



Ecole Supérieure
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Routing and Switching

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Evaluation



Lab Report+ Quiz:**10%**

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Chapter 5 : IPv6

Topics:

- **IPv6 Addressing scheme**
- **IPv6 Address Plan**
- **IPv6 Address Types**
- **IPv6 Address Scopes**
- **IPv6 and Subnetting**

IPv6 Addressing Rules

- **128 bits (or 16 bytes) long:** four times as long as its predecessor.
- 2^{128} : about 340 billion billion billion billion different addresses
- **Colon hexadecimal notation:**
 - addresses are written using 32 hexadecimal digits.
 - digits are arranged into 8 groups of four to improve the readability.
 - Groups are separated by colons
- **2001:0718:1c01:0016:020d:56ff:fe77:52a3**
- Note:
 - DNS plays an important role in the IPv6 world
 - manual typing of IPv6 addresses is not an easy thing,
 - Some **zero suppression rules** are allowed to lighten this task at least a little.

IPv6 Address Notation: Example

128.91.45.157.220.40.0.0.0.0.252.87.212.200.31.255

Binary

```
1000000001011011001011011001110111011100001010000000000000000000  
000000000000000001111100010101111101010011001000000111111111111
```

Dotted Decimal

128	91	45	157	220	40	0	0	0	0	252	87	212	200	31	255
-----	----	----	-----	-----	----	---	---	---	---	-----	----	-----	-----	----	-----

Hexadecimal

0

32

64

96

128

Straight Hex

805B

2D9D

DC28

0000

0000

FC57

D4C8

1FFF

Leading-Zero Suppressed

805B

2D9D

0

0

FC57

D4C8

1FFF

Zero-Compressed

805B

2D9D



FC57

D4C8

1FFF

Mixed Notation

805B

2D9D

FC57

212 | 20

31	25
----	----

Rule 1- IPv6 Zero Suppression

- ✓ Some types of addresses contain long sequences of zeros.
- ✓ To further simplify the representation of IPv6 addresses, a contiguous sequence of 16-bit blocks set to 0 in the colon hexadecimal format can be compressed to “::”, **known as double-colon.**

- ✓ For example:

link-local address

FE80:0:0:0:2AA:FF:FE9A:4CA2 → FE80::2AA:FF:FE9A:4CA2.

multicast address

FF02:0:0:0:0:0:0:2 → FF02::2

loopback address

0:0:0:0:0:0:0:1 → ::1

Rule 1- IPv6 Zero Suppression

- ✓ Zero compression can only be used to compress a single contiguous series of 16-bit blocks expressed in colon hexadecimal notation.
- ✓ You cannot use zero compression to include part of a 16-bit block.

For example,

cannot express FF02:30:0:0:0:0:0:5 as FF02:3::5

correct representation = FF02:30::5

Leading zeroes in every group can be omitted.

2001:718:1c01:16:20d:56ff:fe77:52a3

Rule 1- IPv6 Zero Suppression

To determine the number of 0 bits represented by the “::”

1. count the number of blocks in the compressed address
2. (-) subtract this number from 8
3. (*) multiply the result by 16.

For example

1. FF02::2
2. two blocks - “FF02” block and “2” block.
3. The number of bits expressed by the “::” is 96 ($96 = (8 - 2) \times 16$).

Zero compression can only be used once in a given address.

Otherwise, you could not determine the number of 0 bits represented by each instance of “::”.

IPv6 Prefixes

- ✓ The prefix is the part of the address that indicates the bits that have fixed values or are the bits of the subnet prefix.
- ✓ Prefixes for IPv6 subnets, routes, and address ranges are expressed in the same way as Classless Inter-Domain Routing (CIDR) notation for IPv4.
- ✓ An IPv6 prefix is written in *address/prefix-length* notation.
For example, **21DA:D3::/48** and **21DA:D3:0:2F3B::/64** are IPv6 address prefixes.
- ✓ **Note** IPv4 implementations commonly use a dotted decimal representation of the network prefix known as the subnet mask. A subnet mask is not used for IPv6. Only the prefix length notation is supported.

IPv6 Prefixes

- When writing both a node address and a prefix of that node address (e.g., the node's subnet prefix), the two can be combined as follows:

- The node address:

12AB:0:0:CD30:123:4567:89AB:CDEF

- And its subnet number:

12AB:0:0:CD30::/60

- Can be represented as

12AB:0:0:CD30:123:4567:89AB:CDEF/60

IPv6 Addresses: Types and scopes

- IPv6 addresses come in different **types** (Unicast, multicast, anycast) and different **scopes** (link, global, and so on).
- The **type** of the address determines if packets are destined for one or for many machines.
- The **scope** of the address determines which contexts the address makes sense in.
- IPv6 addresses are assigned to interfaces on nodes, not to the nodes themselves. This is a big change from IPv4, where very often the address associated with a machine's interface is that machine. Instead, IPv6 interfaces commonly and usefully have more than one IPv6 address.

IPv6 Address Categories

There are 3 categories of addresses in IPv6:

- **Unicast**

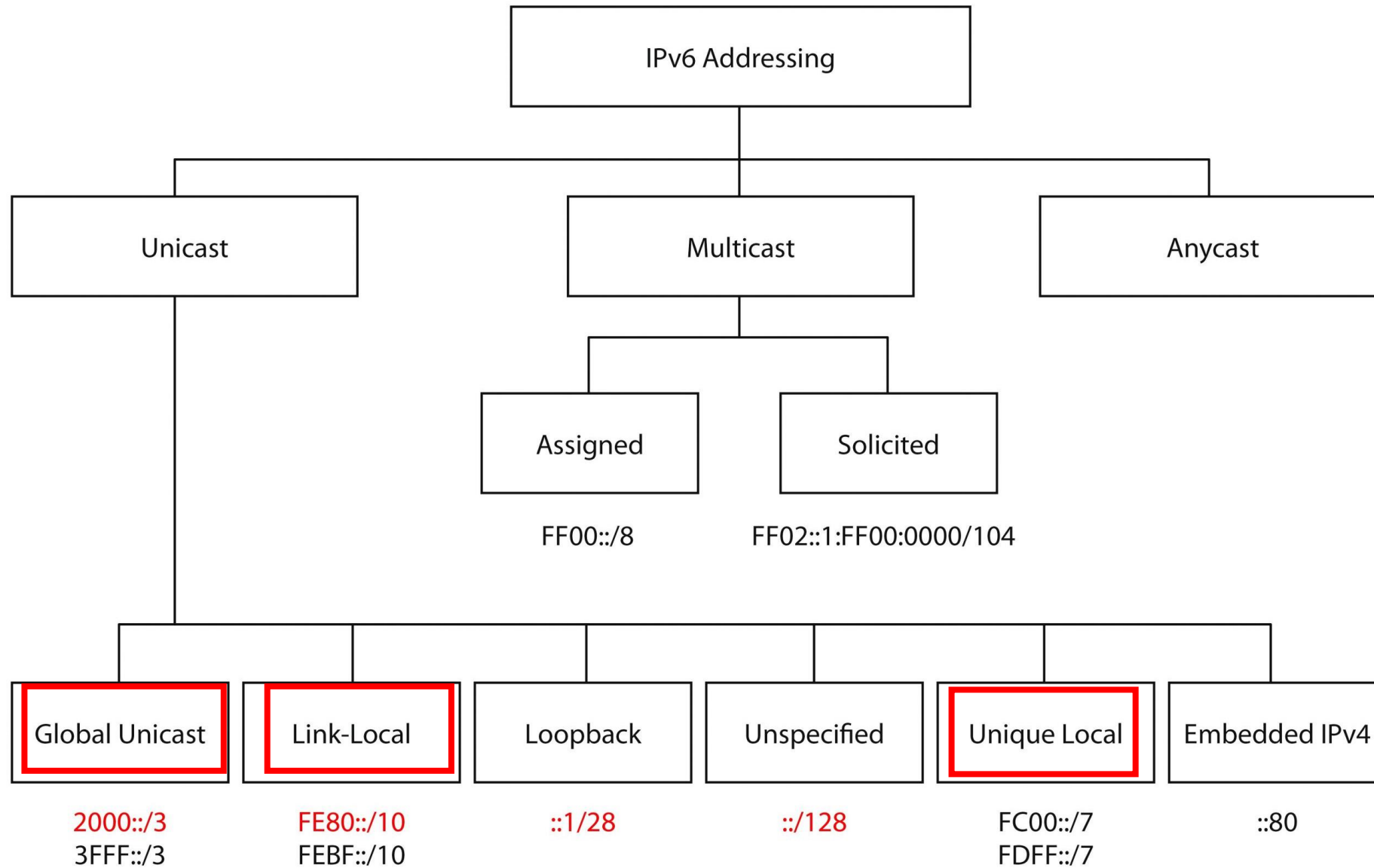
A unicast address uniquely identifies an interface of an IPv6 node. A packet sent to a unicast address is delivered to the interface identified by that address.

- **Multicast**

A multicast address identifies a group of IPv6 interfaces. A packet sent to a multicast address is processed by all members of the multicast group.

- **Anycast**

An anycast address is assigned to multiple interfaces (usually on multiple nodes). A packet sent to an anycast address is delivered to only one of these interfaces, usually the nearest one.



IPv6 Addresses scopes



Address Types and Scope

Global Unicast Address --Scope Internet- Routed on Internet

Unique Local -- Scope Internal Network or VPN -Internally routable but Not routed on Internet

Link Local - Scope network link- Not Routed internally or externally.

IPv6 Unicast Address Scopes

Three types of scopes:

- 1. Link-local scope**

Identifies all hosts within a single layer 2 domain.

Called as **link-local addresses**

- 2. Unique-local scope**

Identifies all devices reachable within an administrative site or domain typically contains multiple distinct links.

Called as **unique-local addresses (ULAs)**

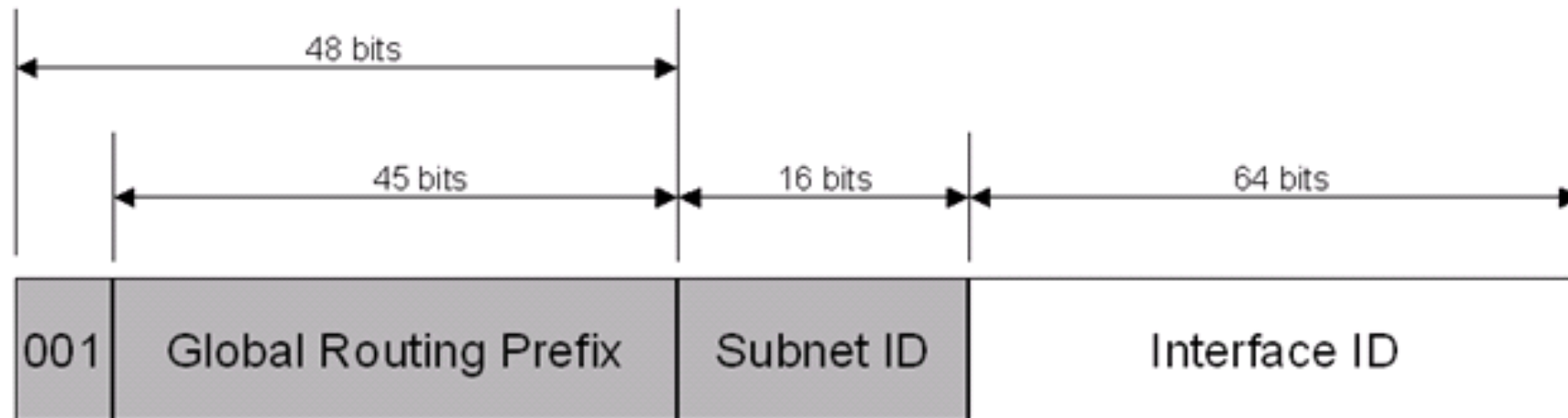
- 3. Global scope**

Identifies all devices reachable across the Internet.

Called as **global unicast addresses (GUAs)**

Global Unicast addresses

- Equivalent to public IPv4 addresses.
- Globally routable and reachable on the IPv6 portion of the Internet.
- The scope of a global unicast address is the entire IPv6 Internet.
- Global scoped communication are identified by high-level 3 bits set to 001 (2000::/3)



Global Unicast addresses

Each aggregatable global unicast IPv6 address has three parts:

Fixed portion set to 001 – The three high-order bits are set to 001. The address prefix for currently assigned global addresses is 2000::/3.

Global Routing Prefix – Site Prefix

Site prefix assigned to an organization (leaf site) by a provider should be at least a /48 prefix = 45 + high-order bits (001).

/48 prefix represents the high-order 48-bit of the network prefix.

prefix assigned to the organization is part of the provider's prefix.

Subnet-id - Site

With one /48 prefix allocated to an organization by a provider, it is possible for that organization to enable up to 65,535 subnets (assignment of 64-bit's prefix to subnets).

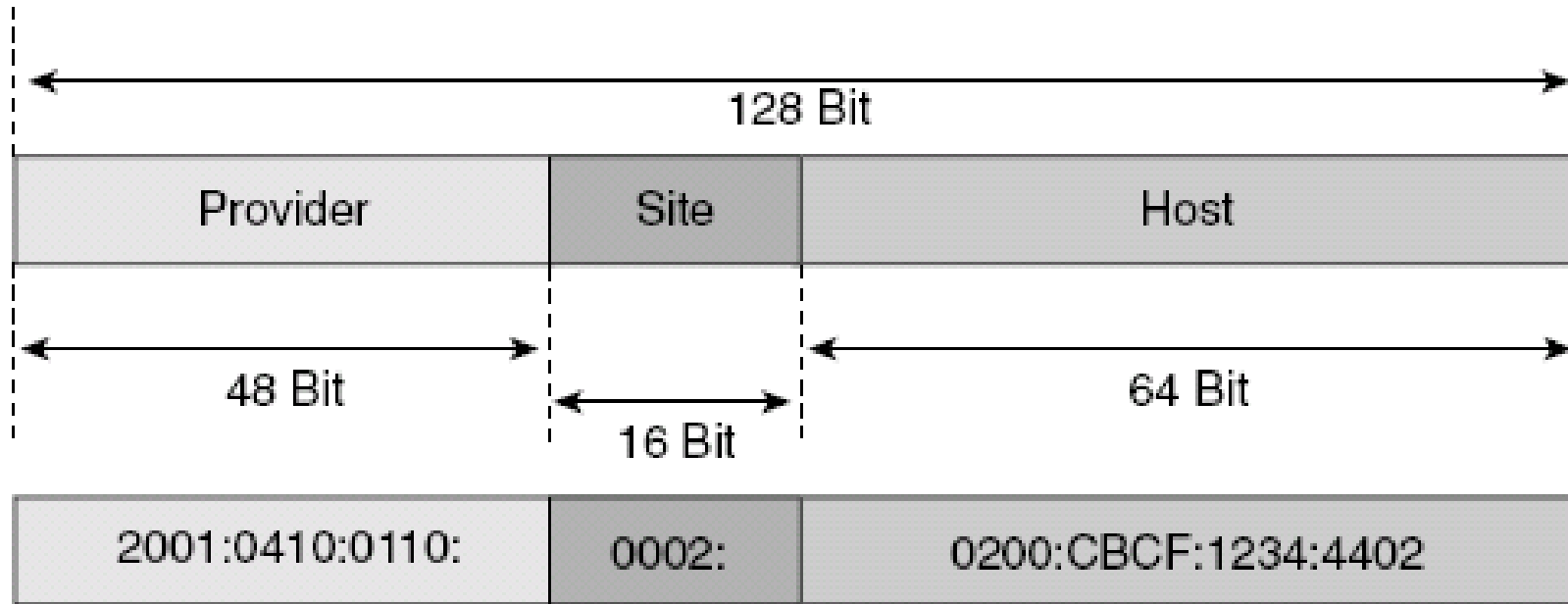
The organization can use bits 49 to 64 (16-bit) of the prefix received for subnetting.

Interface-id – Host

The host part uses each node's interface identifier.

This part of the IPv6 address, which represents the address's low-order 64-bit, is called the *interface ID*.

Global Unicast addresses



2001:0410:0110::/48 is assigned by a provider

2001:0410:0110:0002::/64 network subnet within the organization

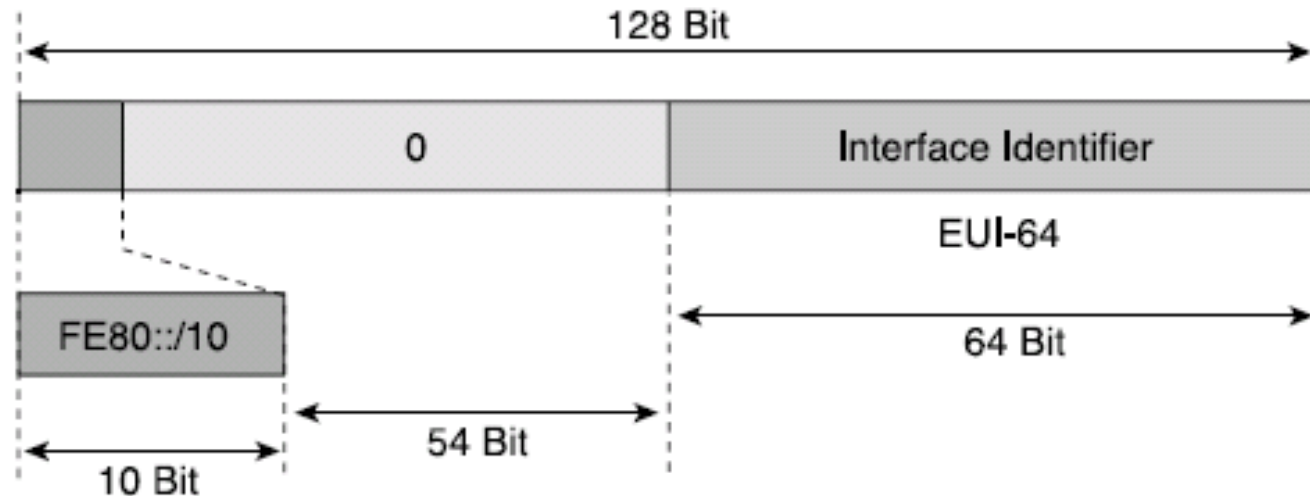
2001:0410:0110:0002:0200:CBCF:1234:4402 – node address within the subnet

Link-local Unicast Address

- IPv6 link-local addresses are equivalent to IPv4 link-local addresses defined in RFC 3927 that use the 169.254.0.0/16 prefix.
- The scope of a link-local address is the local link.
- A link-local address is required for Neighbor Discovery (NDP) processes and is always automatically configured, even in the absence of all other unicast addresses.

Link-local Unicast Address

- ✓ Used only between nodes connected on the same local link.
- ✓ When an IPv6 stack is enabled on a node, one link-local address is automatically assigned to each interface of the node at boot time.
- ✓ IPv6 **link-local prefix FE80::/10** is used and the **interface identifier in Extended Unique Identifier 64 (EUI-64)** format is appended as the address's low-order 64-bit.
- ✓ Bits 11 through 64 are set to 0 (54-bit).
- ✓ Link-local addresses are only for local-link scope and must never be routed between subnets within a site.



EUI-64 Identifier

- The interface identifiers for IPv6 unicast addresses are used to **identify interfaces on a given link**.

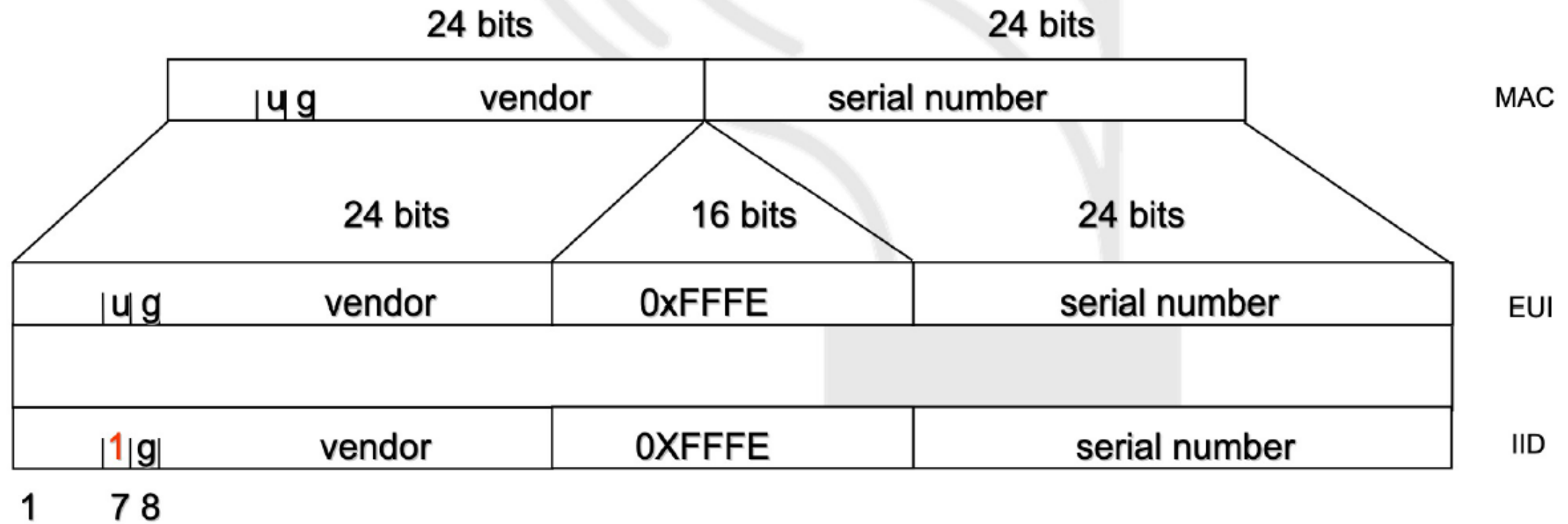
Therefore, this identifier must be **unique within a given subnet**, and in some cases, it can also be **unique on a larger scale**, even **globally** (across the Internet).

- In some cases, the identifier is **directly derived from the MAC address** (Layer 2) of the interface

EUI-64 Identifier

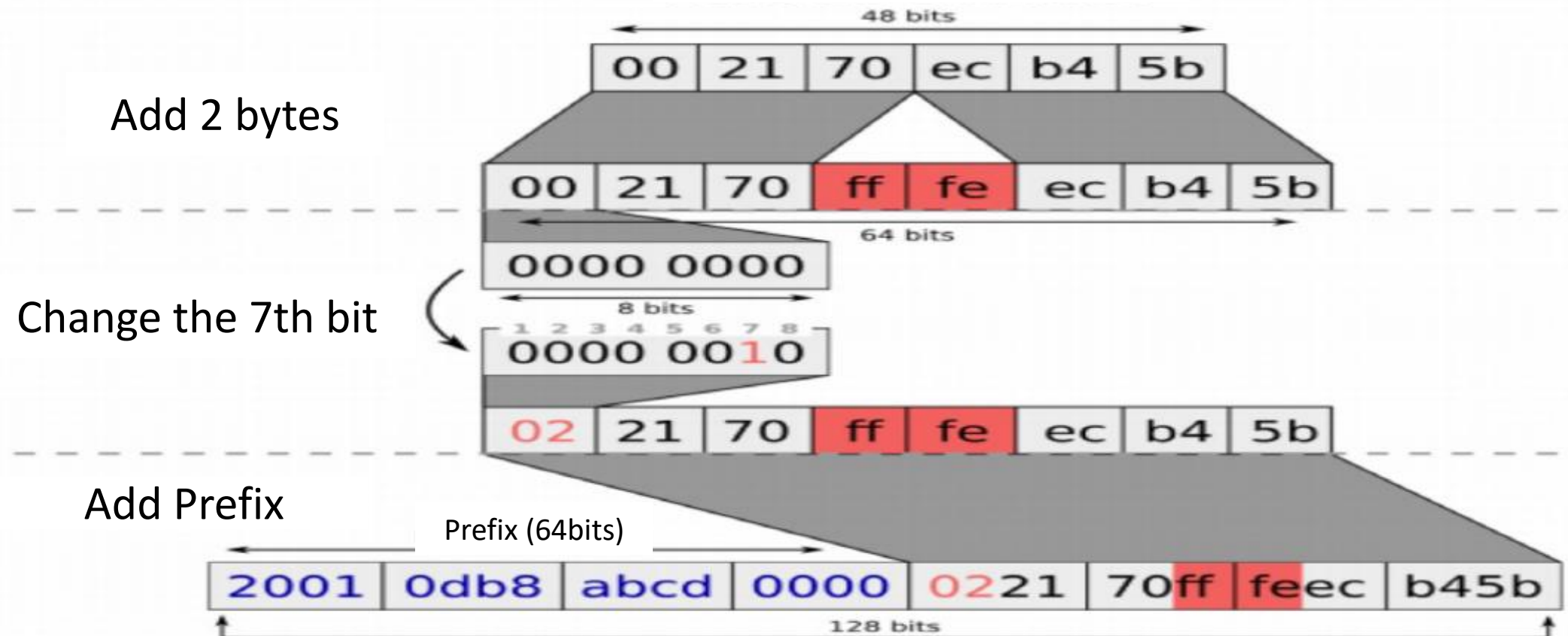
```
eth0    Link encap:Ethernet  HWaddr 08:00:27:78:fc:dc  
        inet addr:172.16.40.2  Bcast:172.16.255.255  Mask:255.255.0.0  
        inet6 addr: 2001:db8:46:0:a00:27ff:fe78:fcdc/64 Scope:Global  
        inet6 addr: fe80::a00:27ff:fe78:fcdc/64 Scope:Link  
        UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1  
        RX bytes 1408 (13.5 KiB)  TX bytes 0 (0 B)
```

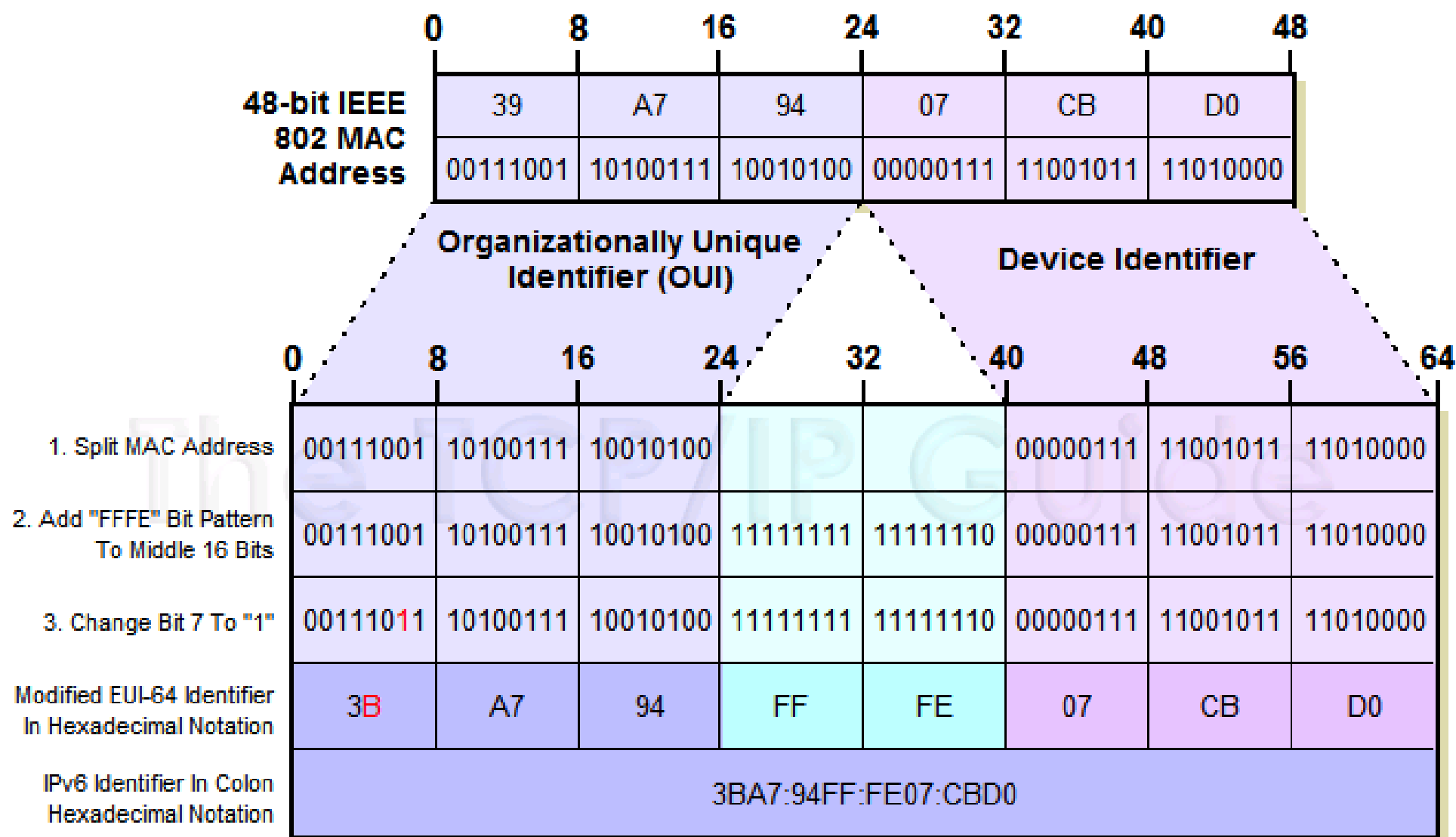
EUI-64 Identifier



EUI-64 Identifier

Ethernet Address





64-Bit IPv6 Modified EUI-64 Interface Identifier

Special IPv6 Addresses

The following are special IPv6 addresses:

Unspecified address

- ✓ unspecified address (0:0:0:0:0:0:0:0 or ::) is only used to indicate the absence of an address.
- ✓ equivalent to the IPv4 unspecified address of 0.0.0.0.
- ✓ used as a source address for packets attempting to verify the uniqueness of a tentative address.
- ✓ never assigned to an interface or used as a destination address.

Loopback address

- ✓ The loopback address (0:0:0:0:0:0:0:1 or ::1) is used to identify a loopback interface, enabling a node to send packets to itself.
- ✓ It is equivalent to the IPv4 loopback address of 127.0.0.1.
- ✓ Packets addressed to the loopback address must never be sent on a link or forwarded by an IPv6 router.



NO BROADCAST IN IPV6

Multicast Address

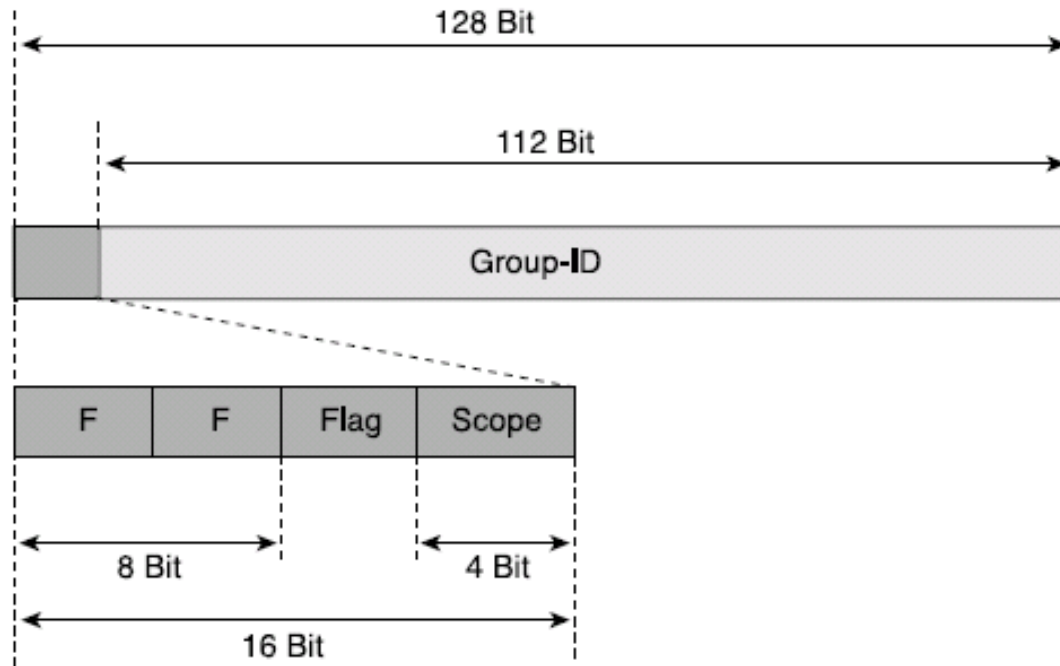
- ✓ In IPv6, multicast traffic operates in the same way that it does in IPv4.
- ✓ Nodes can join or leave a multicast group at any time.
- ✓ IPv6 multicast addresses have the **first eight bits set to 1111 1111**.
- ✓ An IPv6 address is easy to classify as multicast because it always begins with “**FF**”.
- ✓ Multicast addresses cannot be used as source addresses or as intermediate destinations in a Routing extension header.
- ✓ Beyond the first eight bits, multicast addresses include additional structure to identify their flags, scope, and multicast group.

Multicast Address

- ✓ Main goal of multicasting is having an efficient network to save bandwidth on links by optimizing the number of packets exchanged between nodes
- ✓ In IPv4:
224.0.0.0/3, where the high-order 3-bit of the IPv4 address is set to 111
- ✓ In IPv6:

Representation	Value
Preferred format	FF00:0000:0000:0000:0000:0000:0000:0000/8
Compressed format ¹	FF00:0:0:0:0:0:0:0/8
Compressed format	FF00::/8
Binary format	High-order 8-bit is set to 1111 1111

Multicast Address



- ✓ High-order 3-bit of the Flag field is reserved and must be initialized using 0 values.
- ✓ Remaining bit indicates the type of multicast address.

Multicast Address



- ✓ The prefix associated with multicast addresses is **FF00::/8**, meaning addresses range from **FF00 to FFFF**.

The **Scope field** defines a state associated with the multicast address over **4 bits**:

ORTP

T (1 or 0) → *Temporary flag*: specifies whether the address is **temporary (1)** or **permanent (0)**

P (1 or 0) → *Prefix flag*: specifies whether the address is **based on a network prefix (1)** or **not (0)**

R (1 or 0) → *R flag*: specifies whether the address is **constructed from a network, router, or server address**

Scope

- ✓ 0: Reserved
- ✓ 1: Interface local
- ✓ 2: Link-local
- ✓ 3: Subnet-local
- ✓ 4: Admin-local
- ✓ 5: Site-local
- ✓ 8: Organization-local
- ✓ E: Global
- ✓ F: Reserved

Anycast Address

- ✓ Anycast addresses can be considered a conceptual cross between unicast and multicast addressing.

Unicast → send to this one address

Multicast → send to every member of this group

Anycast → send to any one member of this group

- ✓ In choosing which member to send to, for efficiency reasons normally send to the closest one - closest in routing terms.

So, anycast mean **“send to the closest member of this group”**.

- ✓ The network itself plays the key role in anycast by routing the packet to the nearest destination by measuring network distance.
- ✓ Anycast addresses use aggregatable global unicast addresses.
- ✓ They can also use site-local or link-local addresses.
- ✓ Note that it is impossible to distinguish an anycast address from a unicast address.

Anycast Address

Representation	Reserved anycast address
Preferred format	<i>UNICAST_PREFIX</i> :0000:0000:0000:0000, where <i>UNICAST_PREFIX</i> is a 64-bit value
Binary format	Bits 65 through 128 are set to 0

- Also called the **subnet-router anycast address**.
- All IPv6 routers are required to support subnet-router anycast addresses for each of their subnet interfaces.

IPv6 Addresses for a Host

Typical IPv6 hosts are **logically multihomed** because they have at least two addresses with which they can receive packets

1. a link-local address for local link traffic
2. a routable site-local or global address.

IPv6 Addresses for a Router

An IPv6 router is assigned the following unicast addresses:

- A link-local address for each interface
- Unicast addresses for each interface (which one or multiple global unicast addresses)
- A Subnet-Router anycast address
- Additional anycast addresses (optional)
- The loopback address (::1) for the loopback interface