Internet Architecture
Second Stage
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Lecture 3

IPv6 Addressing

Part 3

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.

Three Levels of Hierarchy

❑ An address in this block is divided into three parts:

➢ **Global Routing Prefix.**
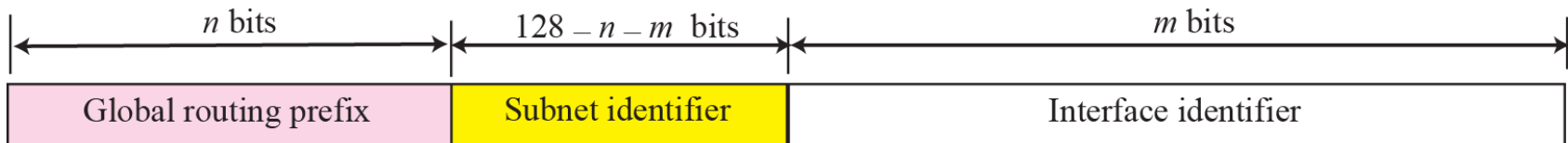
➢ **Subnet Identifier**

➢ **Interface Identifier.**

n bits	$128 - n - m$ bits	m bits
Global routing prefix	Subnet identifier	Interface identifier
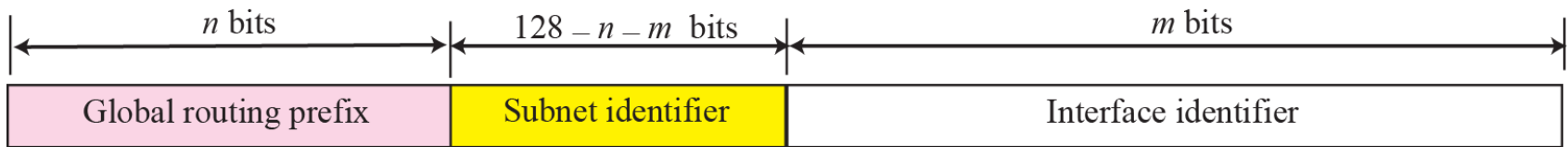
❑ Recommended length of the different parts are shown in the following Table.

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

❑ The first **48 bits** of a global unicast address are called **global routing prefix**. These **48 bits** are used to route the packet through the Internet to the organization site such as ISP that owns the block. Since the first three bits in this part is fixed (**001**), the rest of the **45 bits** can defined up to 2^{45} sites (a private organization or an ISP).

❑ The global routers in the Internet route a packet to its destination site based on the value of **n**.

n bits	$128 - n - m$ bits	m bits
Global routing prefix	Subnet identifier	Interface identifier

❑ The next **16 bits** defines a subnet in an organization. This means that an organization can have up to 2^{16}= **65536** subnets, which is more than enough.

❑ The last **64 bits** define **the interface identifier**.

❑ **The interface identifier** is similar to hosted in IPv4 addressing although the term interface identifier is a better choice because the host identifier actually defines the interface not the host. If the host is moved from one interface to another, its IP address needs to be changed.

❑ Two common physical addressing scheme can be considered for this purpose:

❑ **64-bit Extended Unique Identifier** (**EUI-64**) defined **by IEEE** .

❑ **48-bit** physical address defined **by Ethernet**.

❑ To map a **64-bit** physical address, the global/local bit of this format needs to be changed from **0** to **1** (**local to global**) to define **an interface address**.
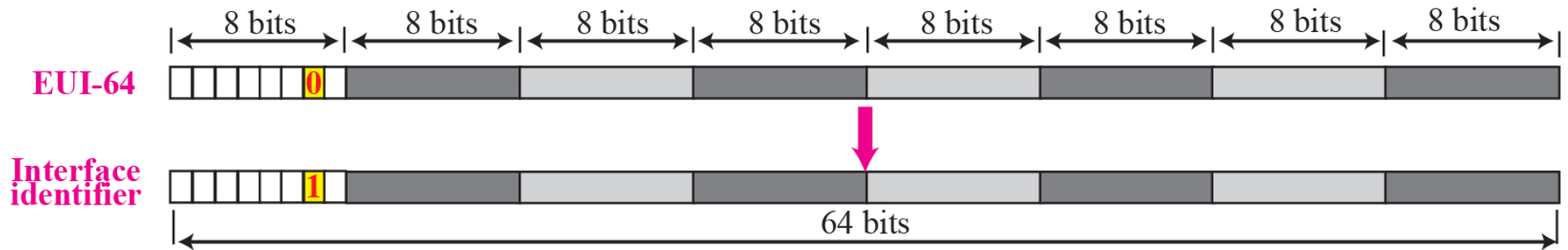
❑ Mapping a **48-bit** Ethernet address into a **64-bit** interface identifier is more involved. We need to change the **local/global bit** to **1** and insert an additional **16 bits**.

❑ The additional **16 bits** are defined as **15 ones** followed by **one zero**, or **FFFE$_{16}$**.
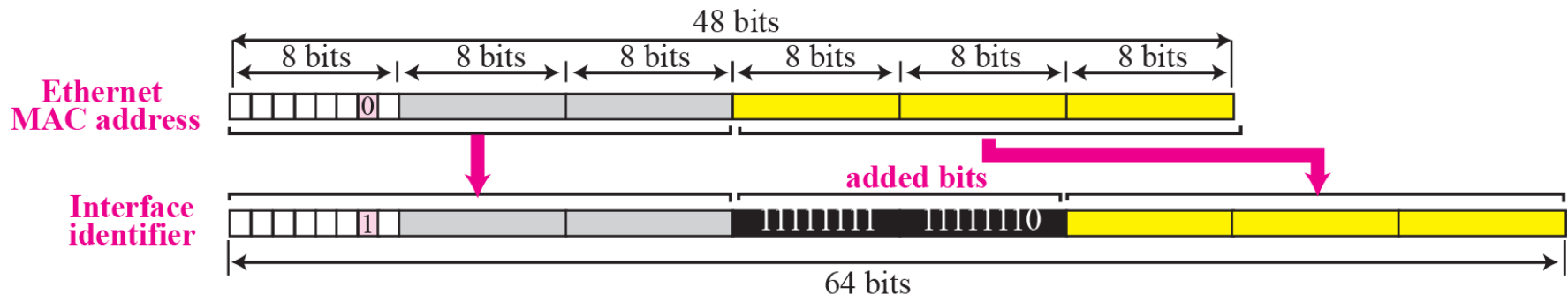
Example 1

Find the interface identifier if the physical address in the EUI is $(F5-A9-23-EF-07-14-7A-D2)_{16}$ 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 2

Find the interface identifier if the Ethernet physical address is $(\text{F5-A9-23-14-7A-D2})_{16}$ 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 3

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

2000:1456:2474:0001/64
and
2000:1456:2474:0002/64.

Example 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 is F7A9:23FF:FE14:7AD2. If we add this identifier to the global prefix and the subnet identifier, we get:

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

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.

When a host in IPv6 joins a network, it can configure itself using the following process:

1. The host first creates a link local address for itself. This is by taking the **10-bit** link local prefix (**1111 1110 10**), adding **54 zeros**, and adding the **64-bit** interface identifier, which any host knows how to generate it from its interface card. The result is a **128-bit** link local address.

2. The host then tests to see if this link local address is unique and not used by other hosts. Since the **64-bit** interface identifier is supposed to be unique, the link local address generated is unique with a high probability. However, to be sure, the host sends a *neighbor solicitation message* and waits for *neighbor advertisement message.* If any host in the subnet is using this link local address, the process fails and the host cannot autoconfigure itself; it needs to use other means such as DHCP protocol for this purpose.

3.   If the uniqueness of the link local address is passed, the host stores this address as its link local address (for private communication), but it still needs a global unicast address. The host then sends a router solicitation to a local router. If there is a router running on the network, the host receives a router advertisement message that includes the global unicast prefix and the subnet prefix that the host needs to add to its interface identifier to generate its global unicast address. If the router cannot help the host with the configuration, it informs the host in the router advertisement message (by setting a flag). The host then needs to use other means for configuration.

Example 5

Assume a host with Ethernet address (F5–A9–23–11–9B–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 5 *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

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.

IPv6