TCP / IP Protocol Suite

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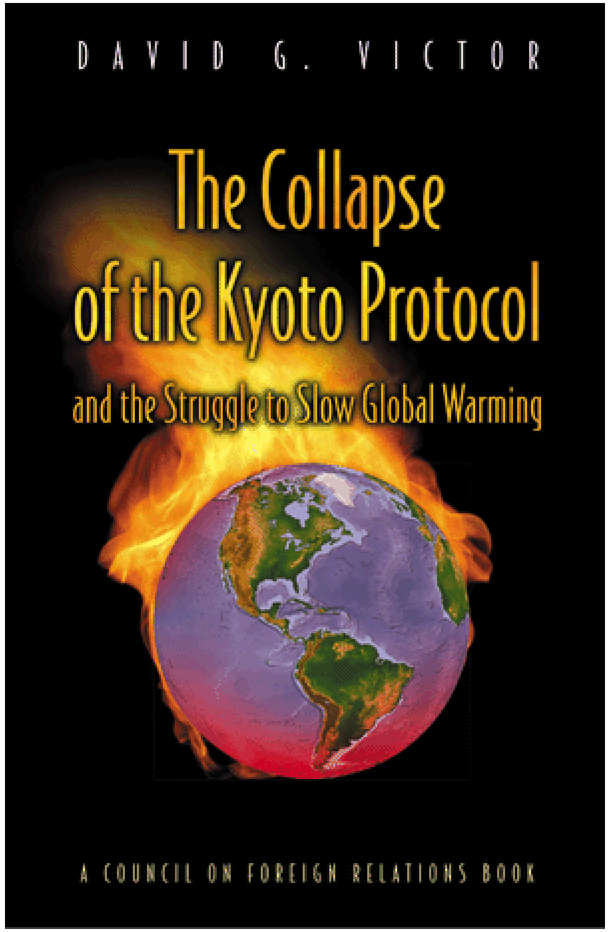
1.2

PROTOCOLS AND STANDARDS

Protocols

- Synta
- Sema
- Timin

NO, WE REALLY DON'T KNOW IF HE'S DEAD OR JUST PLAYING IT. BUT IT'S POSSUM CRIMINAL JUSTICE PROTOCOL TO DRAW THE IMPRESSIVE POLICE OUTLINE



Standards

- De facto: e.g., TCP/IP
- De jure: e.g., ISO OSI

1.3

STANDARDS ORGANIZATIONS

Standards Creation Committees

International Standards Organization (ISO)

International Telecommunications Union–
Telecommunication Standards Sector (ITU-T)

American National Standards Institute (ANSI)

Institute of Electrical and Electronics Engineers (IEEE)

Electronic Industries Association (EIA)

Forums

Frame Relay Forum

ATM Forum

Regulatory Agencies

Federal Communications Commission (FCC)

National Communications Commission (NCC)

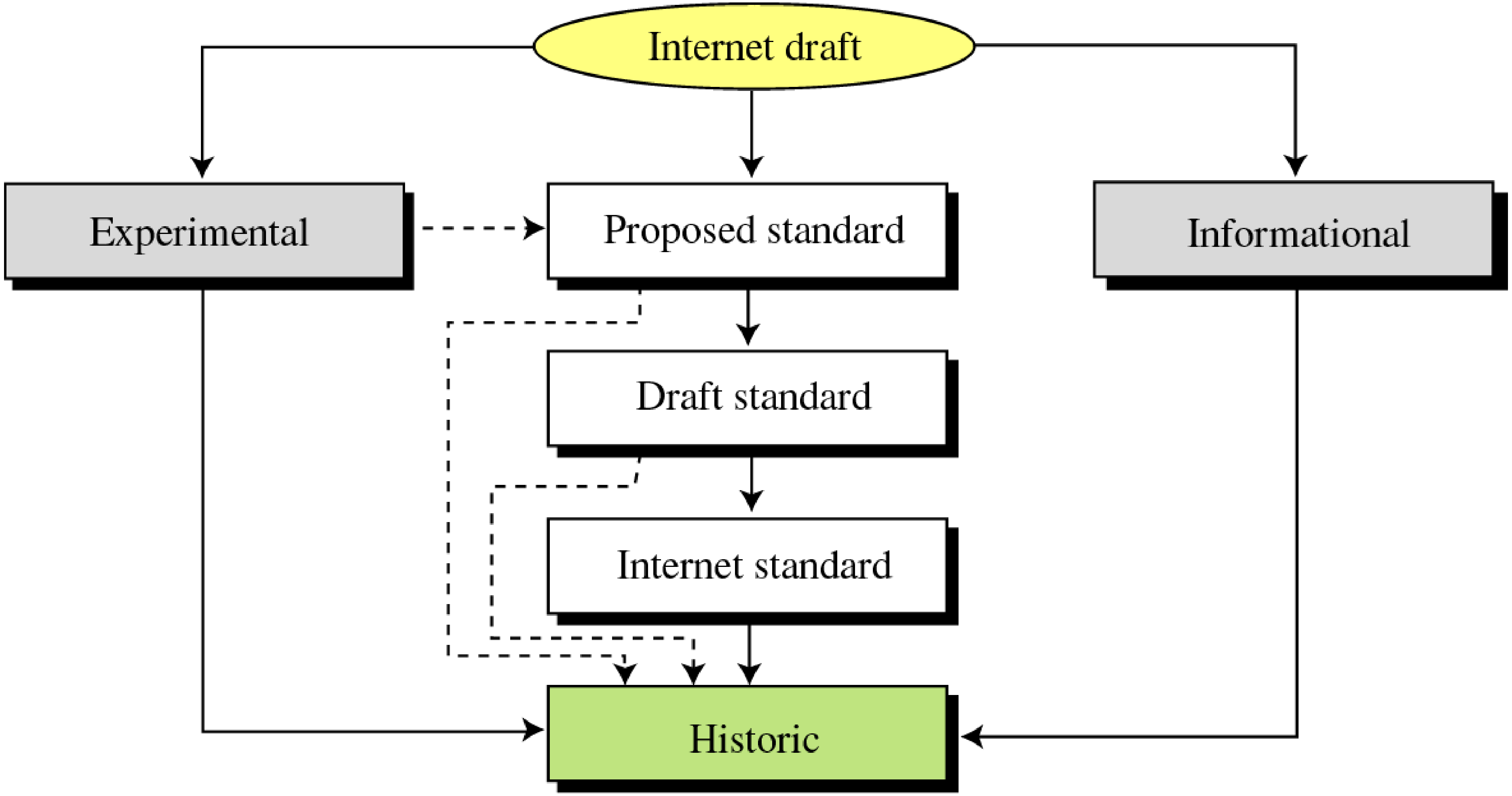
Note

The websites for the above organizations are given in Appendix G.

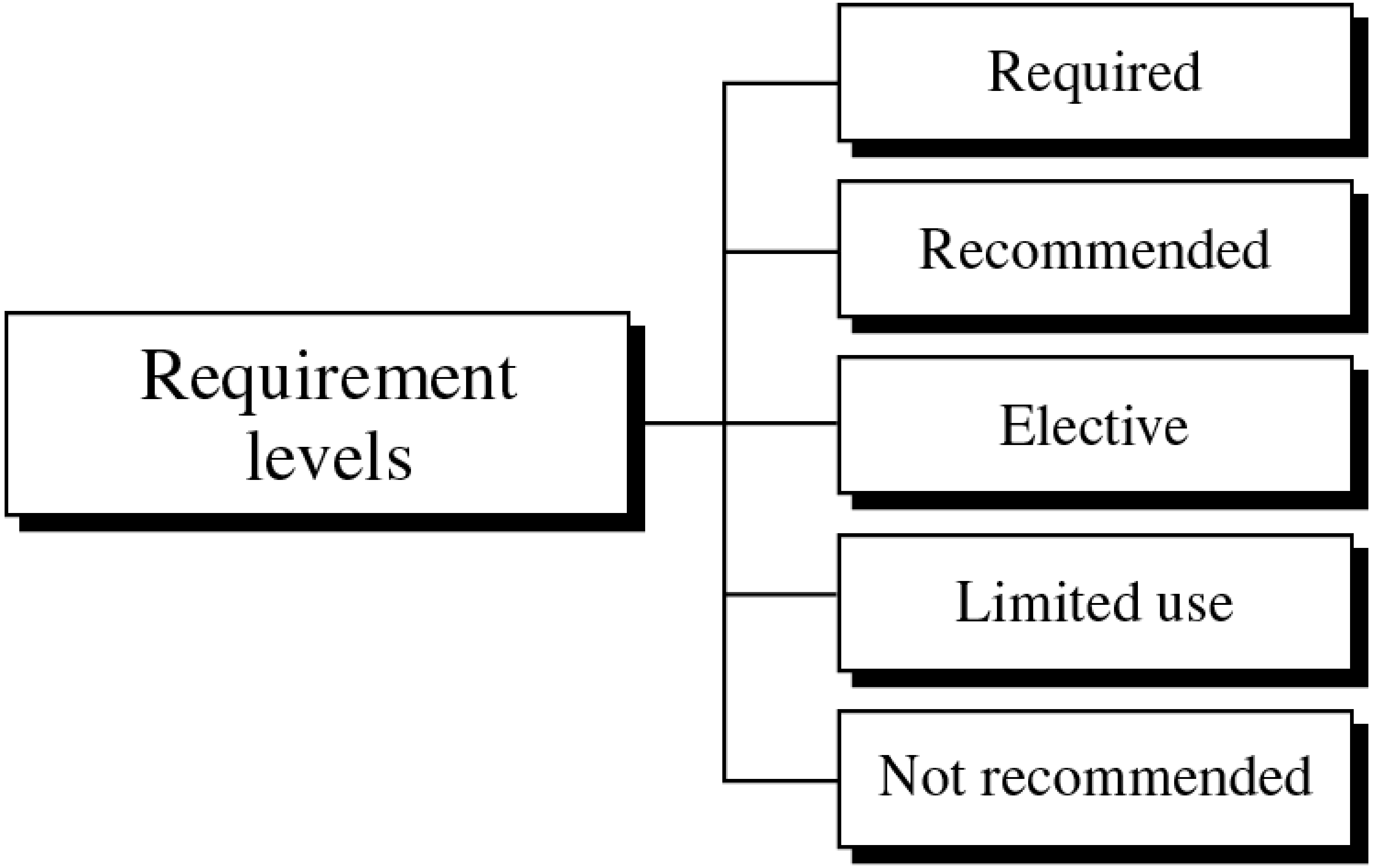
1.4

INTERNET STANDARDS

Maturity levels of an RFC



Requirement levels of an RFC

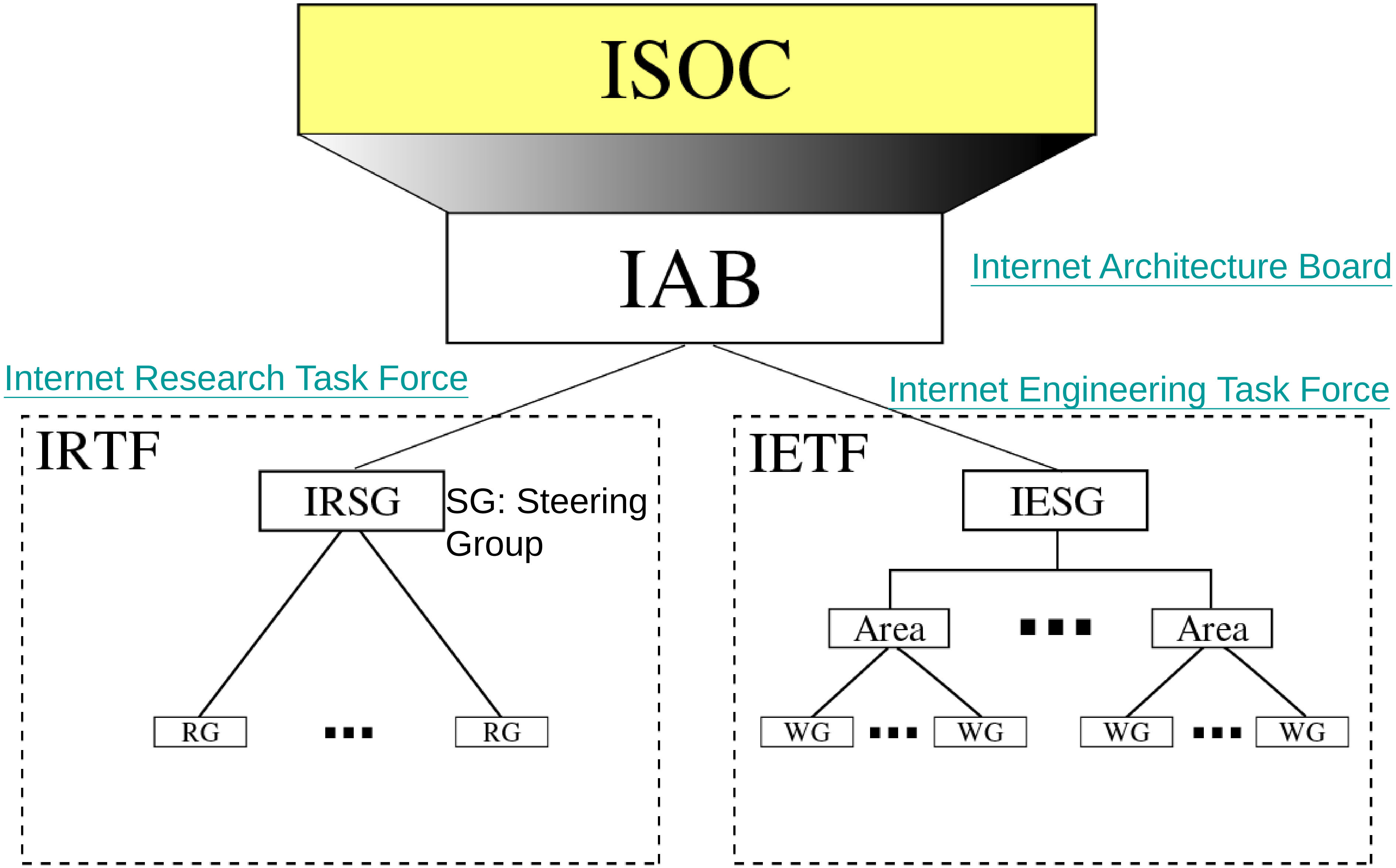


1.5

INTERNET ADMINISTRATION

Figure 1-4

Internet Administration



Internet Numbers

- IP addresses
- Protocol numbers
- Domain names
- …
- IANA (Internet Assigned Numbers Authority)
- ICANN (Internet Corporation for Assigned Names and Numbers)

Chapter 2

The OSI Model and TCP/IP Protocol Suite

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CONTENTS

- THE OSI MODEL
- LAYERS IN THE OSI MODEL
- TCP/IP PROTOCOL SUITE
- ADDRESSING
- TCP/IP VERSIONS

2.1

THE OSI MODEL

Note

ISO is the organization.
OSI is the model.

Note

Headers are added to the data at layers 6, 5, 4, 3, and 2. Trailers are usually added only at layer 2.

Figure 2-3

An exchange using the OSI model

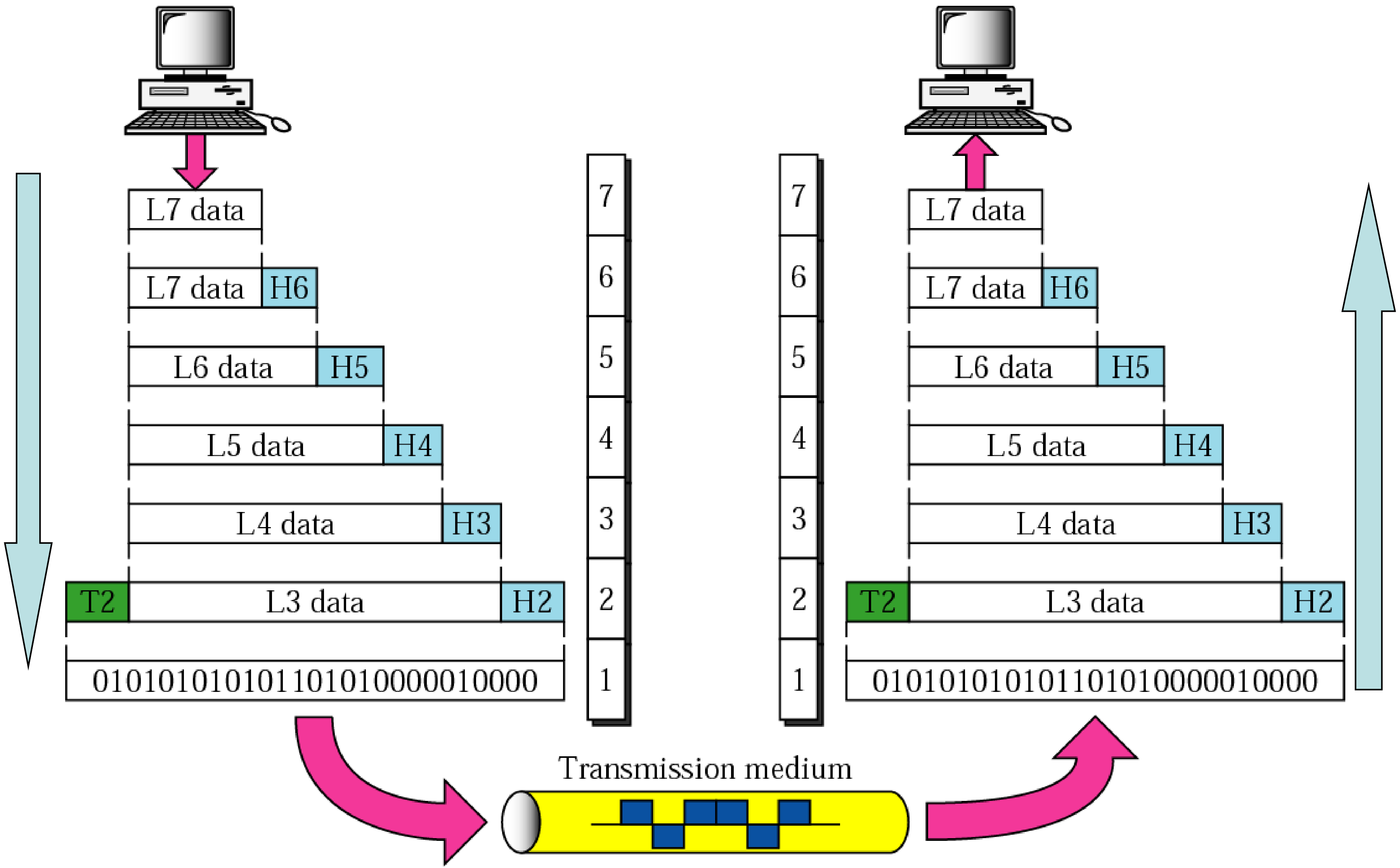


Figure 2-8

End-to-end delivery

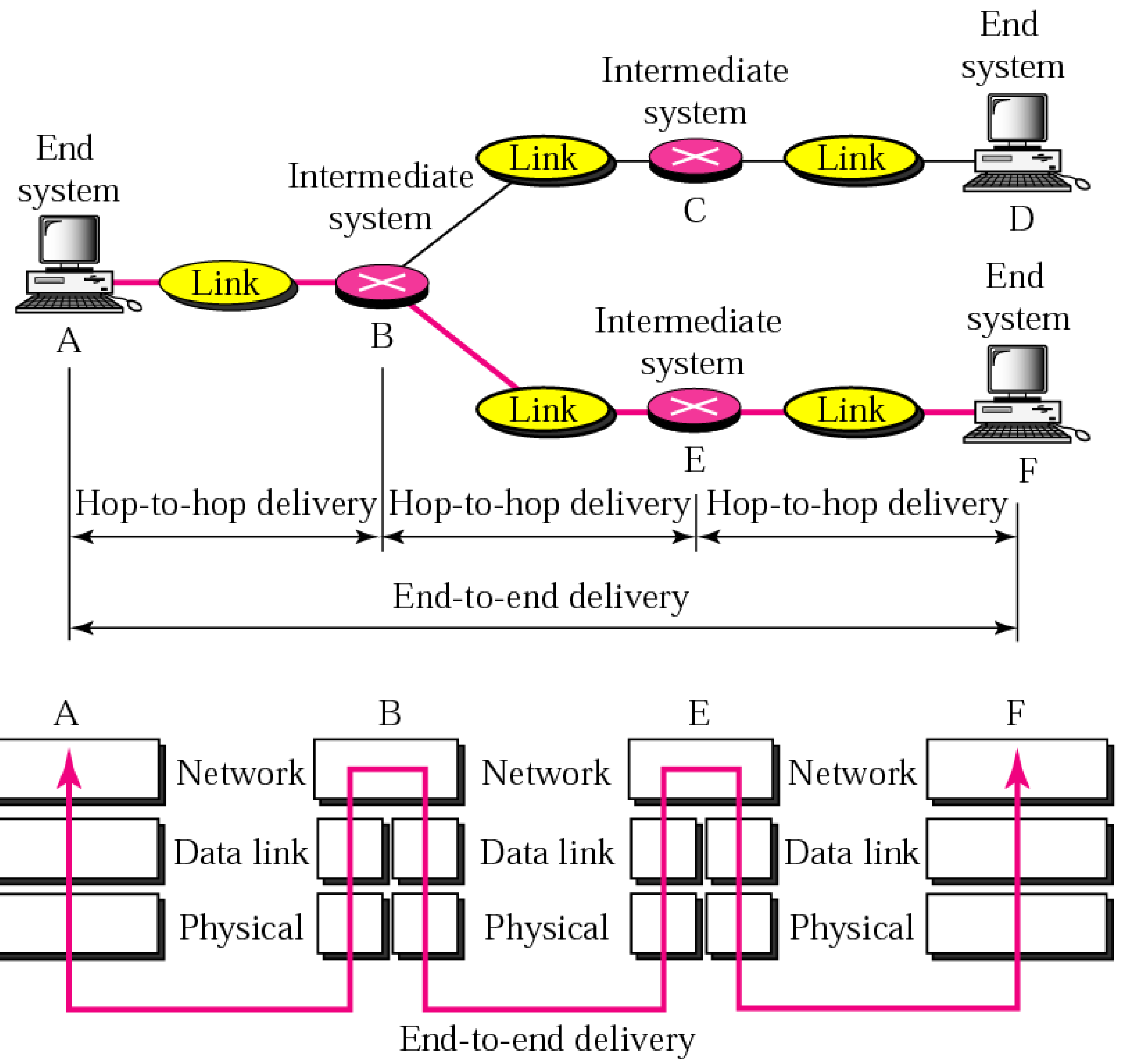


Figure 2-10

Reliable end-to-end delivery of a message

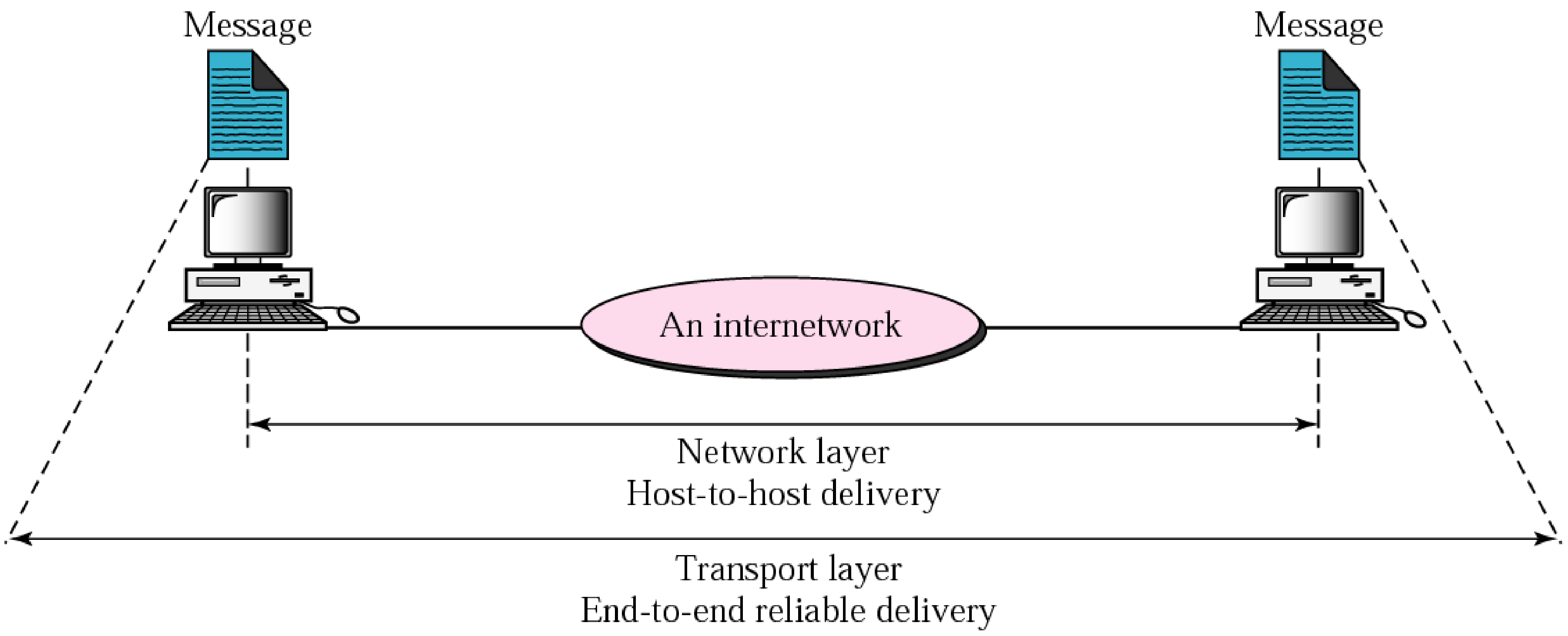
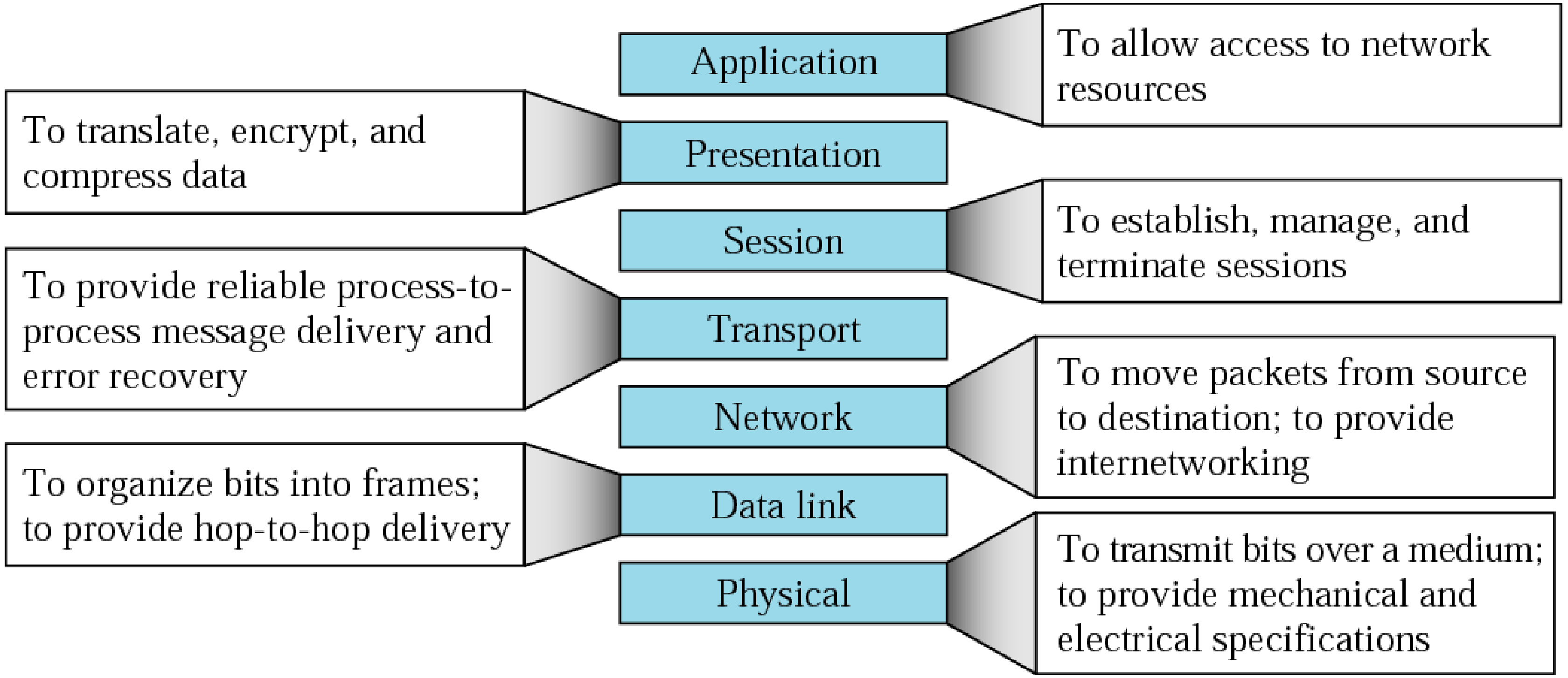


Figure 2-14

Summary of layers

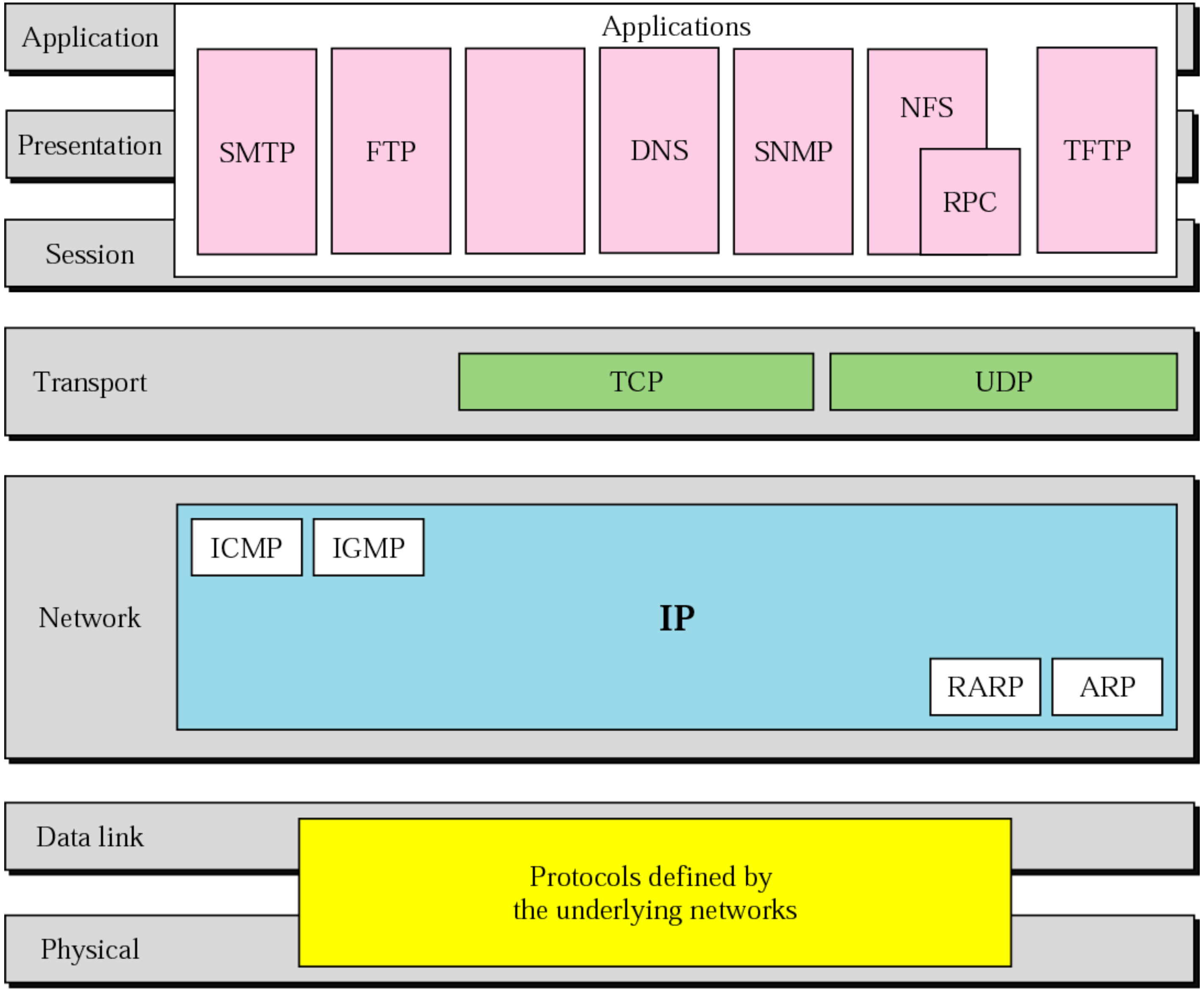


2.3

TCP/IP PROTOCOL SUITE

Figure 2-15

TCP/IP and OSI model

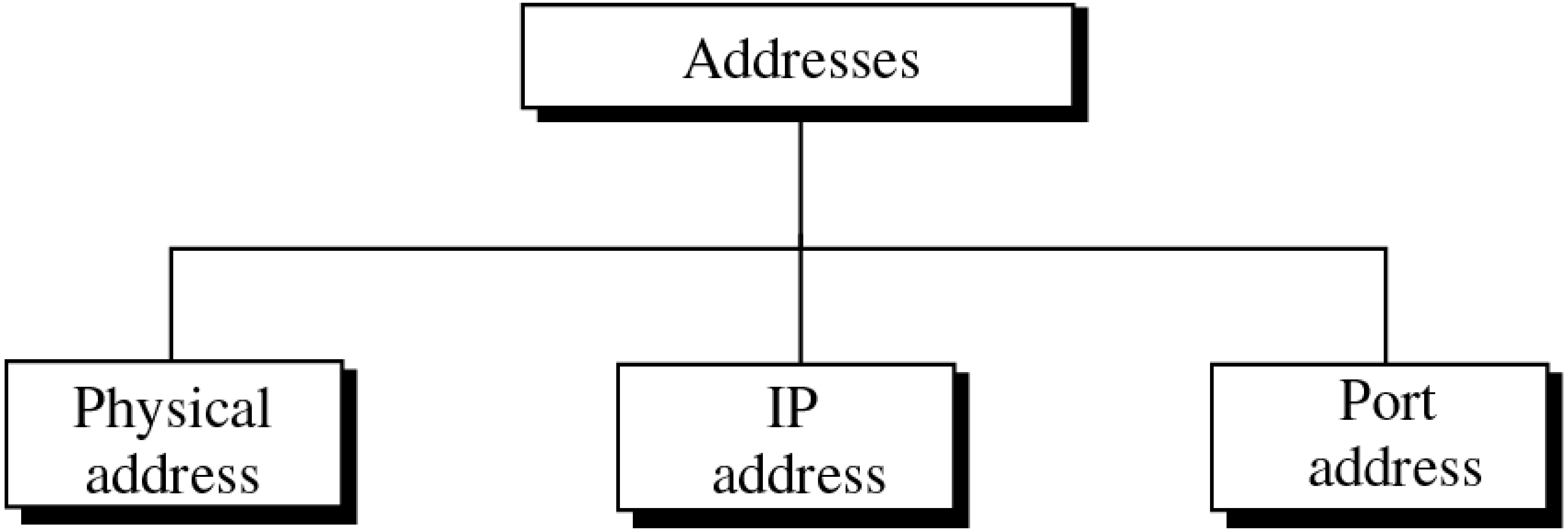


2.4

ADDRESSING

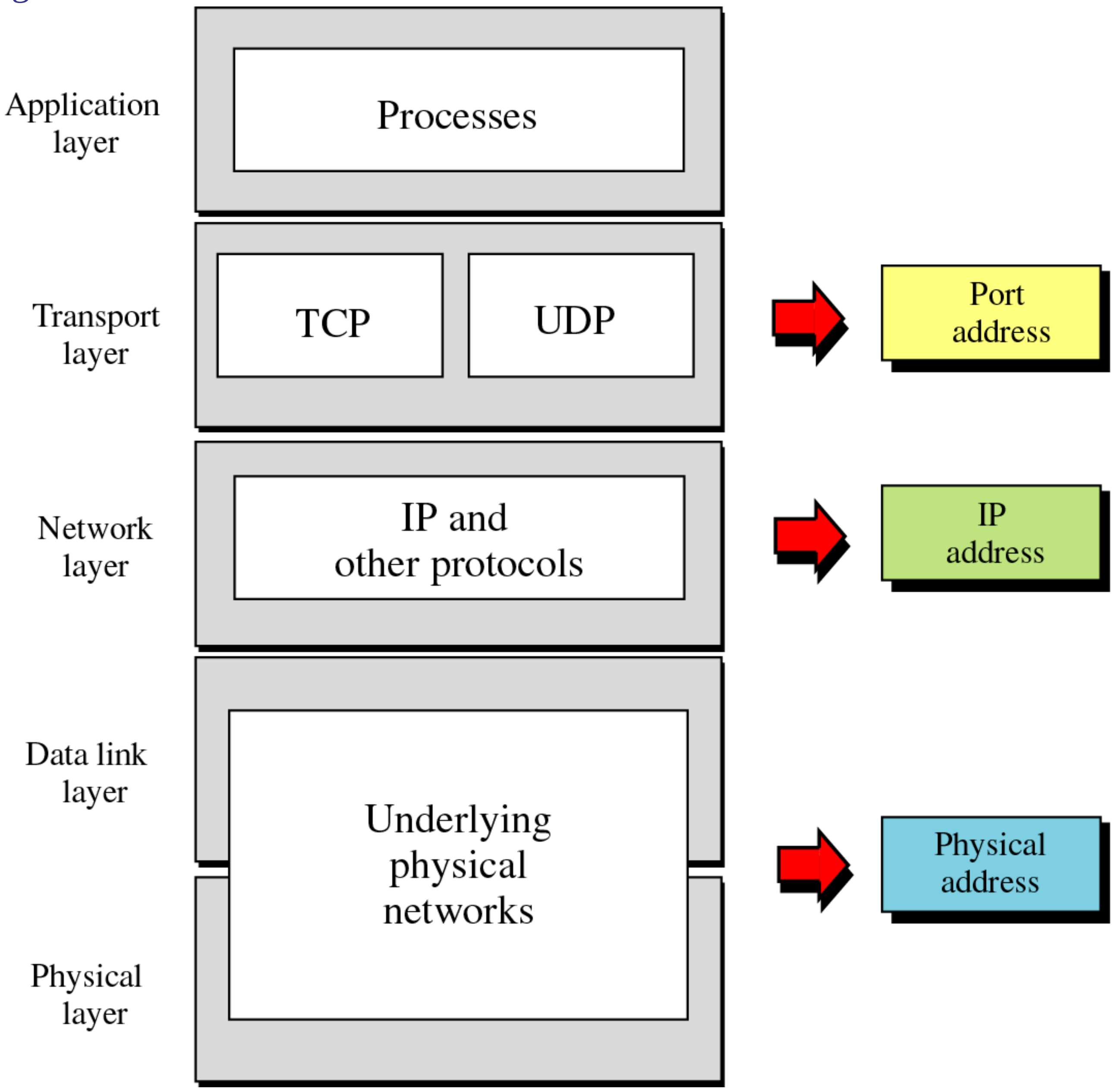
Figure 2-16

Addresses in TCP/IP



Relation-ship of layers and addresses in TCP/IP

Figure 2-17



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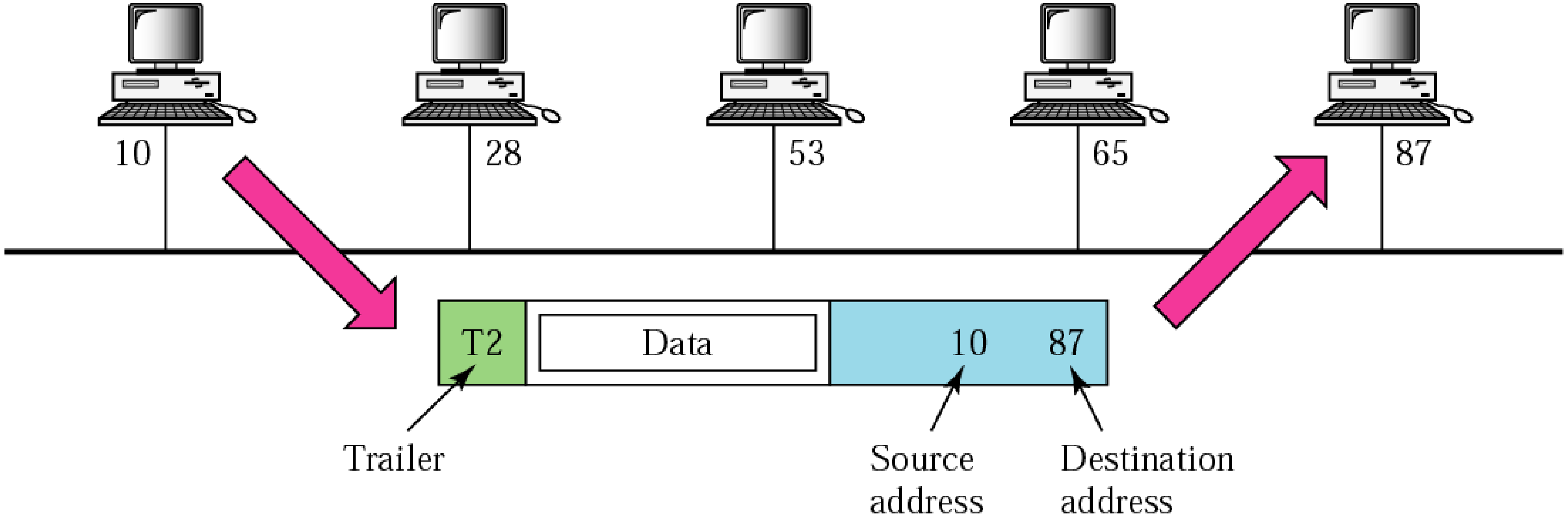
Example 1

Figure 2.18 shows an example of physical addresses.

Figure 2-18

Physical addresses



Example 2

Most local area networks use a 48-bit (6 bytes) physical address written as 12 hexadecimal digits, with every 2 bytes separated by a hyphen as shown below:

07-01-02-01-2C-4B

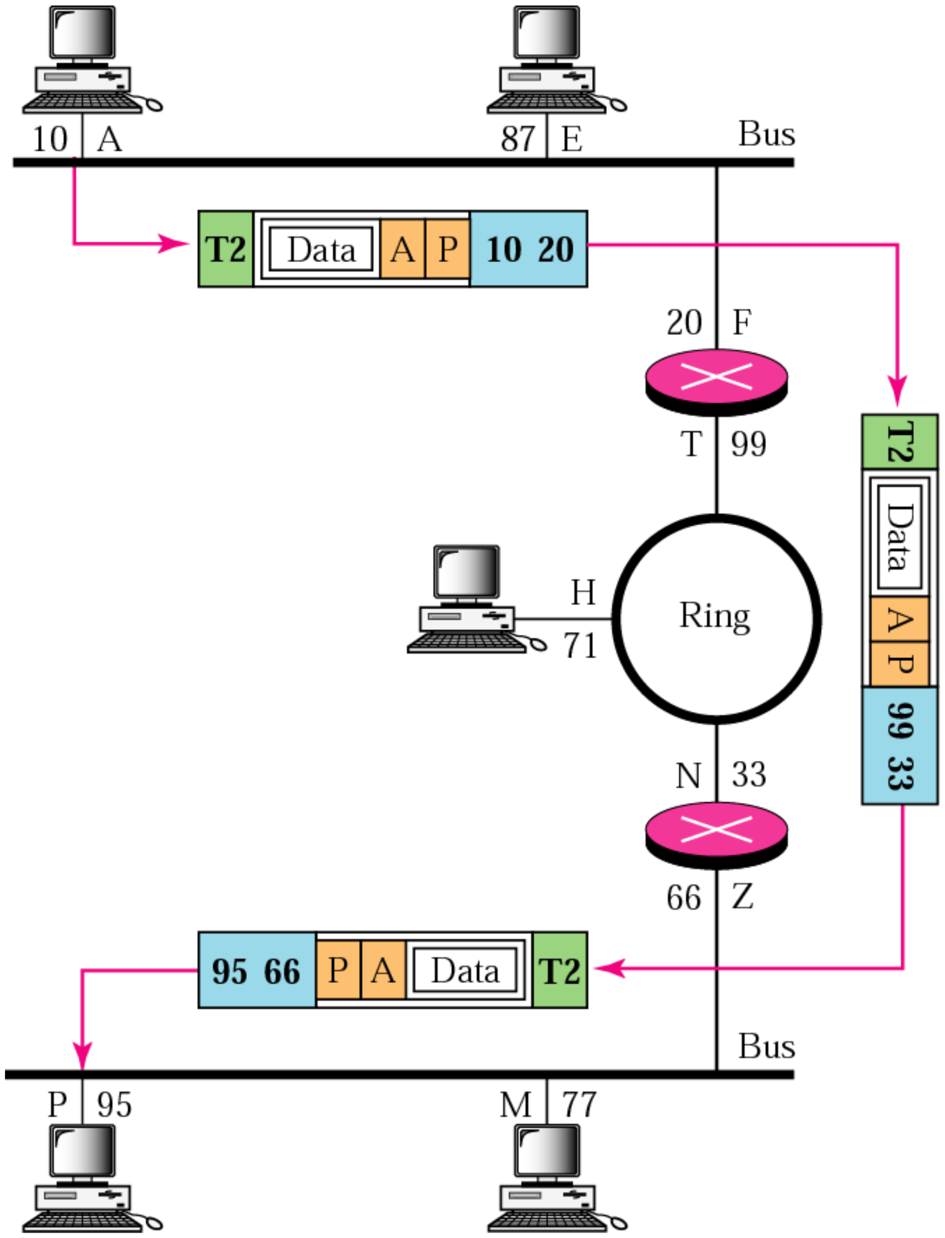
A 6-byte (12 hexadecimal digits) physical address

Example 3

Figure 2.19 shows an example of Internet addresses.

Figure 2-19

IP addresses



Note the changes in physical address!!

Example 4

As we will see in Chapter 4, an Internet address (in IPv4) is 32 bits in length, normally written as four decimal numbers, with each number representing 1 byte. The numbers are separated by a dot. Below is an example of such an address.

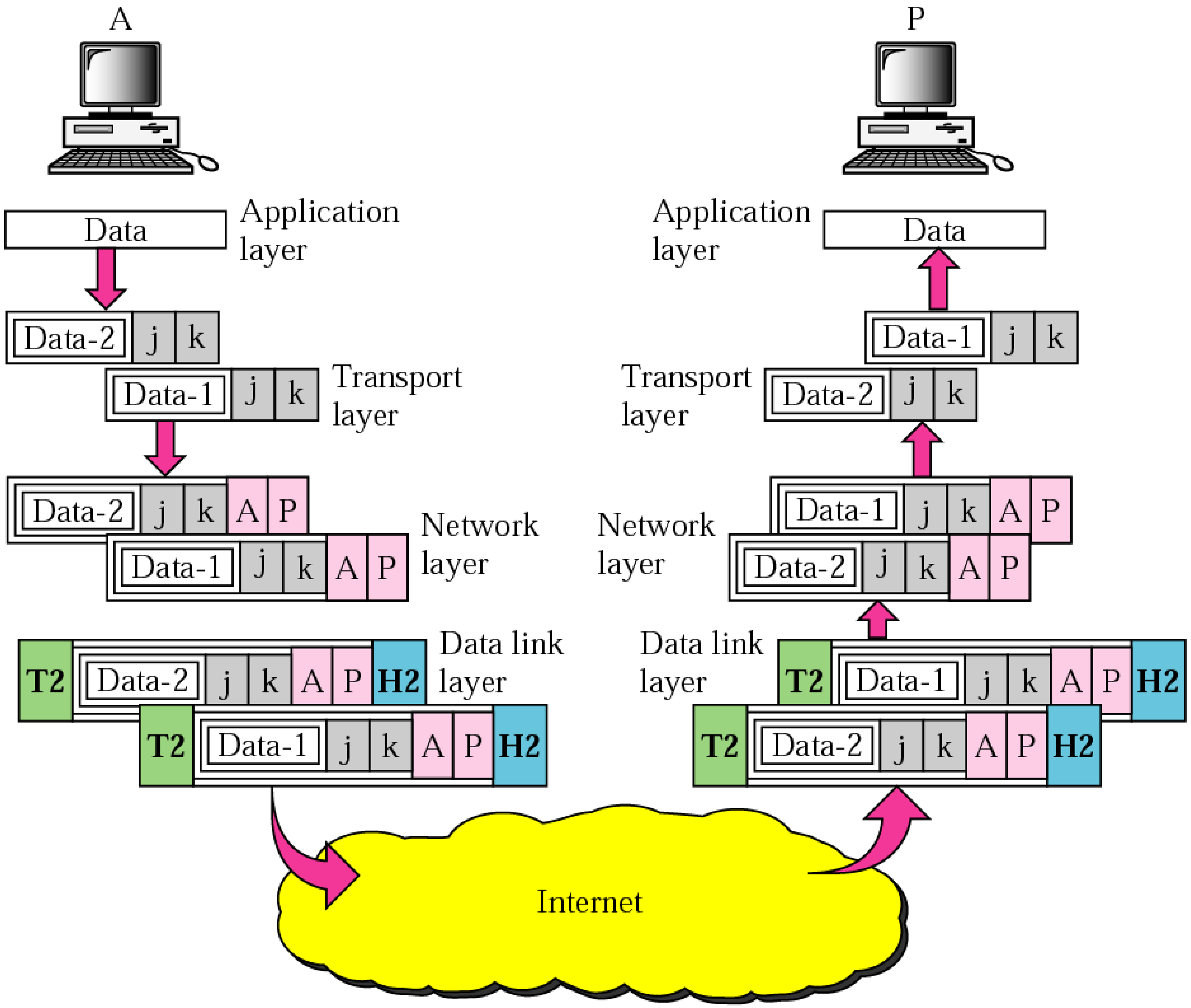
132.24.75.9

Example 5

Figure 2.20 shows an example of transport layer communication.

Figure 2-20

Port addresses



Example 6

As we will see in Chapters 11 and 12, a port address is a 16-bit address represented by one decimal number as shown below.

753 **A 16-bit port address**

2.5

TCP/IP VERSIONS

Versions:

- Version 4 (current): 32-bit IP address
- Version 5
- Version 6 (in promotion): 128-bit IP address

Chapter 4

IP Addresses: Classful Addressing

CONTENTS

- 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.

One IP address points to one computer.
But a computer may have many IP addresses.

Address Space

....

addr1 ....

addr15

addr2 ....

....

....

addr41 addr226

addr31

....

....

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

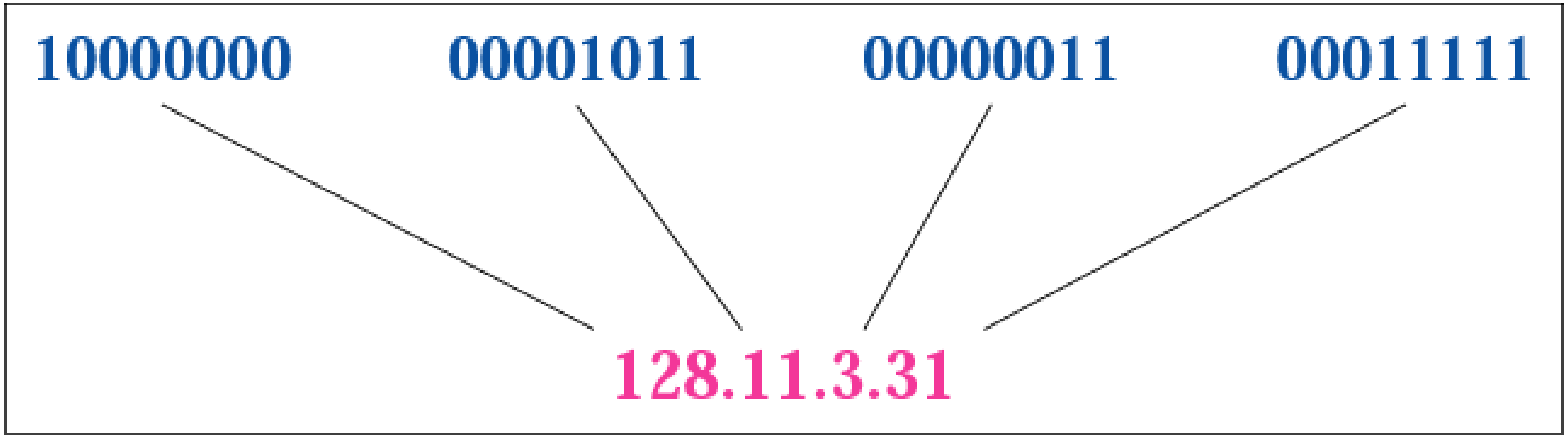
4,294,967,296.

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

Note

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

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

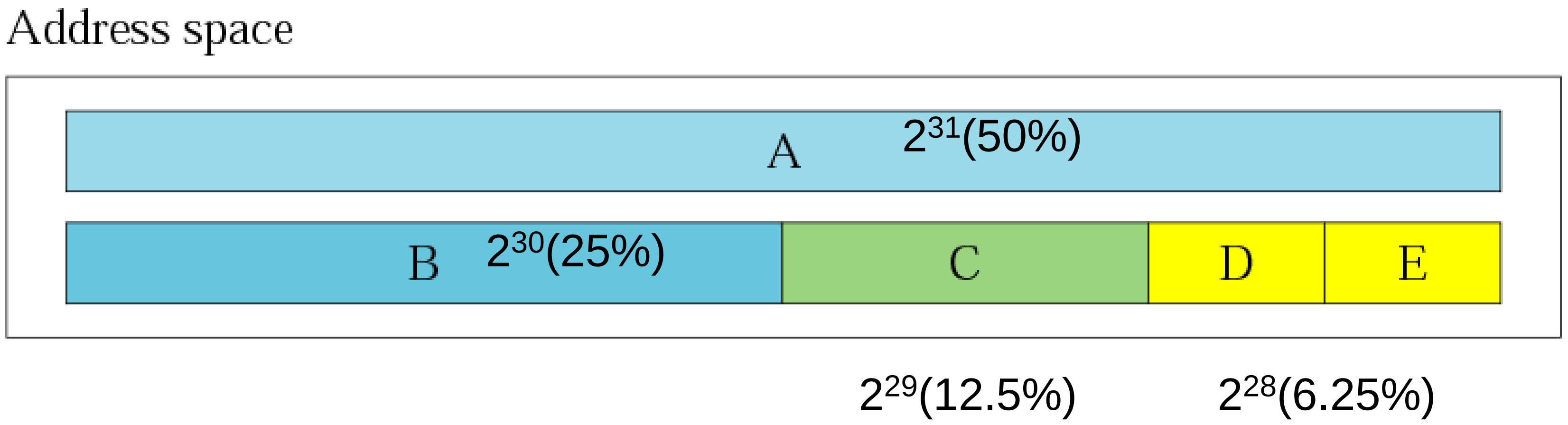
0X810B0BEF or $810B0BEF_{16}$

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.

Finding the class in binary notation

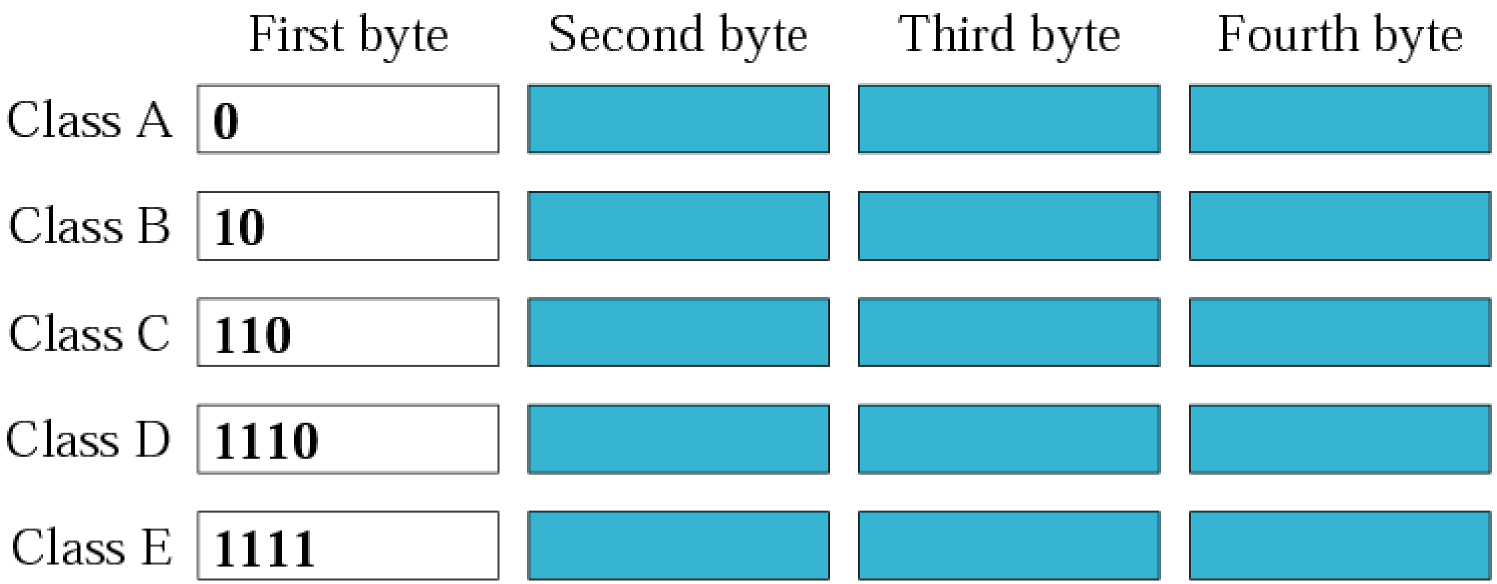
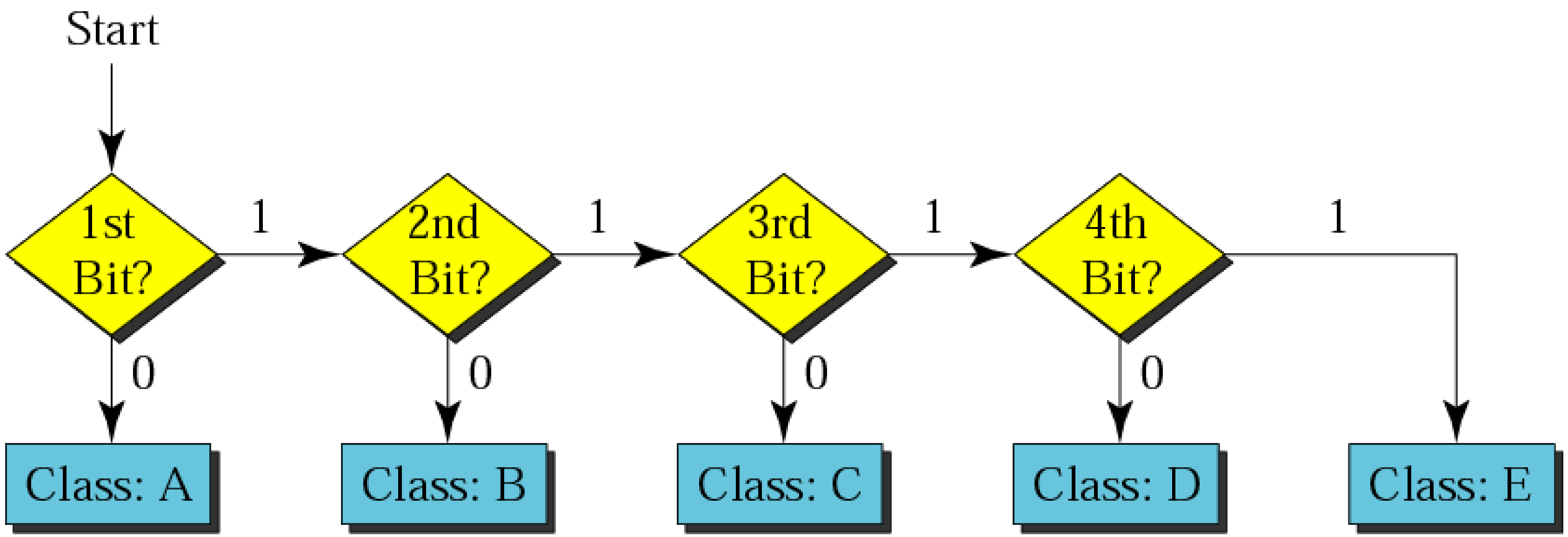


Figure 4-4

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

	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 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.

Network identity (network ID) is a portion of the TCP/IP address that is used to identify individuals or devices on a network such as a local area network or the Internet. ... A network ID is also known as network identification or **NetID**.

Figure 4-6

Netid and hostid

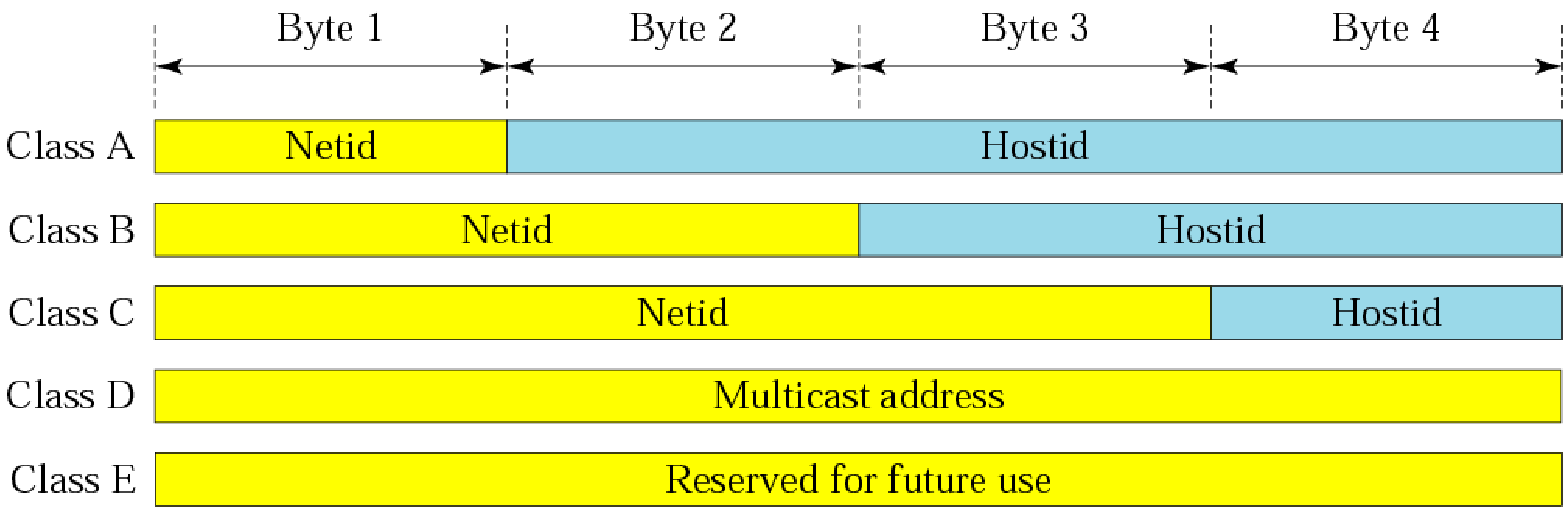
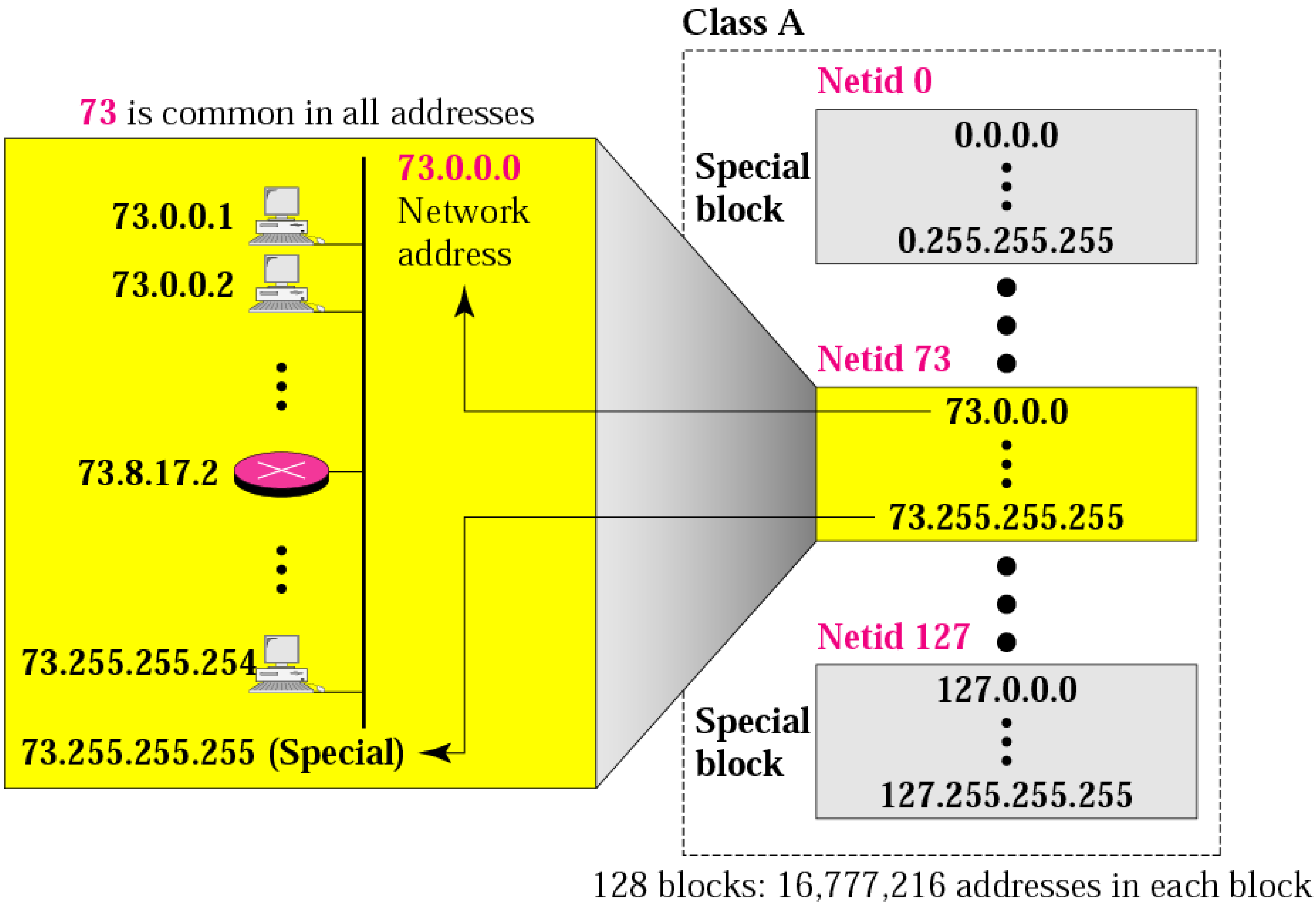


Figure 4-7

Blocks in class A

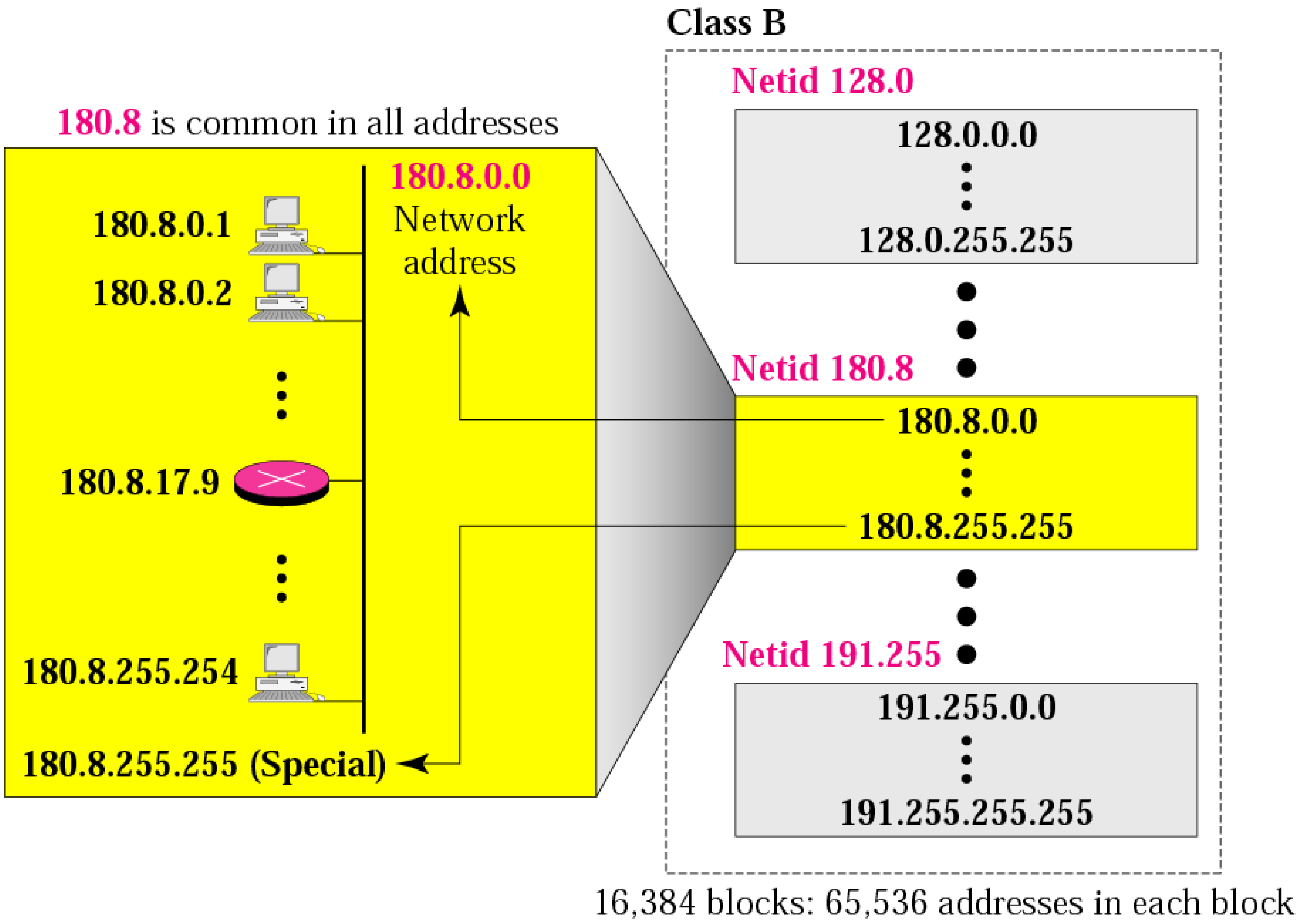


Note

Millions of class A addresses are wasted.

Figure 4-8

Blocks in class B

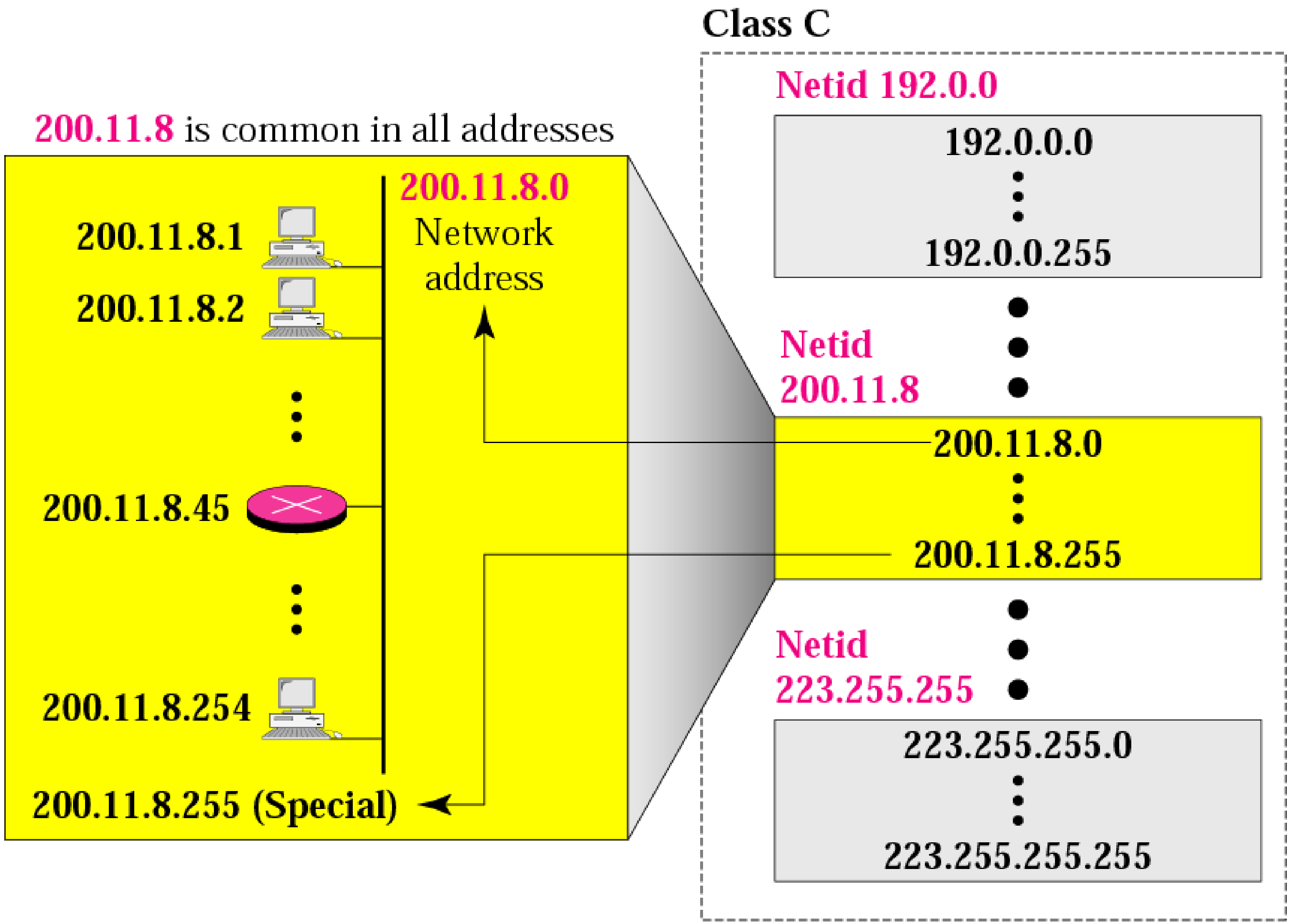


Note

Many class B addresses are wasted.

Figure 4-9

Blocks in class C



2,097,152 blocks: 256 addresses in each block

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

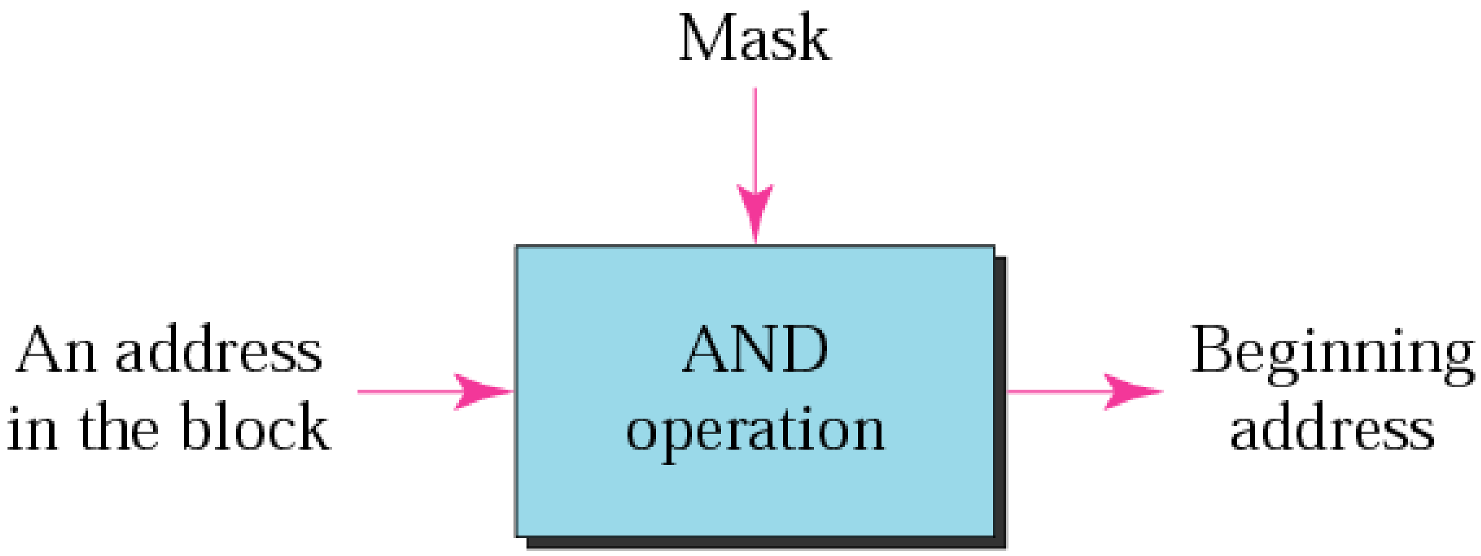
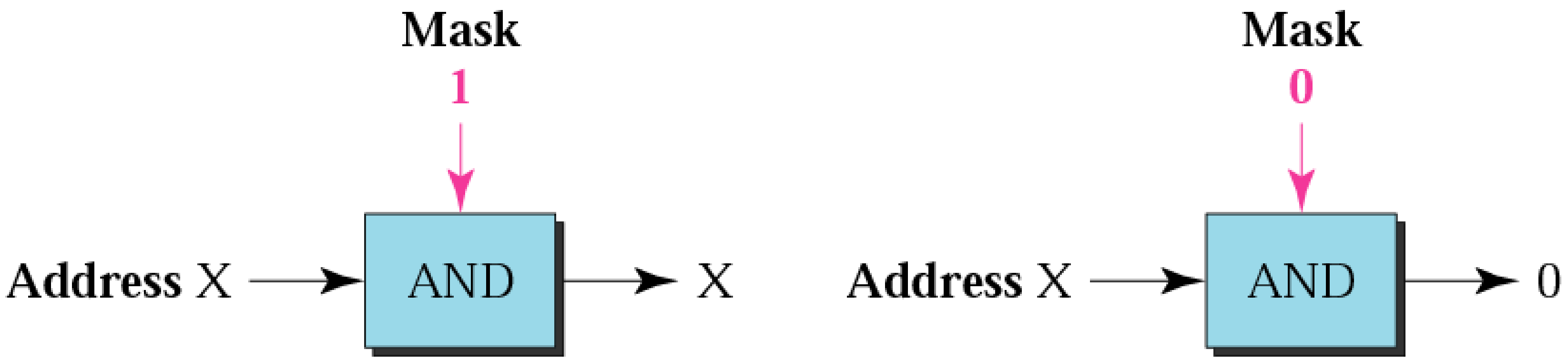


Figure 4-11

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.

Default Masks

Class	Mask in Binary	Mask in dotted-decimal
A	11111111 0…0	255.0.0.0
B	11111111 11111111 0…0	255.255.0.0
C	1…1 00000000	255.255.255.0

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.

CIDR (Classless Inter-Domain Routing) Notation

18.46.74.10/8
141.24.74.69/16
200.14.70.22/24

→ Number of 1's in the mask

Address Depletion

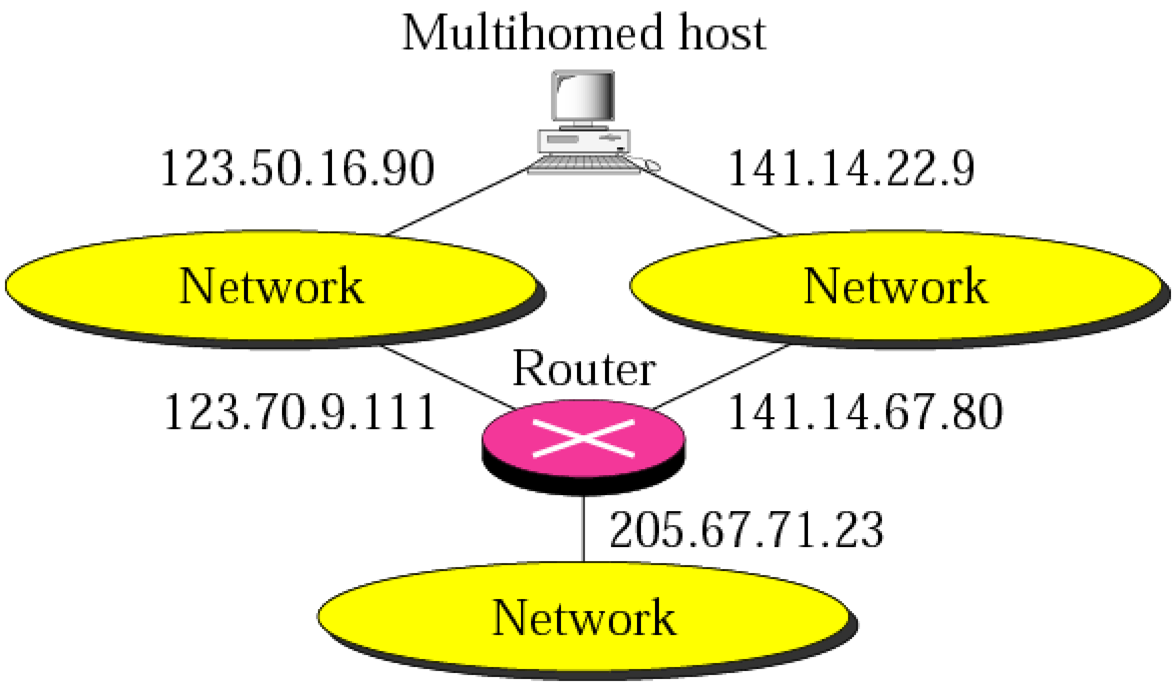
We have run out of class A and B addresses, and a class C block is too small for most middle-sized organizations.

4.13

OTHER ISSUES

Figure 4-12

Multihomed devices



Location, Not Names

- An internet address defines the network location of a device, not its identify.
- Movement of computer from one network to another means that its IP address must be changed.
- Flat addressing vs. hierarchical addressing

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
The 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 addresses

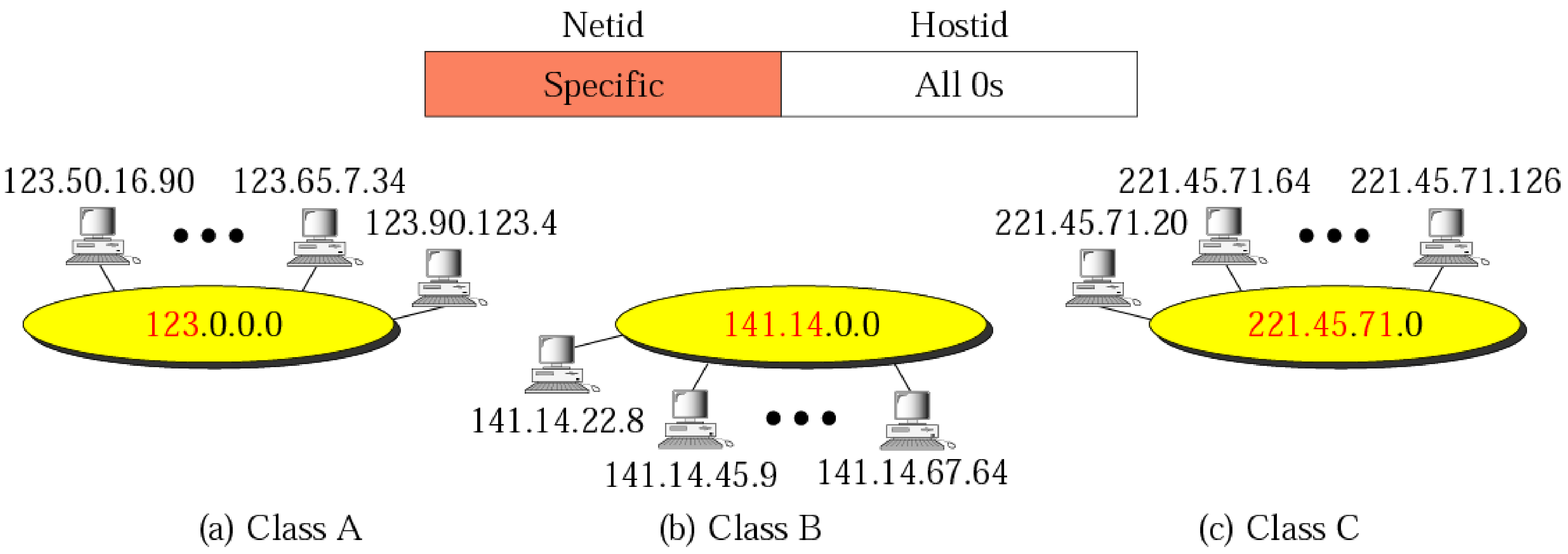
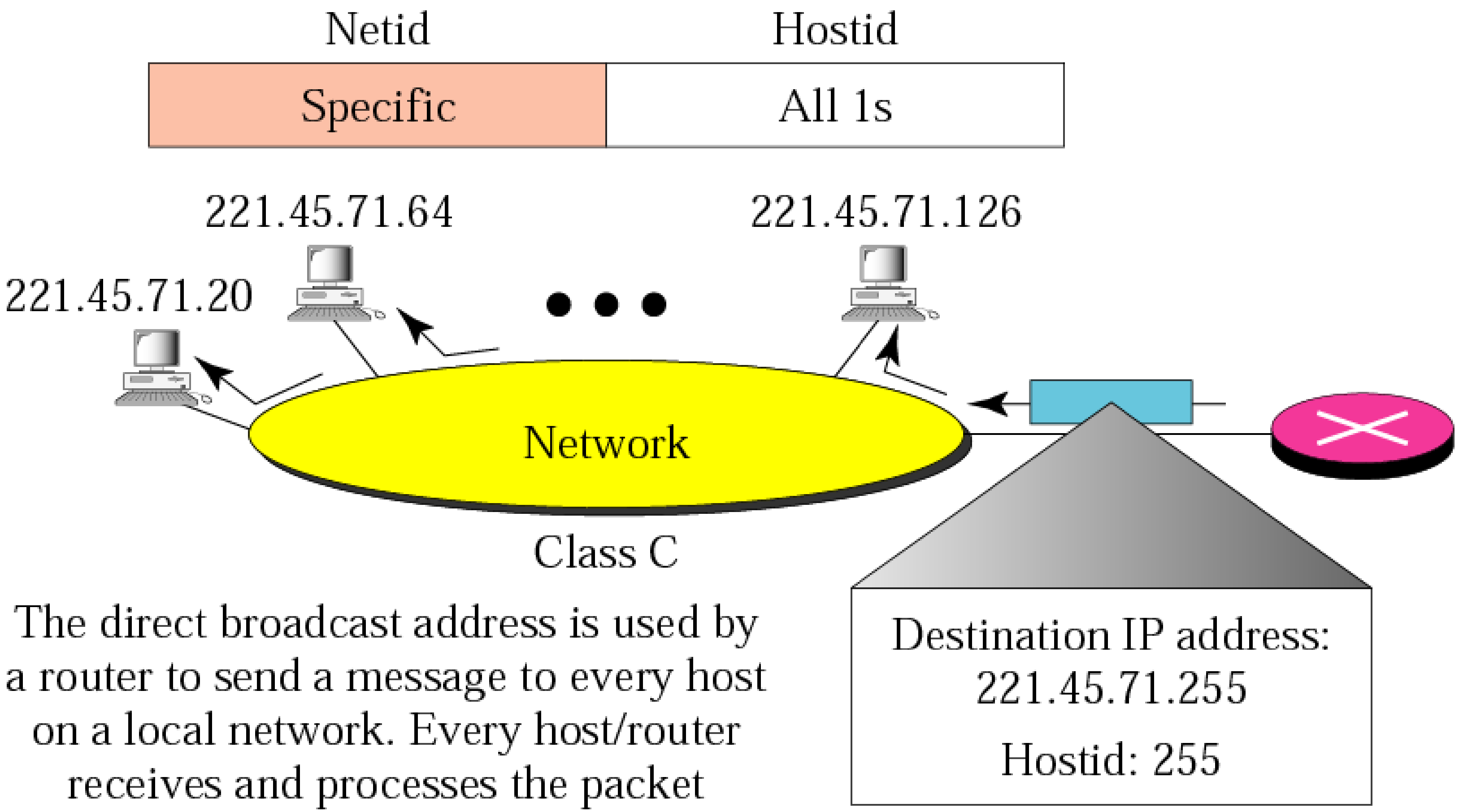


Figure 4-14

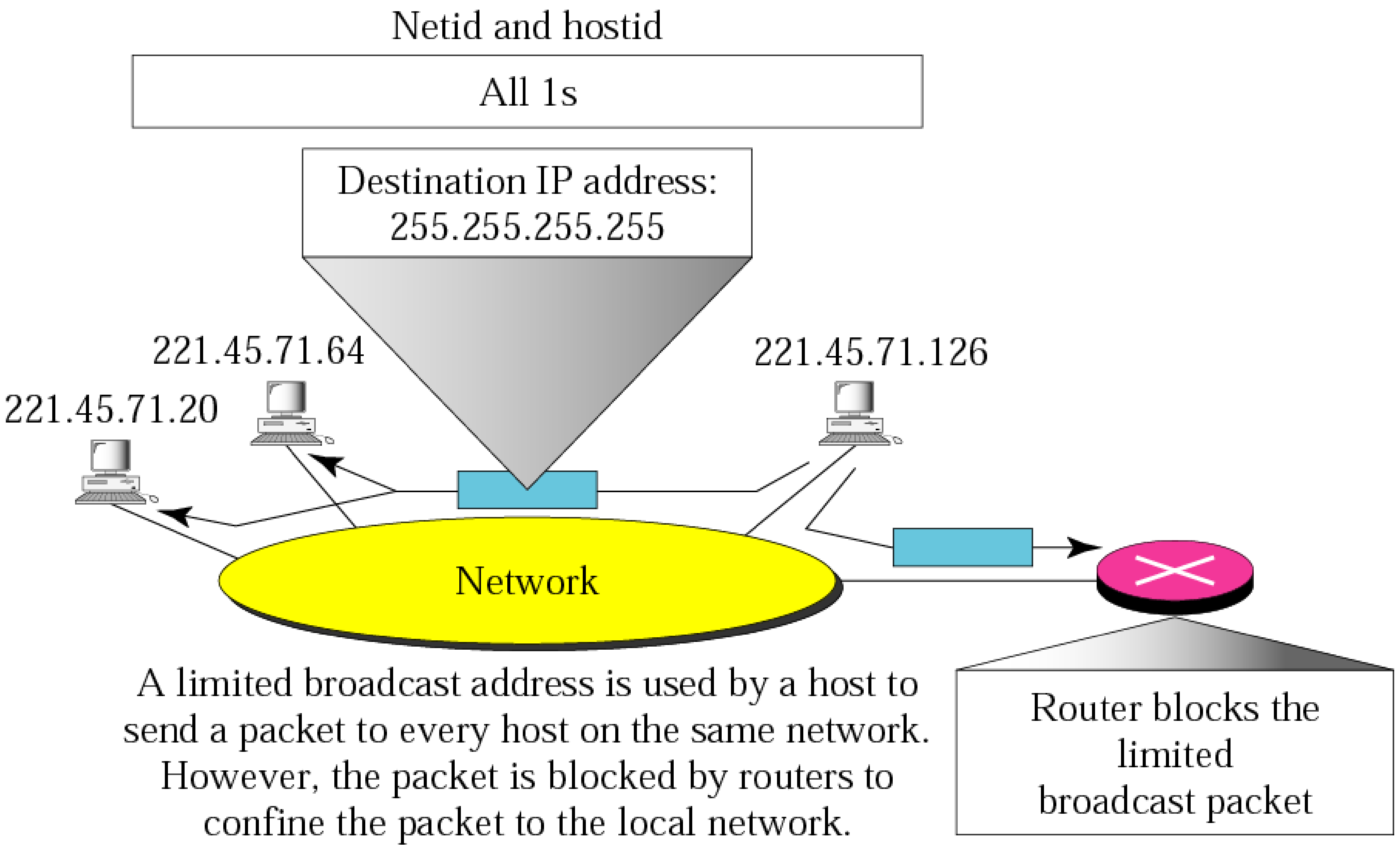
Example of direct broadcast address



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

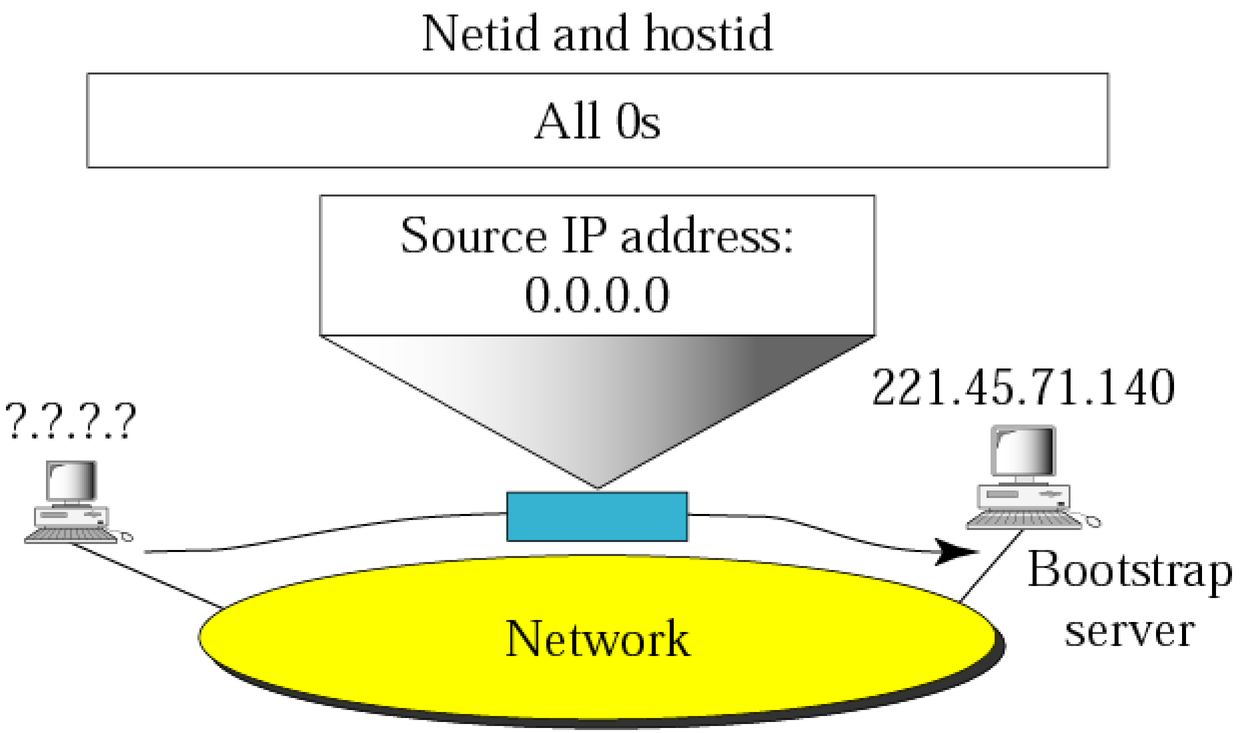
Example of limited broadcast address



A limited broadcast address is used by a host to send a packet to every host on the same network. However, the packet is blocked by routers to confine the packet to the local network.

Figure 4-16

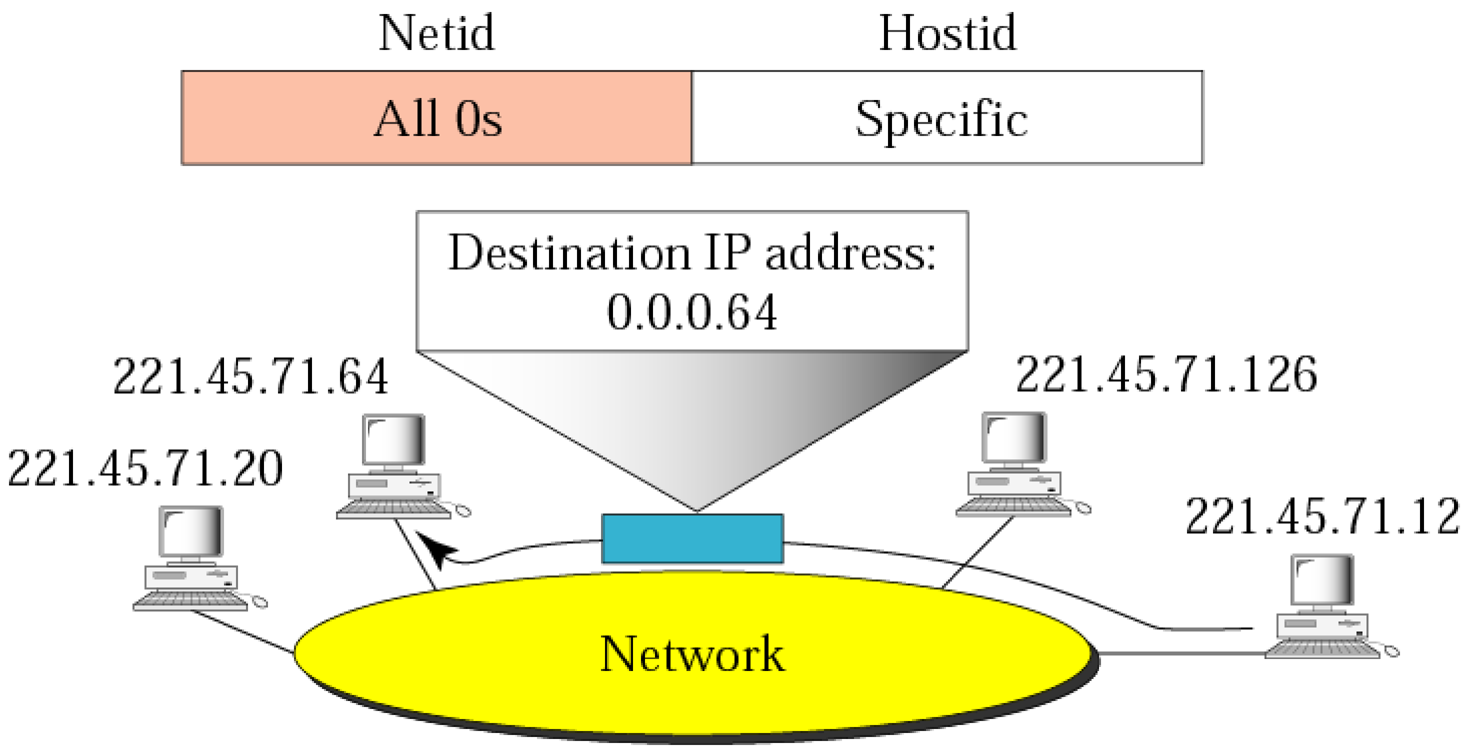
Example of *this* host on *this* address



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

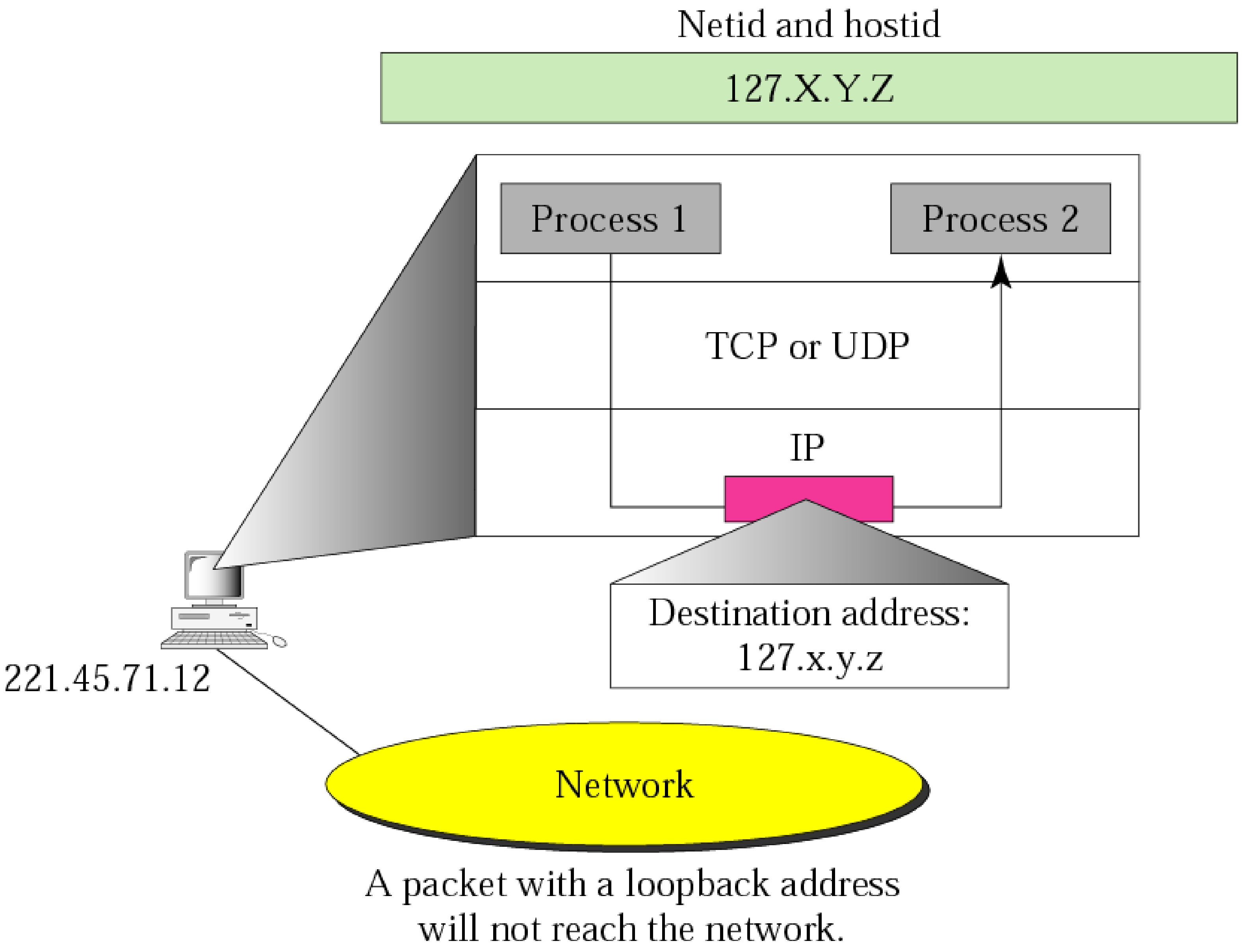
Example of specific host on *this* network



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



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

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

Unicast, Multicast, and Broadcast Addresses

Unicast communication is *one-to-one*.

Multicast communication is *one-to-many*.

Broadcast communication is *one-to-all*.

Note

Multicast delivery will be discussed in depth in Chapter 15.