Next Generation IP

Topics Covered

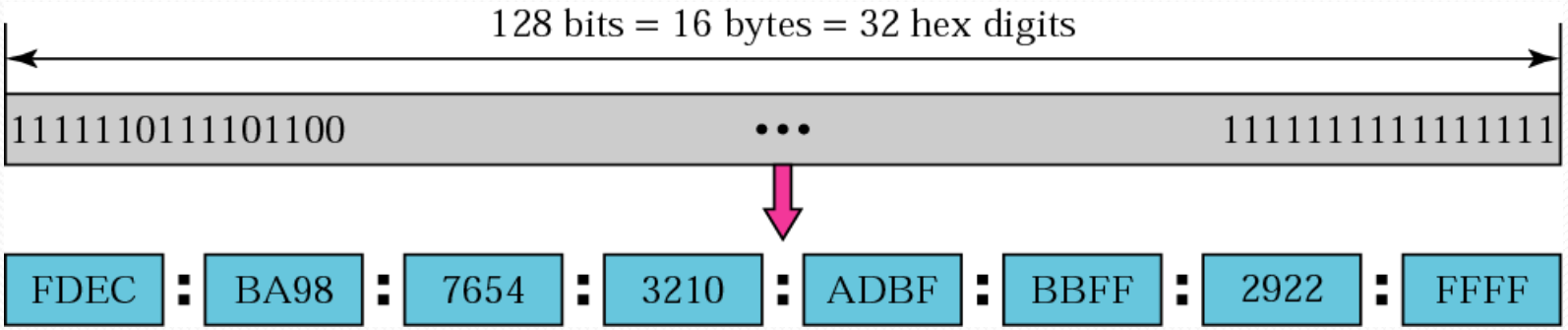
- **Introduction**
- **Representation**
- **Address Space**
- **Special Address**
- **Autoconfiguration**
- **IPv6 Protocol**
  - Packet format
- **Transition from IPv4 to IPv6**

Introduction

- **Internet Protocol version 6 (IPv6) or IP new generation (IPng)**
- **IPv4 has some deficiencies like subnetting, classless addressing, NAT, address depletion, minimum delay, resource reservation, encryption or authentication etc.**

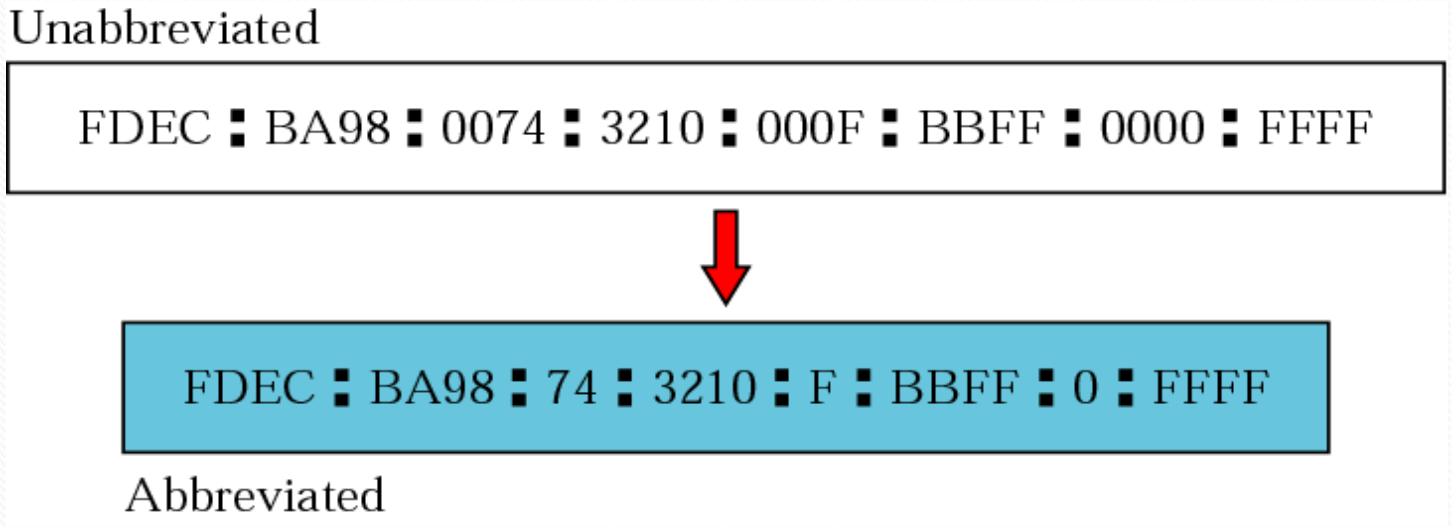
https://www.networkworld.com/article/3254575/what-is-ipv6-and-why-aren-t-we-there-yet.html

Representation (cont.)



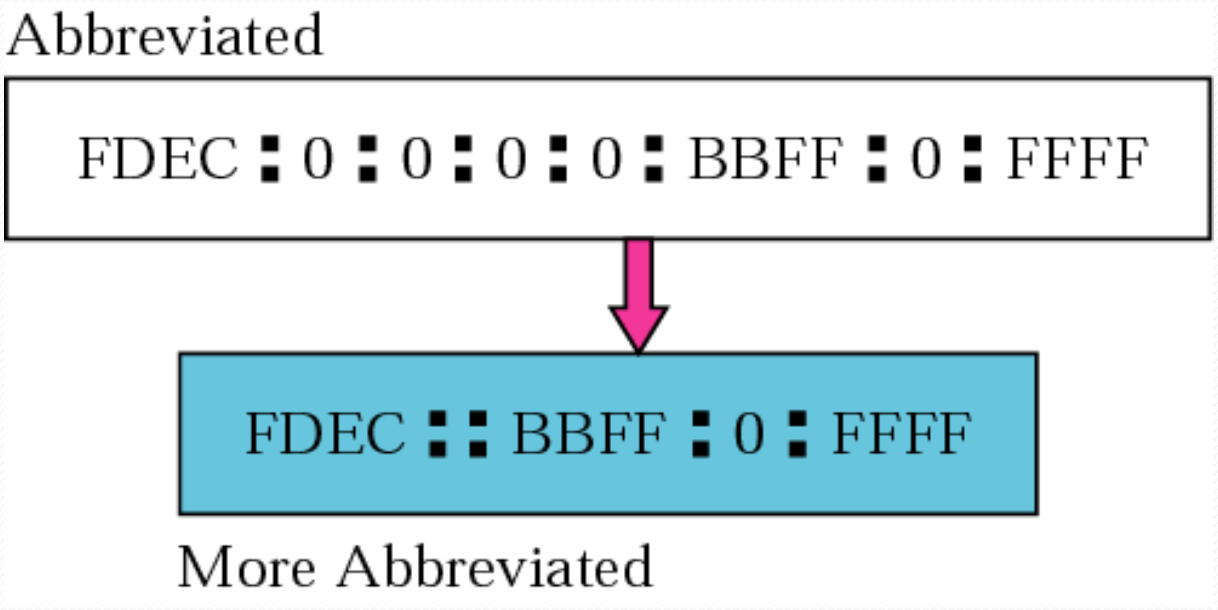
Representation (cont.)

- Mixed notation: colon hex and dotted decimal
- Appropriate in transition period when IPv4 is embedded in the IPv6 (rightmost 32 bits)

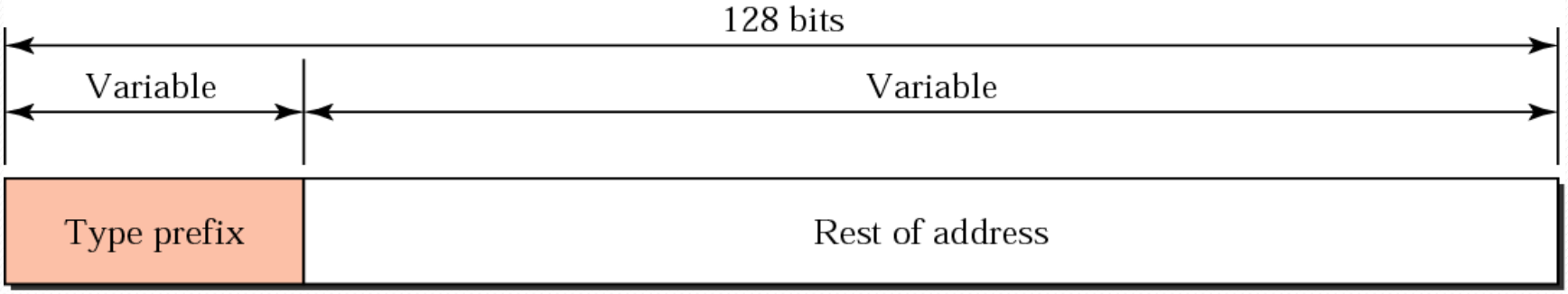


Representation

- Zero compression
- Allowed only once per address



Address Structure



Address Space

- Contains 2^{128} addresses
- Address space is 2^{96} times to the IPv4 address
- No address depletion
- The size of the space is:

340, 282, 366, 920, 938, 463, 374, 607, 431, 768, 211, 456.

Address Types

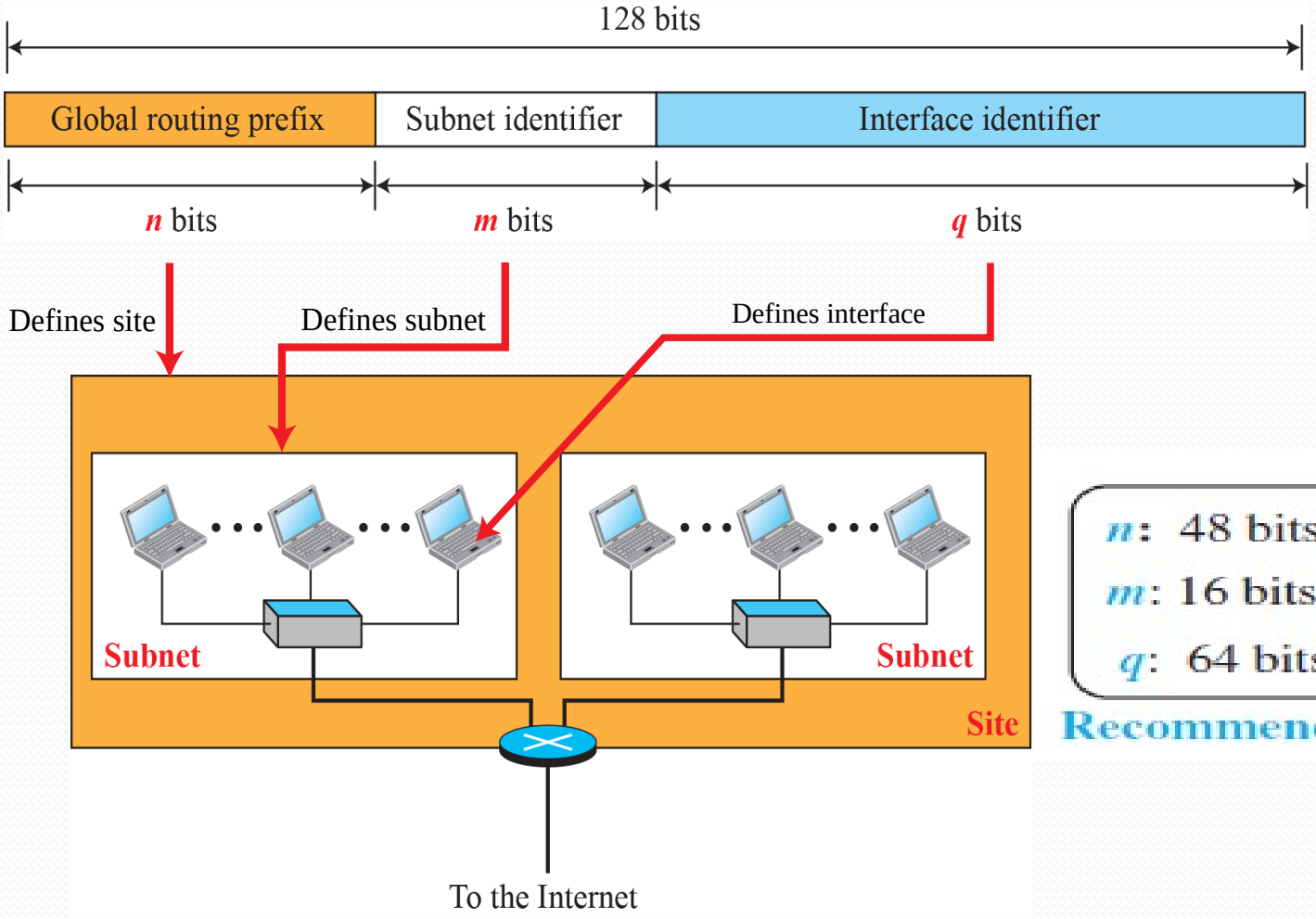
- Unicast
  - Defines a single interface (computer or router)
- Anycast
  - Group of computers that share a single address
  - Generate only one copy of the request
  - Deliver (only one) to the most reachable one
- Multicast
  - Each member of the group receives a copy
  - IPv6 has designated a block for multicasting

Address Space Allocation

- Most of the blocks are still unassigned
- Fraction of each block occupies in the whole address space

Block prefix	*CIDR*	*Block assignment*	*Fraction*
0000 0000	0000::/8	Special addresses	1/256
001	**2000::/3**	**Global unicast**	**1/8**
1111 110	FC00::/7	Unique local unicast	1/128
1111 1110 10	FE80::/10	Link local addresses	1/1024
1111 1111	FF00::/8	Multicast addresses	1/256

Global Unicast Addresses (Cont.)



n: 48 bits
m: 16 bits
q: 64 bits
Recommendation

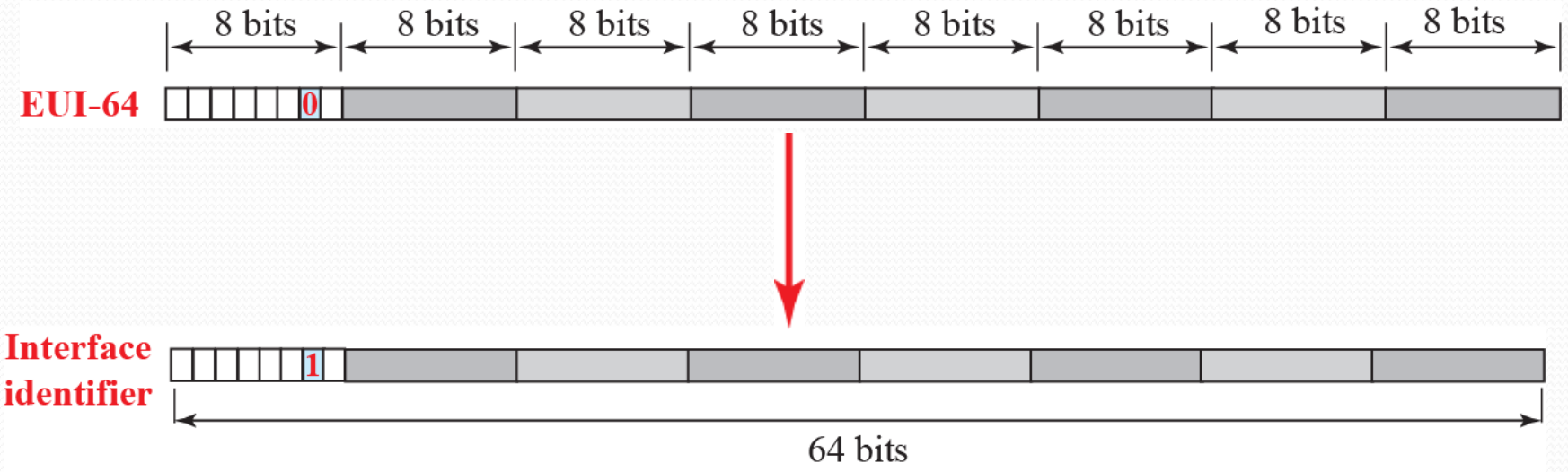
Global Unicast Addresses

- Last q bits define the interface identifier
- In IPv4 addressing
  - No relationship between hostid (IP level) and data link layer address (normally much longer than the hostid)
  - Mapping required for host to data link layer address
- IPv6 allows this relationship
  - 64-bit Extended unique identifier (EUI-64) by IEEE
  - 48-bit link-layer address by Ethernet

Mapping EUI-64

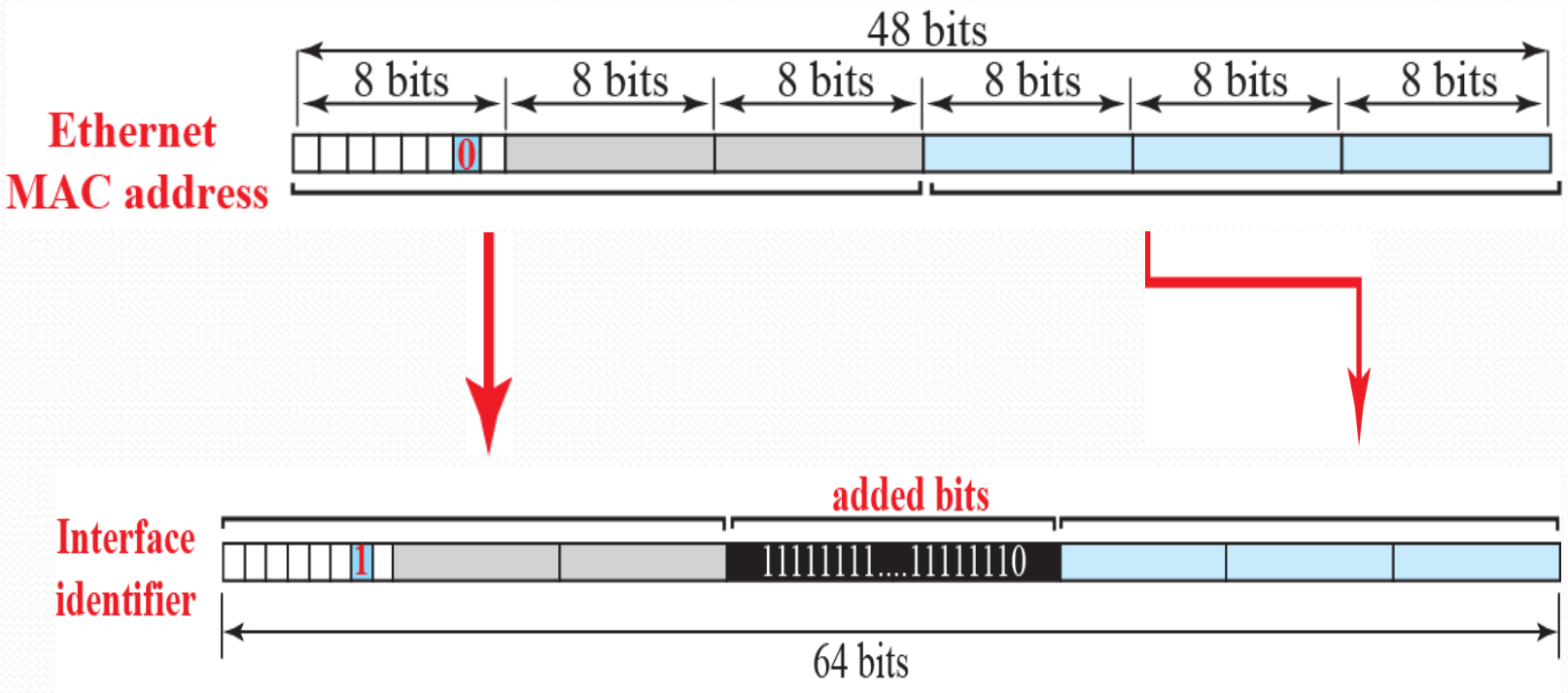
- The global/local bit of this format needs to be changed

from 0 to 1 (local to global) to define an interface address



Mapping Ethernet MAC Address

- Additional 16 bits are defined as 15 ones followed by one zero, or $FFFE_{16}$



Example 22.1

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 blocks 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 22.2

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

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.

- See Example 22.3

Example 22.4

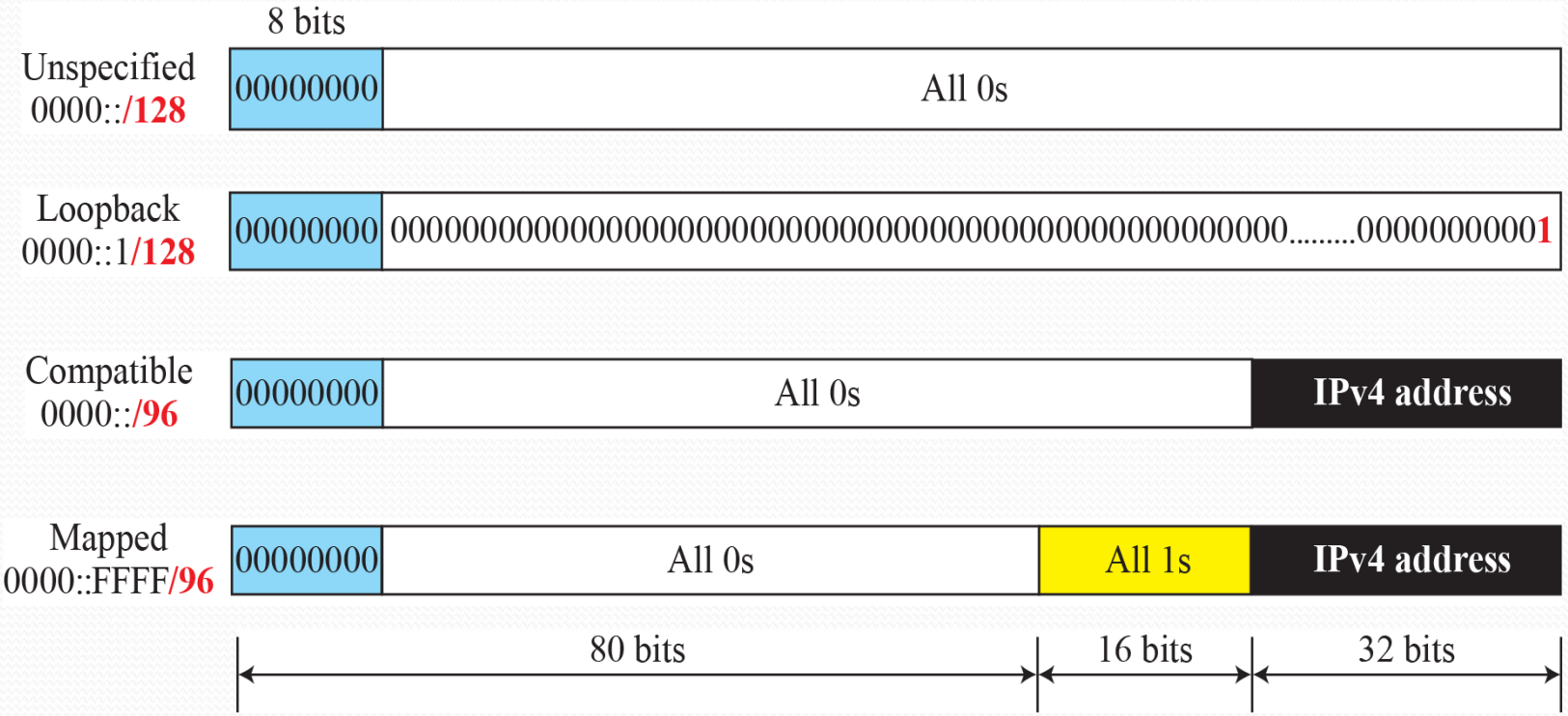
An organization is assigned the block 2000:1456:2474/48. What is the IPv6 address of an interface in the third subnet if the IEEE physical address of the computer is (F5-A9-23-14-7A-D2)16?

Solution

The interface identifier for this interface is F7A9:23FF:FE14:7AD2 (see Example 22.3). If we append this identifier to the global prefix and the subnet identifier, we get:

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

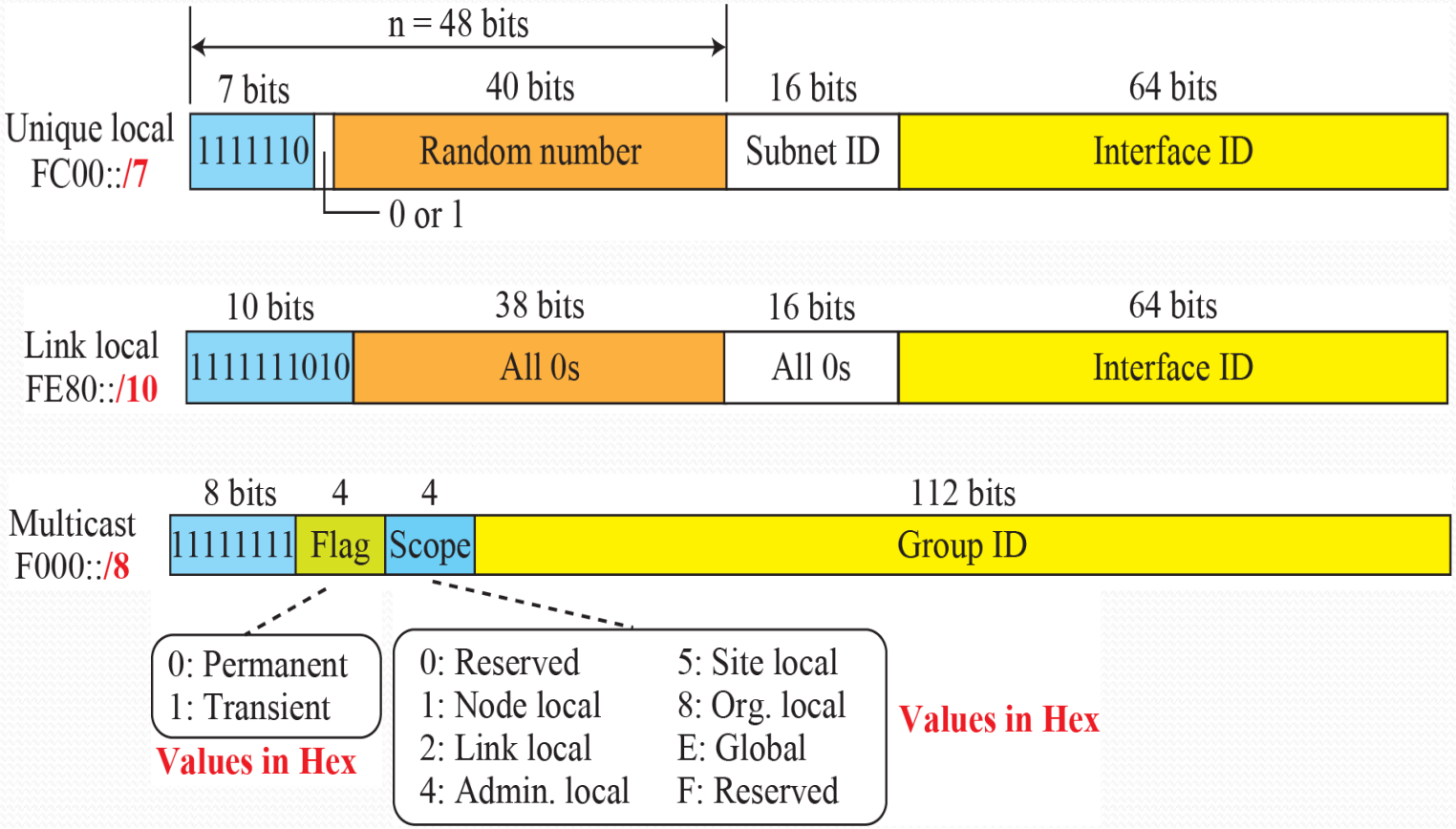
Special Addresses (Cont.)



Special Addresses

- Loopback address
  - Block in IPv4 127.0.0.1/8 but only one in IPv6
- Compatible address
  - IPv6 host to IPv6 host communication
- Mapped address
  - Communication from IPv6 host to IPv4 host

Other Assigned Blocks



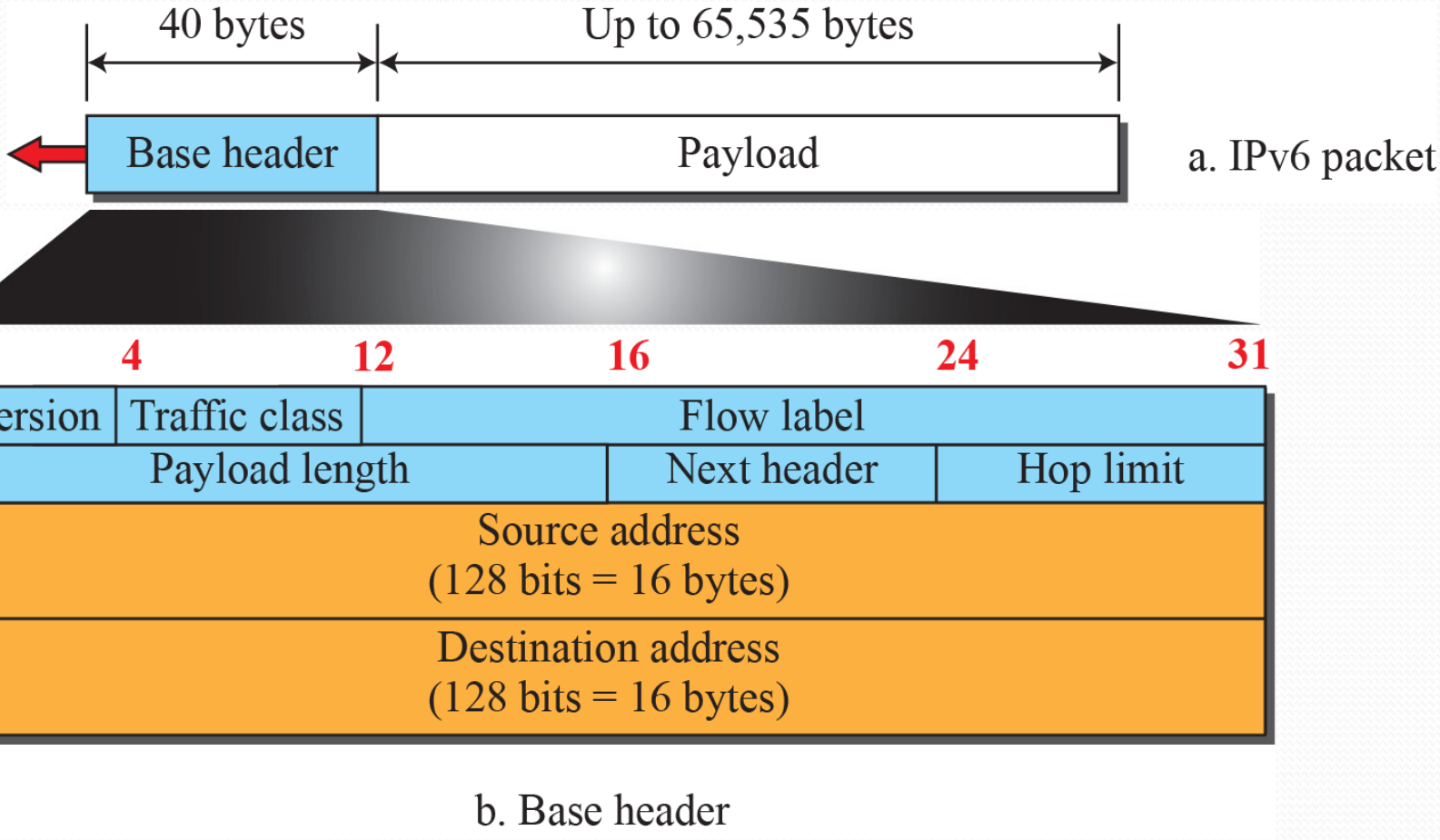
Auto configuration

- DHCP can be used to allocate an IPv4 address to a host
- In IPv6, DHCP protocol can still be used to allocate an IPv6 address to a host, but a host can also configure itself

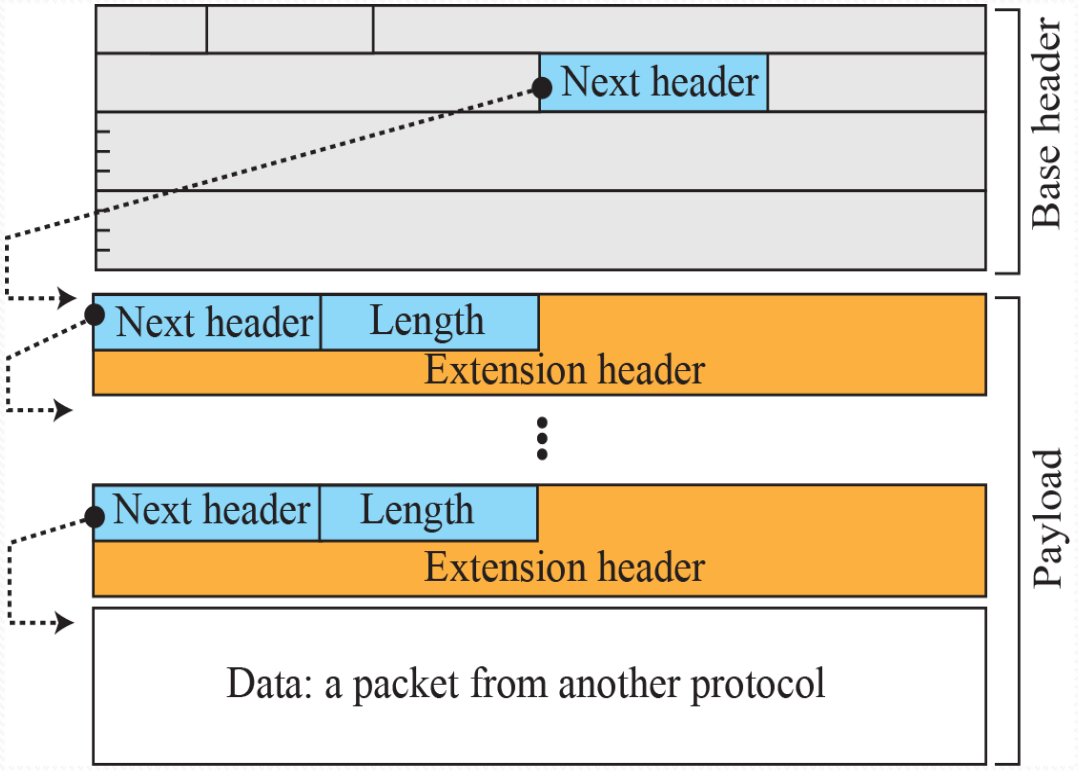
IPv6 Protocol

- **Major changes in the IPv6 protocol**
  - Larger address space: 2^{128}
  - Better header format
    - Options are separated from the base header and inserted when needed
    - Simplifies and speeds up the routing process (most of the options do not need to be checked by router)
  - New options
  - Allowance for extension protocol
  - Support for resource allocation
    - Flow label added: enable special handling of the packet; support real-time audio, video
  - Support for more security: Provide confidentiality and integrity of packet

IPv6 Datagram



Payload in an IPv6 datagram



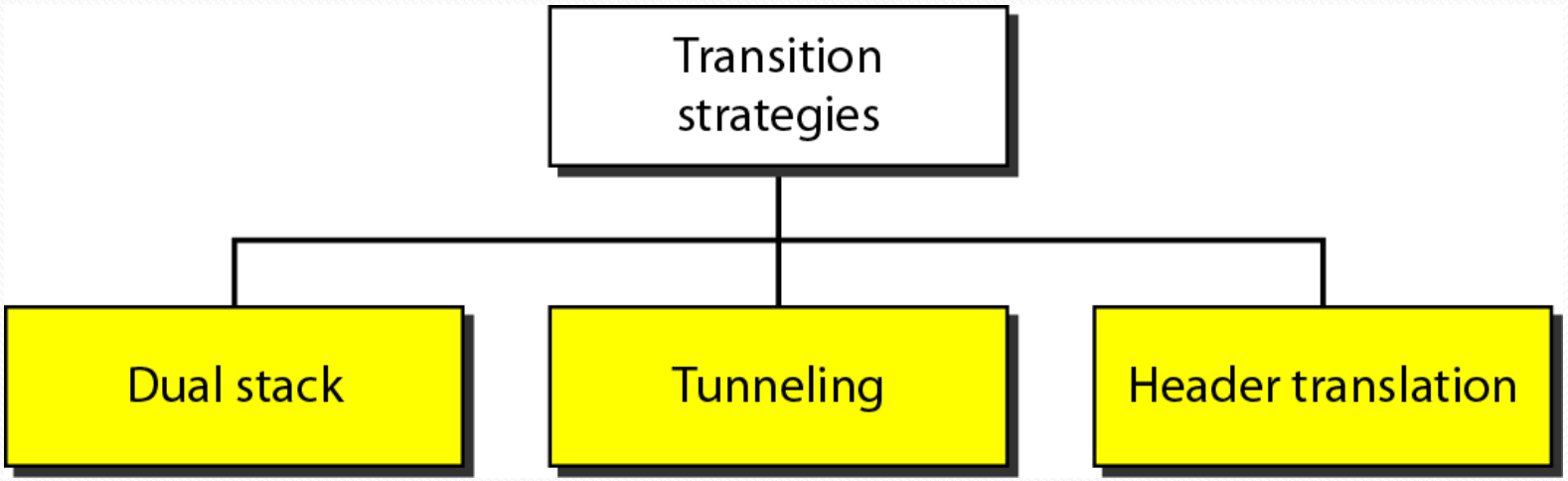
Some next-header codes

00: Hop-by-hop option
02: ICMPv6
06: TCP
17: UDP
43: Source-routing option
44: Fragmentation option
50: Encrypted security payload
51:Authentication header
59: Null (no next header)
60: Destination option

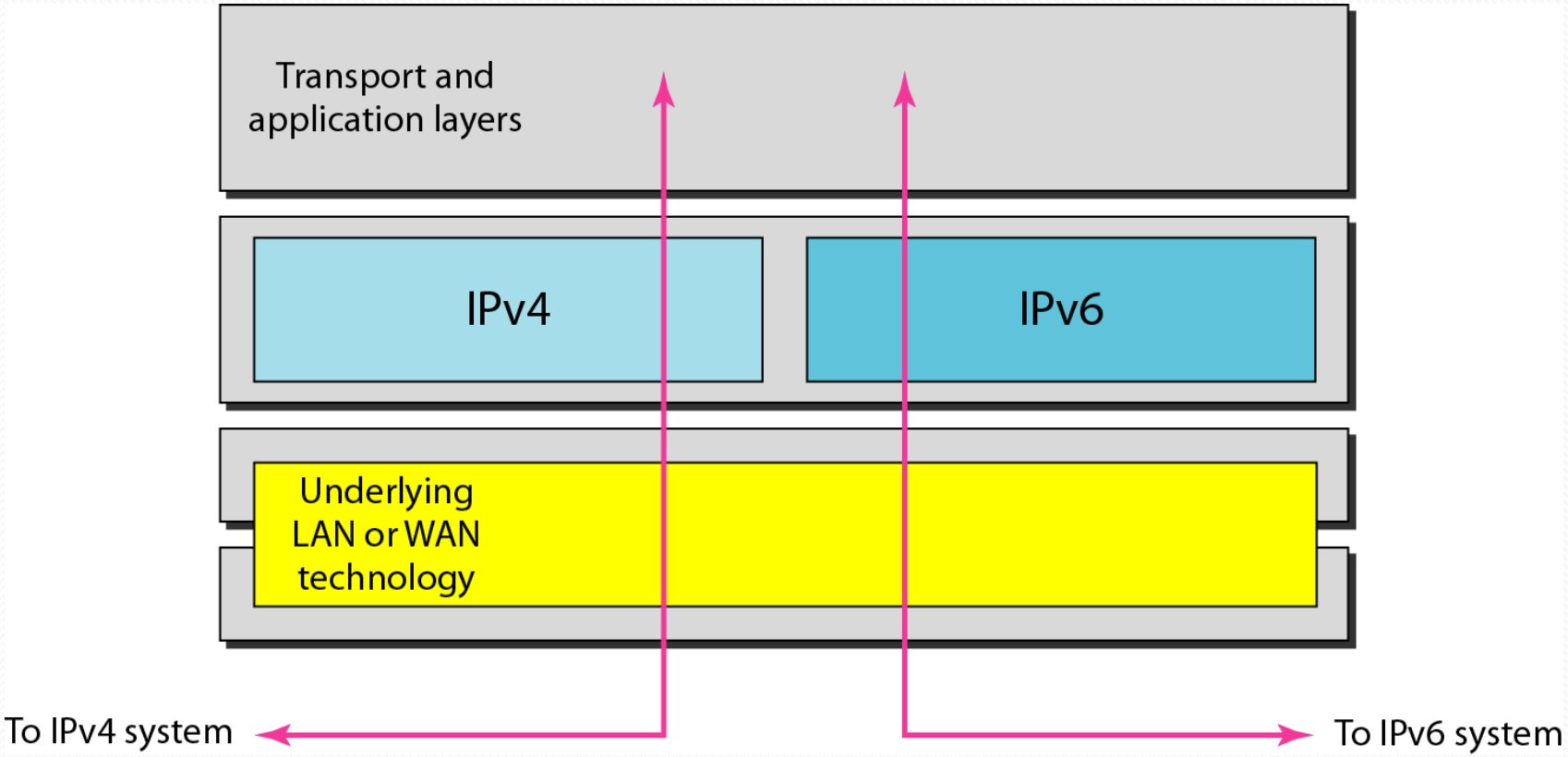
Extension Header

- Base header fixed at 40 bytes
- To give more functionality the base header can be followed by six extension headers
  - hop-by-hop option
  - source routing
  - fragmentation
  - authentication
  - encrypted security payload and
  - destination option

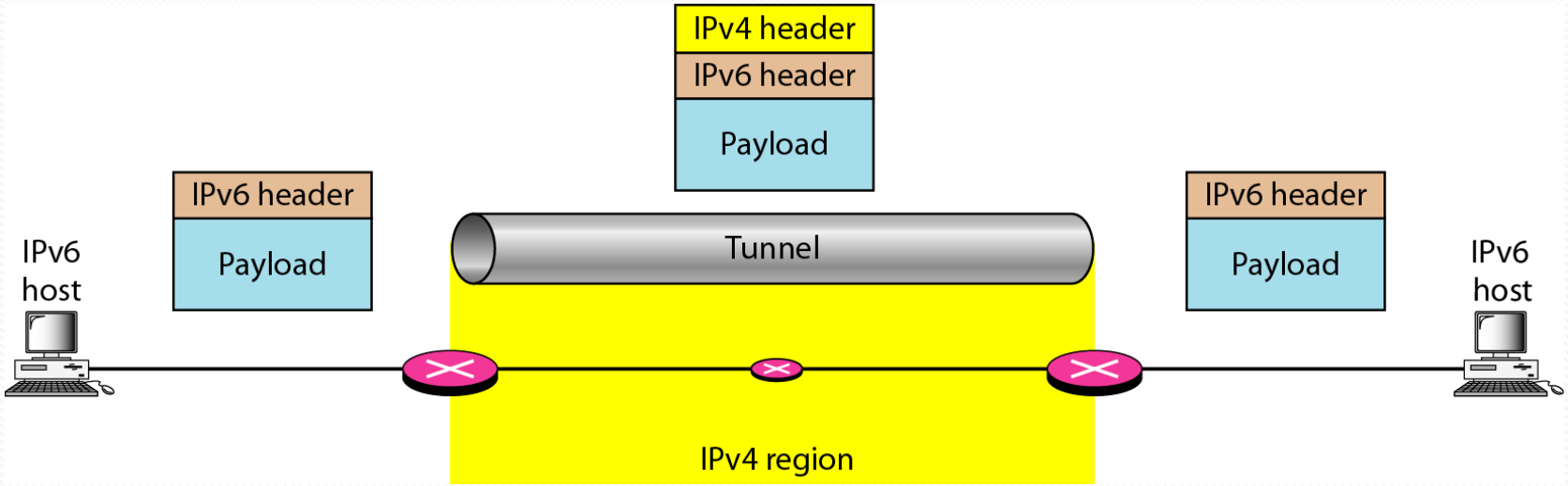
Transition From IPv4 to IPv6



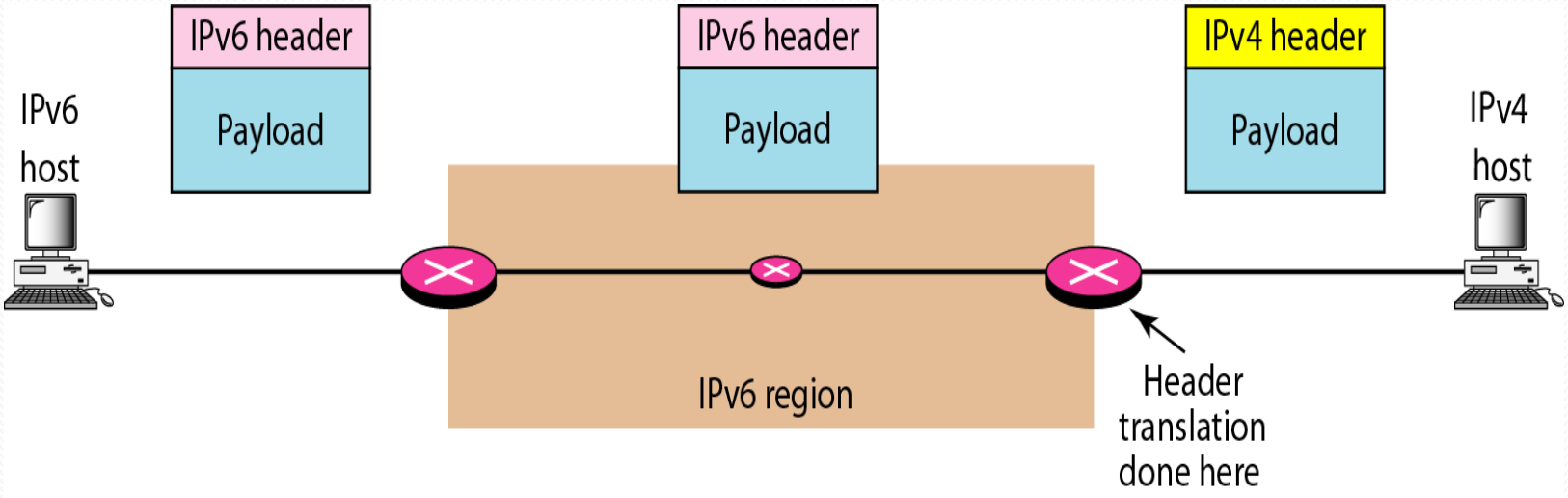
Dual stack


Transport and application layers
IPv4
IPv6
Underlying LAN or WAN technology
To IPv4 system
To IPv6 system

Tunneling strategy



Header translation strategy



Header Translation

Header Translation Procedure
1. The IPv6 mapped address is changed to an IPv4 address by extracting the rightmost 32 bits.
2. The value of the IPv6 priority field is discarded.
3. The type of service field in IPv4 is set to zero.
4. The checksum for IPv4 is calculated and inserted in the corresponding field.
5. The IPv6 flow label is ignored.
6. Compatible extension headers are converted to options and inserted in the IPv4 header. Some may have to be dropped.
7. The length of IPv4 header is calculated and inserted into the corresponding field.
8. The total length of the IPv4 packet is calculated and inserted in the corresponding field.