Variable Length Subnet Mask

Course Title: Computer Networks

Lecture Outline

1. Introduction
2. VLSM
   - Steps of VLSM
   - Example 1
   - Example 2
3. Homework

Introduction

Problems of Large Network

- A large network is difficult to manage
- Less security as each host of the network can reach all other hosts.
- Huge broadcast domain, thereby large bandwidth consumption
- Waste of unused IP addresses

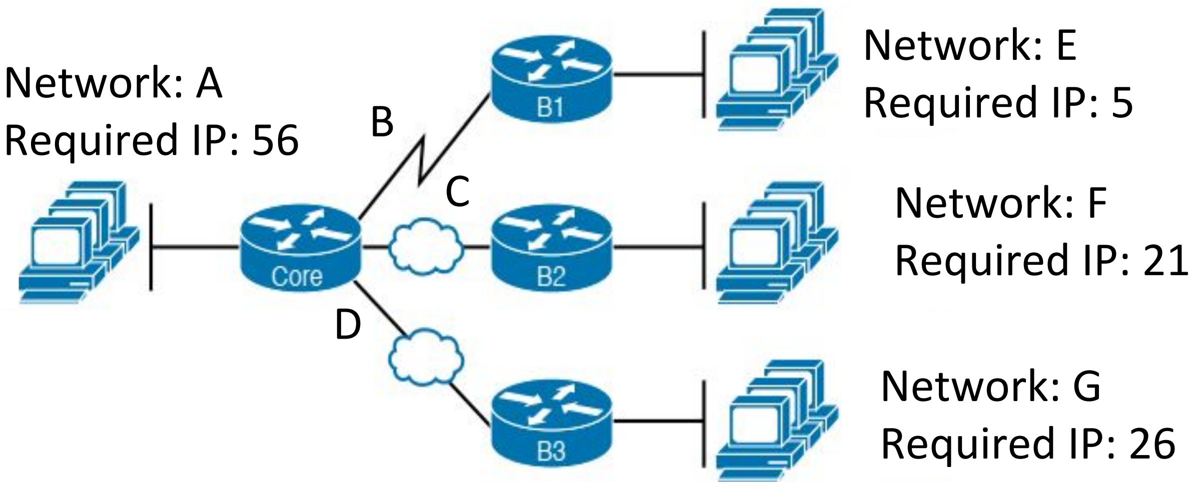
Introduction….

How to overcome the problems?

Dividing a large network into several smaller networks, called subdivided networks or subnets.

Introduction….

For classful addressing



Network	No. of IP addresses allocated
A	256
B	256
C	256
D	256
E	256
F	256
G	256

Introduction

- Required IPs: $56+5+21+26+4+4+4=120$
- Classful address
  - No. o allocated IPs: $256\times7=1792$ IP
  - Percentage of unused IP=93% (approx.)

Introduction

Is there any way to further reduce the unused IP addresses?

YES!

Instead of giving the same number of IP addresses to all subnets, allocate different number of IP addresses depending on each subnet's needs.

VLSM

- Variable Length Subnet Mask (VLSM)
- Instead of allocating the same number of IP addresses to all networks, the number of IP addresses allocated to network depends on the network’s need.
- Different network is provided with different number of IPs

VLSM

Steps of VLSM

- *Step 1:* Write the networks' names and IP requirements in descending order of IP requirements.

  A (56), G(26), F(21), E(5), B(4), C(4), D(4)

- Step 2: Find the number of host bits needed to satisfy the IP requirement of each subnet?
- *Step 3:* Based on the number of host bits, find the subnet mask for each subnet.
- *Step 4:* Allocate IPs to each subnet starting from the beginning of the IP block. Allocate IPs to subnet sequentially according to the sorted network sequence found in Step 1.

VLSM….

Example 1

$\underbrace{11111111.\ 11111111.\ 11111111.\ 11}_{26}\underbrace{000000}_{6}$

Subnet	No. of IPs required	How many bits to borrow	No. of allocated IPs	No. of host bits No. of net bits	Subnet mask	Allocated IP range
A	56		64		255.255.255.192	192.168.5.0-192.168.5.63/26
G	26		32		255.255.255.224	192.168.5.64-192.168.5.95/27
F	21		32		255.255.255.224	192.168.5.96-192.168.5.127/27
E	5		8		255.255.255.248	192.168.5.128-192.168.5.135/29
B	4		4		255.255.255.252	192.168.5.136-192.168.5.139/30
C	4		4		255.255.255.252	192.168.5.140-19

VLSM….

Example 1

VLSM

No. of allocated IPs: 64+32+32+8+4+4+4=148 IP

Percentage of unused IP=% (approx.)

Percentage of unused IP address (for the given network)

Classful Addressing	VLSM
93%	19%

VLSM….

Example 2

- Suppose that we have three networks: A, B and C with IP requirements 50, 4 and 28. If You are given an IP block 130.3.0.0, allocate IPs performing subnetting.

Subnet	No. of IPs required	How many bits to borrow	No. of allocated IPs	No. of host bits No. of net bits	Subnet mask	Allocated IP range
A	50		64		255.255.255.192	130.3.0.0-130.3.0.63/26
C	28		32		255.255.255.224	130.3.0.64-130.3.0.95/27
B	4		4		255.255.255.252	130.3.0.96-130.3.0.99/30

Lab Task

1. Suppose that we have three networks: A, B and C with IP requirements 100, 300 and 2008, respectively. If You are given an IP block 130.3.0.0/16, allocate IPs performing subnetting.
2. Suppose that we have six networks: A, B, C, D, E and F with IP requirements 120, 400, 9, 40, 32, and 7, respectively. If You are given an IP block 210.3.0.0/16, allocate IPs performing subnetting.
3. Suppose you need to create three subnets A, B and C, each requiring 32, 16 and 8 addresses, respectively.. If You are given an IP block 17.12.14.0/26, allocate IPs performing subnetting.

Note

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 19.7 *Configuration and addresses in a subnetted network*

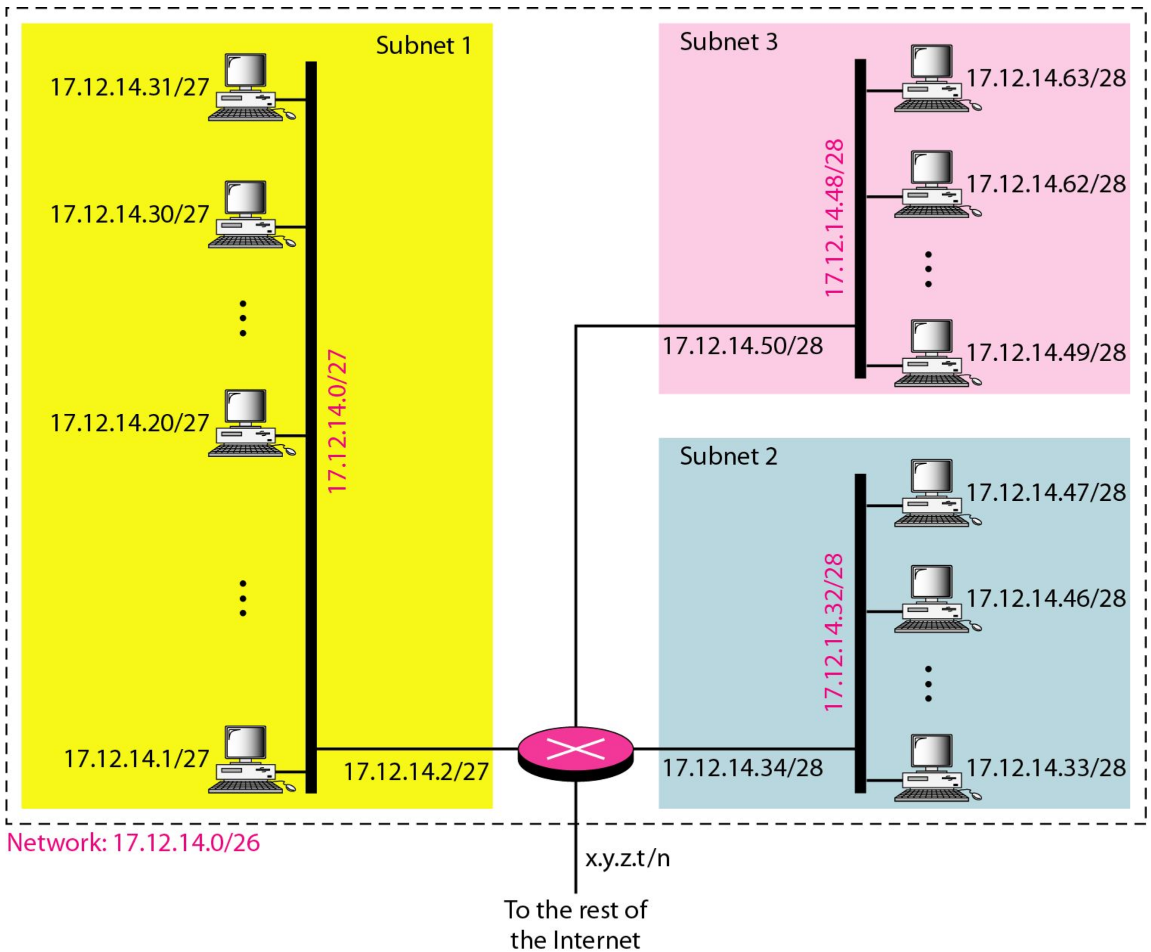
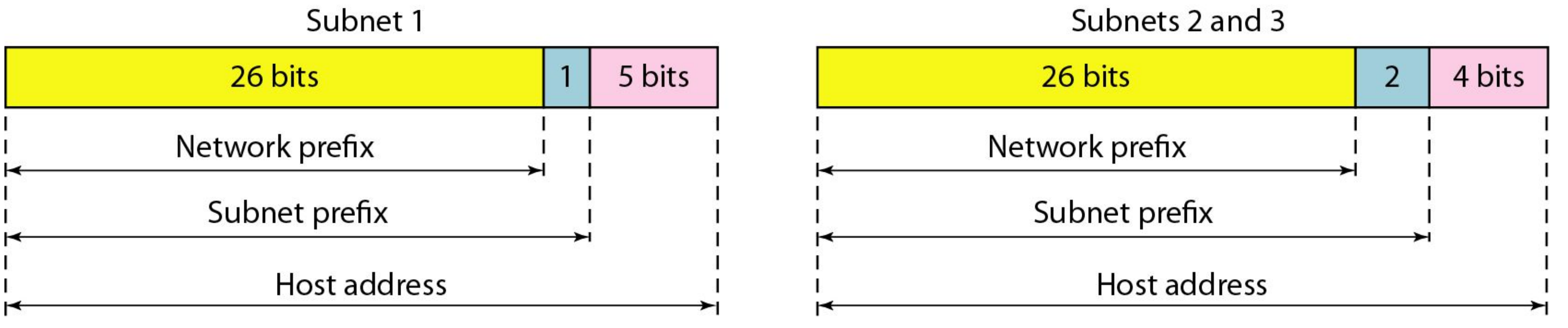


Figure 19.8 *Three-level hierarchy in an IPv4 address*



Example 19.10

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.

Example 19.10 (continued)

Solution

Figure 19.9 shows the situation.

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		

Example 19.10 (continued)

Group 2
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		

Example 19.10 (continued)

Group 3

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 = $128 \times 64 = 8192$		

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

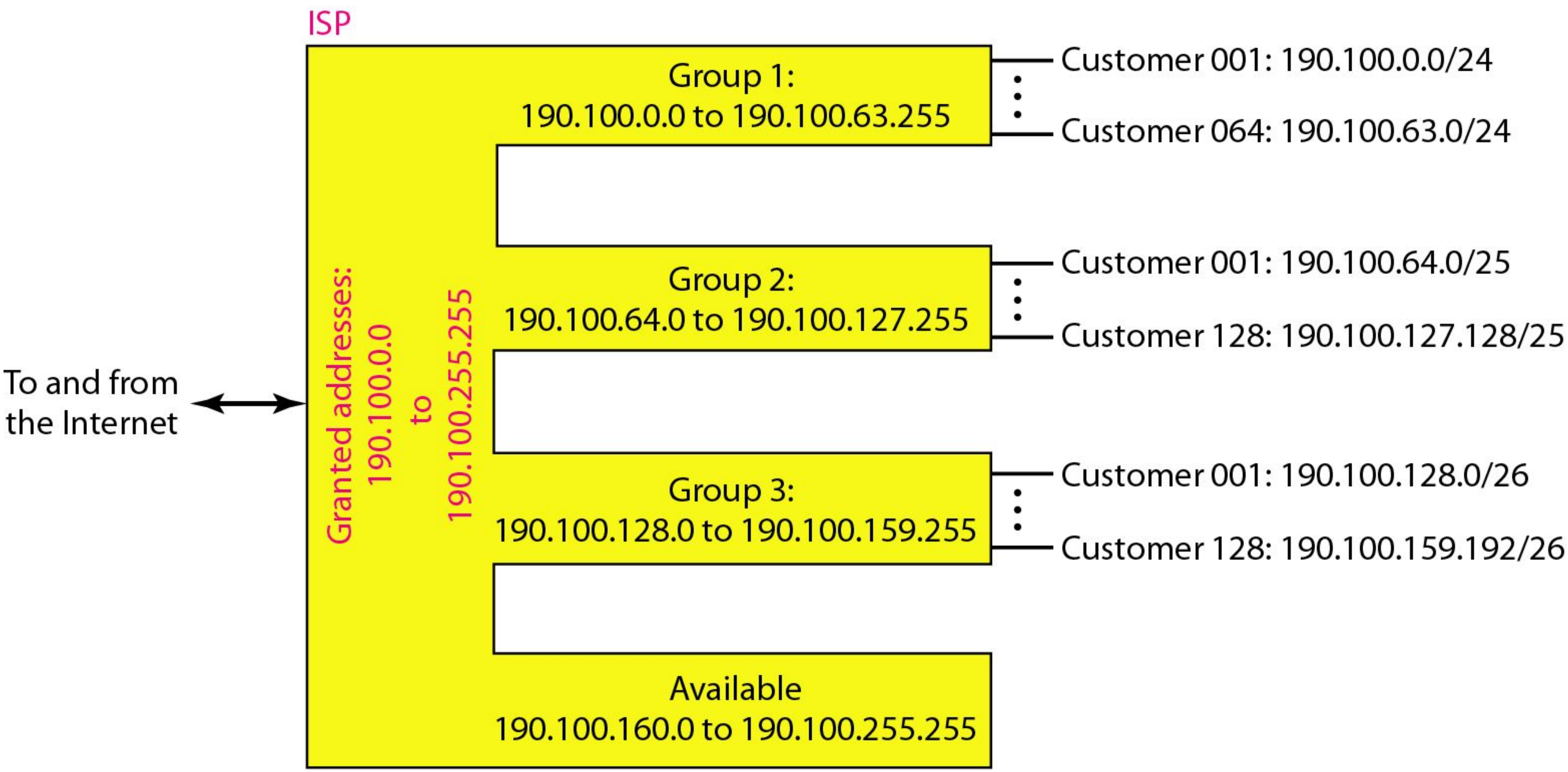


Table 19.3 ***Addresses for private networks***

Range			*Total*
10.0.0.0	to	10.255.255.255	2^{24}
172.16.0.0	to	172.31.255.255	2^{20}
192.168.0.0	to	192.168.255.255	2^{16}

Figure 19.10 *A NAT implementation*

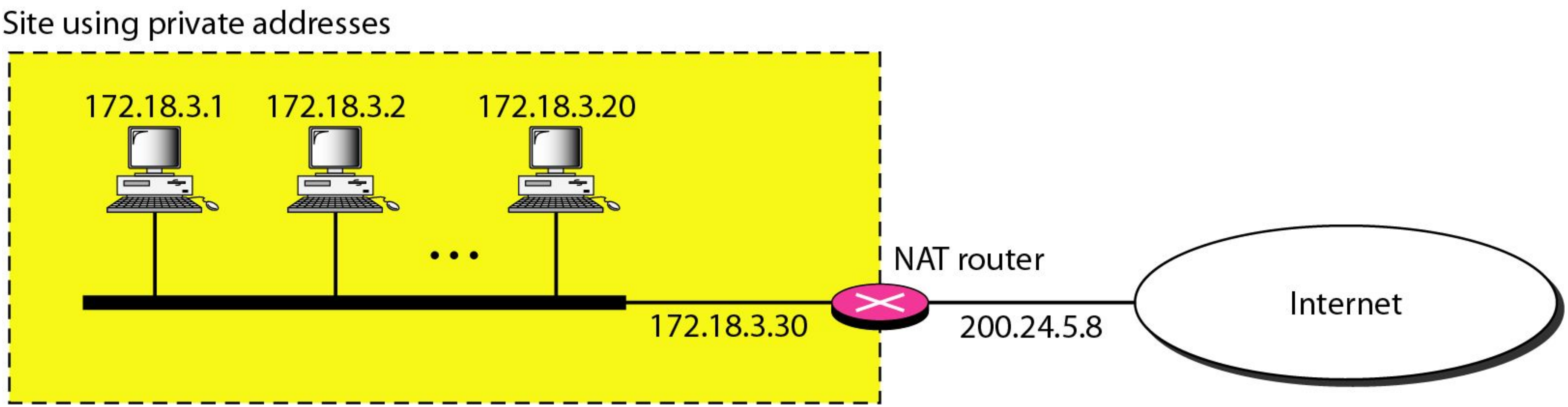


Figure 19.11 *Addresses in a NAT*

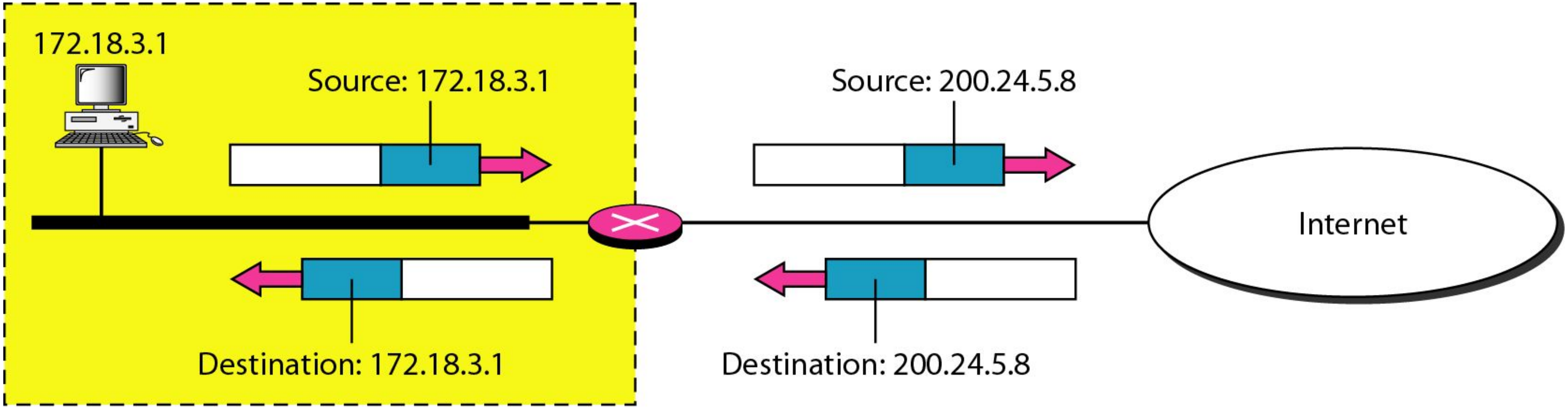


Figure 19.12 *NAT address translation*

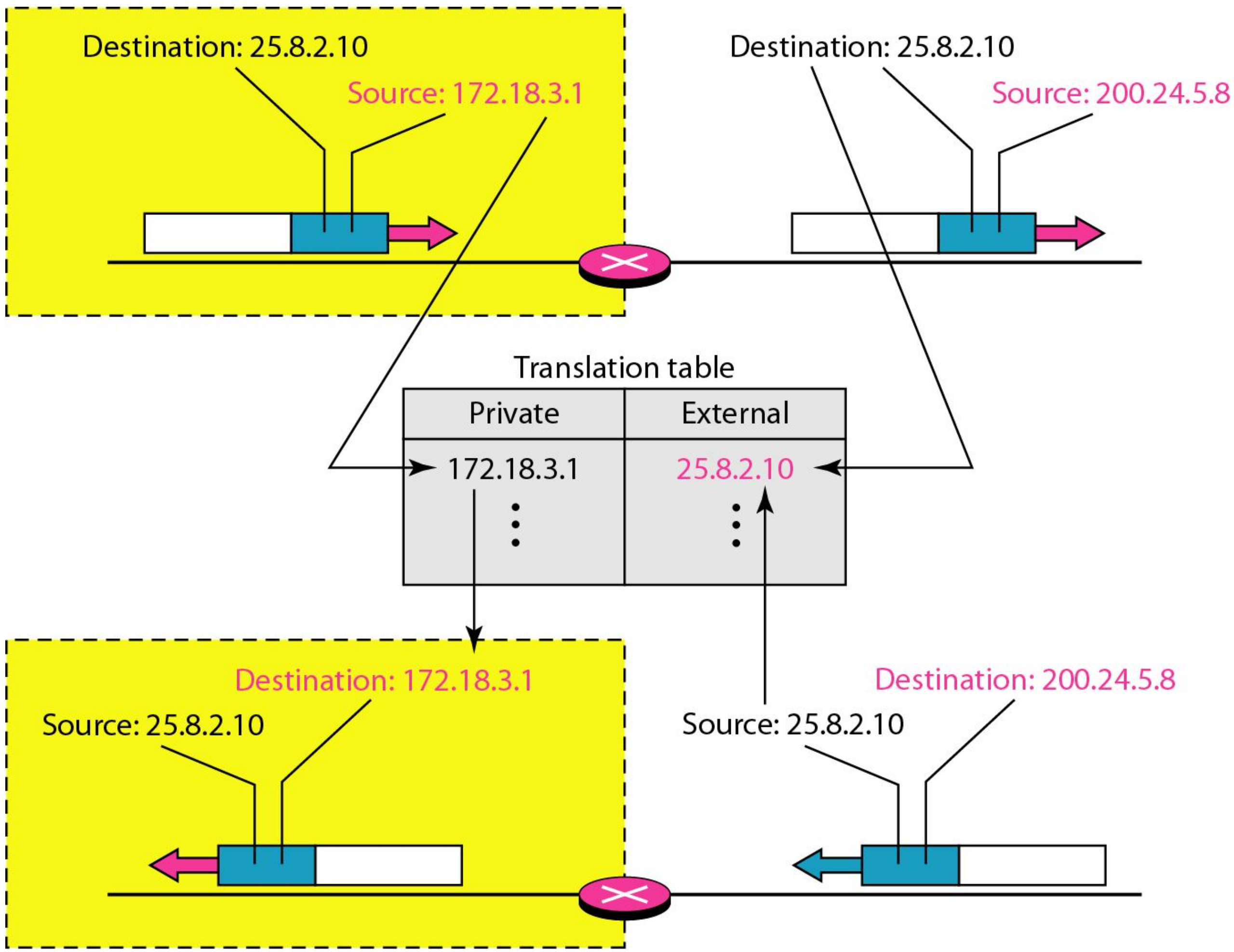
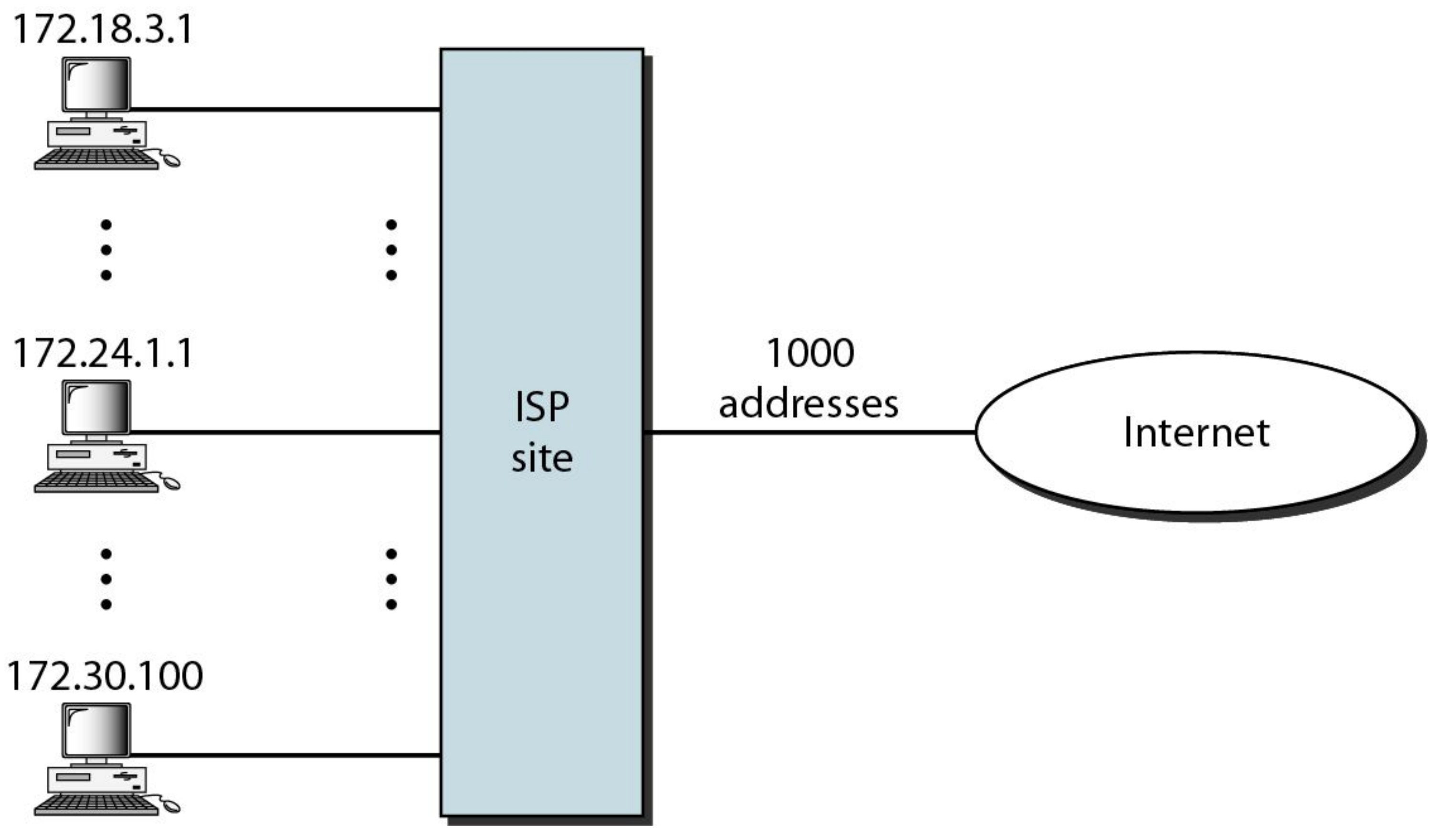


Table 19.4 ***Five-column translation***

Private Address	*Private Port*	*External Address*	*External Port*	*Transport Protocol*
172.18.3.1	1400	25.8.3.2	80	TCP
172.18.3.2	1401	25.8.3.2	80	TCP
...	...	...	...	...

Figure 19.13 *An ISP and NAT*



19-2 IPv6 ADDRESSES

Despite all short-term solutions, address depletion is still a long-term problem for the Internet. This and other problems in the IP protocol itself have been the motivation for IPv6.

Topics discussed in this section:

Structure
Address Space

Note

An IPv6 address is 128 bits long.

Figure 19.14 *IPv6 address in binary and hexadecimal colon notation*

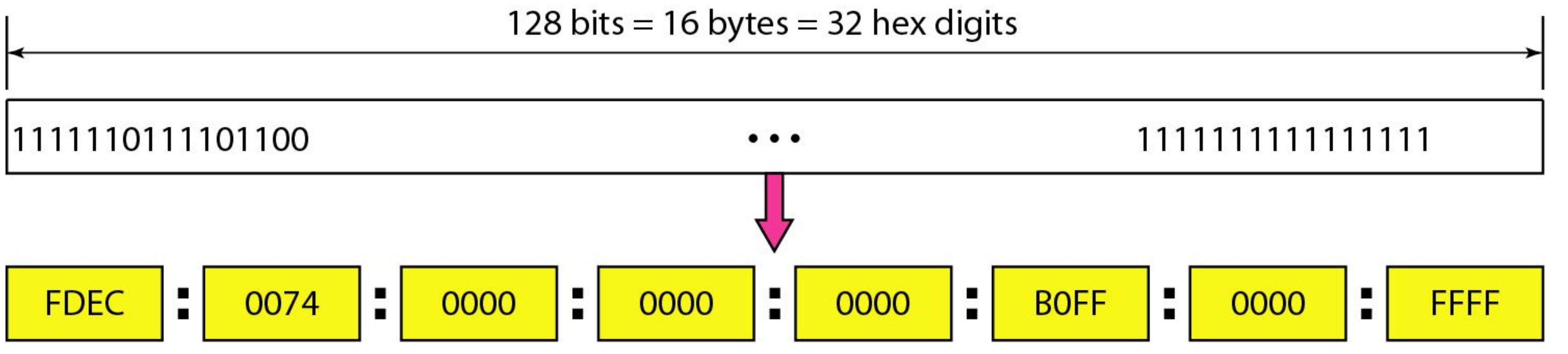
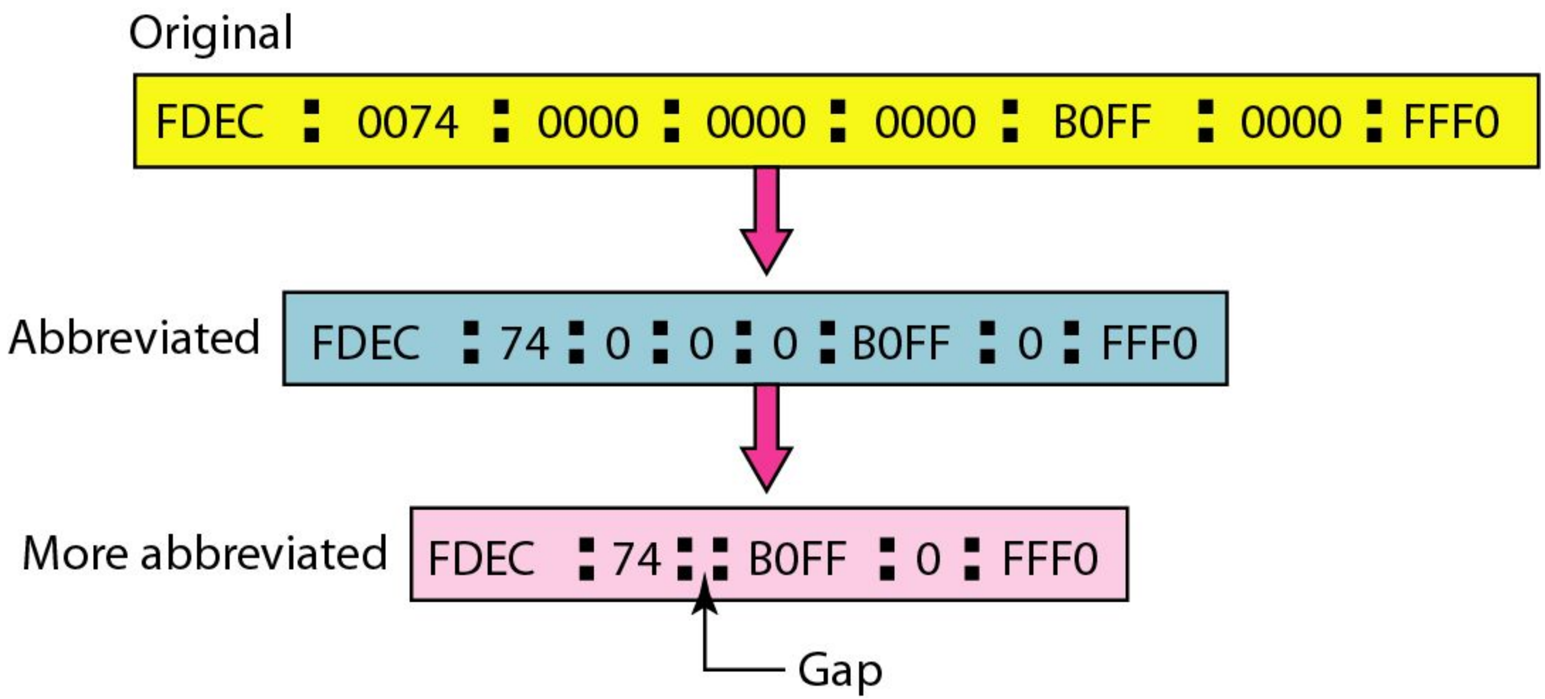


Figure 19.15 *Abbreviated IPv6 addresses*



Example 19.11

Expand the address 0:15::1:12:1213 to its original.

Solution

We first need to align the left side of the double colon to the left of the original pattern and the right side of the double colon to the right of the original pattern to find how many 0s we need to replace the double colon.

```
xxxx:xxxx:xxxx:xxxx:xxxx:xxxx:xxxx:xxxx
   0:  15:                 :   1:  12:1213
```

This means that the original address is.

```
0000:0015:0000:0000:0000:0001:0012:1213
```