Unit-iv
Network Layer: Logical Addressing

Tauseef

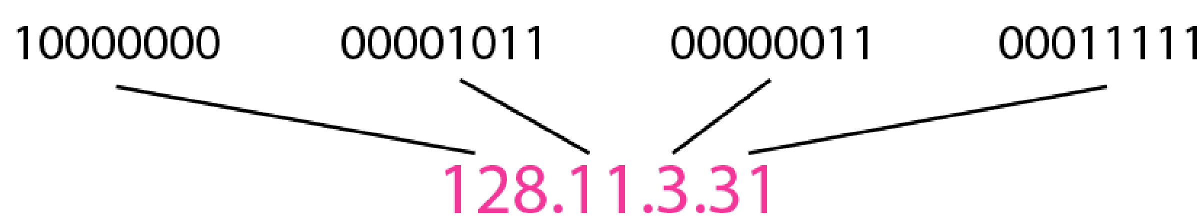
Vit university

IPV4 ADDRESSES

An IPv4 address is a 32-bit address that uniquely and universally defines the connection of a device (for example, a computer or a router) to the Internet.

IPv4 Address

- The IPv4 addresses are unique and universal.
- An IPv4 address is 32 bits long.
  - The address space of IPv4 is 2^{32} (4,294,967,296)
  - Notation.
    - Binary notation
    - Dotted-decimal notation



Example 1

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

Example 2

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

Example 3

Find the error, if any, in the following IPv4

a. 111.56.045.78

b. 221.34.7.8.20

c. 75.45.301.14

d. 11100010.23.14.67

Solution

a. There must be no leading zero (045).

b. There can be no more than four numbers.

c. Each number needs to be less than or equal to 255.

d. A mixture of binary notation and dotted-decimal notation is not allowed.

Classful Addressing

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

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

a. Binary notation

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

b. Dotted-decimal notation

Example 19.4

Find the class of each address.

a. <u>**0**</u>0000001 00001011 00001011 11101111

b. <u>**110**</u>00001 10000011 00011011 11111111

c. <u>**14**</u>.23.120.8

d. <u>**252**</u>.5.15.111

Solution

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 byte is 14; the class is A.***

d. ***The first byte is 252; the class is E.***

Classes and Blocks

- The classful addressing wastes a large part of the address space.
  - Class A:
  - Class B:
  - Class C:
  - Class D:

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

Structure of IPv4 Address

- Consists of Net ID and Host ID.

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

- Mask
  - 32-bit number of contiguous 1's followed by contiguous 0's.
  - To help to find the net ID and the host ID.

Techniques to reduce address shortage in IPv4

- Subnetting
- Network Address Translation (NAT)
- MPLS
- ATM

Use of IPv4 Address

- Subnetting
  - Divide a large address block into smaller sub-groups.
  - Use of flexible net mask.

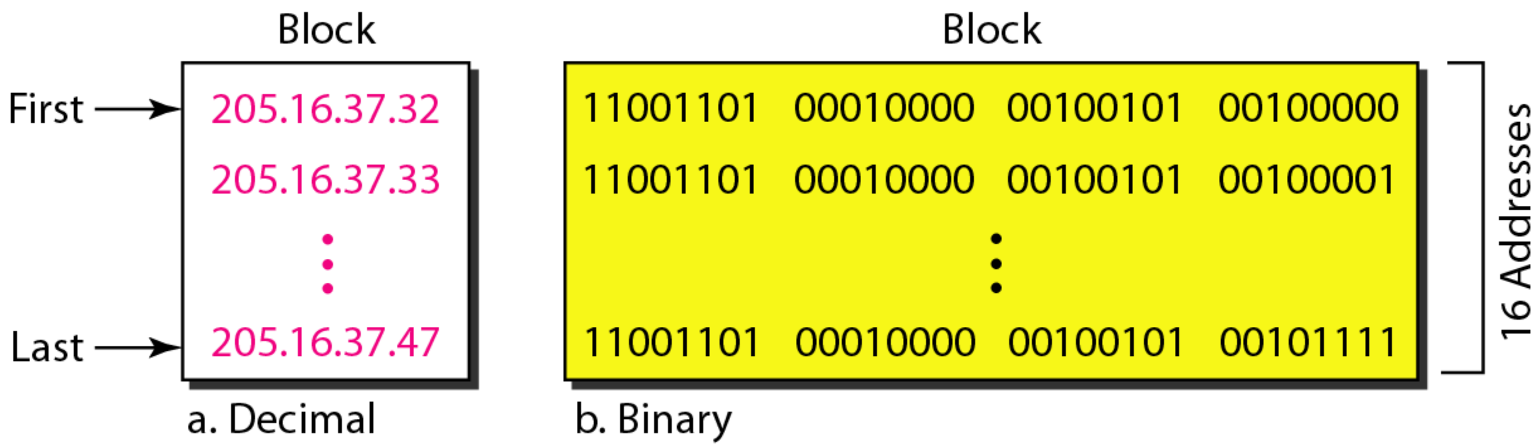
Subnetting

- Dividing a major network into small networks is called Subneting.
- Size of the broadcast domain will get reduced.
- To reduce address shortage in IPv4
- Number of systems processing the broadcast packet will get reduced.
- Thus it will improve the performance of network.

Classless Addressing

- To overcome the depletion of address space.
- Restriction
  - The addresses in a block must be contiguous.
  - The number of addresses in a block must be a power of 2.
  - The first address must be evenly divisible by the number of address.
- Mask
  - Consists of *n* consecutive 1's followed by zeros.
  - *n* can be any number b/w 0 and 32.
- Tips:
  - 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.
  - The first address in the block can be found by setting the rightmost 32 − n bits to 0s.
  - The last address in the block can be found by setting the rightmost 32 − n bits to 1s.
  - The number of addresses in the block can be found by using the formula 2^{32-n}.

Figure 19.3 *A block of 16 addresses granted to a small organization*



Example 19.6

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.

This is actually the block shown in Figure 19.3.

Example 19.7

Find the last address for the block in Example 19.6.

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

This is actually the block shown in Figure 19.3.

Example 19.8

Find the number of addresses in Example 19.6.

Solution

The value of n is 28, which means that number of addresses is 2^{32-28} or 16.

Example 19.9

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 19.5 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.

Example 19.9 (continued)

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

Example 19.9 (continued)

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

Example 19.9 (continued)

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

Mask complement:	**000000000 00000000 00000000 00001111**
Number of addresses:	15 + 1 = 16

Special Addresses

- Network address
  - 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.
- Broadcast address
  - The last address in a block is used for broadcasting to all devices under the network.

Figure 24-9

A Network with Two Levels of Hierarchy

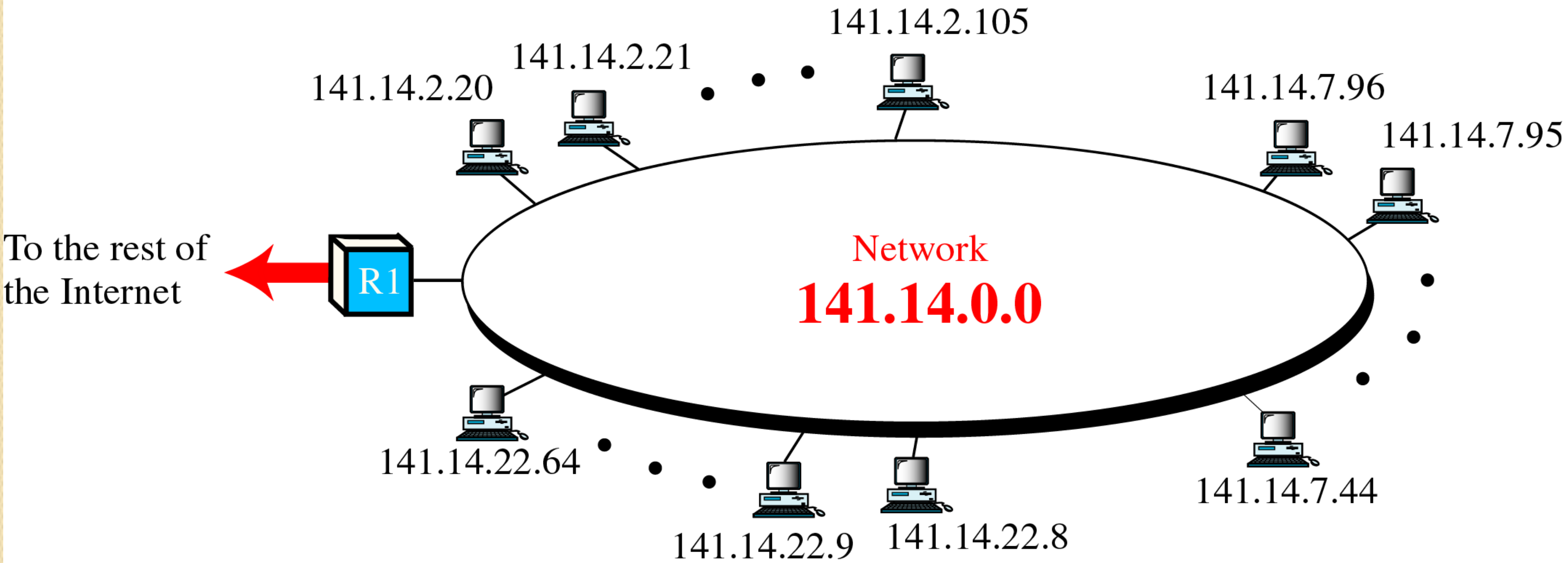


Figure 24-10

A Network with Three Levels of Hierarchy

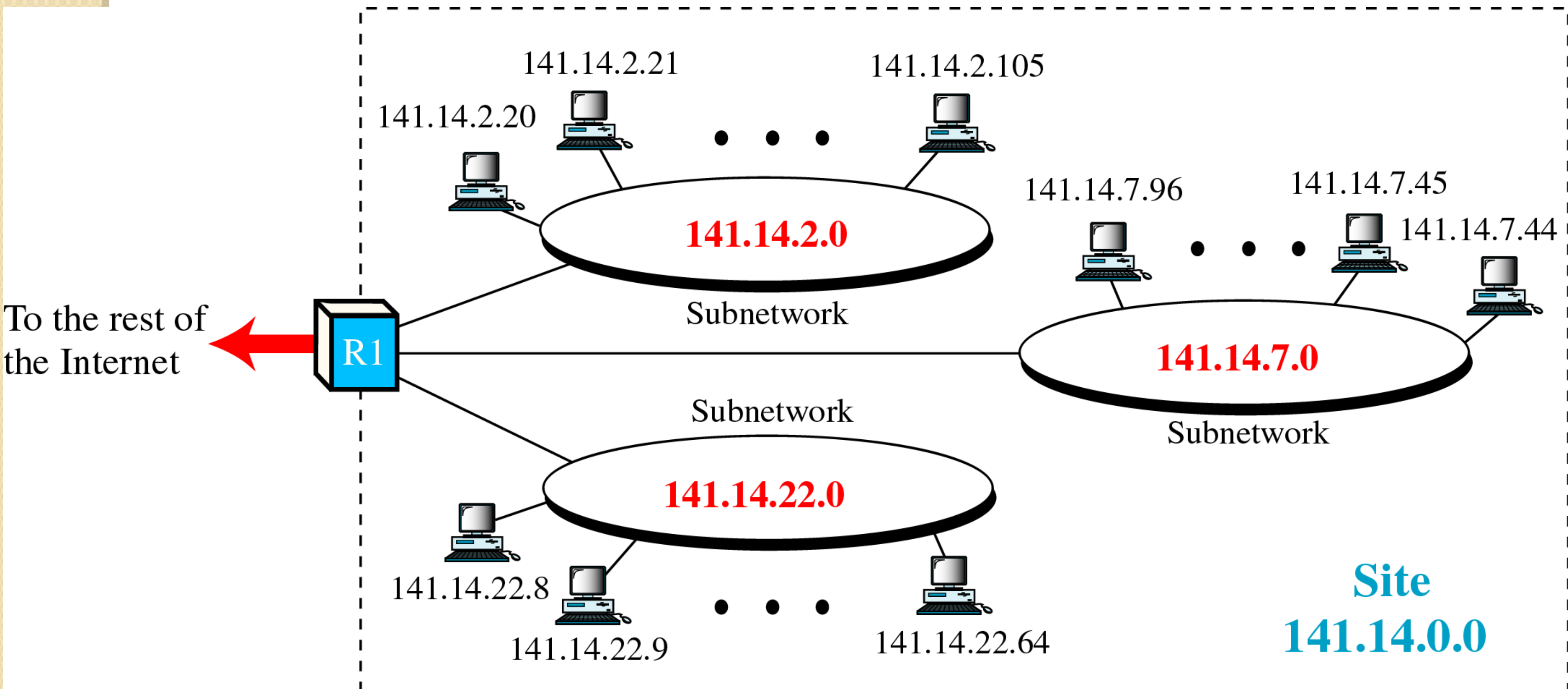


Figure 24-11

Addresses with and without Subnetting

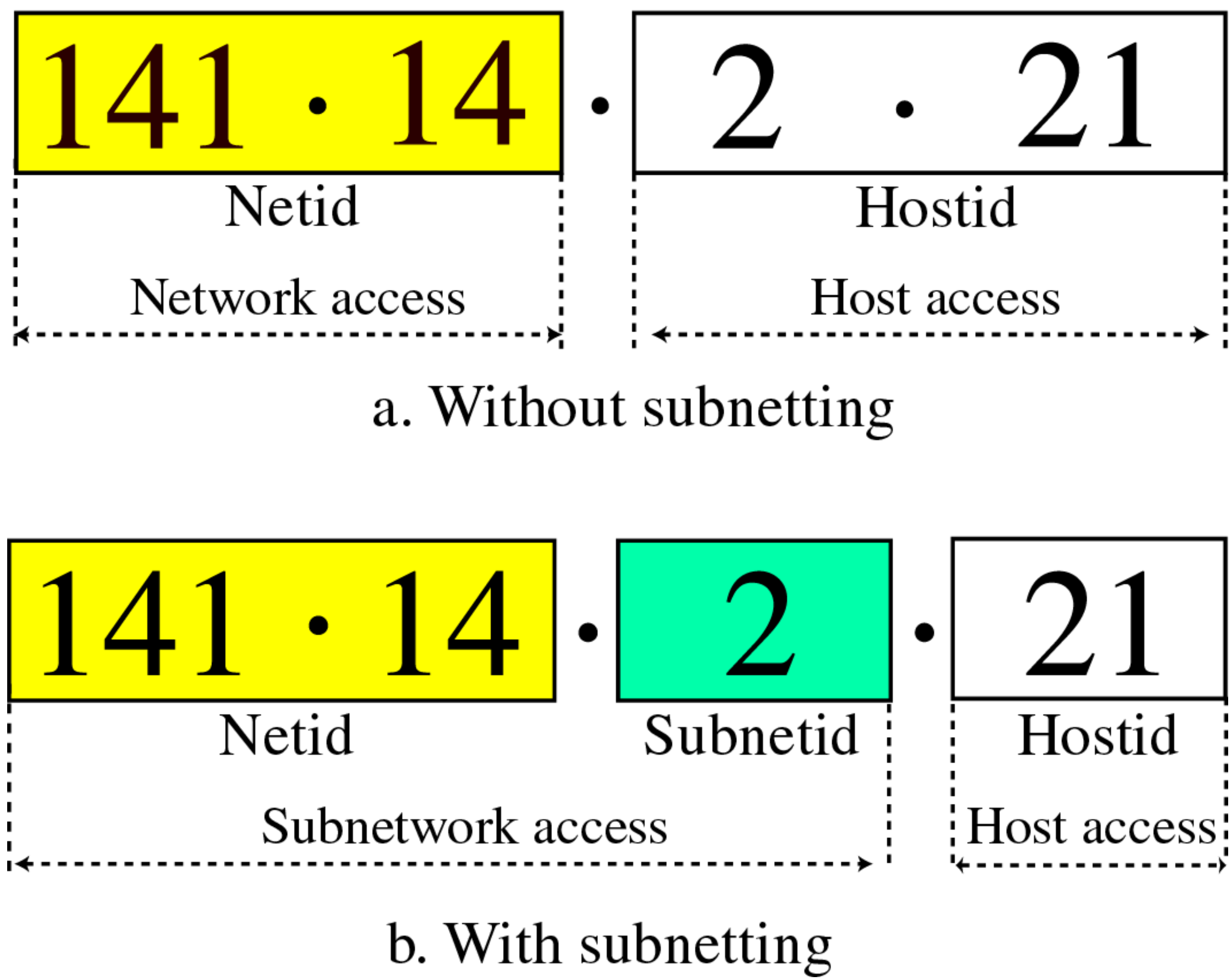


Figure 24-12

Masking

a. Without subnetting

b. With subnetting

Unsubnetted & Subnetting Example

- Mask for unsubnetted networks: To find network address)
  - 15.32.56.7/255.0.0.0
  - 135.67.13.9/16
  - 201.34.12.72/24
- Mask for subnetted networks: To find network address)
  - 15.32.56.7/255.255.0.0
  - 135.67.13.9/24
  - 201.34.12.72/26

To find FHID,LHID & BIP

- 10.0.0.0
  (10.0.0.1: 10.255.255.254: 10.255.255.255)

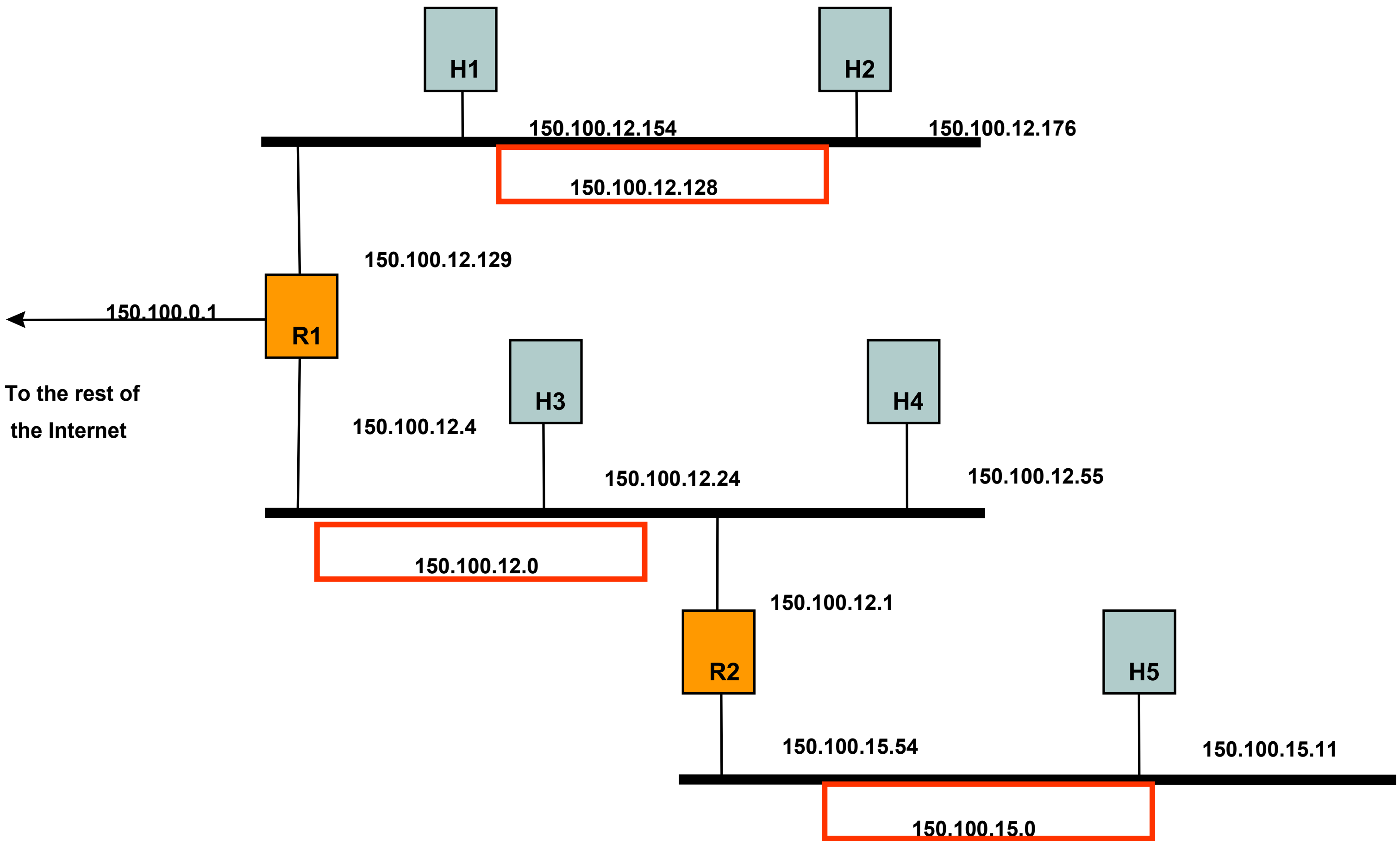
- 192.168.1.0
  (192.168.1.1: 192.168.1.254: 192.168.1.255)

- Subnetting Example: 10.0.0.0 (4-SUBNETS)
  1)10.32.0.0: (2) 10.64.0.0: (3) 10.96.0.0
  4) 10.128.0.0: (5) 10.160.0.0: (6) 10.192.0.0

Subnetting Example

- Organization has Class B address (16 host ID bits) with network ID: 150.100.0.0
- Create subnets with up to 100 hosts each
  - 7 bits sufficient for each subnet
  - 16-7=9 bits for subnet ID
- Apply subnet mask to IP addresses to find corresponding subnet
  - Example: Find subnet for 150.100.12.176
  - IP add = 10010110 01100100 00001100 10110000
  - Mask = 11111111 11111111 11111111 10000000
  - AND = 10010110 01100100 00001100 10000000
  - Subnet = 150.100.12.128
  - Subnet address used by routers within organization

Subnet Example



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 = $64 \times 256 = 16{,}384$		

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 × 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

Network Address Translation (NAT)

- Benefits
  - Use of a single IP address among many devices in a network
  - Use of a dynamic IP address for home user for sharing
- Private Addresses

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*

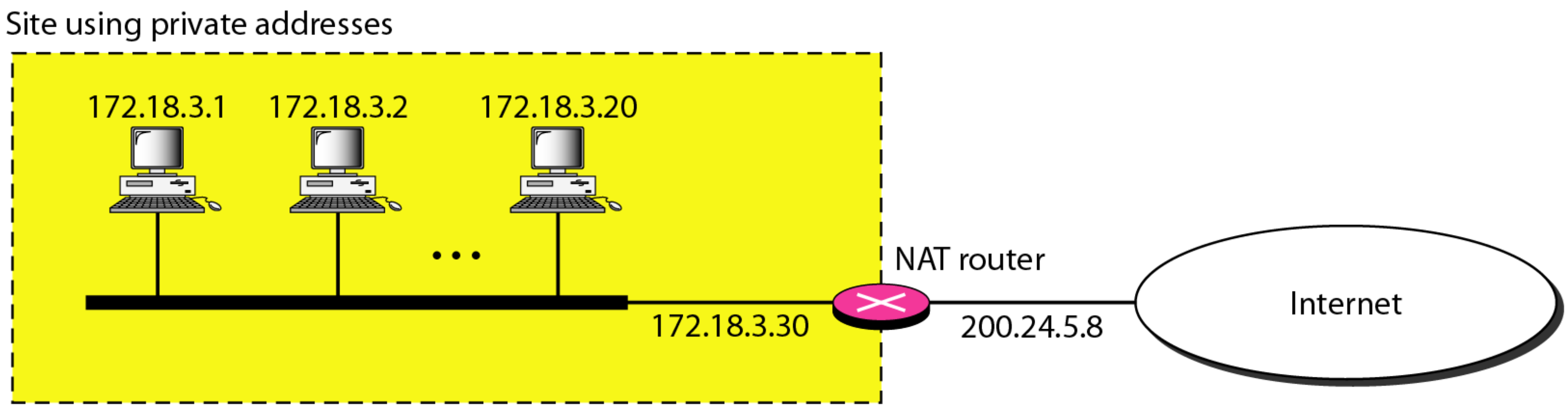


Figure 19.11 *Addresses in a NAT*

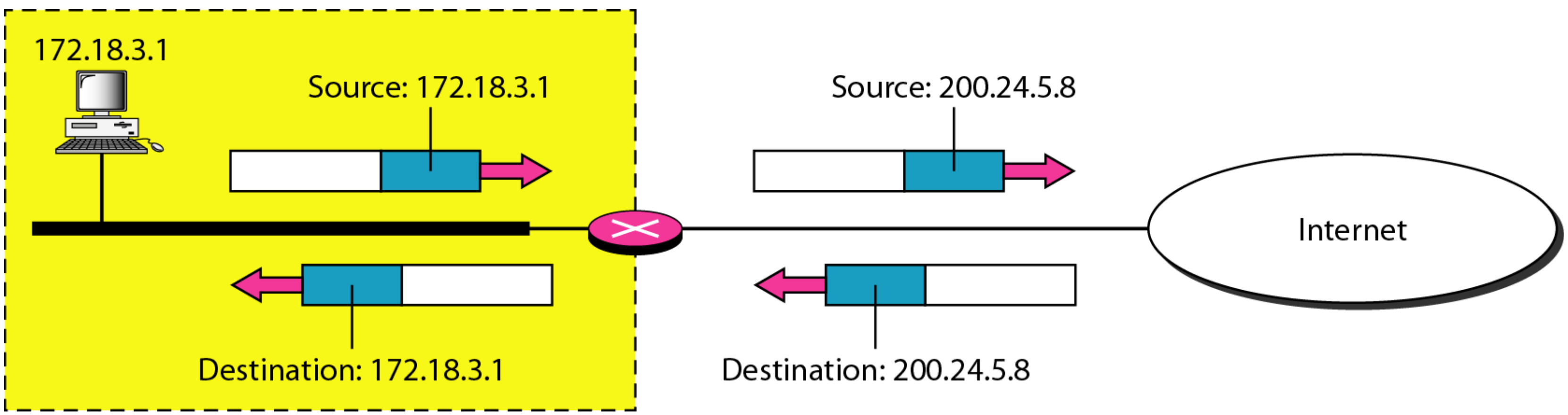


Figure 19.12 *NAT address translation*

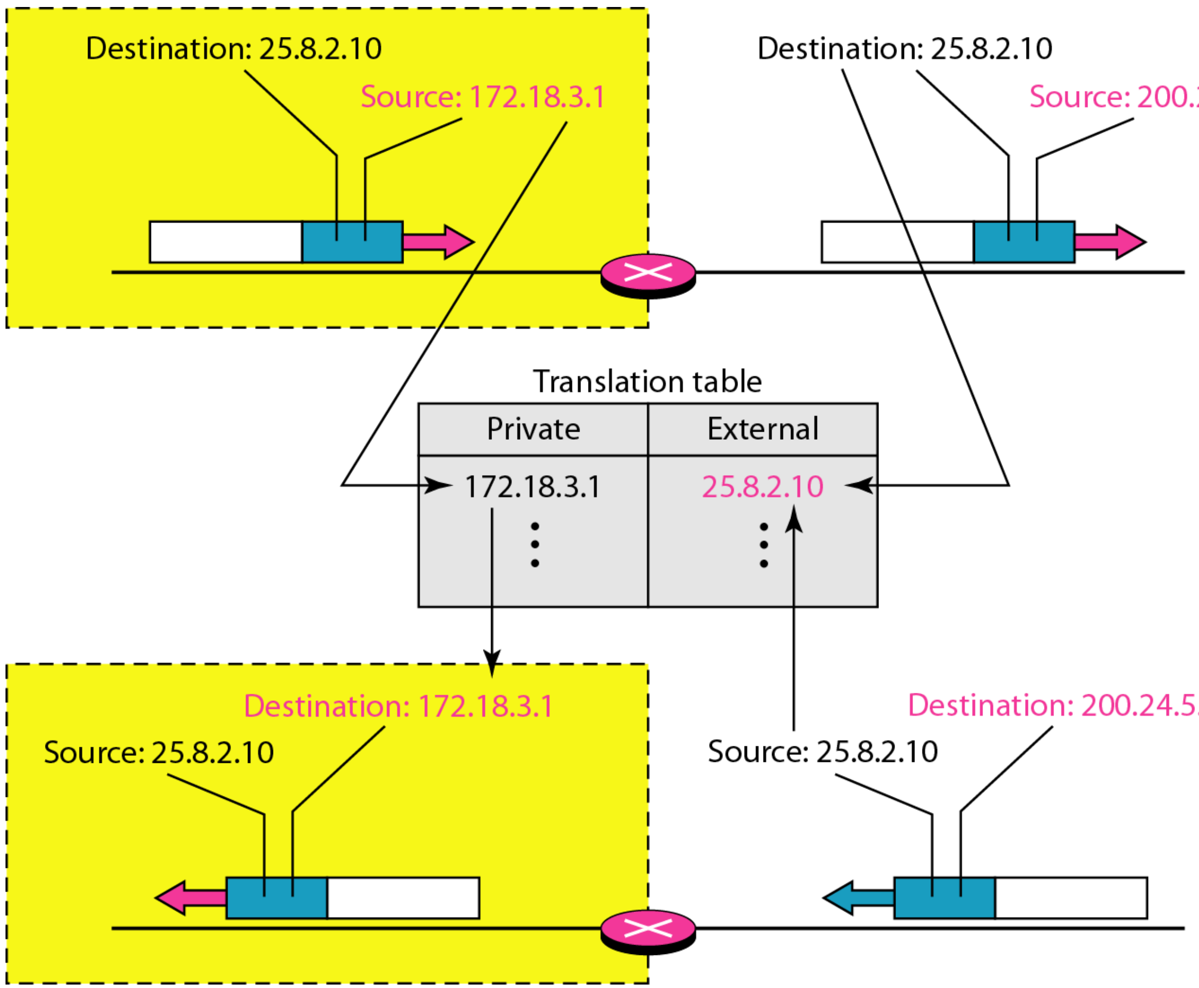
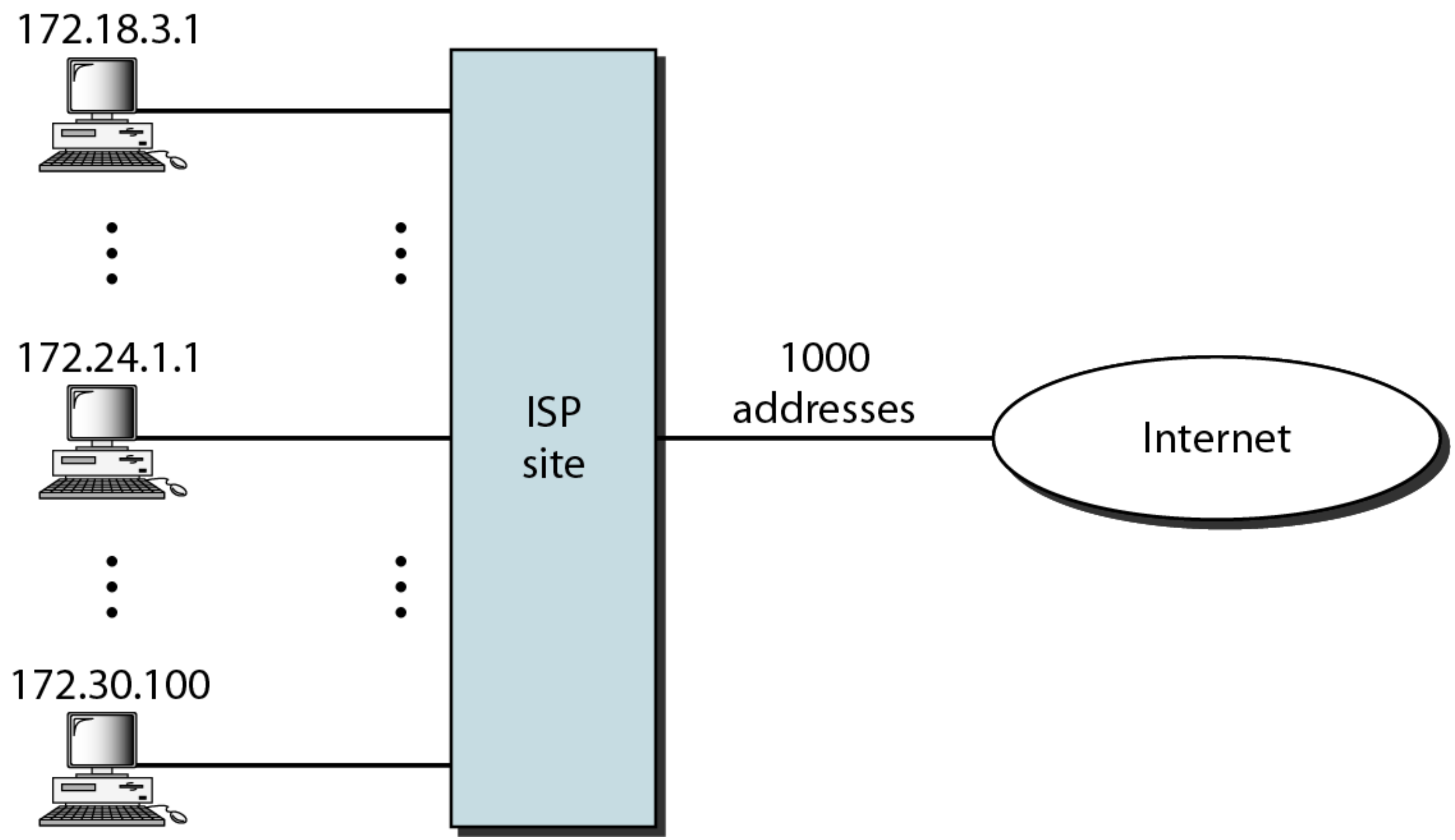


Table 19.4 *Five-column translation table*

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*



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.

DIFFERENCE BETWEEN IPV4 & IPV6

IPV4:

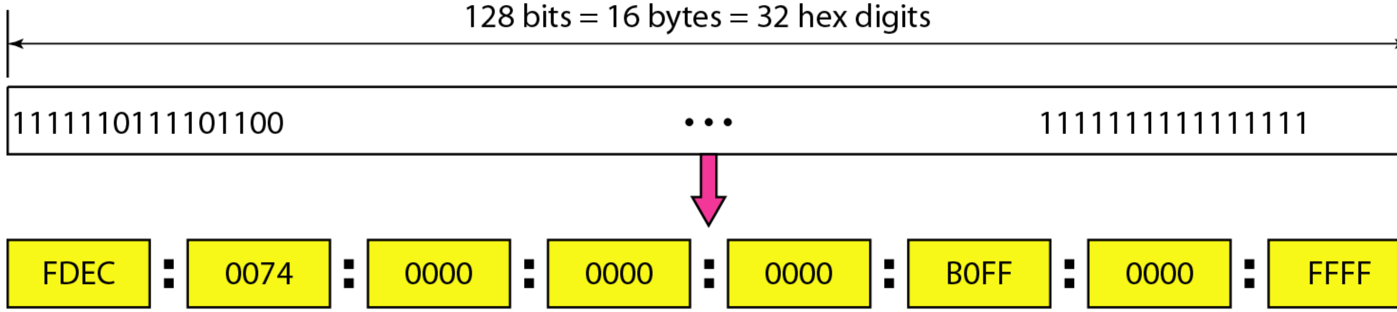
- Each host has a globally unique logical 32 bit IP address.
- Dotted Decimal Notation.
- HEADER FIELD.
- SLOWER.
- Unicast.
  Multicast.
  Broadcast.
- SECURITY.

IPV6:

- Each host has a globally unique logical 128 bit IP address.
- Hexa Decimal.
- HEADER FIELD.
- Faster.
- Unicast.
  Multicast.
  Anycast.
- SECURITY.

IPv6 Address

- An IPv6 address is 128 bits long (16-byte).
- Hexadecimal Colon Notation



- Abbreviation

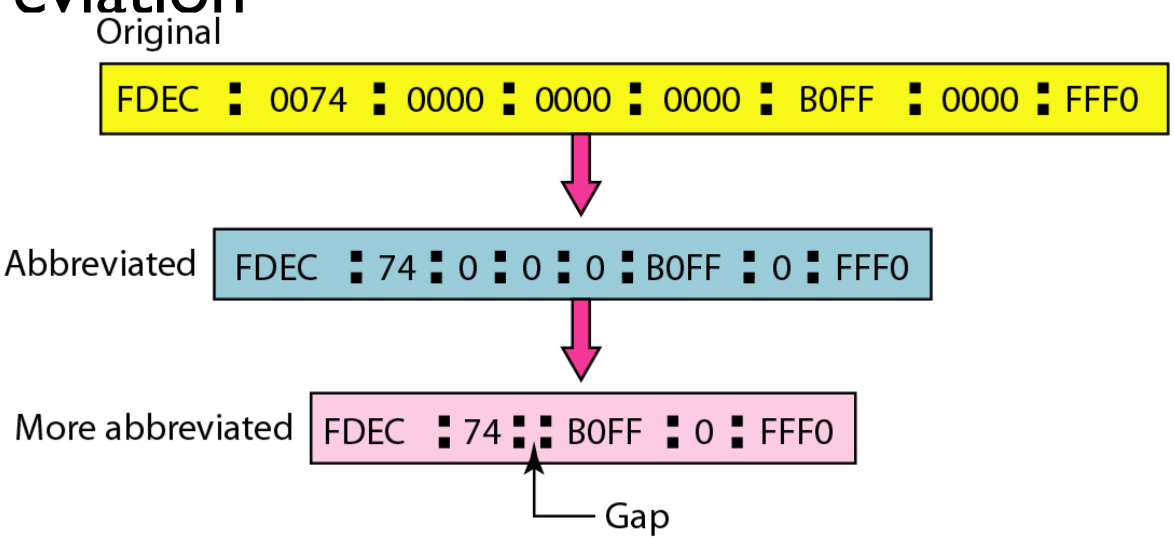
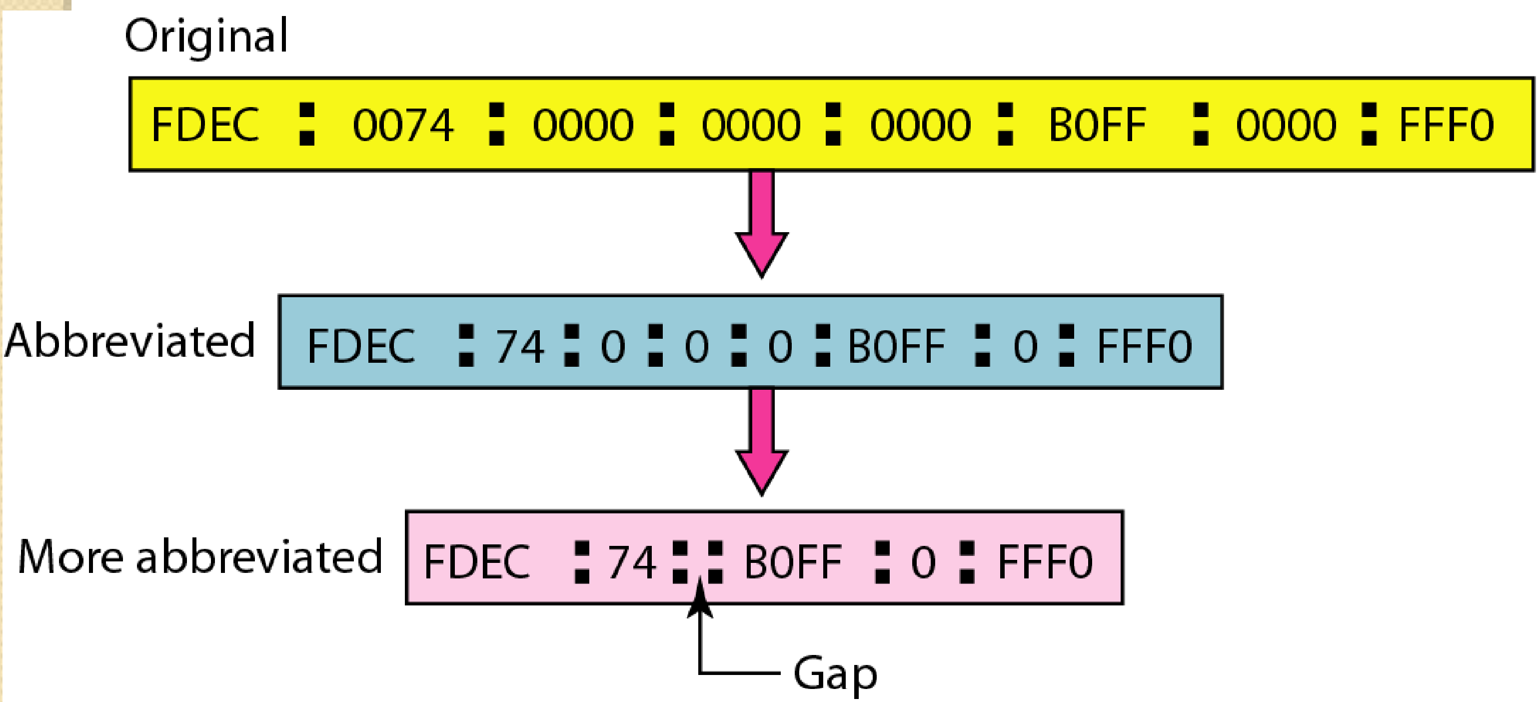


Figure 19.15 *Abbreviated IPv6 addresses*



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
```

Structure of IPv6 Address

- Type prefix
  - For categorization,
  - Variable length,
  - No partial conflict among the different prefix
  -

IPv6 creates addresses based on the hardware interface address.

It uses 48 bit MAC Address in a special encapsulation called EUI64 which results in a standardised 64 bit hardware address that denotes the host.

It implies that hardware attached to any communication across the internet will be given an address immediately it attaches to the system, i.e. auto address generation system which provides more security.

Address Classes in IPv6:

- **Link Local Address**
- **Site Local Address**
- **Global Address**

Link Local Address:

It works on the Local Area Network. It cannot be used outside as it lacks all network identification.

It just consists of host's hardware address.

Adding a prefix FE80 to the address makes it a link local address.

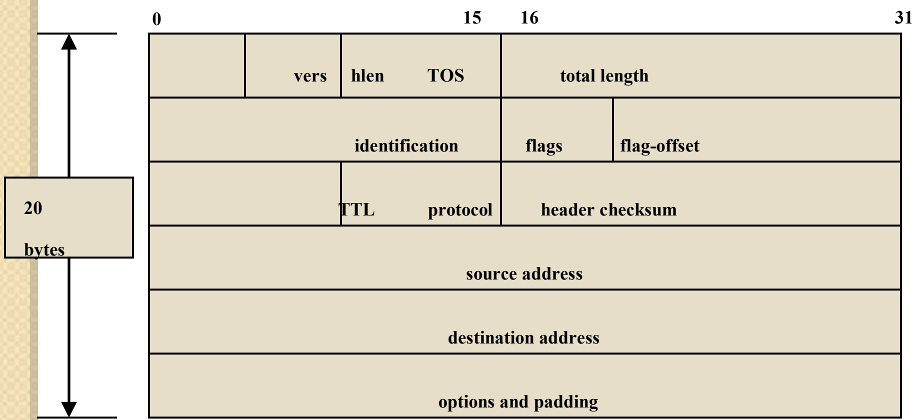
Site Local Address:

It includes a subnet identification within the corporate n/w or at the most at the intranet level but can't be used in the internet since internet requires a global identifier. FEC0 in the address implies it as the Site Local Address.

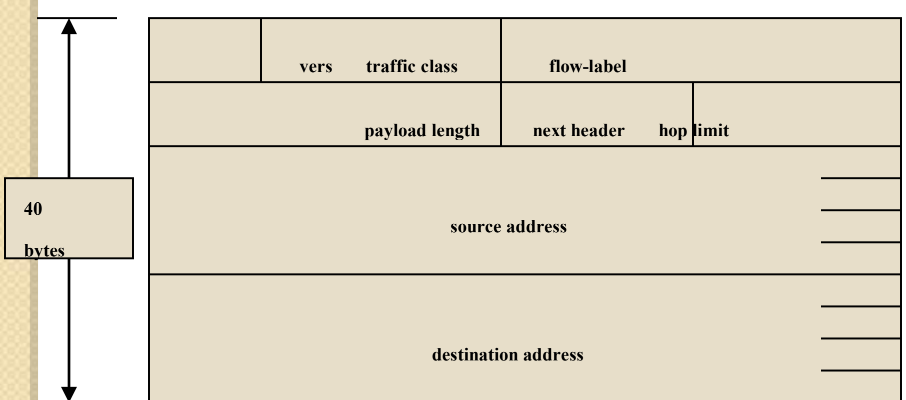
Global Address:

The global n/w identifier is assigned by the Internet Service Provider and it is used globally on the internet.

Header comparison



IPv4



IPv6

Removed (6)

- ID, flags, flag offset
- TOS, hlen
- header checksum

Changed (3)

- total length => payload
- protocol => next header
- TTL => hop limit

Added (2)

- traffic class
- flow label

Expanded

- address 32 to 128 bits

Type prefixes for IPv6 addresses

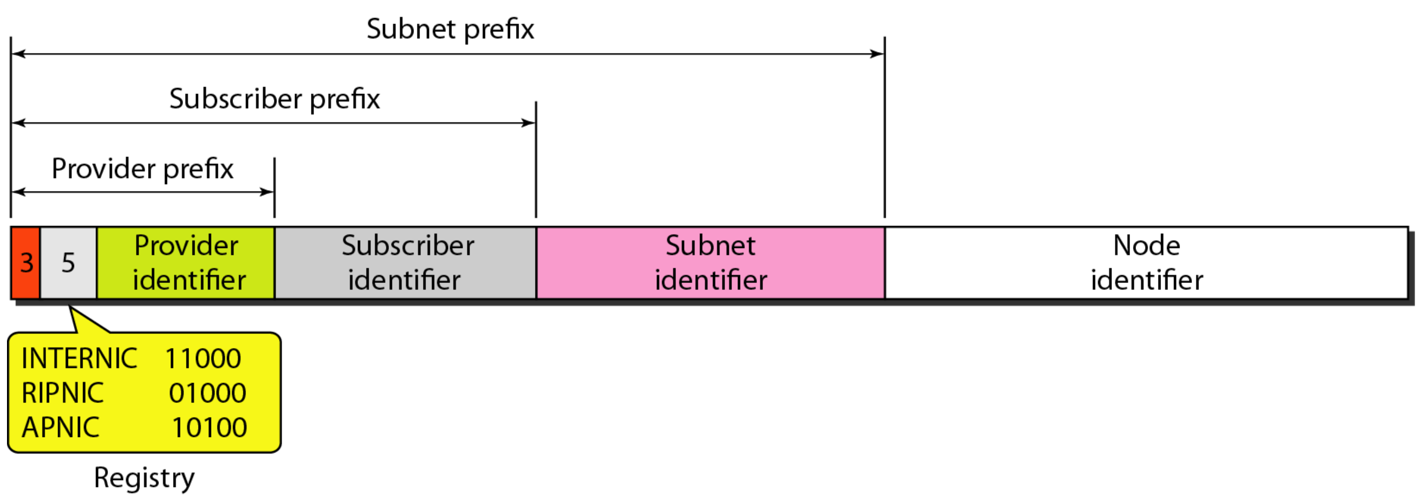
Type Prefix	*Type*	*Fraction*
0000 0000	Reserved	1/256
0000 0001	Unassigned	1/256
0000 001	ISO network addresses	1/128
0000 010	IPX (Novell) network addresses	1/128
0000 011	Unassigned	1/128
0000 1	Unassigned	1/32
0001	Reserved	1/16
001	Reserved	1/8
010	**Provider-based unicast addresses**	**1/8**

Type prefixes for IPv6 addresses

Type Prefix	*Type*	*Fraction*
011	Unassigned	1/8
100	Geographic-based unicast addresses	1/8
101	Unassigned	1/8
110	Unassigned	1/8
1110	Unassigned	1/16
1111 0	Unassigned	1/32
1111 10	Unassigned	1/64
1111 110	Unassigned	1/128
1111 1110 0	Unassigned	1/512
1111 1110 10	Link local addresses	1/1024
1111 1110 11	Site local addresses	1/1024
1111 1111	Multicast addresses	1/256

Unicast

- For a single computer
- Two types of unicast addresses
  - Geographically based
  - Provider-based
- Fields
  - Type ID (3-bit), Registry ID (5-bit), Provider ID (16-bit), Subscriber ID (24-bit), Subnet ID (32-bit), Node ID (48-bit)



Multicast address in IPv6

- For a group of hosts
- To deliver packets to each member

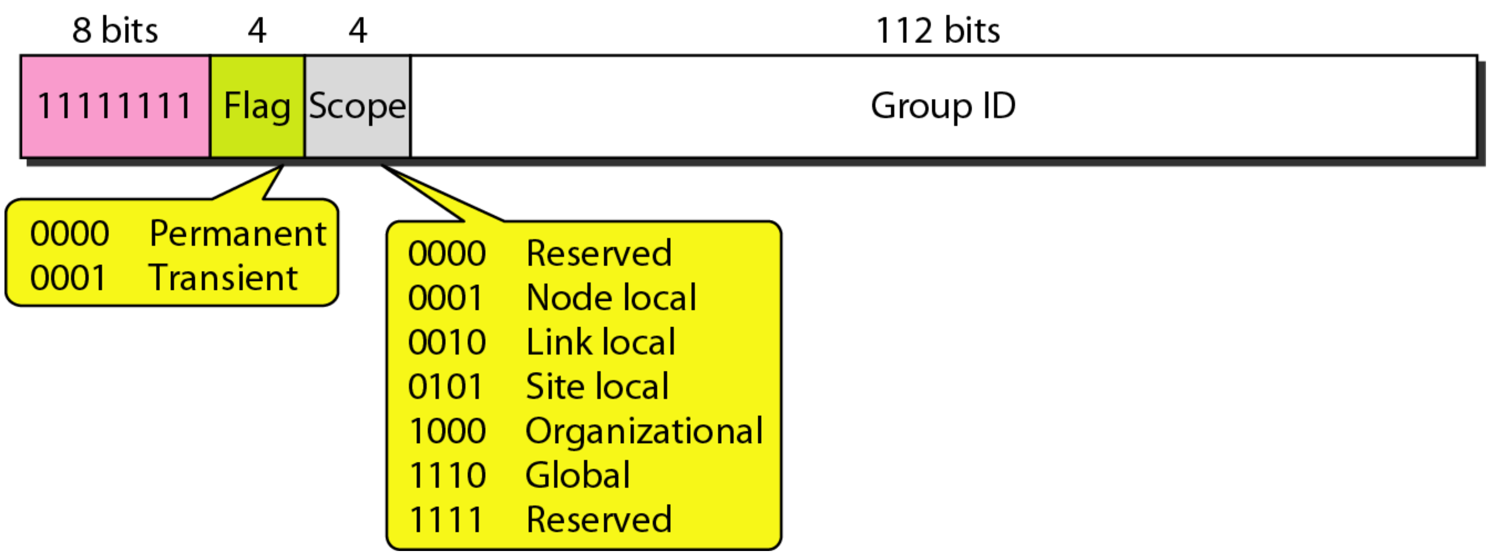
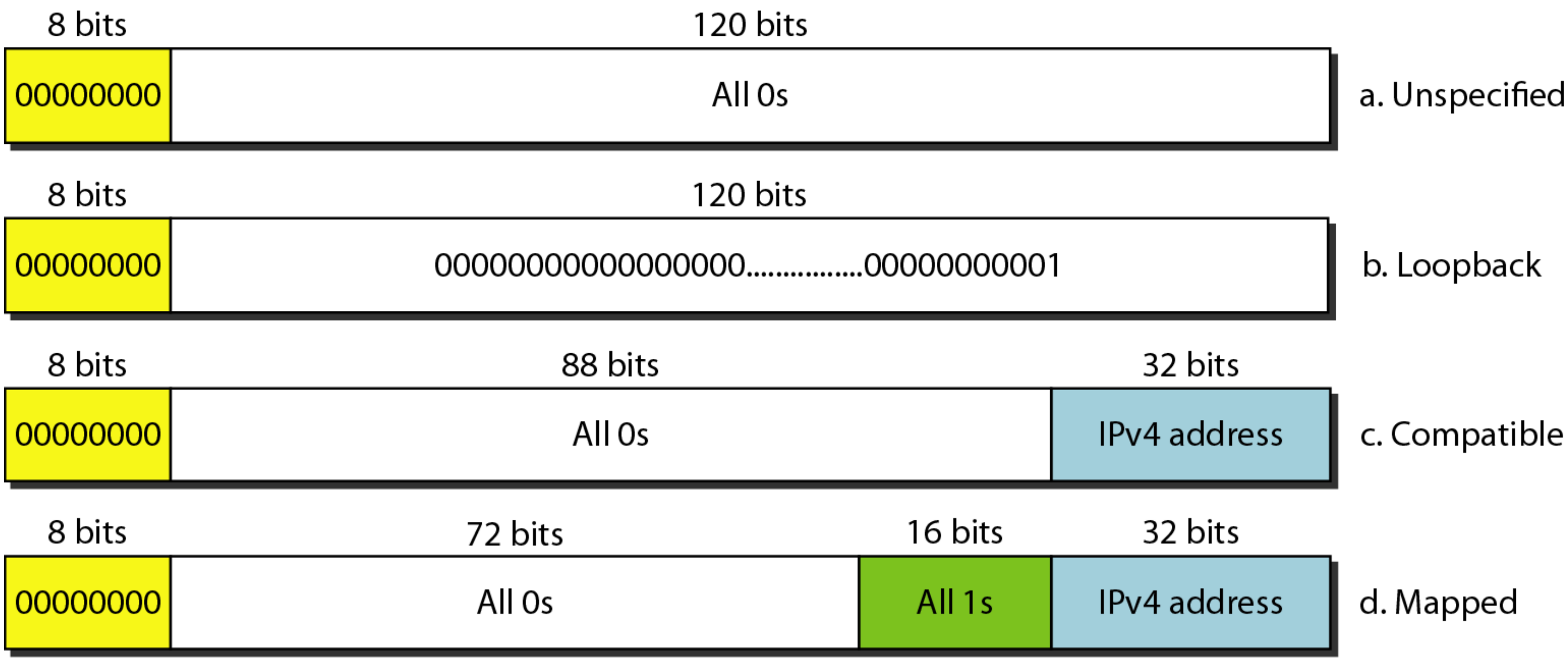


Figure 19.18 *Reserved addresses in IPv6*



Local addresses in IPv6

- to use IPv6 without connecting to the global Internet.