Chapter 26

IPv6 Addressing

INTRODUCTION

An IPv6 address is 128 bits or 16 bytes (octet) long as shown in Figure. The address length in IPv6 is four times of the length address in IPv4.

Figure 26.1 *IPv6 addresses*

Binary Notation :

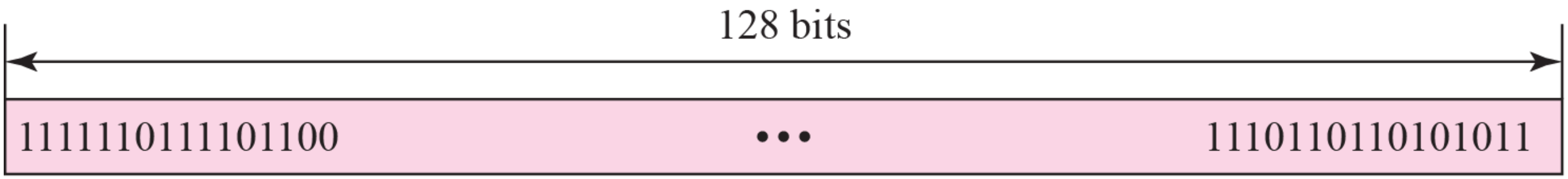


Figure 26.2 *Colon hexadecimal notation*

Colon Hexadecimal Notation :

FDEC : BA98 : 7654 : 3210 : ADBF : BBFF : 2922 : FFFF

Figure 26.3 ***Zero compression***

Figure 26.4 ***CIDR address***

FDEC :: BBFF : 0 : FFFF/60

Example 26.1

Show the unabbreviated colon hex notation for the following IPv6 addresses:

a. An address with 64 0s followed by 64 1s.
b. An address with 128 0s.
c. An address with 128 1s.
d. An address with 128 alternative 1s and 0s.

Solution

a. 0000:0000:0000:0000:FFFF:FFFF:FFFF:FFFF
b. 0000:0000:0000:0000:0000:0000:0000:0000
c. FFFF:FFFF:FFFF:FFFF:FFFF:FFFF:FFFF:FFFF
d. AAAA:AAAA:AAAA:AAAA:AAAA:AAAA:AAAA:AAAA

Example 26.2

The following shows the zero contraction version of addresses in Example 26.1 (part c and d cannot be abbreviated)

a. :: FFFF:FFFF:FFFF:FFFF
b. ::
c. FFFF:FFFF:FFFF:FFFF:FFFF:FFFF:FFFF:FFFF
d. AAAA:AAAA:AAAA:AAAA:AAAA:AAAA:AAAA:AAAA

Example 26.3

Show abbreviations for the following addresses:

a. 0000:0000:FFFF:0000:0000:0000:0000:0000

b. 1234:2346:0000:0000:0000:0000:0000:1111

c. 0000:0001:0000:0000:0000:0000:1200:1000

d. 0000:0000:0000:0000:0000:FFFF:24.123.12.6

Solution

a. 0:0:FFFF::

b. 1234:2346::1111

c. 0:1::1200:1000

d. ::FFFF:24.123.12.6

Example 26.4

Decompress the following addresses and show the complete unabbreviated IPv6 address:

a. 1111::2222
b. ::
c. 0:1::
d. AAAA:A:AA::1234

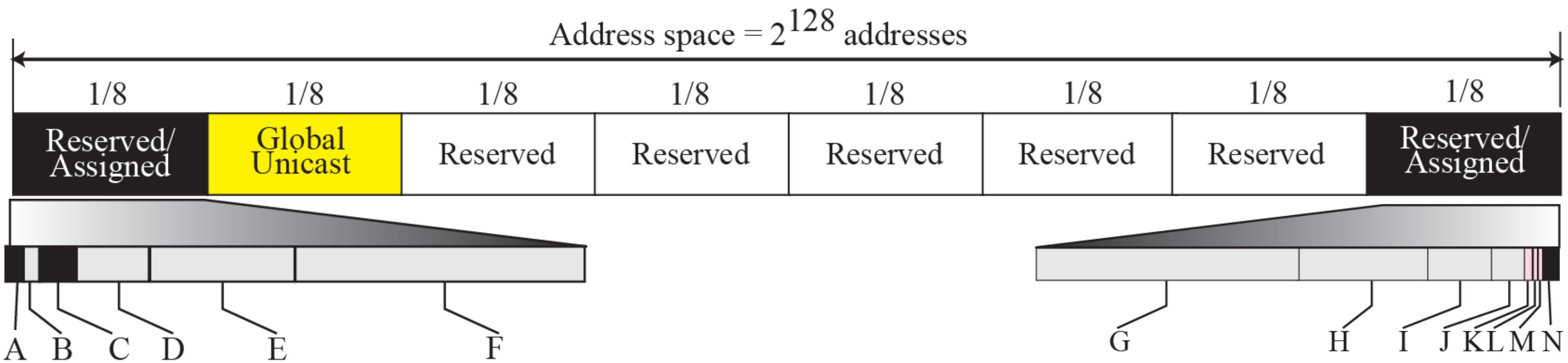
Solution

a. 1111:0000:0000:0000:0000:0000:0000:2222
b. 0000:0000:0000:0000:0000:0000:0000:0000
c. 0000:0001:0000:0000:0000:0000:0000:0000
d. AAAA:000A:00AA:0000:0000:0000:0000:1234

26-2 ADDRESS SPACE ALLOCATION

Like the address space of IPv4, the address space of IPv6 is divided into several blocks of varying size and each block is allocated for special purpose. Most of the blocks are still unassigned and have been left aside for future use. To better understand the allocation and the location of each block in address space, we first divide the whole address space into eight equal ranges. This division does not show the block allocation, but we believe it shows where each actual block is located (Figure 26.5).

Figure 26.5 *Address space allocation*



A: 1/256 IPv4 Compatible
B: 1/256 Reserverd
C: 1/128 Reserved
D: 1/64 Reserved
E: 1/32 Reserved
F: 1/16 Reserved

G: 1/16 Reserved
H: 1/32 Reserved
I: 1/64 Reserved
J: 1/128 Unique Local Unicast
K: 1/512 Reserved
L: 1/1024 Link Local
M: 1/256 Reserved
N: 1/256 Multicast

Table 26.1 *Prefixes for IPv6 Addresses*

	Block Prefix	*CIDR*	*Block Assignment*	*Fraction*
1	0000 0000	0000::/8	Reserved (IPv4 compatible)	1/256
	0000 0001	0100::/8	Reserved	1/256
	0000 001	0200::/7	Reserved	1/128
	0000 01	0400::/6	Reserved	1/64
	0000 1	0800::/5	Reserved	1/32
	0001	1000::/4	Reserved	1/16
2	**001**	**2000::/3**	**Global unicast**	**1/8**
3	010	4000::/3	Reserved	1/8
4	011	6000::/3	Reserved	1/8
5	100	8000::/3	Reserved	1/8
6	101	A000::/3	Reserved	1/8
7	110	C000::/3	Reserved	1/8
8	1110	E000::/4	Reserved	1/16
	1111 0	F000::/5	Reserved	1/32
	1111 10	F800::/6	Reserved	1/64
	1111 110	FC00::/7	Unique local unicast	1/128
	1111 1110 0	FE00::/9	Reserved	1/512
	1111 1110 10	FE80::/10	Link local addresses	1/1024
	1111 1110 11	FEC0::/10	Reserved	1/1024
	1111 1111	FF00::/8	Multicast addresses	1/256

Example 26.8

Figure 26.5 shows that only a portion of the address space can be used for global unicast communication. How many addresses are in this block?

Solution

This block occupies only one-eighth of the address spaces. To find the number of addresses, we can divide the total address space by 8 or 2^3 . The result is $(2^{128})/(2^3) = 2^{125}$ —a huge block.

Figure 26.6 *Algorithm for finding the allocated blocks*

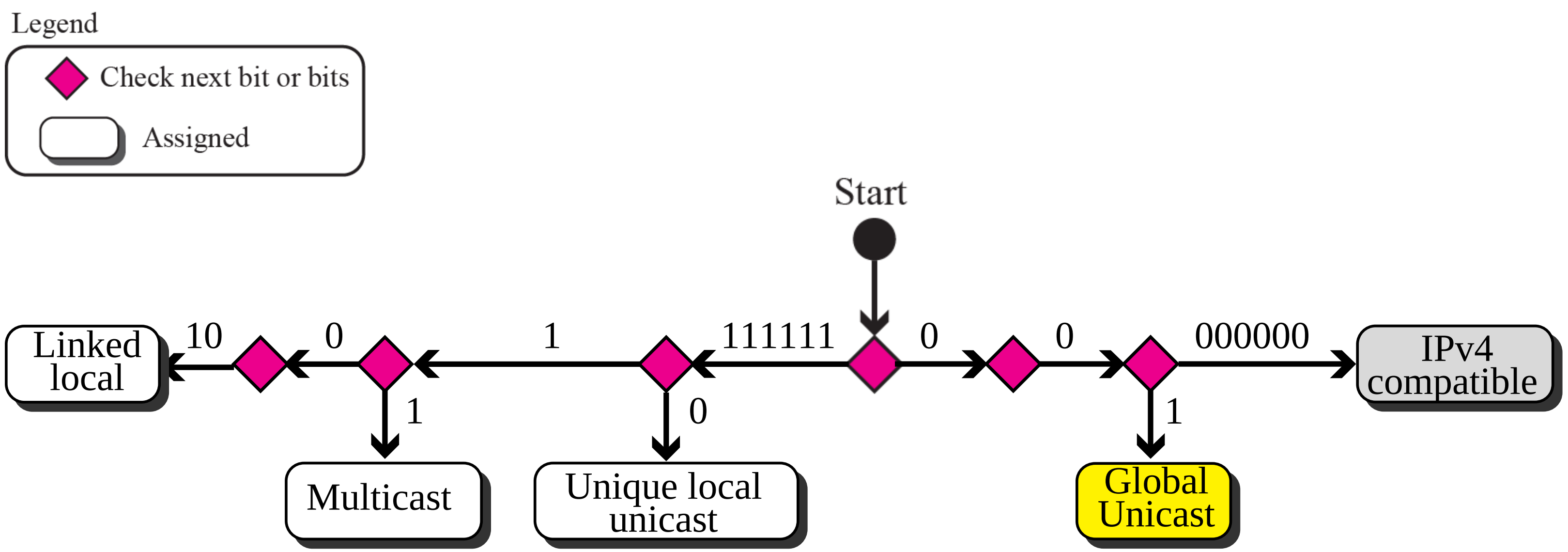
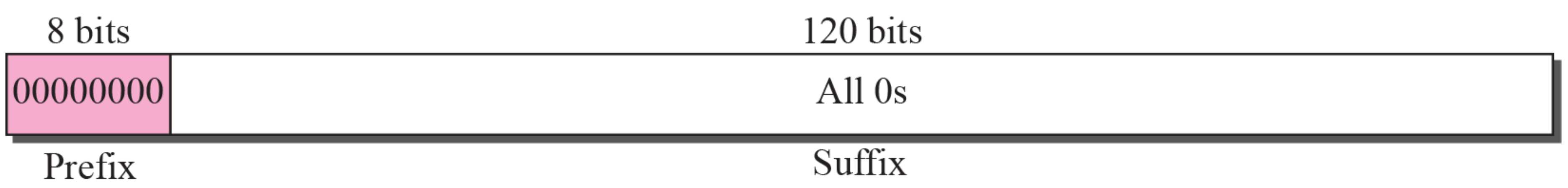


Figure 26.7 *Unspecified address*



Note

The unspecified address in IPv6 is ::/128. It should never be used as a destination address.

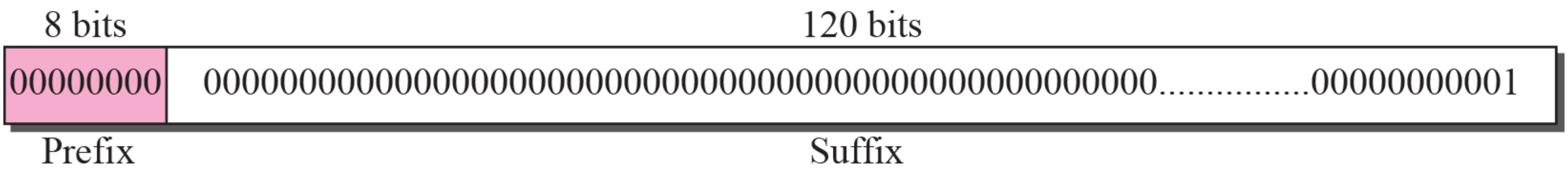
Example 26.9

Comparing the unspecified address in IPv4 to the unspecified addresses in IPv6.

Solution

In both architectures, an unspecified address is an all-zero address. In IPv4 this address is part of class A address; in IPv6 this address is part of the reserved block.

Figure 26.8 *Loopback address*



Note

The loopback address in IPv6 is ::1/128. It should never be used as a destination address.

Example 26.10

Compare the loop addresses in IPv4 to the loopback address in IPv6.

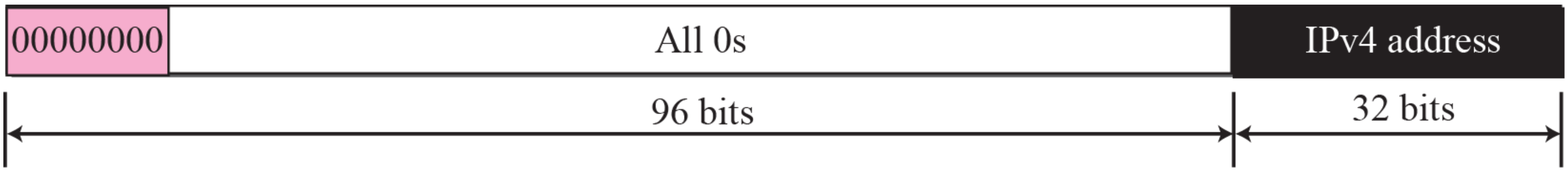
Solution

There are two differences in this case. In classful addressing, a whole block is allocated for loopback addresses; in IPv6 only one address is allocated as the loopback address. In addition, the loopback block in classful addressing is part of the class A block. In IPv6, it is only one single address in the reserved block.

Embedded IPv4 Addresses :

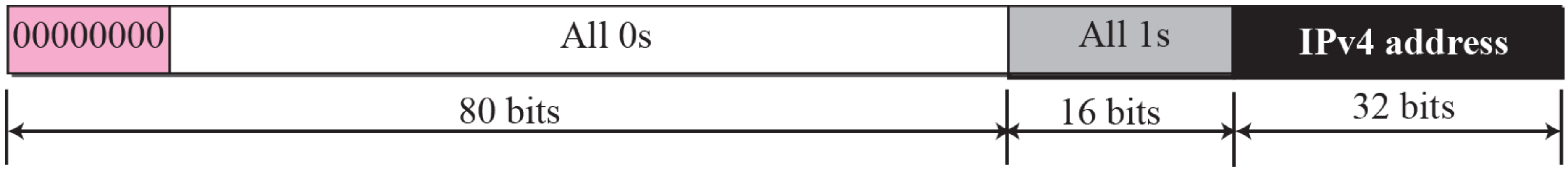
During the transition from IPv4 to IPv6, hosts can use their IPv4 addresses embedded in IPv6 addresses

Figure 26.9 ***Compatible address***



- Used when a computer using IPv4 wants to send a message to another computer using IPv6.
- **For example,** the IPv4 address 2.13.17.14 **(in dotted decimal format)** becomes 0::2.13.17.14 **(in mixed format).**

Figure 26.10 ***Mapped address***



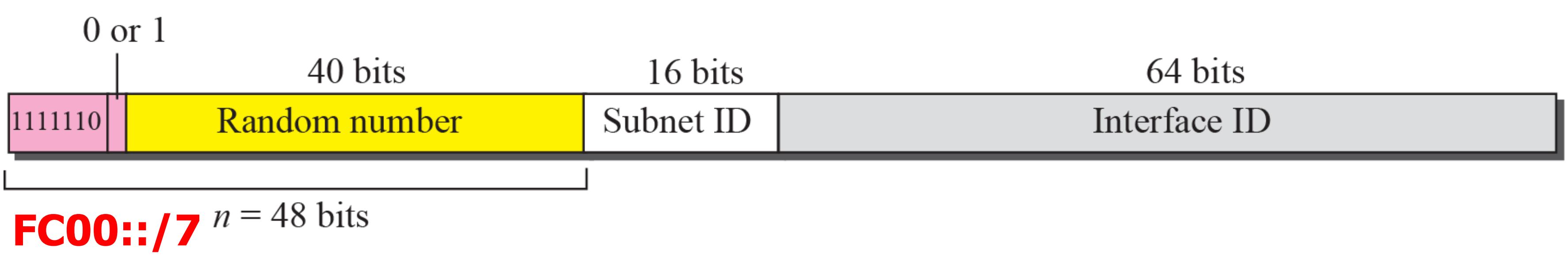
- Used when a computer that has migrated to IPv6 wants to send a packet to a computer still using IPv4

- For example, the IPv4 address 2.13.17.14 (**in dotted decimal format**) becomes 0::FFFF:2.13.17.14 (**in hexadecimal colon format**).

IPv6 uses two large blocks for private addressing: one at the site level and one at the link level.

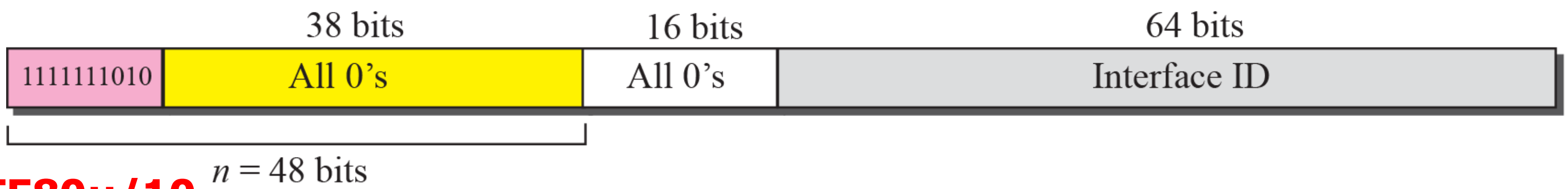
- **Unique Local Unicast**
- **Link Local Unicast**

Figure 26.11 ***Unique local unicast address***



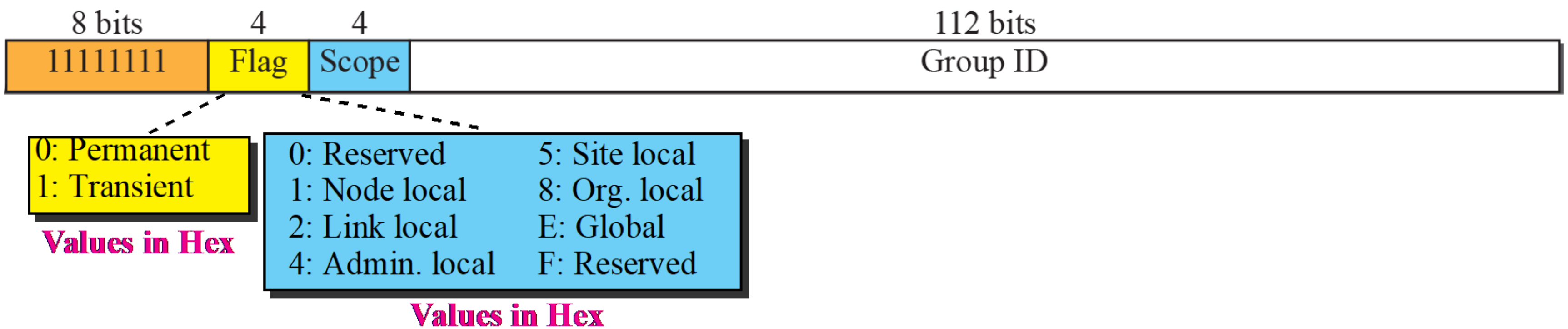
- a **unique local unicast block** can be privately created and used by a site.
- not expected to be routed

Figure 26.12 ***Link local address***



FE80::/10

Figure 26.13 *Multicast address*



- A permanent group address is defined by the Internet authorities and can be accessed at all times.
- A transient group address, on the other hand, is used only temporarily.
- The third field defines the scope of the group address.

26-3 GLOBAL UNICAST ADDRESSES

This block in the address space that is used for unicast (one-to-one) communication between two hosts in the Internet is called global unicast address block. CIDR notation for the block is 2000::/3, which means that the three leftmost bits are the same for all addresses in this block (001). The size of this block is 2^{125} bits, which is more than enough for the Internet expansion in the many years to come.

Figure 26.14 *Global unicast address*

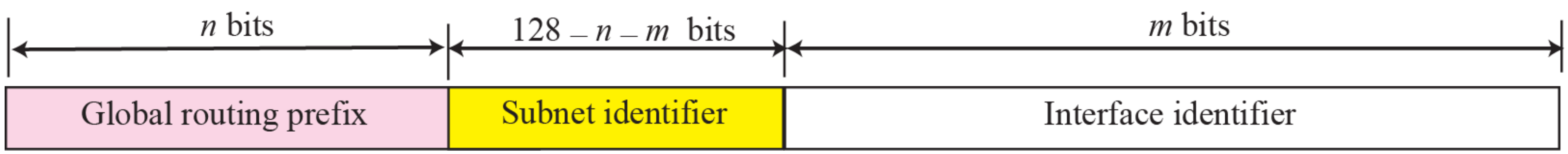


Table 26.2 *Recommended Length of Different Parts in Unicast Addressing*

Block Assignment	*Length*
Global routing prefix (n)	48 bits
Subnet identifier ($128 - n - m$)	16 bits
Interface identifier (m)	64 bits

Figure 26.15 *Mapping for EUI-64*

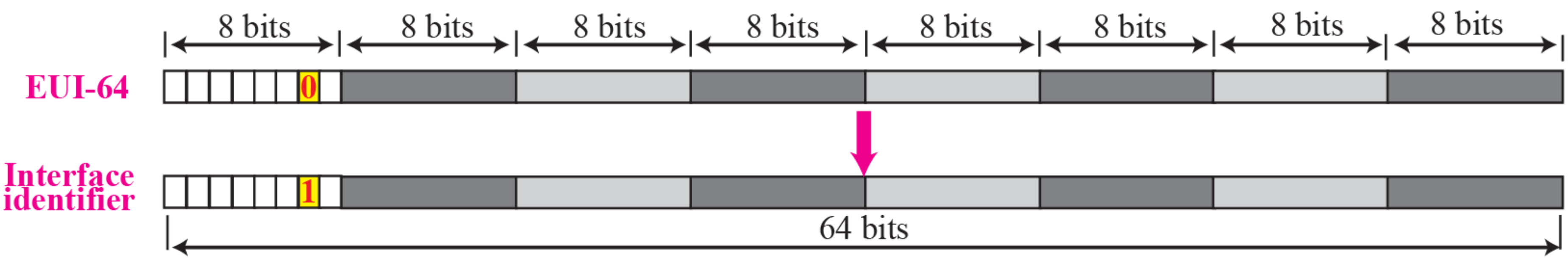
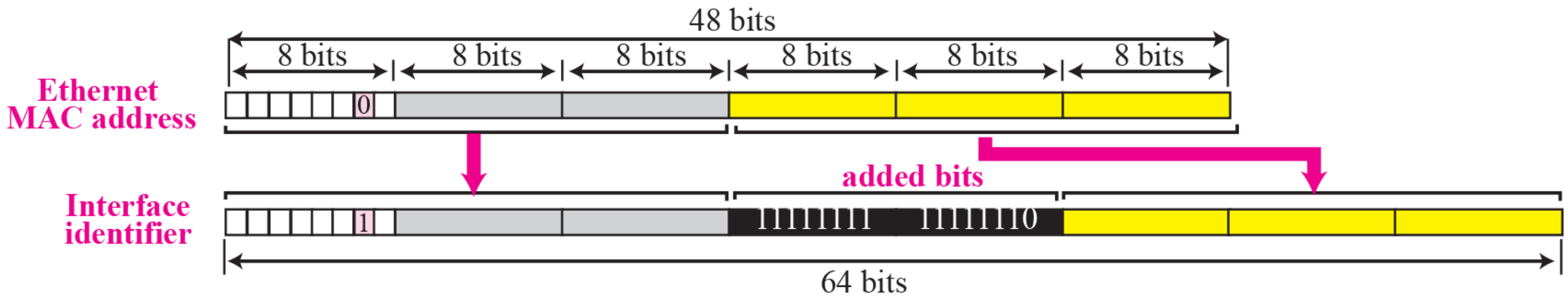


Figure 26.16 *Mapping for Ethernet MAC*



Example 26.11

Find the interface identifier if the physical address in the EUI is $(F5\text{-}A9\text{-}23\text{-}EF\text{-}07\text{-}14\text{-}7A\text{-}D2)_{16}$ using the format we defined for Ethernet addresses.

Solution

We only need to change the seventh bit of the first octet from 0 to 1 and change the format to colon hex notation. The result is F7A9:23EF:0714:7AD2.

Example 26.12

Find the interface identifier if the Ethernet physical address is $(F5\text{-}A9\text{-}23\text{-}14\text{-}7A\text{-}D2)_{16}$ using the format we defined for Ethernet addresses.

Solution

We only need to change the seventh bit of the first octet from 0 to 1, insert two octet FFFE16 and change the format to colon hex notation. The result is F7A9:23FF:FE14:7AD2 in colon hex.

Example 26.13

An organization is assigned the block 2000:1456:2474/48. What is the CIDR notation for the blocks in the first and second subnets in this organization.

Solution

Theoretically, the first and second subnets should use the block with subnet identifier 0001_{16} and 0002_{16}. This means that the blocks are

2000:1456:2474:0000/64

and

2000:1456:2474:0001/64.

Example 26.14

An organization is assigned the block 2000:1456:2474/48. What is the IPv6 address of an interface in the third subnet if the IEEE physical address of the computer is $(F5\text{-}A9\text{-}23\text{-}14\text{-}7A\text{-}D2)_{16}$.

Solution

The interface identifier is F7A9:23FF:FE14:7AD2 (see Example 26.12). If we add this identifier to the global prefix and the subnet identifier, we get:

```
2000:1456:2474:0003:F7A9:23FF:FE14:7AD2/128
```

26-4 AUTOCONFIGURATION

One of the interesting features of IPv6 addressing is the autoconfiguration of hosts. As we discussed in IPv4, the host and routers are originally configured manually by the network manager. However, the Dynamic Host Configuration Protocol, DHCP, can be used to allocate an IPv4 address to a host that joins the network. In IPv6, DHCP protocol can still be used to allocate an IPv6 address to a host, but a host can also configure itself.

Example 26.15

Assume a host with Ethernet address $(F5\text{-}A9\text{-}23\text{-}11\text{-}9B\text{-}E2)_{16}$ has joined the network. What would be its global unicast address if the global unicast prefix of the organization is 3A21:1216:2165 and the subnet identifier is A245:1232.

Solution

The host first creates its interface identifier as

F7A9:23FF:FE11:9BE2

using the Ethernet address read from its card. The host then creates its link-local address as

```
FE80::F7A9:23FF:FE11:9BE2
```

Example 26.15 *Continued*

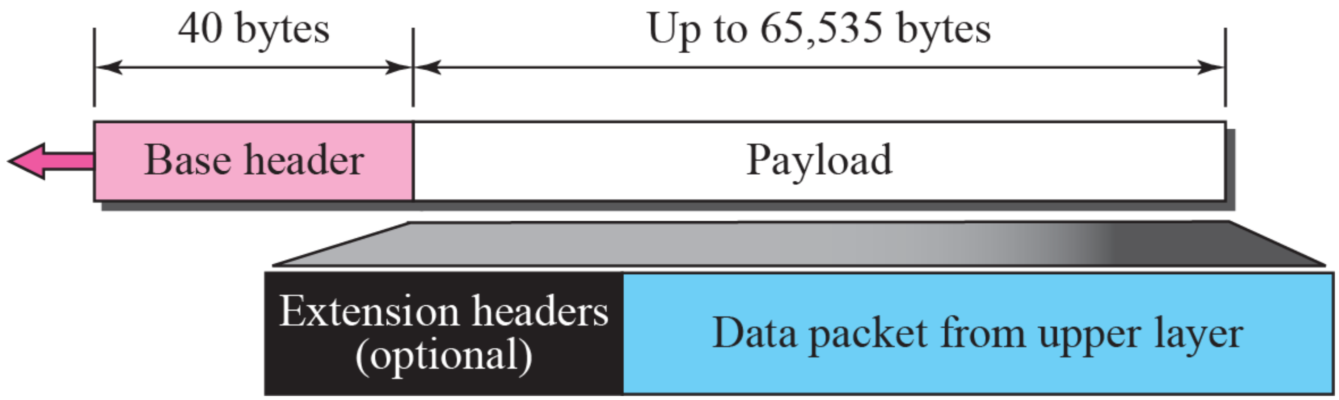
Assuming that this address is unique, the host sends a router solicitation message and receives the router advertisement message that announces the combination of global unicast prefix and the subnet identifier as 3A21:1216:2165:A245:1232. The host then appends its interface identifier to this prefix to find and store its global unicast address as:

```
3A21:1216:2165:A245:1232:F7A9:23FF:FE11:9BE2
```

26-5 RENUMBERING

To allow sites to change the service provider, Renumbering of the address prefix (*n*) was built into IPv6 addressing. As we discussed before, each site is given a prefix by the service provider to which it is connected. If the site changes the provider, the address prefix needs to be changed. A router to which the site is connected can advertise a new prefix and let the site use the old prefix for a short time before disabling it. In other words, during the transition period, a site has two prefixes.

Figure 27.1 *IPv6 datagram*



27-3 TRANSITION FROM IPv4 TO IPv6

Because of the huge number of systems on the Internet, the transition from IPv4 to IPv6 cannot happen suddenly. It will take a considerable amount of time before every system in the Internet can move from IPv4 to IPv6. The transition must be smooth to prevent any problems between IPv4 and IPv6 systems. Three strategies have been devised by the IETF to help the transition (see Figure 27.16).

Figure 27.16 *Three transition strategies*

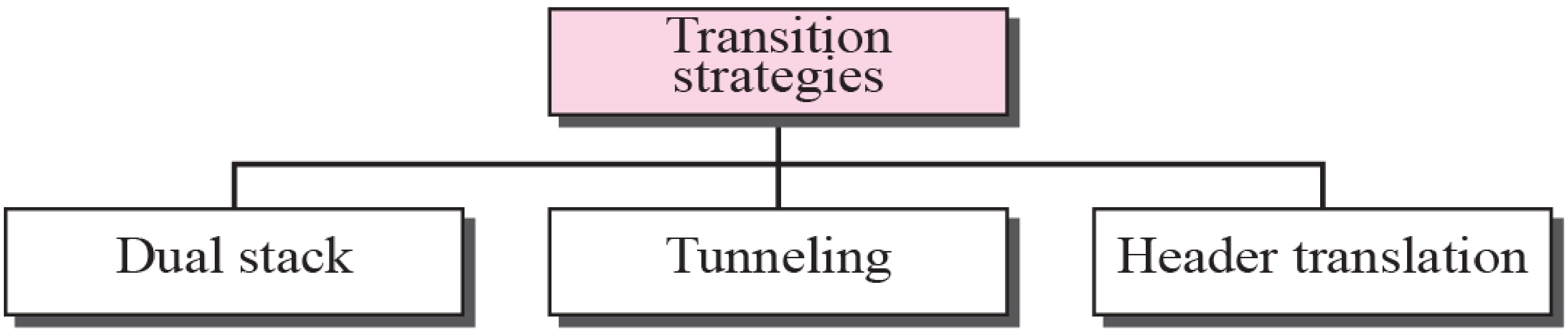


Figure 27.17 *Dual stack*

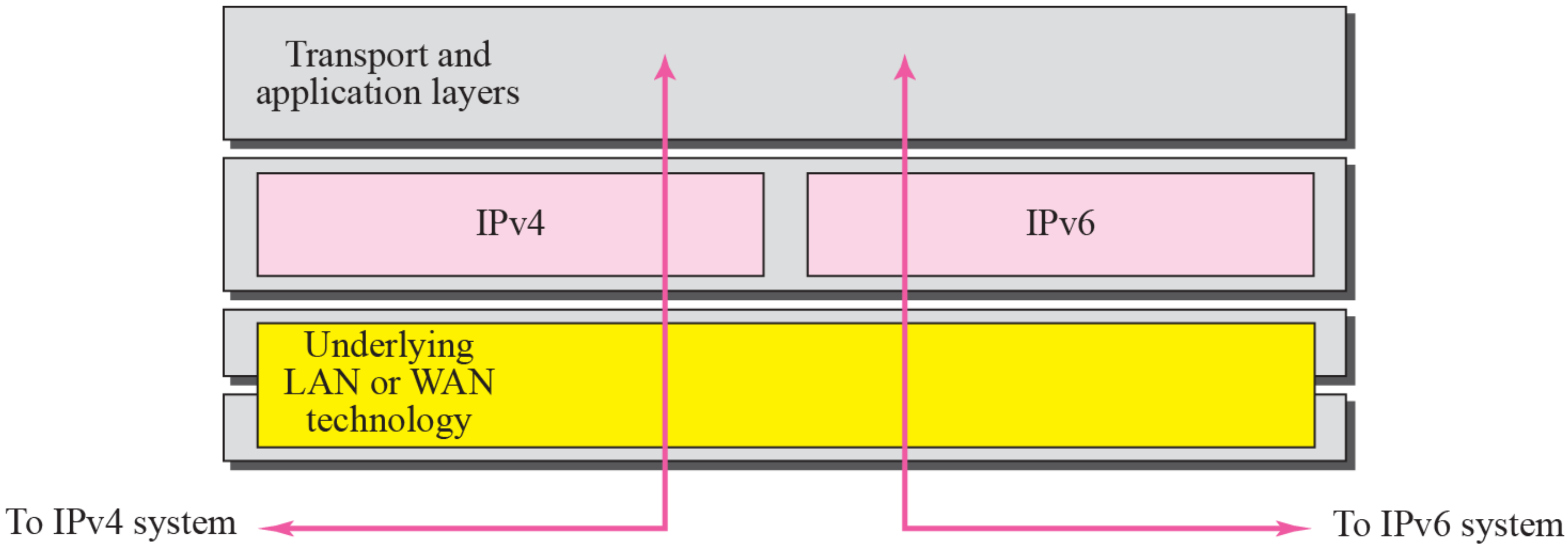


Figure 27.18 *Tunneling strategy*

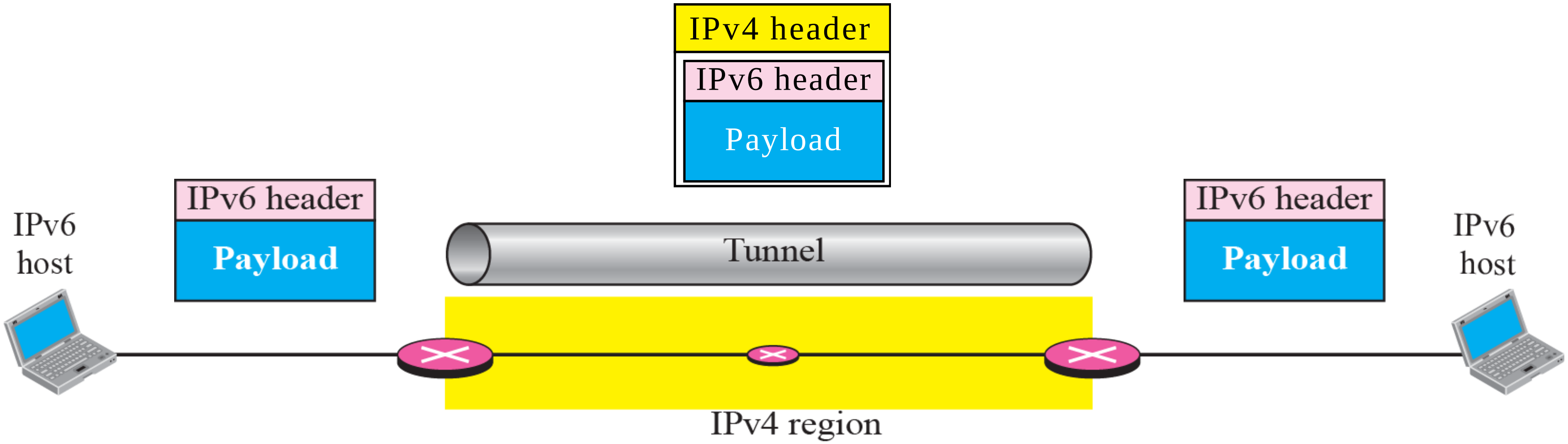


Figure 27.19 *Header translation strategy*