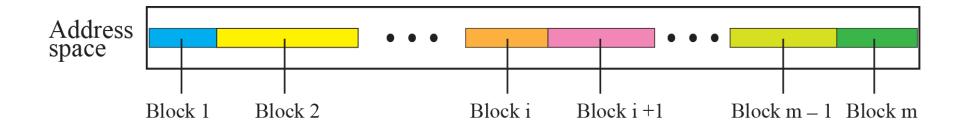
5-3 CLASSLESS ADDRESSING

Subnetting and supernetting in classful addressing did not really solve the address depletion (نضوب) problem. With the growth of the Internet, it was clear that a larger address space was needed as a long-term solution. Although the long-range solution has already been devised (تم ابتكاره)and is called IPv6, a short-term solution was also devised to use the same address space but to change the distribution of addresses to provide a fair share to each organization. The shortterm solution still uses IPv4 addresses, but it is called classless addressing.

Topics Discussed in the Section

- **✓ Variable –Length Blocks**
- **✓ Two-Level Addressing**
- **✓** Block Allocation
- **✓** Subnetting



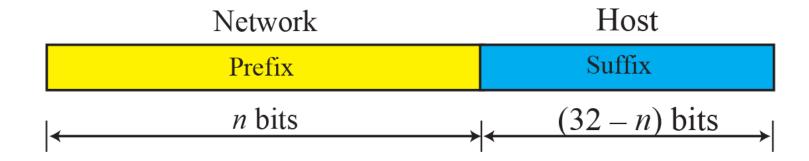




Note

In classless addressing, the prefix defines the network and the suffix defines the host.

Figure 5.28 Prefix and suffix





Note

The prefix length in classless addressing can be 1 to 32.

What is the prefix length and suffix length if the whole Internet is considered as one single block with 4,294,967,296 addresses?

Solution

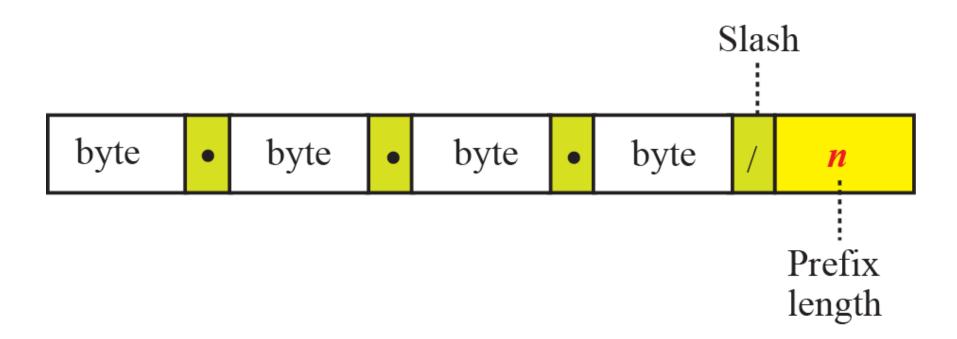
In this case, the prefix length is 0 and the suffix length is 32. All 32 bits vary to define $2^{32} = 4,294,967,296$ hosts in this single block.

What is the prefix length and suffix length if the Internet is divided into 4,294,967,296 blocks and each block has one single address?

Solution

In this case, the prefix length for each block is 32 and the suffix length is 0. All 32 bits are needed to define $2^{32} = 4,294,967,296$ blocks. The only address in each block is defined by the block itself.

The number of addresses in a block is inversely related to the value of the prefix length, *n*. A small *n* means a larger block; a large *n* means a small block.





Note

In classless addressing, we need to know one of the addresses in the block and the prefix length to define the block.

In classless addressing, an address cannot per se(في حد ذاته)
define the block the address belongs to. For example, the address 230.8.24.56 can belong to many blocks some of them are shown below with the value of the prefix associated with that block:

Prefix length:16	\rightarrow	Block:	230.8.0.0	to	230.8.255.255
Prefix length:20	\rightarrow	Block:	230.8.16.0	to	230.8.31.255
Prefix length:26	\rightarrow	Block:	230.8.24.0	to	230.8.24.63
Prefix length:27	\rightarrow	Block:	230.8.24.32	to	230.8.24.63
Prefix length:29	\rightarrow	Block:	230.8.24.56	to	230.8.24.63
Prefix length:31	\rightarrow	Block:	230.8.24.56	to	230.8.24.57

The following addresses are defined using slash notations.

- a. In the address 12.23.24.78/8, the network mask is 255.0.0.0. The mask has eight 1s and twenty-four 0s. The prefix length is 8; the suffix length is 24.
- b. In the address 130.11.232.156/16, the network mask is 255.255.0.0. The mask has sixteen 1s and sixteen 0s.The prefix length is 16; the suffix length is 16.
- c. In the address 167.199.170.82/27, the network mask is 255.255.255.224. The mask has twenty-seven 1s and five 0s. The prefix length is 27; the suffix length is 5.

One of the addresses in a block is 167.199.170.82/27. Find the number of addresses in the network, the first address, and the last address.

Solution

The value of n is 27. The network mask has twenty-seven 1s and five 0s. It is 255.255.255.240.

- a. The number of addresses in the network is $2^{32-n} = 32$.
- b. We use the AND operation to find the first address (network address). The first address is 167.199.170.64/27.

Address in binary:	10100111	11000111	10101010	01010010
Network mask:	11111111	11111111	11111111	11100000
First address:	10100111	11000111	10101010	01000000

Example 5.27 Continued

c. To find the last address, we first find the complement of network mask and then OR it with the given address: The last address is 167.199.170.95/27.

Address in binary:	10100111	11000111	10101010	01010010
Complement of network mask:	0000000	0000000	0000000	00011111
Last address:	10100111	11000111	10101010	01011111

One of the addresses in a block is 17.63.110.114/24. Find the number of addresses, the first address, and the last address in the block.

Solution

The network mask is 255.255.255.0.

- a. The number of addresses in the network is $2^{32-24} = 256$.
- b. To find the first address, we use the short cut methods discussed early in the chapter. The first address is 17.63.110.0/24.

Address:	17	•	63	•	110	114
Network mask:	255	•	255	•	255	0
First address (AND):	17	•	63	•	110	0

Example 5.28 Continued

c. To find the last address, we use the complement of the network mask and the first short cut method we discussed before. The last address is 17.63.110.255/24.

One of the addresses in a block is 110.23.120.14/20. Find the number of addresses, the first address, and the last address in the block.

Solution

The network mask is 255.255.240.0.

- a. The number of addresses in the network is $2^{32-20} = 4096$.
- b. To find the first address, we apply the first short cut to bytes 1, 2, and 4 and the second short cut to byte 3. The first address is 110.23.112.0/20.

Address:	110	•	23	•	120	•	14
Network mask:	255	•	255	•	240	•	0
First address (AND):	110	•	23		112	•	0

Example 5.29 Continued

c. To find the last address, we apply the first short cut to bytes 1, 2, and 4 and the second short cut to byte 3. The OR operation is applied to the complement of the mask. The last address is 110.23.127.255/20.

Address:	110	•	23	120	•	14
Network mask:	0		0	15	•	255
Last address (OR):	110	•	23	127	•	255

An ISP has requested a block of 1000 addresses. The following block is granted.

- a. Since 1000 is not a power of 2, 1024 addresses are granted (1024 = 2^{10}).
- b. The prefix length for the block is calculated as n = 32 $log_2 1024 = 22$.
- c. The beginning address is chosen as 18.14.12.0 (which is divisible by 1024).

The granted block is 18.14.12.0/22. The first address is 18.14.12.0/22 and the last address is 18.14.15.255/22.



Class	Prefix length	Class	Prefix length
A	/8	D	/4
В	/16	Е	/4
С	/24		

Assume an organization has given a class A block as 73.0.0.0 in the past. If the block is not revoked (لم يتم الغاء) by the authority, the classless architecture assumes that the organization has a block 73.0.0.0/8 in classless addressing.



Note

The restrictions applied in allocating addresses for a subnetwork are parallel to the ones used to allocate addresses for a network.

An organization is granted the block 130.34.12.64/26. The organization needs four subnetworks, each with an equal number of hosts. Design the subnetworks and find the information about each network.

Solution

The number of addresses for the whole network can be found as $N = 2^{32} - 2^6 = 64$. The first address in the network is 130.34.12.64/26 and the last address is 130.34.12.127/26. We now design the subnetworks:

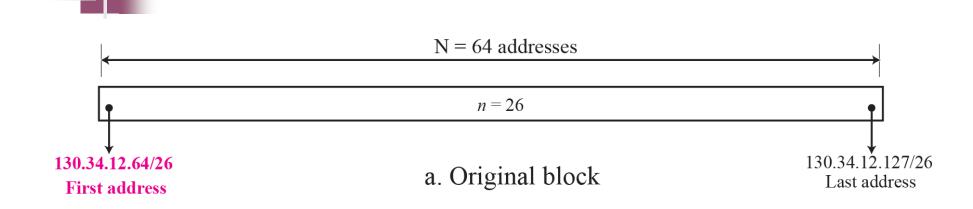
- 1. We grant 16 addresses for each subnetwork to meet the first requirement (64/16 is a power of 2).
- 2. The subnetwork mask for each subnetwork is:

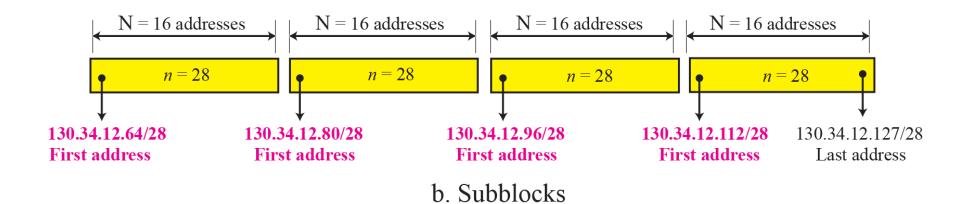
$$n_1 = n_2 = n_3 = n_4 = n + \log_2(N/N_i) = 26 + \log_2 4 = 28$$

Example 5.32 Continued

3. We grant 16 addresses to each subnet starting from the first available address. Figure 5.30 shows the subblock for each subnet. Note that the starting address in each subnetwork is divisible by the number of addresses in that subnetwork.

Figure 5.30 Solution to Example 5.32





An organization is granted a block of addresses with the beginning address 14.24.74.0/24. The organization needs to have 3 subblocks of addresses to use in its three subnets as shown below:

- ☐ One subblock of 120 addresses.
- ☐ One subblock of 60 addresses.
- ☐ One subblock of 10 addresses.

Solution

There are $2^{32-24} = 256$ addresses in this block. The first address is 14.24.74.0/24; the last address is 14.24.74.255/24.

- a. The number of addresses in the first subblock is not a power of 2. We allocate 128 addresses. The subnet mask is 25. The first address is 14.24.74.0/25; the last address is 14.24.74.127/25.
- b. 14.24.74.0 0000000 /25 first address

14.24.74. 10 000000 1st address of sub 2 14.24.74.128/26 14.24.74.10 111111 last address of sub2 14.24.74.191/26

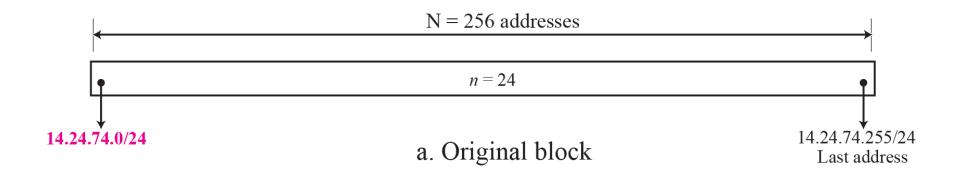
14.24.74.1100 0000 1st address of sub3 14.24.74.192 / 28 14.24.74.1100 1111 last address of sub3 14.24.74.207/28

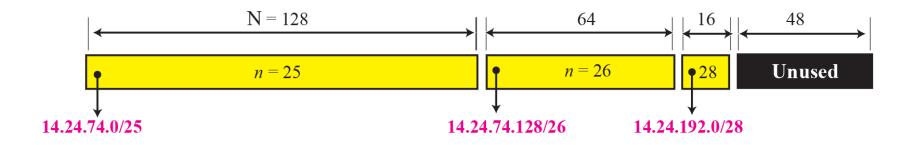
14.24.74. 11

Example 5.33 Continued

- b. The number of addresses in the second subblock is not a power of 2 either. We allocate 64 addresses. The subnet mask is 26. The first address in this block is 14.24.74.128/26; the last address is 14.24.74.191/26.
- c. The number of addresses in the third subblock is not a power of 2 either. We allocate 16 addresses. The subnet mask is 28. The first address in this block is 14.24.74.192/28; the last address is 14.24.74.207/28.
- d. If we add all addresses in the previous subblocks, the result is 208 addresses, which means 48 addresses are left in reserve. The first address in this range is 14.24.74.208. The last address is 14.24.74.255.
- e. Figure 5.31 shows the configuration of blocks. We have shown the first address in each block.

Figure 5.31 Solution to Example 5.33





b. Subblocks

Assume a company has three offices: Central, East, and West. The Central office is connected to the East and West offices via private, WAN lines. The company is granted a block of 64 addresses with the beginning address 70.12.100.128/26. The management has decided to allocate 32 addresses for the Central office and divides the rest of addresses between the two other offices.

1. The number of addresses are assigned as follows:

Central office $N_c = 32$

East office $N_e = 16$

West office $N_w = 16$

2. We can find the prefix length for each subnetwork:

$$n_c = n + \log_2(64/32) = 27$$

$$n_e = n + \log_2(64/16) = 28$$

$$n_w = n + \log_2(64/16) = 28$$

Central office 70.12.100.10 0 00000 1st address of central 70.12.100.128/27 70.12.100.10 0 11111 last address of central 70.12.100.159/27 Subnet mask: 255.255.254 11111111.111111111.11111111.11100000 **East office** 1st address of east **70.12.100. 10 1 0 0000** 70.12.100.160/28 70.12.100.1010 1111 last address of east 70.12.100.175/28 **Subnet mask:** 255.255.255.1111 0000 255.255.255.240 West office 1st address of west 70.12.100.10 1 1 0000 70.12.100.176 /28 70.12.100.1011 1111 last address of west

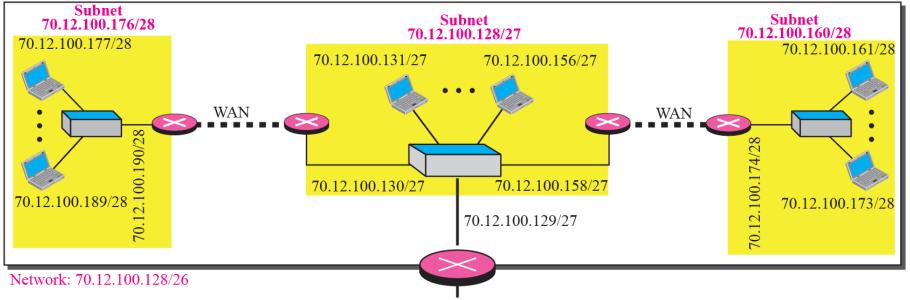
70.12.100.191/28 Subnet mask:

255.255.255.240

Example 5.34 Continued

3. Figure 5.32 shows the configuration designed by the management. The Central office uses addresses 70.12.100.128/27 to 70.12.100.159/27. The company has used three of these addresses for the routers and has reserved the last address in the subblock. The East office uses the addresses 70.12.100.160/28 to 70.12.100.175/28. One of these addresses is used for the router and the company has reserved the last address in the subblock. The West office uses the addresses 70.12.100.176/28 to 70.12.100.191/28. One of these addresses is used for the router and the company has reserved the last address in the subblock. The company uses no address for the point-to-point connections in WANs.





All addresses from 70.12.100.128 to 70.12.100.191 are delivered to this network

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: ☐ The first group has 64 customers; each needs approximately 256 addresses. ☐ The second group has 128 customers; each needs approximately 128 addresses. ☐ The third group has 128 customers; each needs approximately 64 addresses. We design the subblocks and find out how many addresses are still available after these allocations.

Example 5.35 Continued

Solution

Let us solve the problem in two steps. In the first step, we allocate a subblock of addresses to each group. The total number of addresses allocated to each group and the prefix length for each subblock can found as

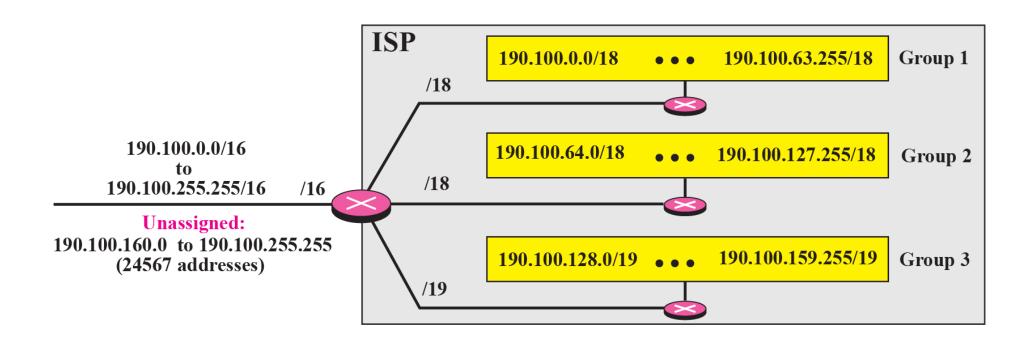
```
Group 1: 64 \times 256 = 16,384 n_1 = 16 + \log_2 (65536/16384) = 18

Group 2: 128 \times 128 = 16,384 n_2 = 16 + \log_2 (65536/16384) = 18

Group 3: 128 \times 64 = 8192 n_3 = 16 + \log_2 (65536/8192) = 19
```

Figure 5.33 shows the design for the first hierarchical level. Figure 5.34 shows the second level of the hierarchy. Note that we have used the first address for each customer as the subnet address and have reserved the last address as a special address.

Figure 5.33 Solution to Example 5.35: first step



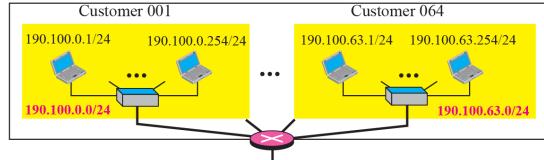
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Figure 5.34 Solution to Example 5.35: second step

Group 1

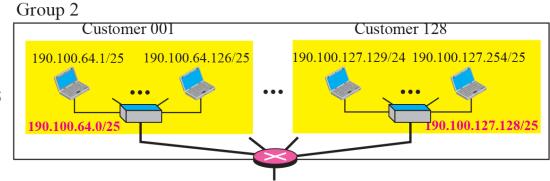
Group: n = 18

Subnet: $n = 18 + \log_2 (16385/256) = 24$



Group: n = 18

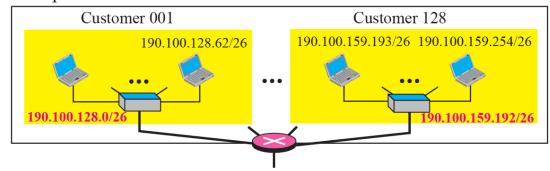
Subnet: $n = 18 + \log_2 (16385/128) = 25$



Group 3

Group: n = 19

Subnet: $n = 19 + \log_2 (8192/64) = 26$



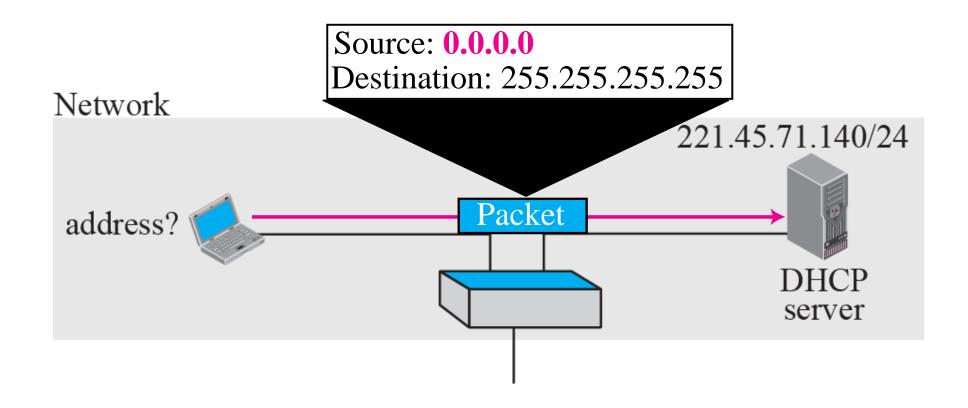
5-4 SPECIAL ADDRESSES

In classful addressing some addresses were reserved for special purposes. The classless addressing scheme inherits some of these special addresses from classful addressing.

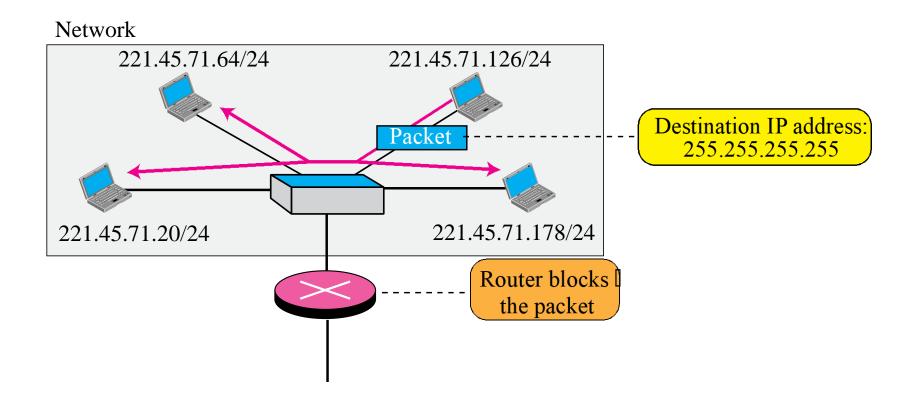
Topics Discussed in the Section

- **✓** Special Blocks
- **✓** Special Addresses in each Block

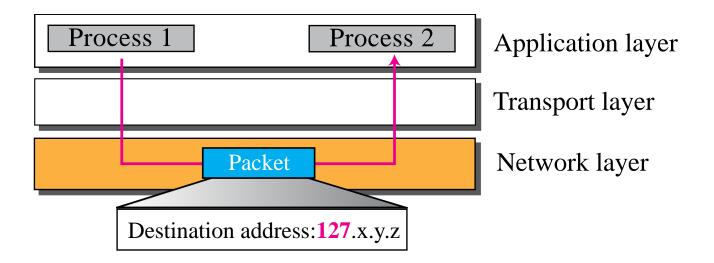


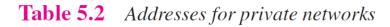






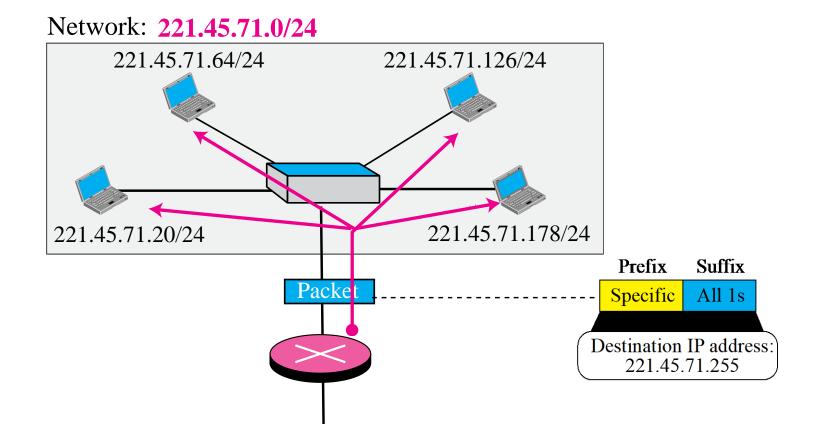






Block	Number of addresses	Block	Number of addresses
10.0.0.0/8	16,777,216	192.168.0.0/16	65,536
172.16.0.0/12	1,047,584	169.254.0.0/16	65,536





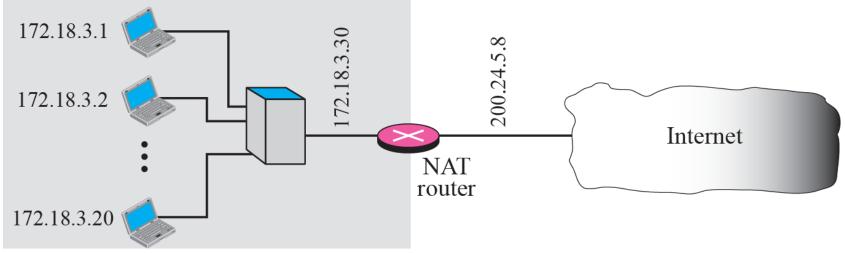
5-5 NAT

The distribution of addresses through ISPs has created a new problem. If the business grows or the household needs a larger range, the ISP may not be able to grant the demand because the addresses before and after the range may have already been allocated to other networks. In most situations, however, only a portion of computers in a small network need access to the Internet simultaneously. A technology that can help in this cases is *network* address translation (NAT).

Topics Discussed in the Section

- **✓** Address Translation
- **✓** Translation Table





Site using private addresses



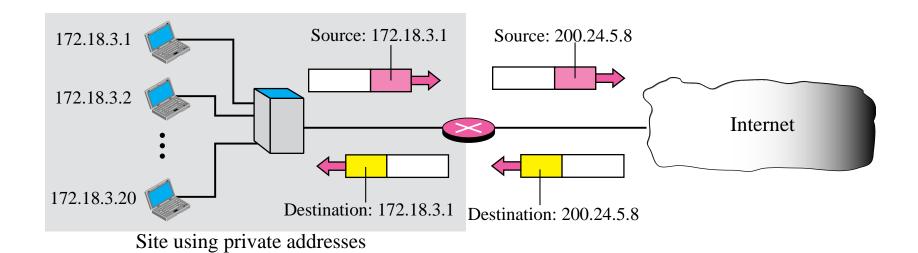


Figure 5.41 Translation

