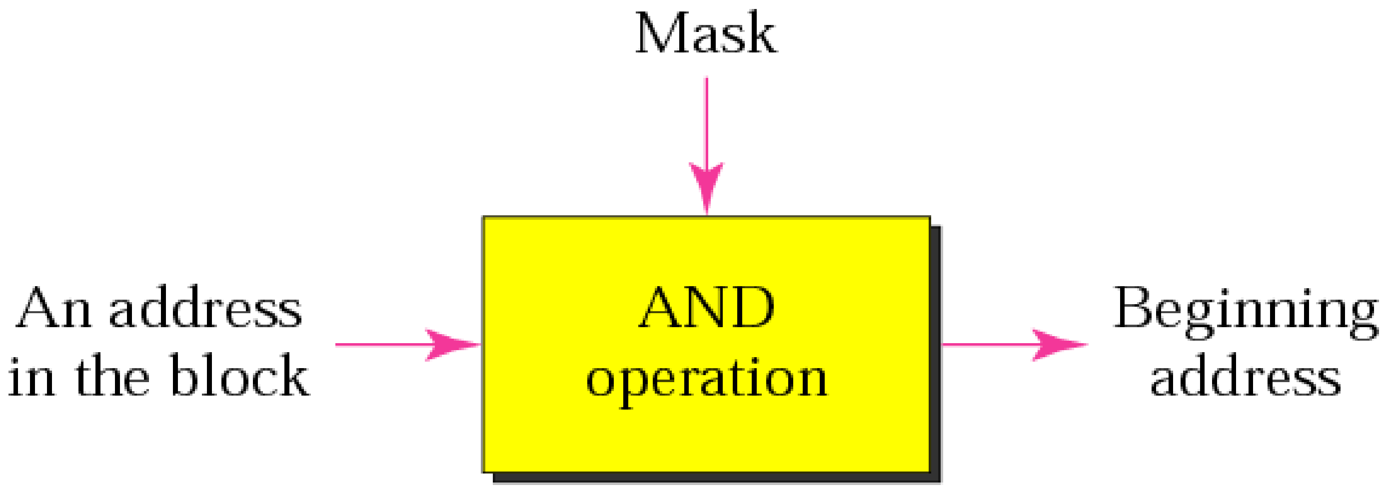


Figure 4.11 *AND operation*

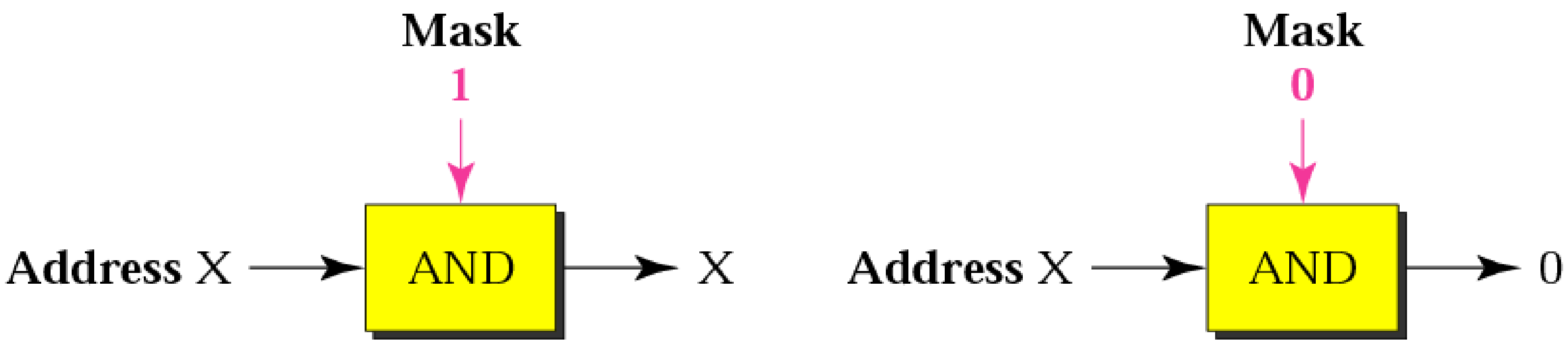
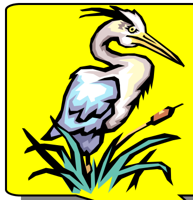


Table 4.2 Default masks

Class	*Mask in binary*	*Mask in dotted-decimal*
A	**11111111** 00000000 00000000 00000000	**255.**0.0.0
B	**11111111 11111111** 00000000 00000000	**255.255.**0.0
C	**11111111 111111111 11111111** 00000000	**255.255.255.**0



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, find the beginning address (network address).

Solution

•

EXAMPLE 13

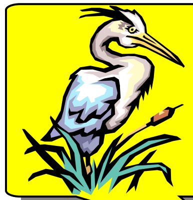
Given the address 132.6.17.85, find the beginning address (network address).

Solution

EXAMPLE 14

Given the address 201.180.56.5, find the beginning address (network address).

Solution



Note:

Note that we must not apply the default mask of one class to an address belonging to another class.

4.3 OTHER ISSUES

In this section, we discuss some other issues that are related to addressing in general and classful addressing in particular.

The topics discussed in this section include:

Multihomed Devices
Location, Not Names
Special Addresses
Private Addresses
Unicast, Multicast, and Broadcast Addresses

Figure 4.12 *Multihomed devices*

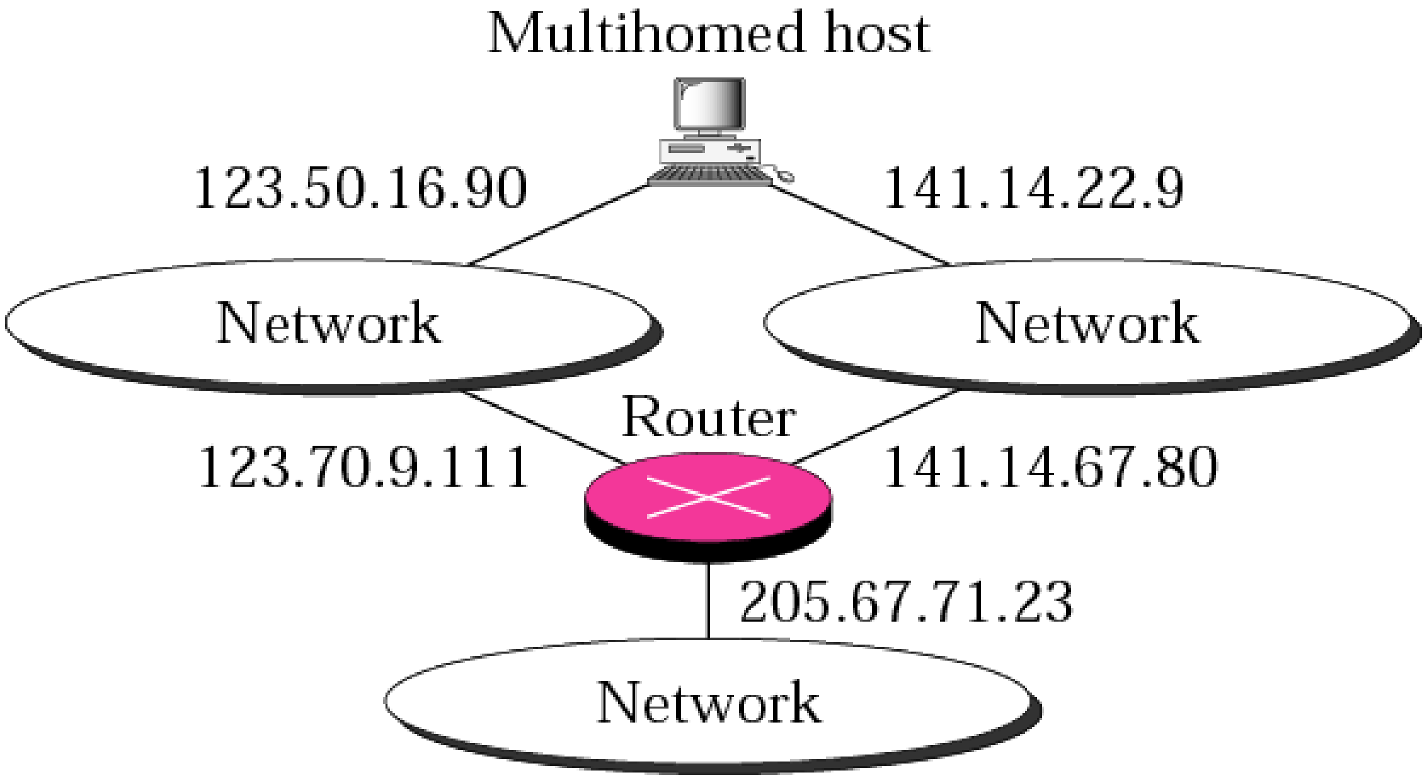


Table 4.3 Special addresses

Special Address	*Netid*	*Hostid*	*Source or Destination*
Network address	Specific	All 0s	None
Direct broadcast address	Specific	All 1s	Destination
Limited broadcast address	All 1s	All 1s	Destination
This host on this network	All 0s	All 0s	Source
Specific host on this network	All 0s	Specific	Destination
Loopback address	127	Any	Destination

Figure 4.13 *Network address*

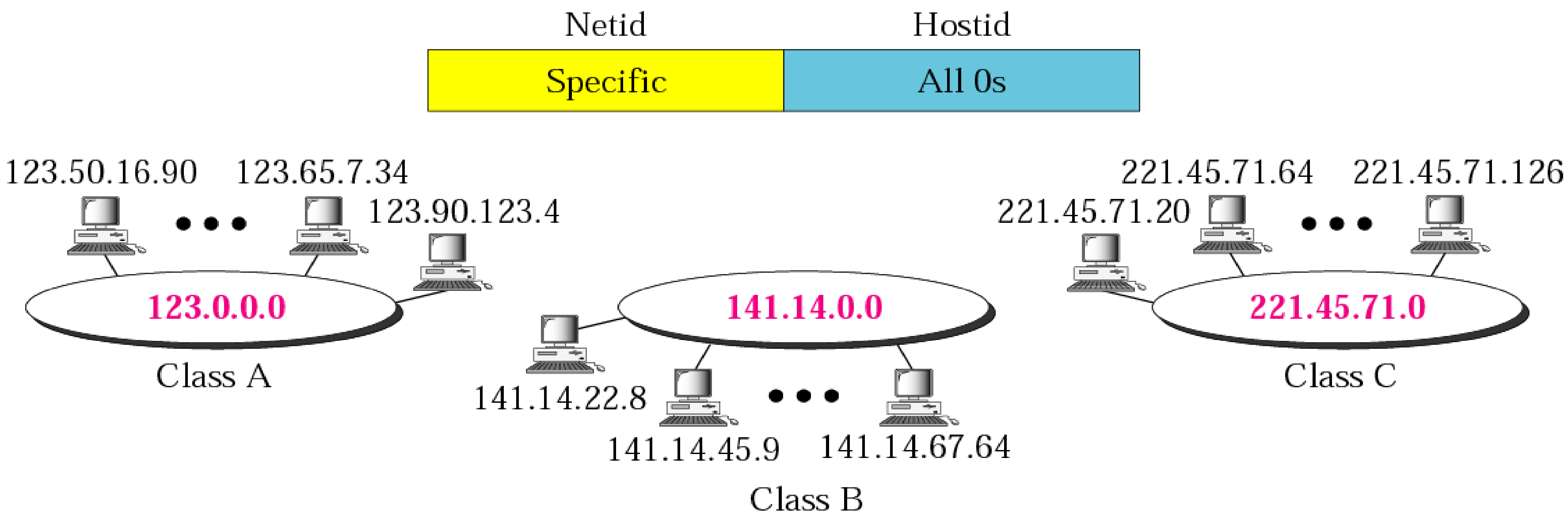
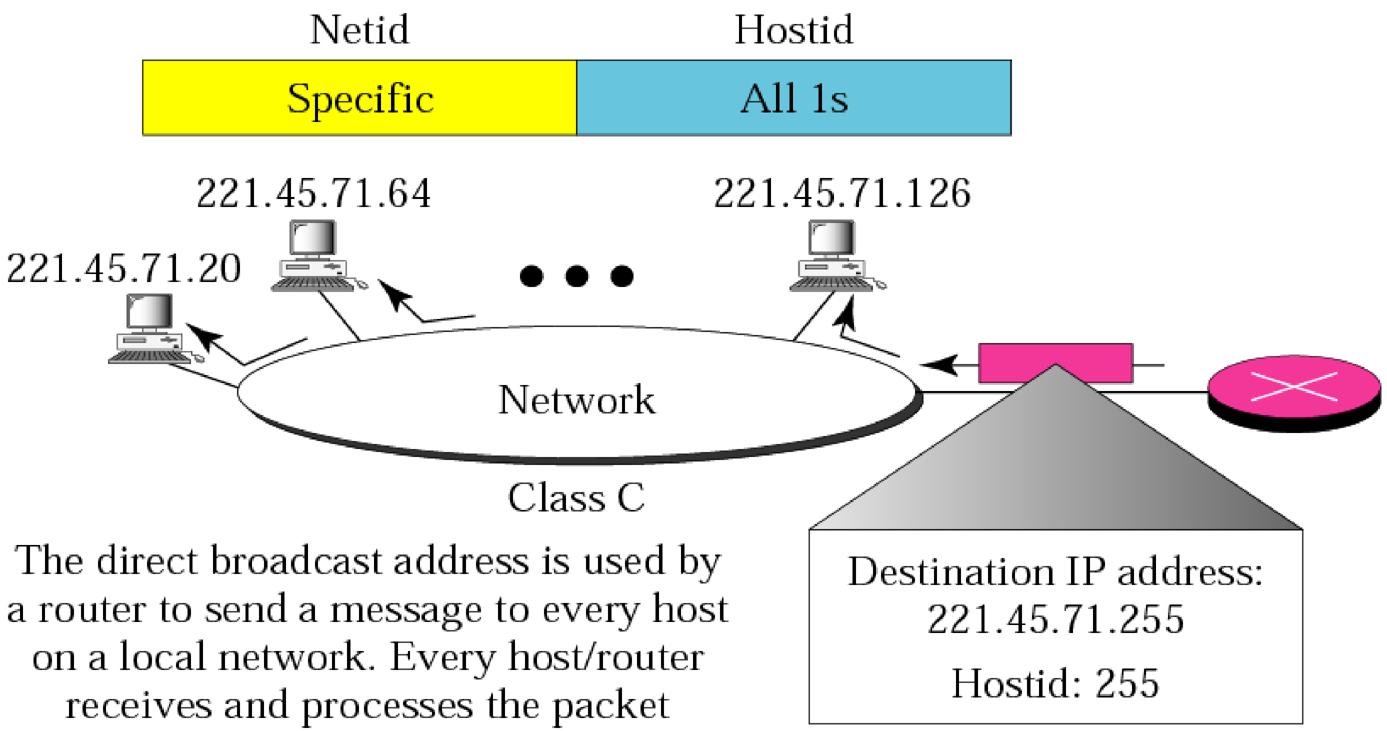


Figure 4.14 *Example of direct broadcast address*



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*

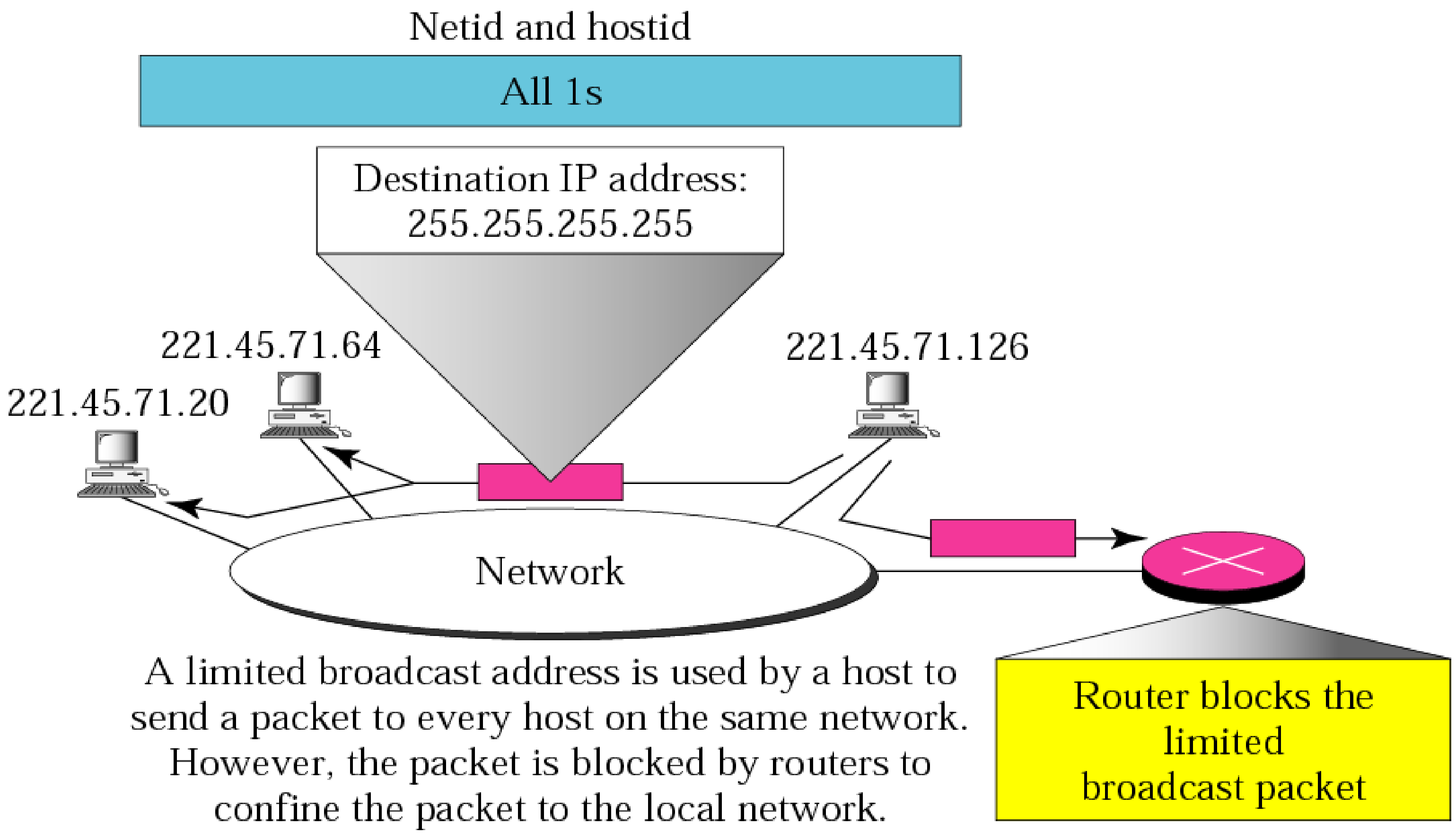
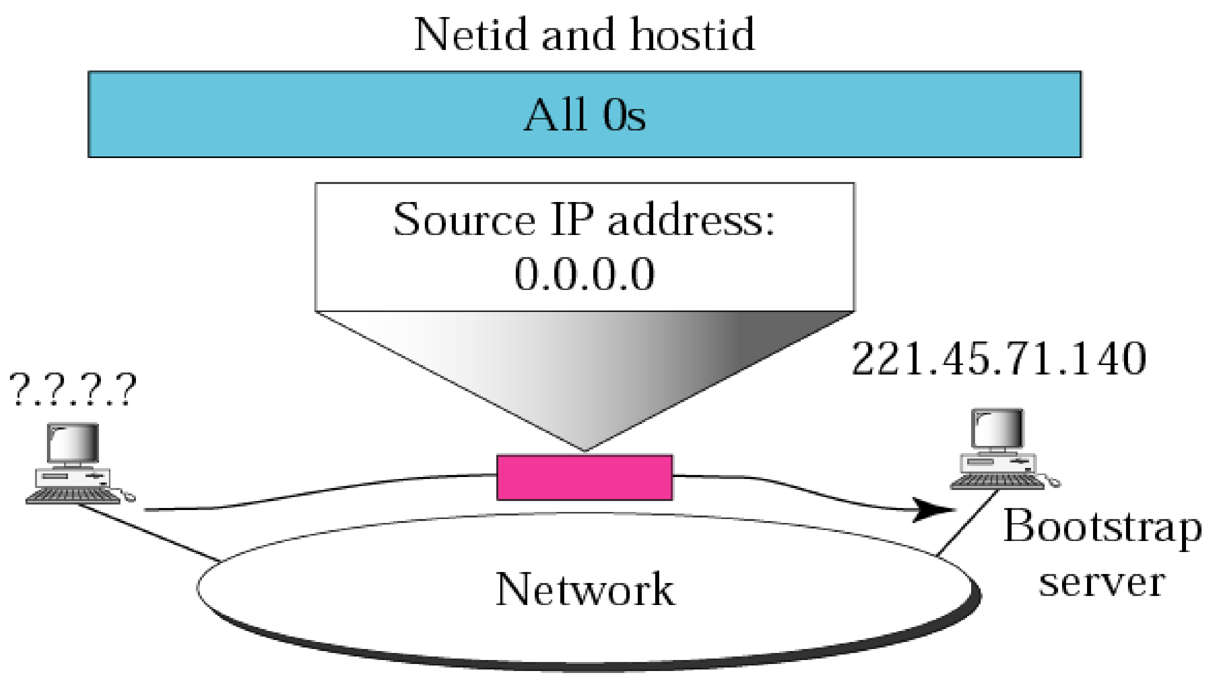
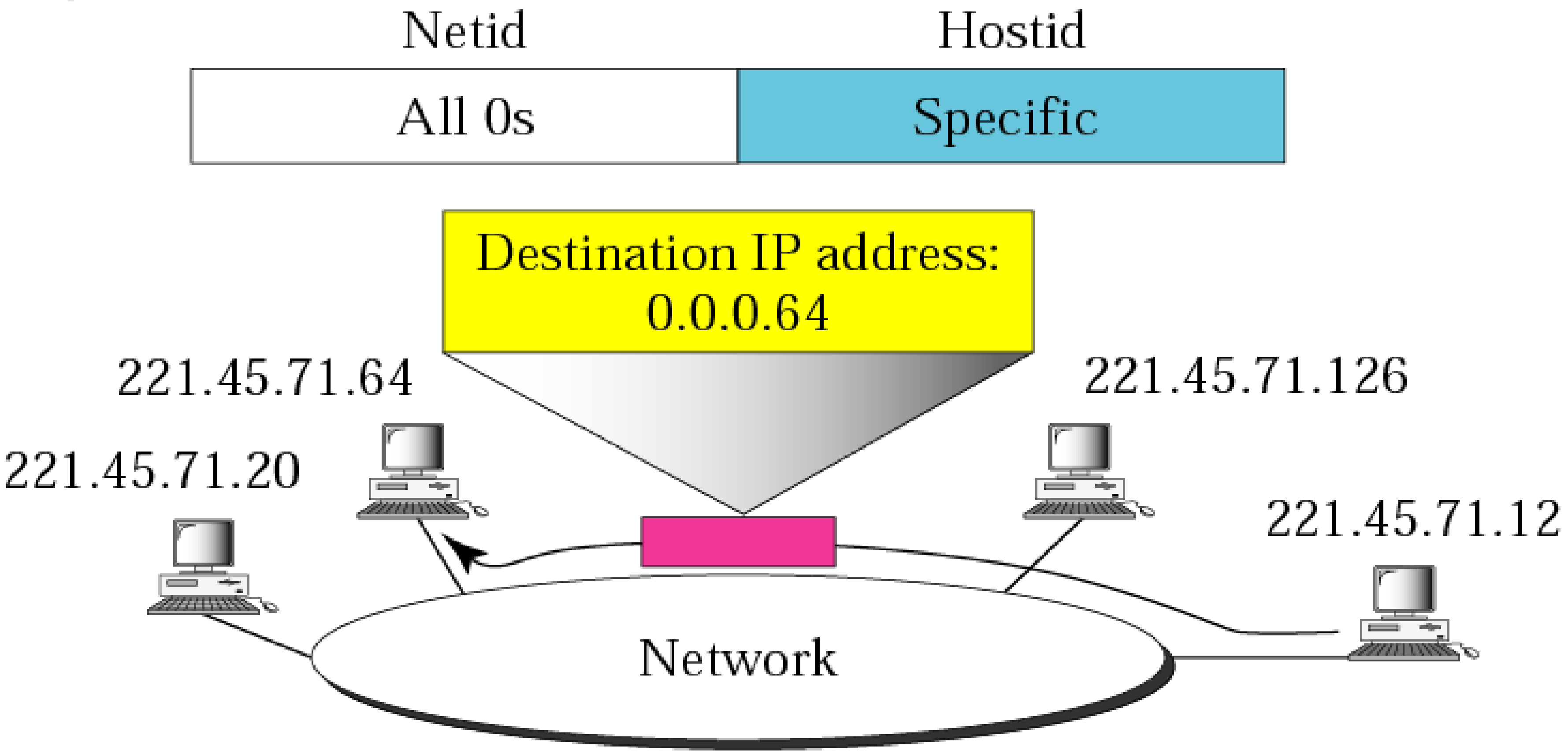


Figure 4.16 *Examples of "this host on this network"*



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*

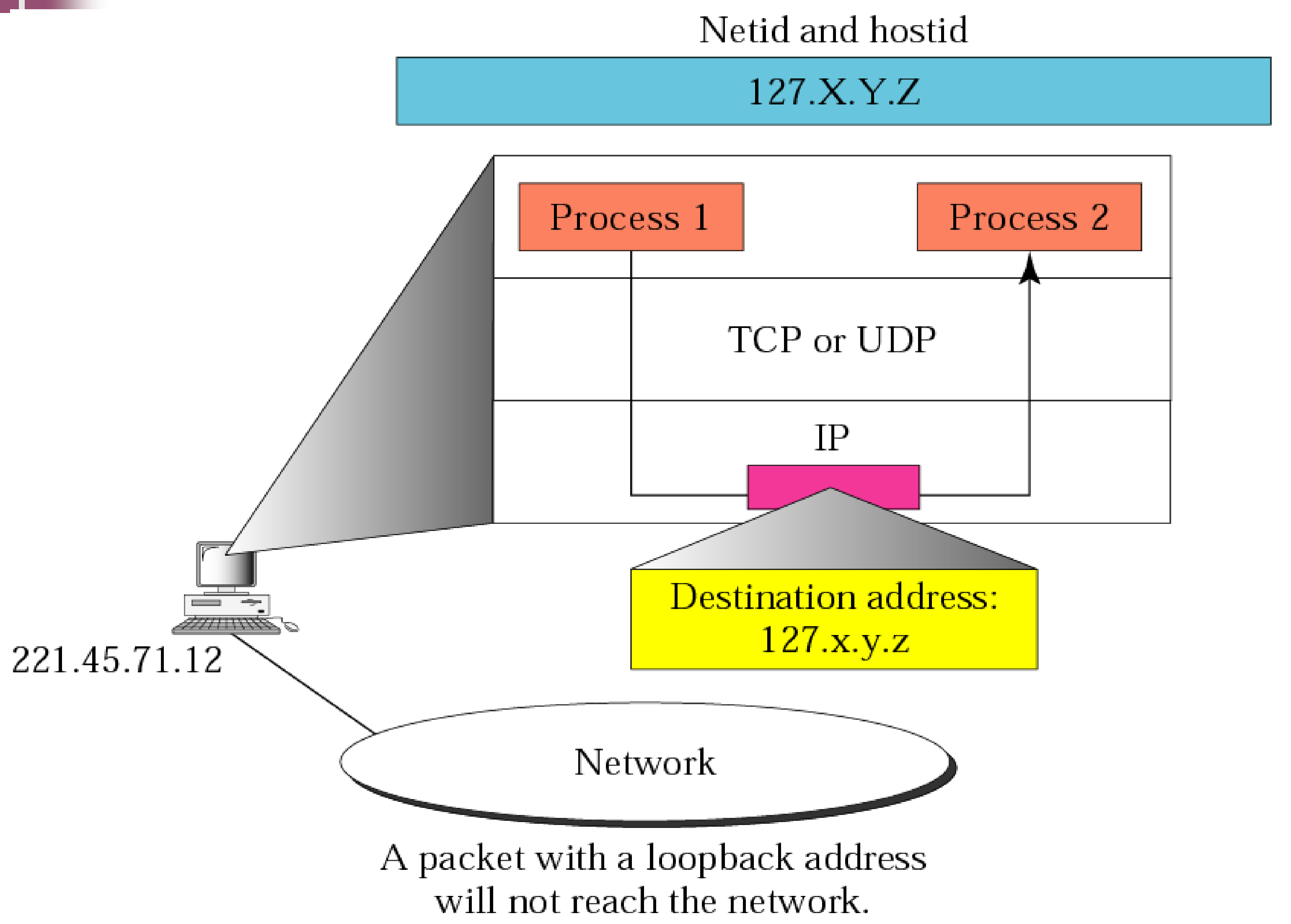
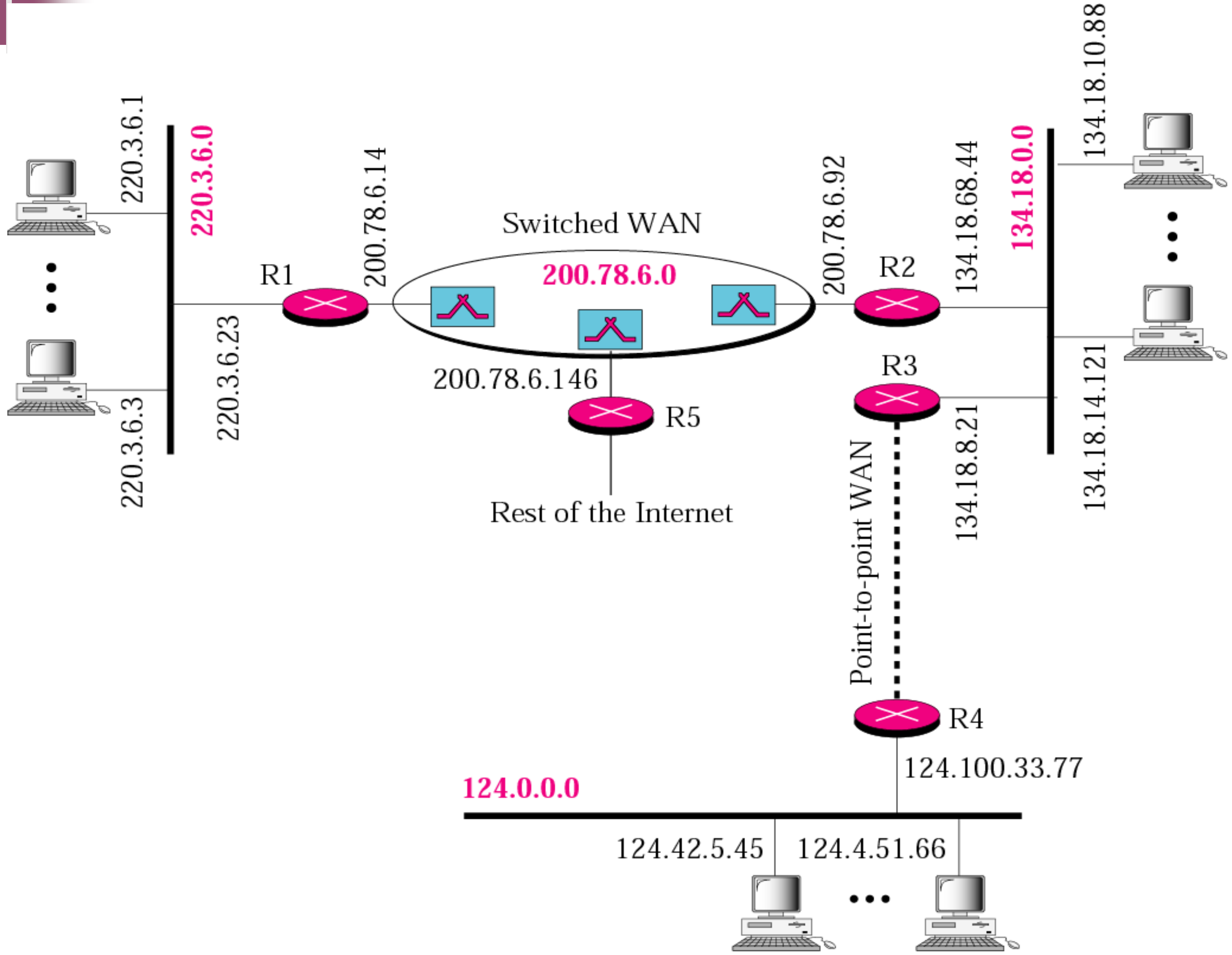


Table 4.5 Addresses for private networks

Class	*Netids*	*Blocks*
A	10.0.0	1
B	172.16 to 172.31	16
C	192.168.0 to 192.168.255	256

Figure 4.19 *Sample internet*



4.4 SUBNETTING AND SUPERNETTING

In the previous sections we discussed the problems associated with classful addressing. Specifically, the network addresses available for assignment to organizations are close to depletion. This is coupled with the ever-increasing demand for addresses from organizations that want connection to the Internet. In this section we briefly discuss two solutions: subnetting and supernetting.

The topics discussed in this section include:

Subnetting
Supernetting
Supernet Mask
Obsolescence

Note:

IP addresses are designed with two levels of hierarchy.

Figure 4.20 *A network with two levels of hierarchy (not subnetted)*

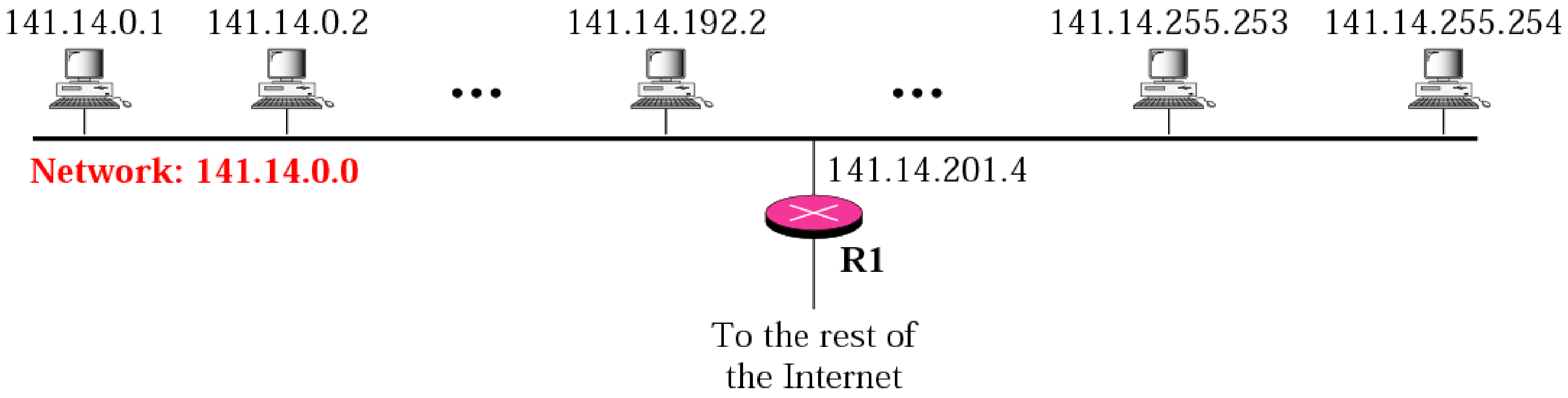


Figure 4.21 *A network with three levels of hierarchy (subnetted)*

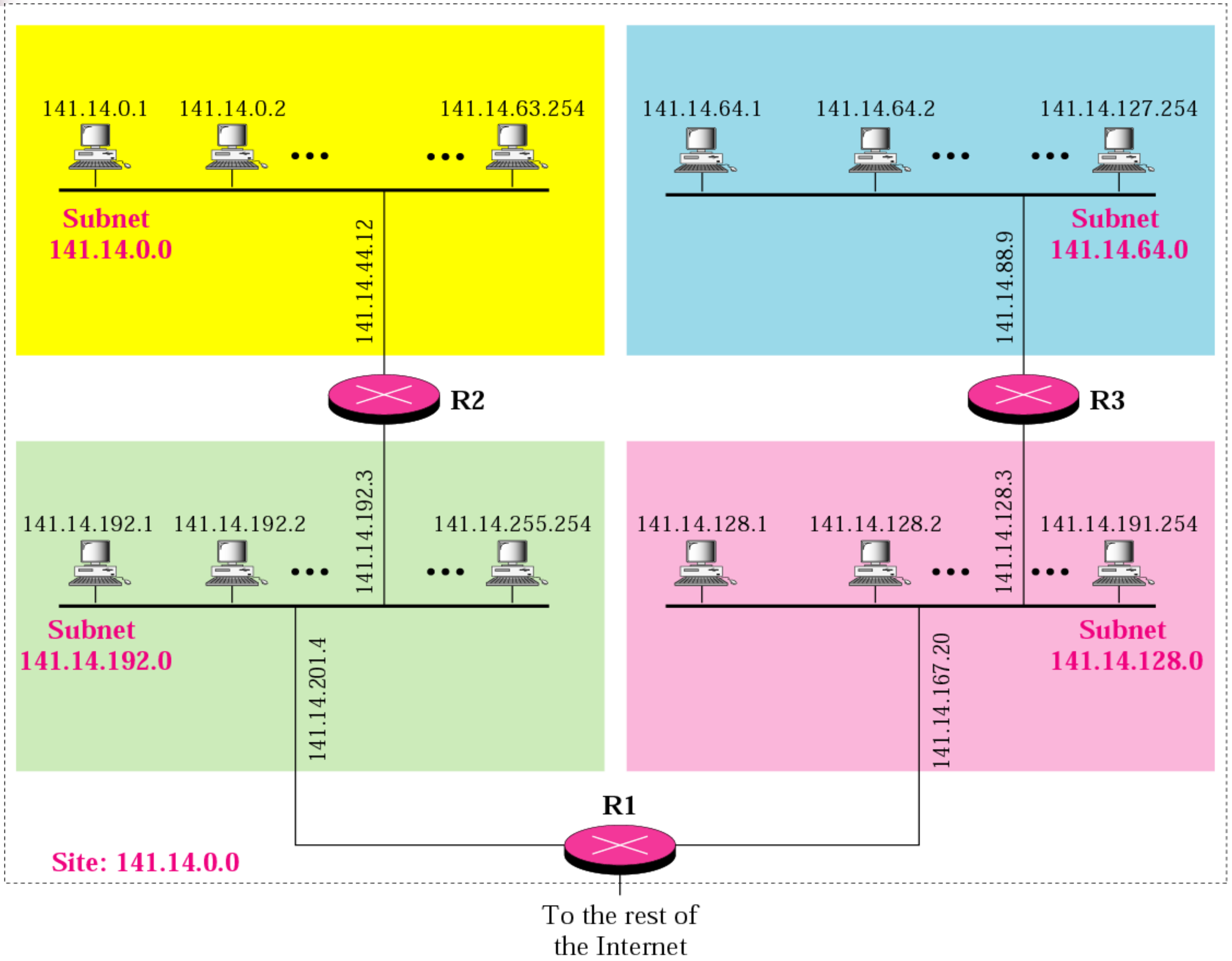


Figure 4.22 *Addresses in a network with and without subnetting*

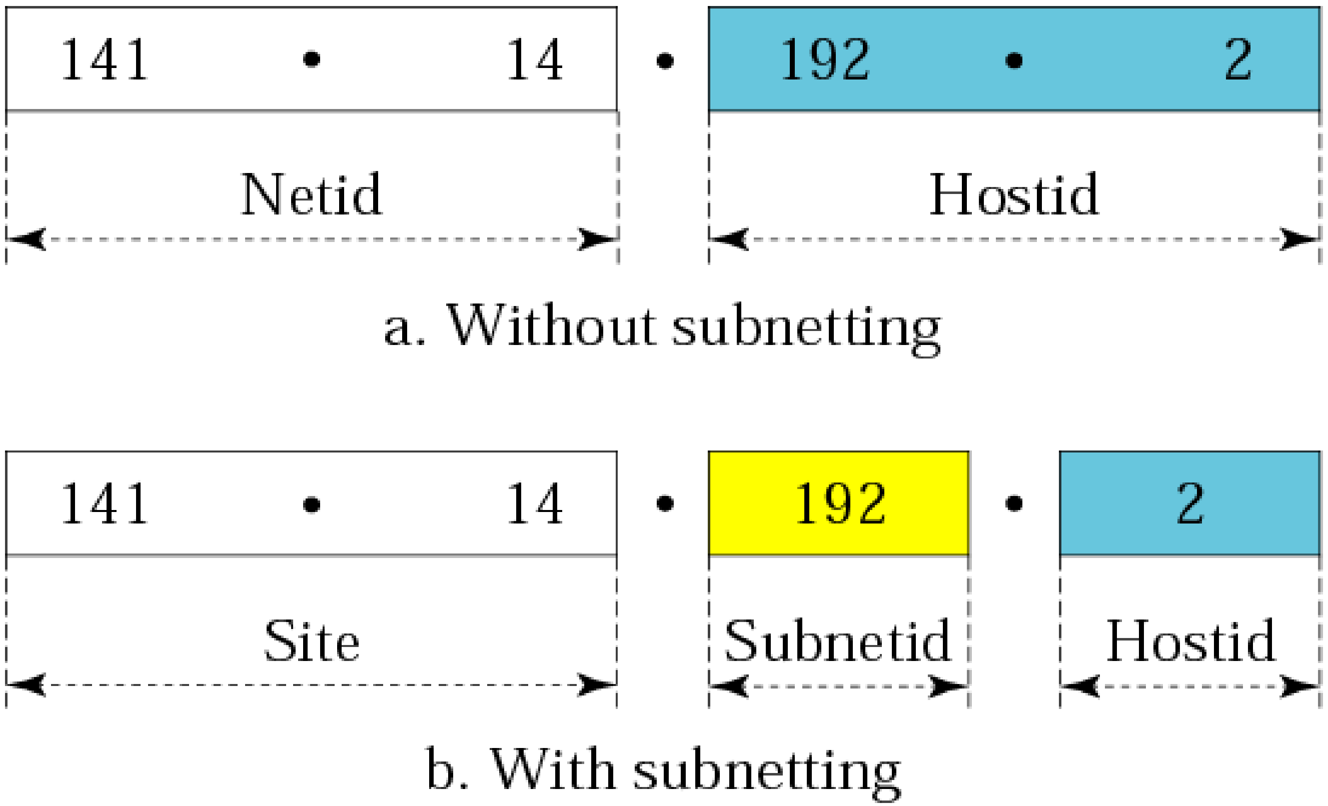
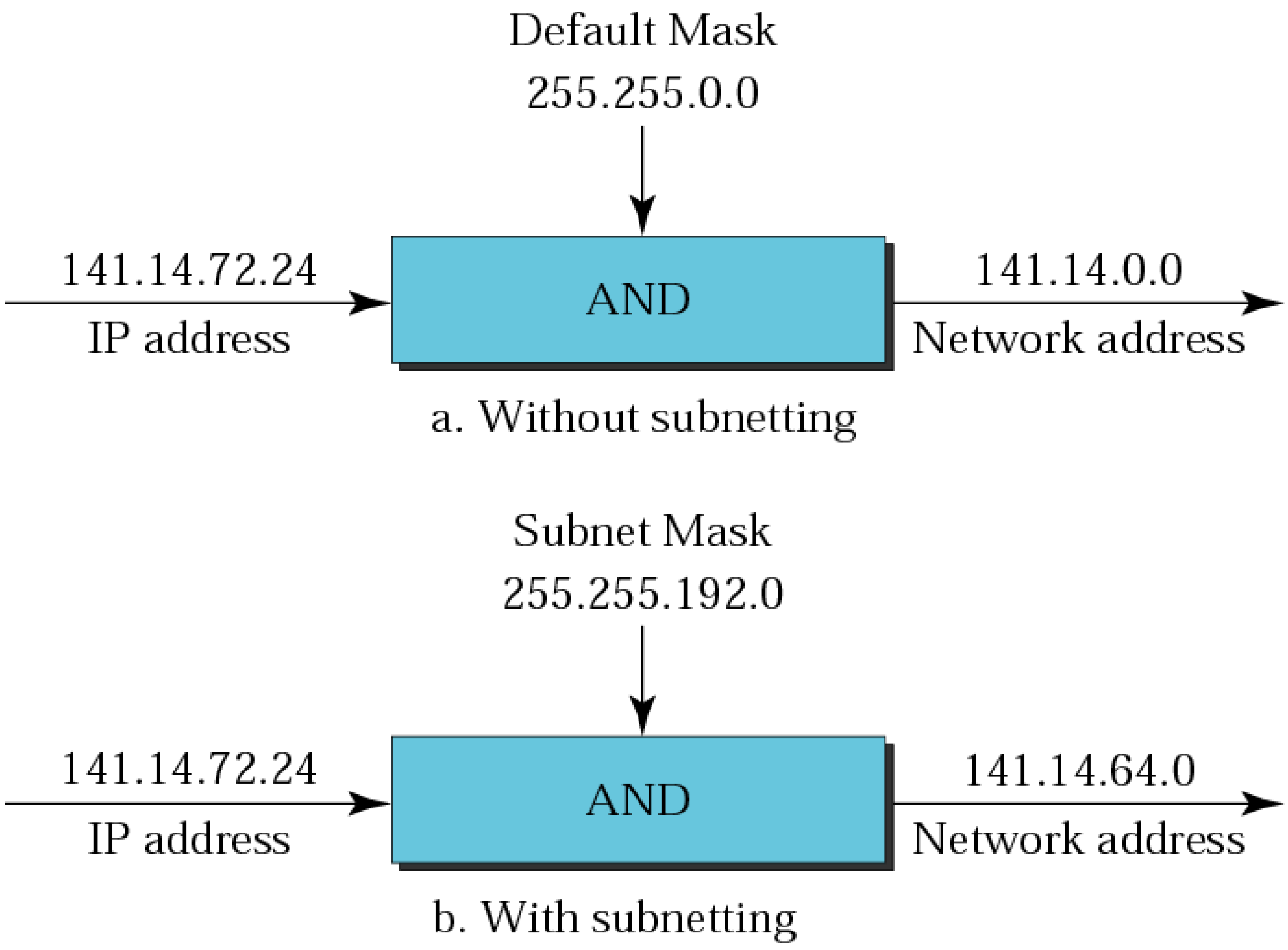


Figure 4.23 *Hierarchy concept in a telephone number*

Figure 4.24 *Default mask and subnet mask*



Example 15

What is the subnetwork address if the destination address is 200.45.34.56 and the subnet mask is 255.255.240.0?

Solution

We apply the AND operation on the address and the subnet mask.

Address	***➞ 11001000 00101101 00100010 00111000***
Subnet Mask	***➞ 11111111 11111111 11110000 00000000***
Subnetwork Address	***➞ 11001000 00101101 00100000 00000000.***

Figure 4.25 *Comparison of a default mask and a subnet mask*

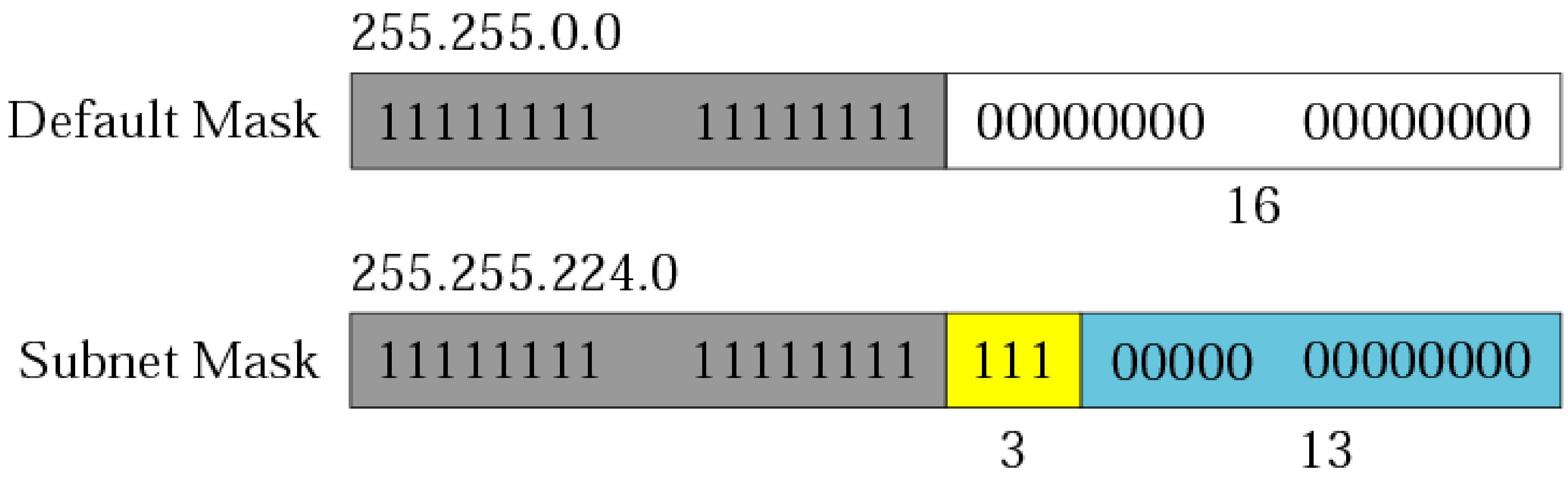
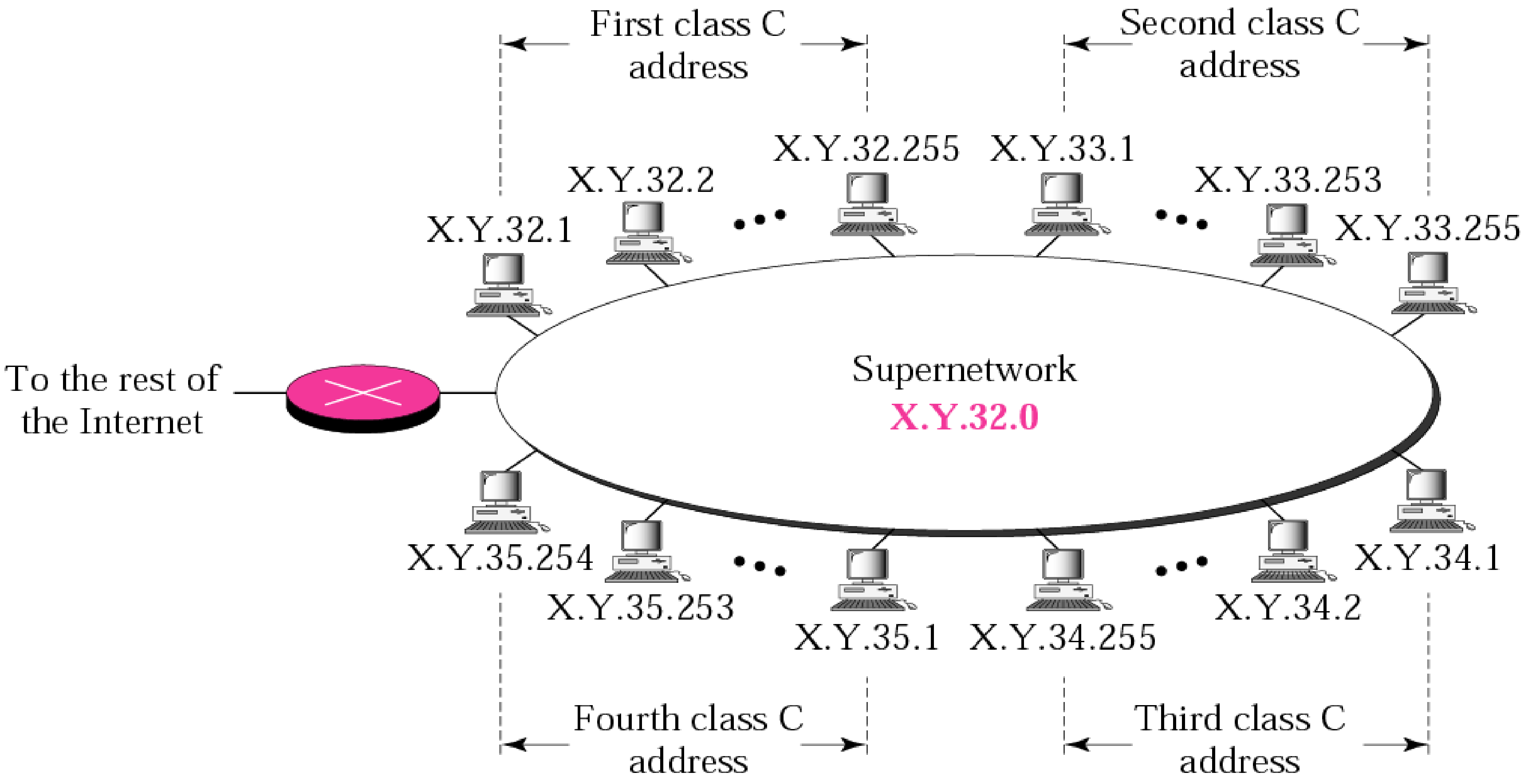
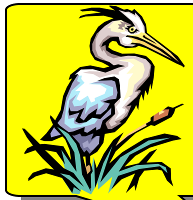


Figure 4.26 *A supernetwork*



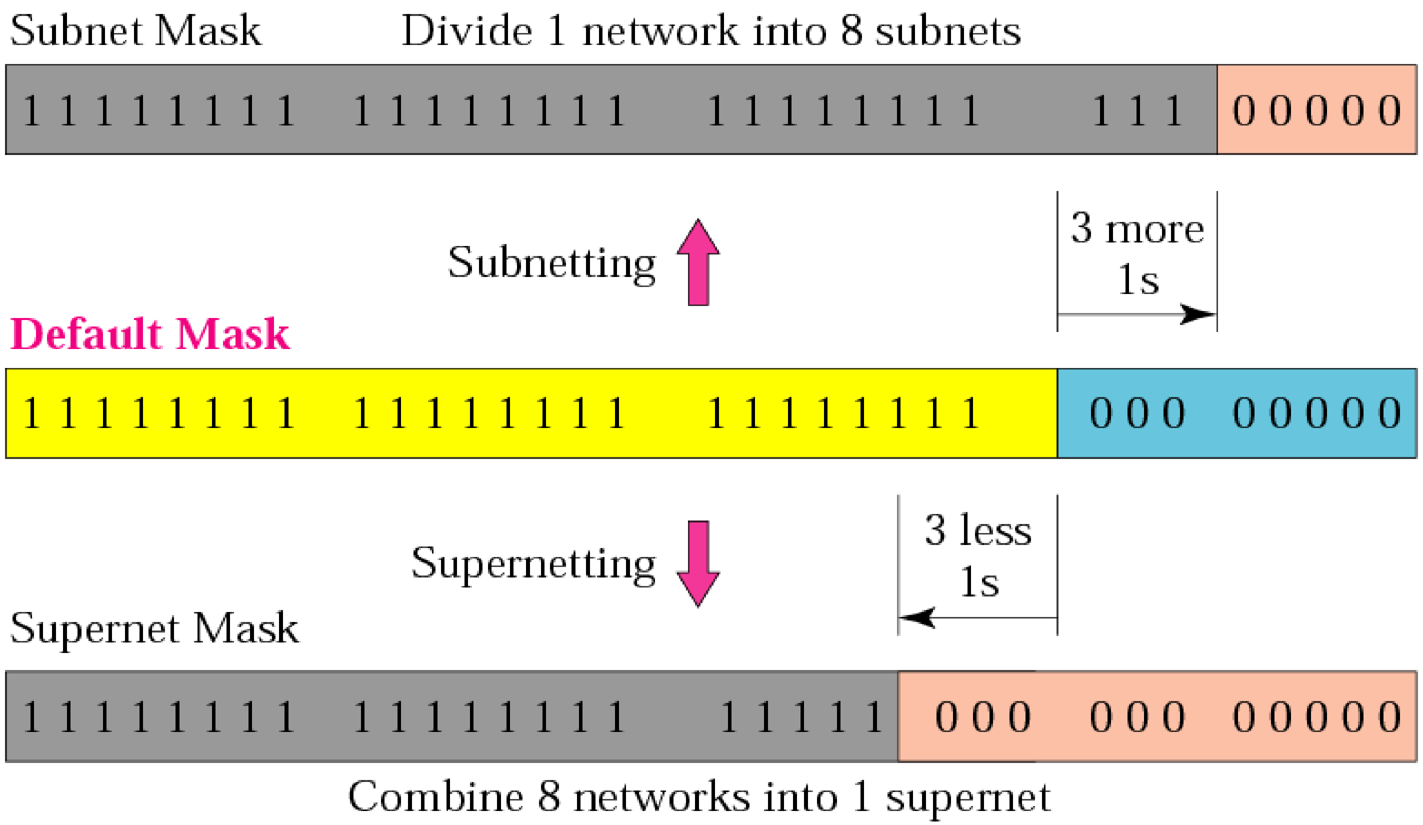


Note:

In subnetting, we need the first address of the subnet and the subnet mask to define the range of addresses.

In supernetting, we need the first address of the supernet and the supernet mask to define the range of addresses.

Figure 4.27 *Comparison of subnet, default, and supernet masks*



Note:

The idea of subnetting and supernetting of classful addresses is almost obsolete.

The 4 byte IP address consists of
A) Network address B) host address C) both (a) and (b) D) none of the mentioned

Which of the following IP address class is multicast?
A) Class A B) Class B C) Class C D) Class D

Which of the following is a valid IP address for a host?
A) 176.01.0.2 B) 96.255.0.256 C) 137.192.11.2 D) 255.128.0.0

What is the subnet address of the IP address 192.168.100.30 255.255.255.248?
A) 192.168.100.32 B) 192.168.100.24 C) 192.168.100.0 D) 192.168.100.16

Which of the following is a valid subnet mask?
A) 176.0.0.0 B) 96.0.0.0 C) 127.192.0.0 D) 255.128.0.0