Note

An IPv4 address is 32 bits long.

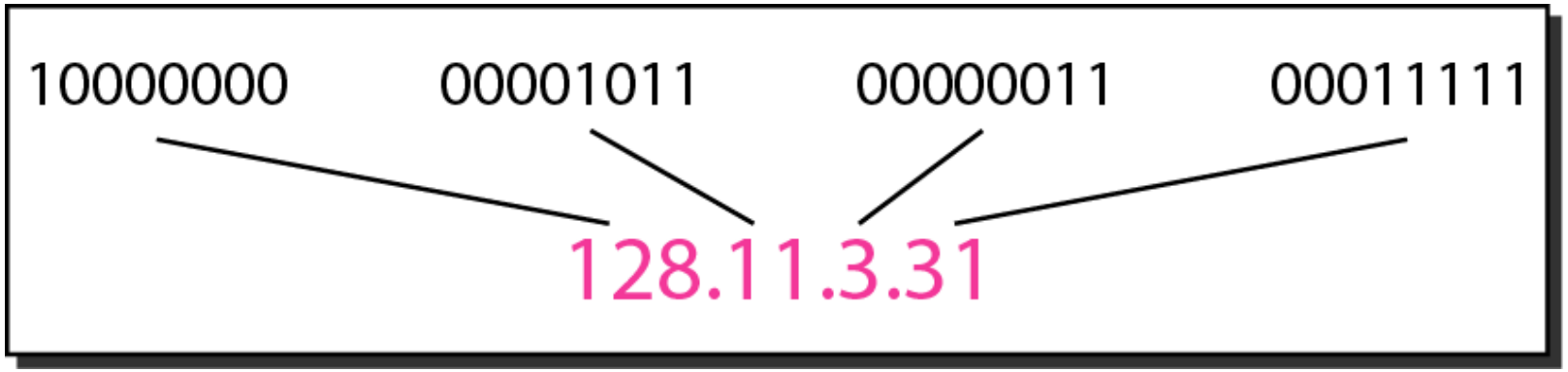
Note

The IPv4 addresses are unique and universal.

The address space of IPv4 is

2^{32} or 4,294,967,296.

Figure Dotted-decimal notation and binary notation for an IPv4 address



Change the following IPv4 addresses from binary notation *to dotted-decimal notation.*

a. 10000001 00001011 00001011 11101111

b. 11000001 10000011 00011011 11111111

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

Change the following IPv4 addresses from dotted-decimal *notation to binary notation.*

a. 111.56.45.78

b. 221.34.7.82

Solution

We replace each decimal number with its binary equivalent (see Appendix B).

a. 01101111 00111000 00101101 01001110

b. 11011101 00100010 00000111 01010010

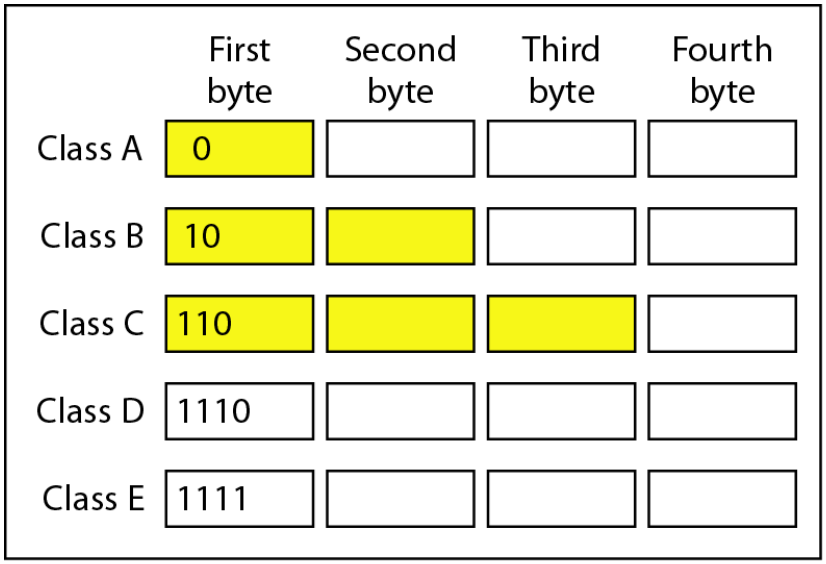
Find the error, if any, in the following IPv4 addresses.

a. 111.56.045.78
b. 221.34.7.8.20
c. 75.45.301.14
d. 11100010.23.14.67

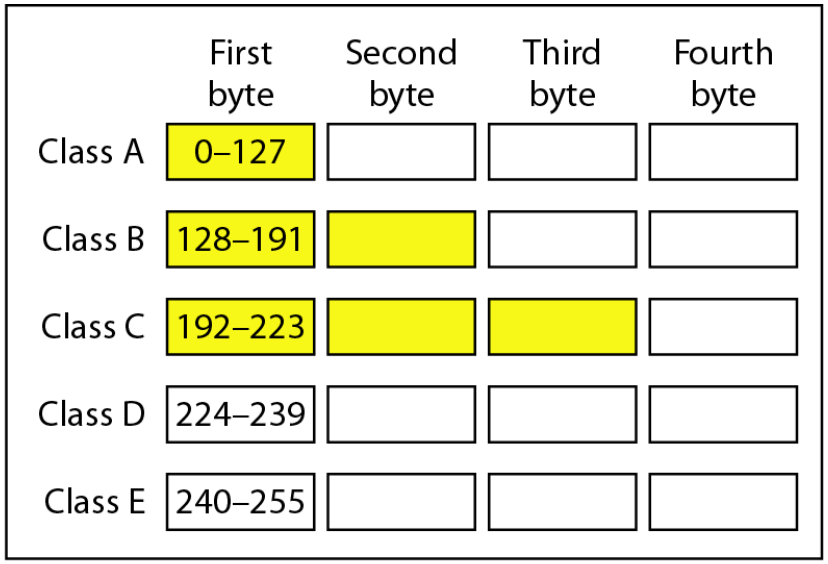
Note

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

Figure Finding the classes in binary and dotted-decimal notation



a. Binary notation



b. Dotted-decimal notation

Find the class of each address.

a. 00000001 00001011 00001011 11101111

b. 11000001 10000011 00011011 11111111

c. 14.23.120.8

d. 252.5.15.111

Table Number of blocks and block size in classful IPv4 addressing

Class	*Number of Blocks*	*Block Size*	*Application*
A	128	16,777,216	Unicast
B	16,384	65,536	Unicast
C	2,097,152	256	Unicast
D	1	268,435,456	Multicast
E	1	268,435,456	Reserved

Note

In classful addressing, a large part of the available addresses were wasted.

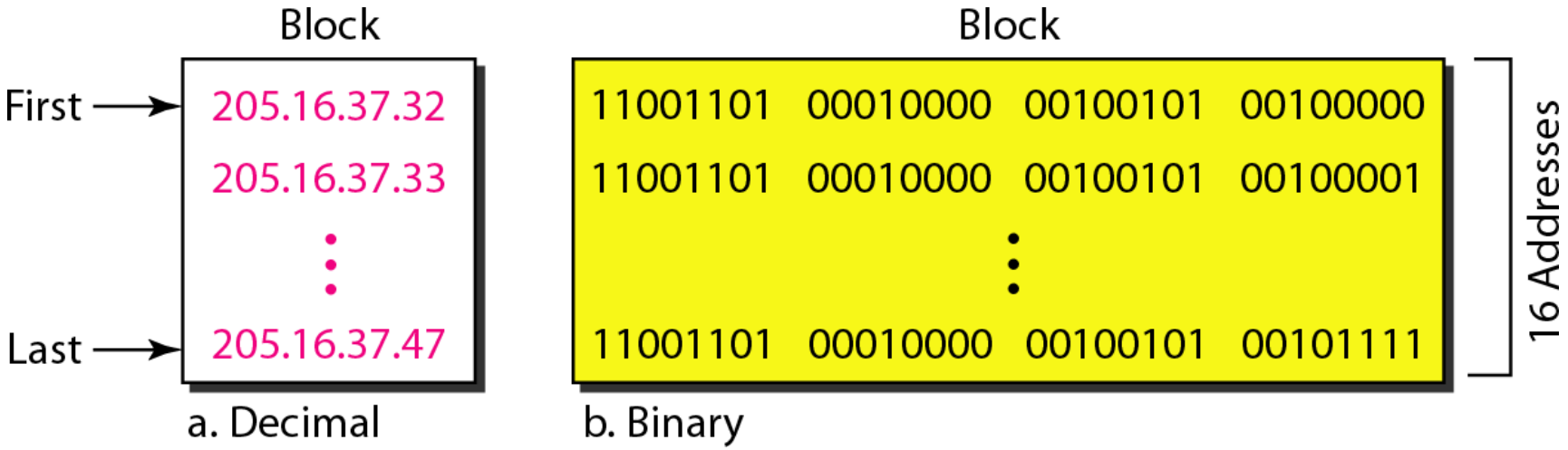
Table Default masks for classful addressing

Class	*Binary*	*Dotted-Decimal*	*CIDR*
A	**11111111** 00000000 00000000 00000000	**255**.0.0.0	/8
B	**11111111 11111111** 00000000 00000000	**255.255**.0.0	/16
C	**11111111 11111111 11111111** 00000000	**255.255.255**.0	/24

Note

Classful addressing, which is almost obsolete, is replaced with classless addressing.

Figure A block of 16 addresses granted to a small organization



In IPv4 addressing, a block of addresses can be defined as

x.y.z.t /*n*

in which x.y.z.t defines one of the addresses and the /*n* defines the mask.

Note

The first address in the block can be found by setting the rightmost $32 - n$ bits to 0s.

A block of addresses is granted to a small organization. We know that one of the addresses is 205.16.37.39/28. What is the first address in the block?

Solution

The binary representation of the given address is *11001101*

00010000 *00100101* *00100111*

If we set 32−28 rightmost bits to 0, we get

11001101 *00010000* *00100101* *0010000*

or *205.16.37.32*.

Note

The last address in the block can be found by setting the rightmost $32 - n$ bits to 1s.

Find the last address for the block in Last Example

Solution

The binary representation of the given address is

11001101 00010000 00100101 00100111

If we set 32 − 28 rightmost bits to 1, we get 11001101 00010000 00100101 00101111

or 205.16.37.47

Note

The number of addresses in the block can be found by using the formula 2^{32-n}.

Find the number of addresses in last example

Solution

The value of n is 28, which mean the number of addresses is 2^{32-28} *or 16.*

Another way to find the first address, the last address, and

the number of addresses is to represent the mask as a 32-bit binary (or 8-digit hexadecimal) number. This is particularly useful when we are writing a program to find these pieces of information. In Example the /28 can be represented as

11111111 11111111 11111111 11110000

(twenty-eight 1s and four 0s).

Find

a. The first address

b. The last address

c. The number of addresses.

Solution

a. *The first address can be found by ANDing the given addresses with the mask. ANDing here is done bit by bit. The result of ANDing 2 bits is 1 if both bits are 1s; the result is 0 otherwise.*

Address:	11001101	00010000	00100101	00100111
Mask:	**11111111**	**11111111**	**11111111**	**11110000**
First address:	11001101	00010000	00100101	00100000

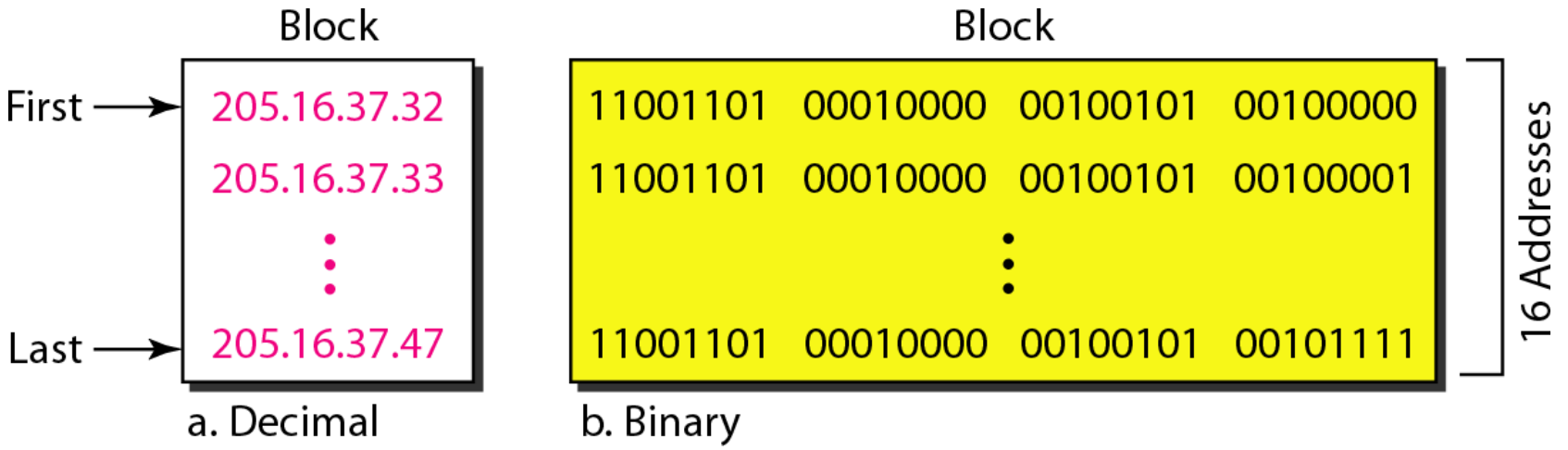
b. The last address can be found by ORing the given addresses with the complement of the mask. ORing here is done bit by bit. The result of ORing 2 bits is 0 if both bits are 0s; the result is 1 otherwise. The complement of a number is found by changing each 1 to 0 and each 0 to 1.

Address:	11001101	00010000	00100101	00100111
Mask complement:	**00000000**	**00000000**	**00000000**	**00001111**
Last address:	11001101	00010000	00100101	00101111

The number of addresses can be found by complementing the mask, interpreting it as a decimal number, and adding 1 to it.

Mask complement:	**00000000 00000000 00000000 00001111**
Number of addresses:	15 + 1 = 16

Figure *A network configuration for the block 205.16.37.32/28*



The first address in a block is normally not assigned to any device;
it is used as the network address that represents the organization to the rest of the world.

Figure *Two levels of hierarchy in an IPv4 address*

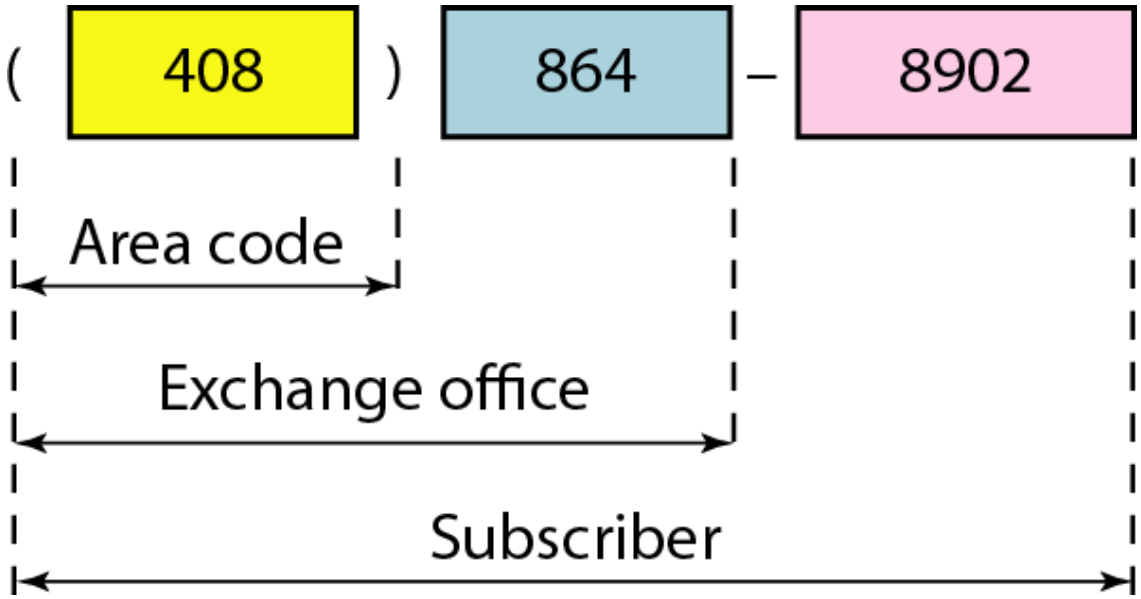
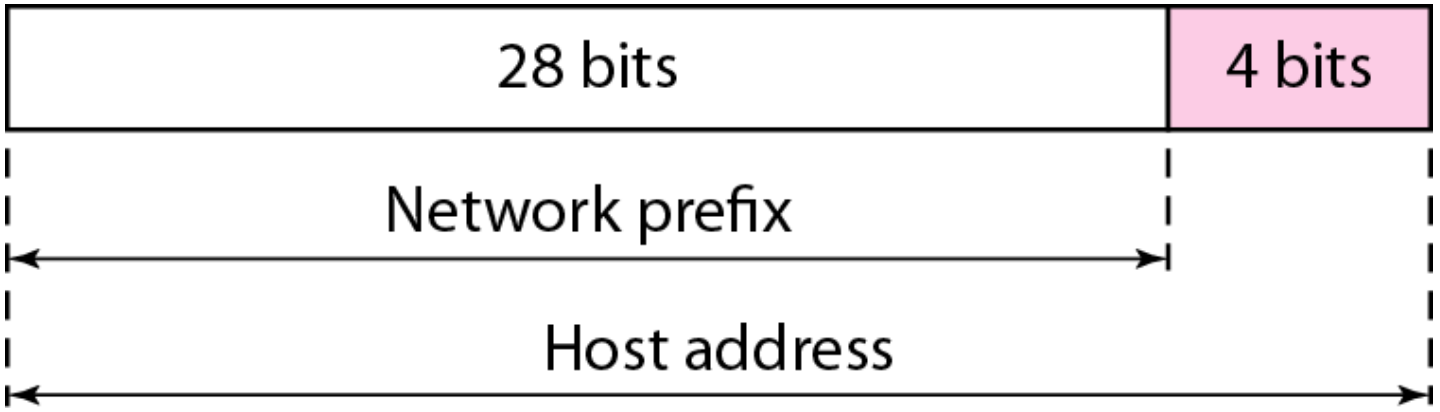
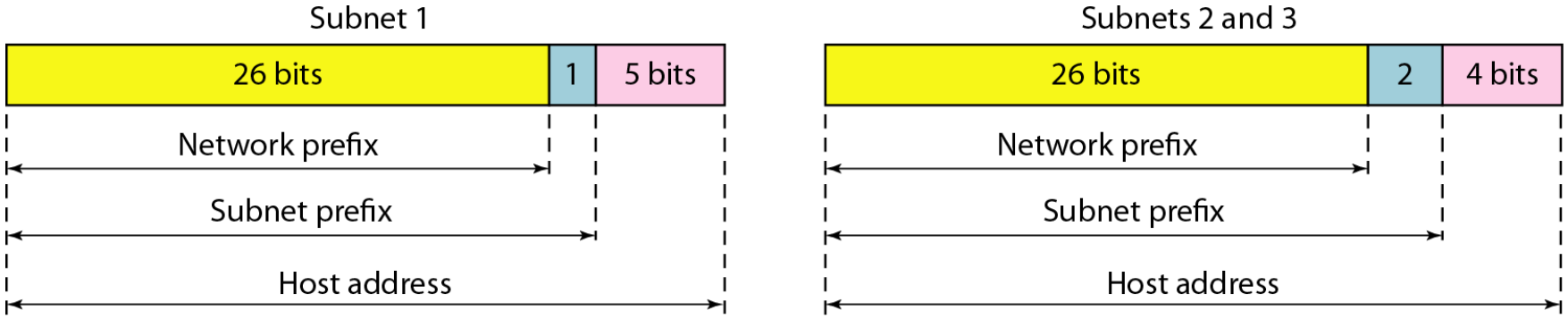


Figure *A frame in a character-oriented protocol*



Each address in the block can be considered as a two-level hierarchical structure: the leftmost *n* bits (prefix) define the network; the rightmost 32 − n bits define the host.

Figure *Three-level hierarchy in an IPv4 address*



- *An ISP is granted a block of addresses starting with* 190.100.0.0/16 (65,536 addresses). The ISP needs to distribute these addresses to three groups of customers as follows:

a. *The first group has 64 customers; each needs 256 addresses.*
b. *The second group has 128 customers; each needs 128 addresses.*
c. *The third group has 128 customers; each needs 64 addresses.*

Design the subblocks and find out how many addresses are still available after these allocations.

Group 1

For this group, each customer needs 256 addresses. This means that 8 (log2 256) bits are needed to define each host. The prefix length is then 32 − 8 = 24. The addresses are

1st Customer:	190.100.0.0/24	190.100.0.255/24
2nd Customer:	190.100.1.0/24	190.100.1.255/24
. . .		
64th Customer:	190.100.63.0/24	190.100.63.255/24

Total = 64 × 256 = 16,384

Group2

For this group, each customer needs 128 addresses. This means that 7 (log2 128) bits are needed to define each host. The prefix length is then 32 − 7 = 25. The addresses are

1st Customer:	*190.100.64.0/25*	*190.100.64.127/25*
2nd Customer:	*190.100.64.128/25*	*190.100.64.255/25*
. . .		
128th Customer:	*190.100.127.128/25*	*190.100.127.255/25*
Total = 128 × 128 = 16,384		

For this group, each customer needs 64 addresses. This means that 6 ($log_2 64$) bits are needed to each host. The prefix length is then 32 − 6 = 26. The addresses are

1st Customer:	*190.100.128.0/26*	*190.100.128.63/26*
2nd Customer:	*190.100.128.64/26*	*190.100.128.127/26*
. . .		
128th Customer:	*190.100.159.192/26*	*190.100.159.255/26*

Total = 128 × 64 = 8192

Number of granted addresses to the ISP: 65,536 Number of allocated addresses by the ISP: 40,960 Number of available addresses: 24,576

Figure *An example of address allocation and distribution by an ISP*