

IPv6 Addressing

ICT 2255

Introduction

- Reason for migration.
- 128 bits or 16 bytes or 16 octets.

Notation

- Binary
- Dotted-Decimal
 - To be compatible with IPv4.
 - Too long for 16-byte addresses.
- Colon Hexadecimal (colon hex)
 - 128 bits divided into 8 sections.
 - Each section is 2 Bytes.
 - Uses **hex** digits separated by a **colon**.

```
1111111011110110    ...    1111111100000000  
FEF6:BA98:7654:3210:ADEF:BBFF:2922:FF00
```

Colon Hexadecimal: Abbreviation

- Many of the digits are zeros, hence can be abbreviated.
- Leading zeros can be omitted.
- Zero Compression : Applied **only once per address**.

FDEC:0:0:0:0:BBFF:0:FFFF **→** **FDEC::BBFF:0:FFFF**

Mixed Representation

- Colon hex and dotted-decimal.
- Appropriate during the transition period in which an IPv4 address is embedded in an IPv6 address (as the rightmost 32 bits).
- Happens when **all or most** of the leftmost sections of the IPv6 address are 0s.
- Example
(::130.24.24.18)

CIDR Notation

- IPv6 uses hierarchical addressing.
- Hence, allows classless addressing and CIDR notation.
- Example: FDEC::BBAA:0:FFFF/60

Questions

- Show the unabbreviated colon hex notation for the following IPv6 addresses.
 - a. 64 0s followed by 64 1s.
 - b. 128 0s.
 - c. 128 1s.
 - d. 128 alternative 1s and 0s.
- Show the zero contraction version of the above addresses.

Questions

- Abbreviate:

- a. 0000: 0000: FFFF: 0000: 0000: 0000: 0000: 0000
- b. 1234: 5678: 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

Questions

- Decompress

a. 1111 :: 2222

b. ::

c. 0: 1 ::

d. AAAA: A: AA :: 1234

Address Types

- Unicast Address
- Anycast Address (No separate block assigned)
- Multicast Address
- Broadcasting??

Address Space

- 2^{128} addresses.
- 2^{96} times of IPv4.
- Current human population?
- With 16 billion humans (2^{34}), each person can have 2^{94} addresses.
- If we assign 2^{60} addresses to each user each year, it takes 2^{68} years to deplete address.

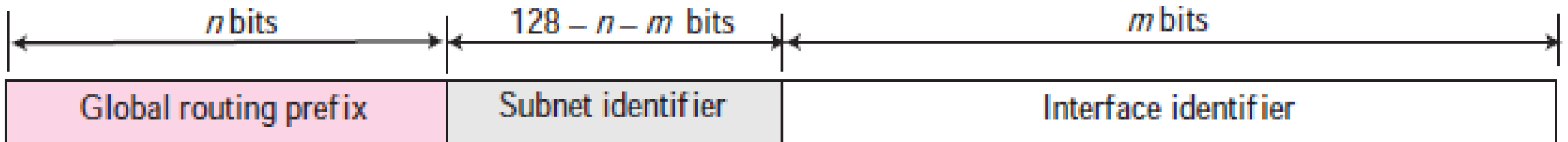
Address Space Allocation



$1/8 = 2^{125}$ addresses in each section.

Global Unicast Addresses

- Block Prefix : 001
- CIDR: 2000:: /3 → 3 leftmost bits are same for all addresses in the block.
- 3 Levels of Hierarchy.

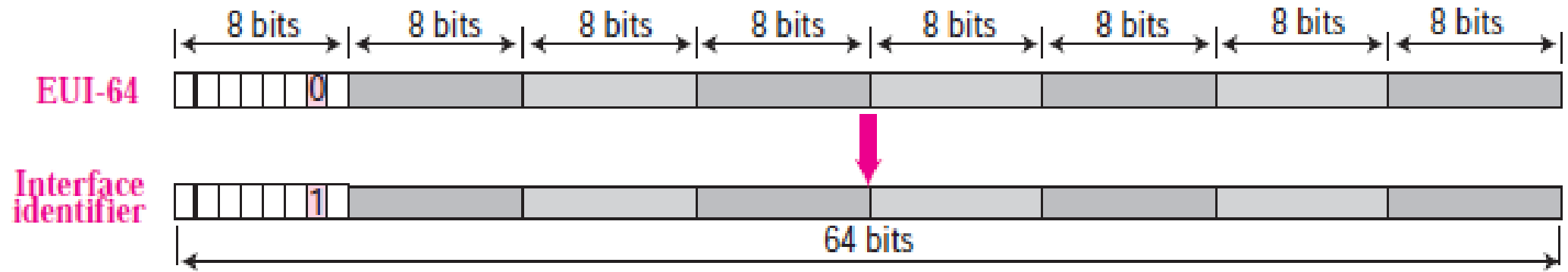


- Global Routing Prefix (48 bits):
 - Route the packet through the Internet to the organization site.
 - How many sites can be defined?
- Subnet Identifier (16 bits): How many subnets in an organization can be identified?

Global Unicast Addresses: Interface Identifier

- 64 bits (similar to hostid in IPv4). Nomenclature?
- Relation between the hostid (at the IP level) and MAC address (at DLL).
 - Not possible in IPv4. Why?
 - Possible in IPv6, albeit with a **constraint**.
- Embedding facility of physical address eliminates the mapping process.
- Two common physical addressing schemes to be considered:
 - Extended Unique Identifier (EUI-64) defined by IEEE.
 - MAC address defined by ethernet.

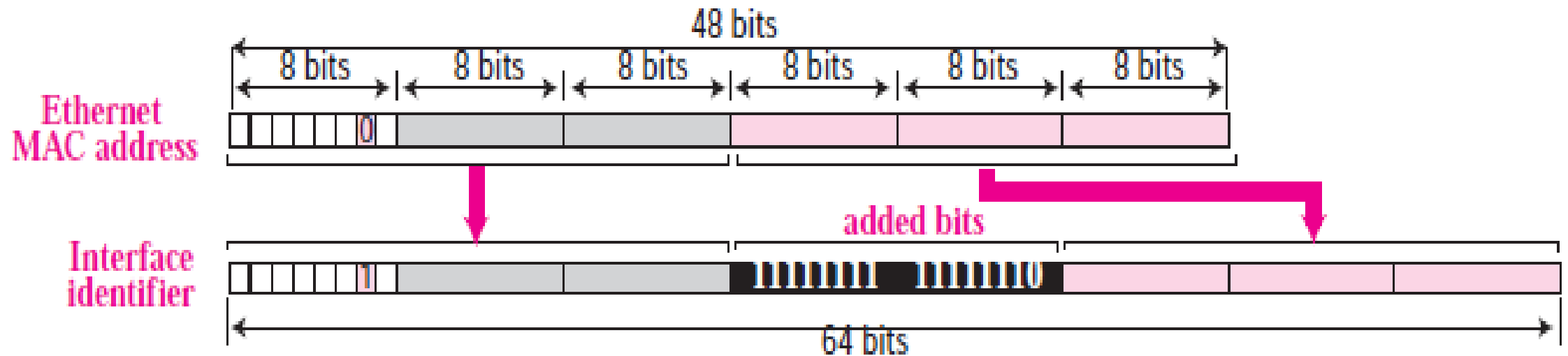
EUI-64 to Interface Identifier



- Find the interface identifier if the physical address in the EUI is

$(F5-A9-23-EF-07-14-7A-D2)_{16}$

MAC address to Interface Identifier



- Find the interface identifier if the Ethernet physical address is

$(F5-A9-23-EF-07-14-7A-D2)_{16}$

Questions

Q: 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?

Ans: 2000:1456:2474:0000/64 and 2000:1456:2474:0001/64.

Q: 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**?

Ans: 2000:1456:2474:0002:F7A9:23FF:FE14:7AD2/128

IPv4 Compatible

Reserved/Assigned: First Section

A: 1/256	B: 1/256	D: 1/64	F: 1/16
C: 1/128			
E: 1/32			

Reserved/Assigned: First Section

	<i>Block Prefix</i>	<i>CIDR</i>	<i>Block Assignment</i>	<i>Fraction</i>
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

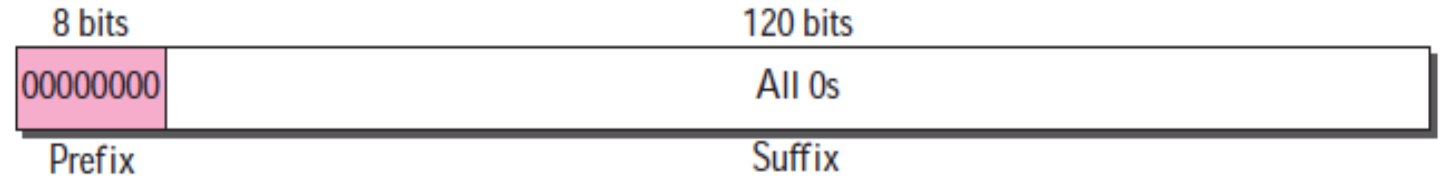
How many addresses for the first sub-block?

$$2^{120}$$

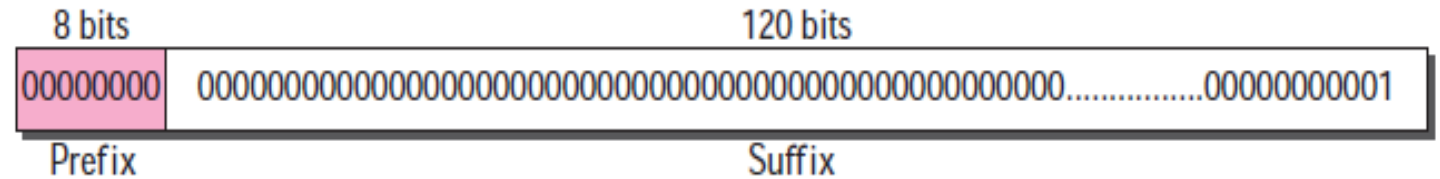
Reserved/Assigned: First Section

- Unspecified Address (::/128)

- Used during Bootstrap.

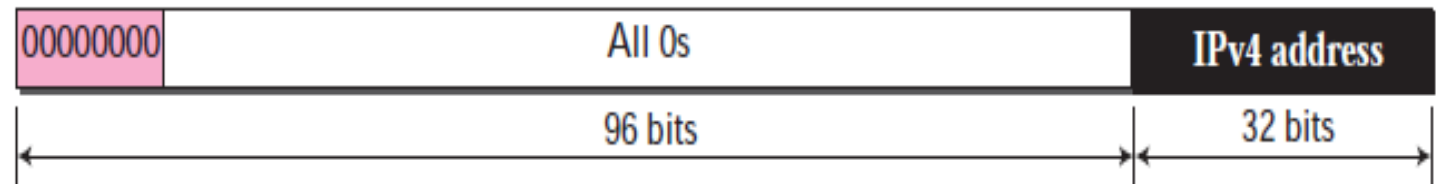


- Loopback Address (::1/128)

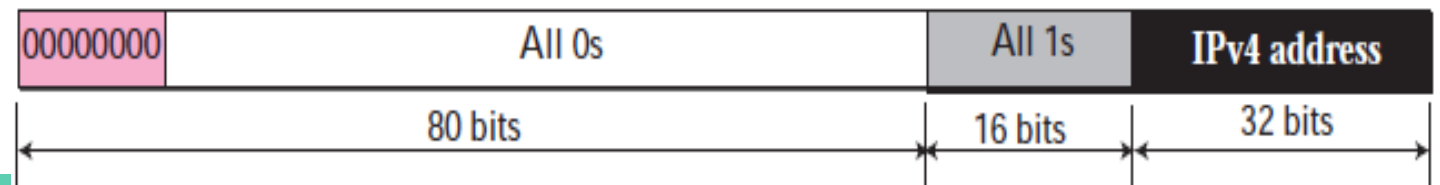


- Embedded IPv4 Address

Compatible



Mapped



Address Space Allocation



$1/8 = 2^{125}$ addresses in each section.

Reserved/Assigned: Last Section			
9	100	1000	Reserved
10	100	1000	Reserved
11	100	1000	Reserved
12	1000	10000	Reserved
13	10000	100000	Reserved
14	100000	1000000	Reserved
15	1000000	10000000	Reserved
16	10000000	100000000	Reserved
17	100000000	1000000000	Reserved
18	1000000000	10000000000	Reserved
19	10000000000	100000000000	Reserved
20	100000000000	1000000000000	Reserved
21	1000000000000	10000000000000	Reserved
22	10000000000000	100000000000000	Reserved
23	100000000000000	1000000000000000	Reserved
24	1000000000000000	10000000000000000	Reserved
25	10000000000000000	100000000000000000	Reserved
26	100000000000000000	1000000000000000000	Reserved
27	1000000000000000000	10000000000000000000	Reserved
28	10000000000000000000	100000000000000000000	Reserved
29	100000000000000000000	1000000000000000000000	Reserved
30	1000000000000000000000	10000000000000000000000	Reserved
31	10000000000000000000000	100000000000000000000000	Reserved
32	100000000000000000000000	1000000000000000000000000	Reserved
33	1000000000000000000000000	10000000000000000000000000	Reserved
34	10000000000000000000000000	100000000000000000000000000	Reserved
35	100000000000000000000000000	1000000000000000000000000000	Reserved
36	1000000000000000000000000000	10000000000000000000000000000	Reserved
37	10000000000000000000000000000	100000000000000000000000000000	Reserved
38	100000000000000000000000000000	1000000000000000000000000000000	Reserved
39	1000000000000000000000000000000	10000000000000000000000000000000	Reserved
40	10000000000000000000000000000000	100000000000000000000000000000000	Reserved
41	100000000000000000000000000000000	1000000000000000000000000000000000	Reserved
42	1000000000000000000000000000000000	10000000000000000000000000000000000	Reserved
43	10000000000000000000000000000000000	100000000000000000000000000000000000	Reserved
44	100000000000000000000000000000000000	1000000000000000000000000000000000000	Reserved
45	1000000000000000000000000000000000000	10000000000000000000000000000000000000	Reserved
46	10000000000000000000000000000000000000	100000000000000000000000000000000000000	Reserved
47	100000000000000000000000000000000000000	1000000000000000000000000000000000000000	Reserved
48	1000000000000000000000000000000000000000	100	Reserved
49	100	1000	Reserved
50	1000	100	Reserved
51	100	1000	Reserved
52	1000	100	Reserved
53	100	1000	Reserved
54	1000	100	Reserved
55	100	1000	Reserved
56	1000	100	Reserved
57	100	1000	Reserved
58	1000	100	Reserved
59	100	1000	Reserved
60	1000	100	Reserved
61	100	1000	Reserved
62	1000	100	Reserved
63	100	1000	Reserved
64	1000	100	Reserved
65	100	1000	Reserved
66	1000	100	Reserved
67	100	1000	Reserved
68	1000	100	Reserved
69	100	1000	Reserved
70	1000	100	Reserved
71	100	1000	Reserved
72	1000	100	Reserved
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74	1000	100	Reserved
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76	1000	100	Reserved
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79	100	1000	Reserved
80	1000	100	Reserved
81	100	1000	Reserved
82	1000	100	Reserved
83	100	1000	Reserved
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85	100	1000	Reserved
86	1000	100	Reserved
87	100	1000	Reserved
88	1000	100	Reserved
89	100	1000	Reserved
90	1000	100	Reserved
91	100	1000	Reserved
92	1000	100	Reserved
93	100	1000	Reserved
94	1000	100	Reserved
95	100	1000	Reserved
96	1000	100	Reserved
97	100	1000	Reserved
98	1000	100	Reserved
99	100	1000	Reserved
100	1000	100	Reserved

(The previous assignment for private addressing was within the first and last of the last row)

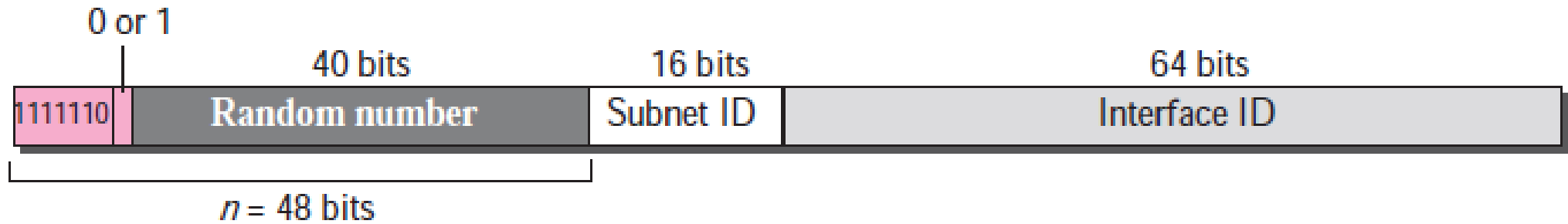
Reserved/Assigned: Last Section

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

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

Unique Local Unicast Block

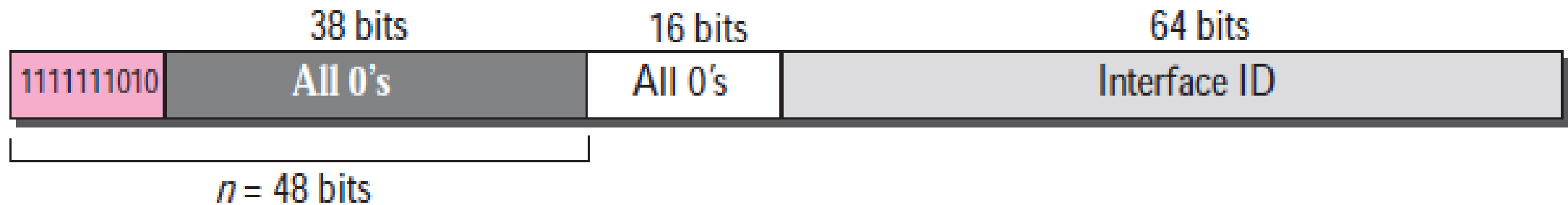
- A subblock in a **unique local unicast block** can be **privately created and used by a site**.



- The packet carrying this type of address as the destination address is **not expected to be routed**.
- 8th bit can be 0 or 1 to define how the address is selected (locally or by an authority).
- First 48 bits defines a subblock that looks like a global unicast address.

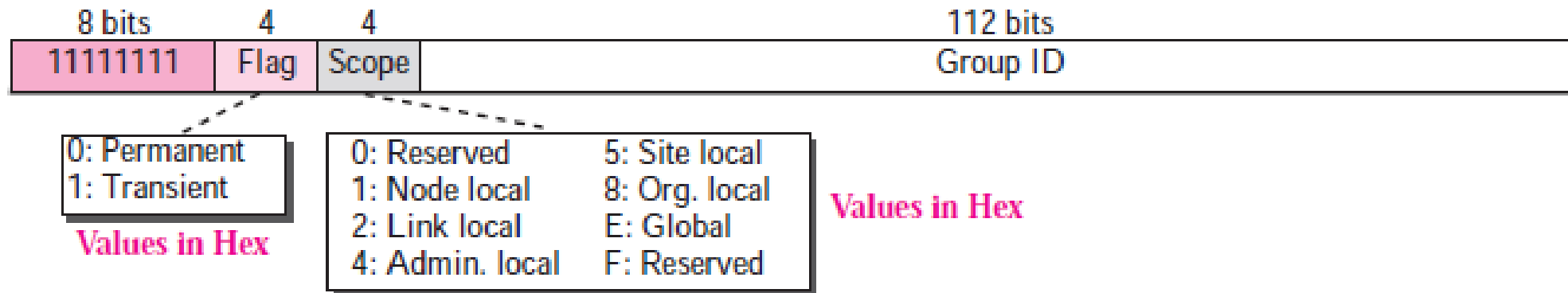
Link Local Block

- A subblock in this block can be used as a **private address in a network**.
- Has the block identifier 1111111010. The next 54 bits are set to zero.
- The last 64 bits can be changed to define the interface for each computer.



Multicast Block

- Multicast addresses are used to define a **group of hosts** instead of just one.
- In IPv6 a large block of addresses are assigned for multicasting.
- The third field defines the **scope of the group** address.



Autoconfiguration

1. The host first creates a link local address for itself. How?
2. The host then tests to see if this link local address **is unique** and not used by other hosts.
 - Sends a ***neighbor solicitation message*** and waits for ***neighbor advertisement message***.
 - If fails, uses other means for the purpose.
3. The host stores this address as its link-local address (for ?) and generates a global unicast address.
 - Sends a ***router solicitation message*** to a local router and waits for ***router advertisement message*** (content?).

Question

- Assume a host with Ethernet address (**F5-A9-23-11-9B-E2**)₁₆ has joined the network.
- Global unicast prefix of the organization is 3A21:1216:2165.
- Subnet identifier is A245.
- What would be its global unicast address ?

Renumbering

- **Renumbering** of the address prefix (n) was built into IPv6 addressing.
- 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.
- During the transition period, a site has two prefixes.
- Problem?

Book

- Behrouz A. Forouzan, “TCP/IP Protocol Suite”, 4th Ed. Chapter 26.