bd NOG
Bangladesh Network Operators Group

IPv6

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Agenda

- IPv6 Intro
- Subnetting
- Discussion

IPv6 Addressing

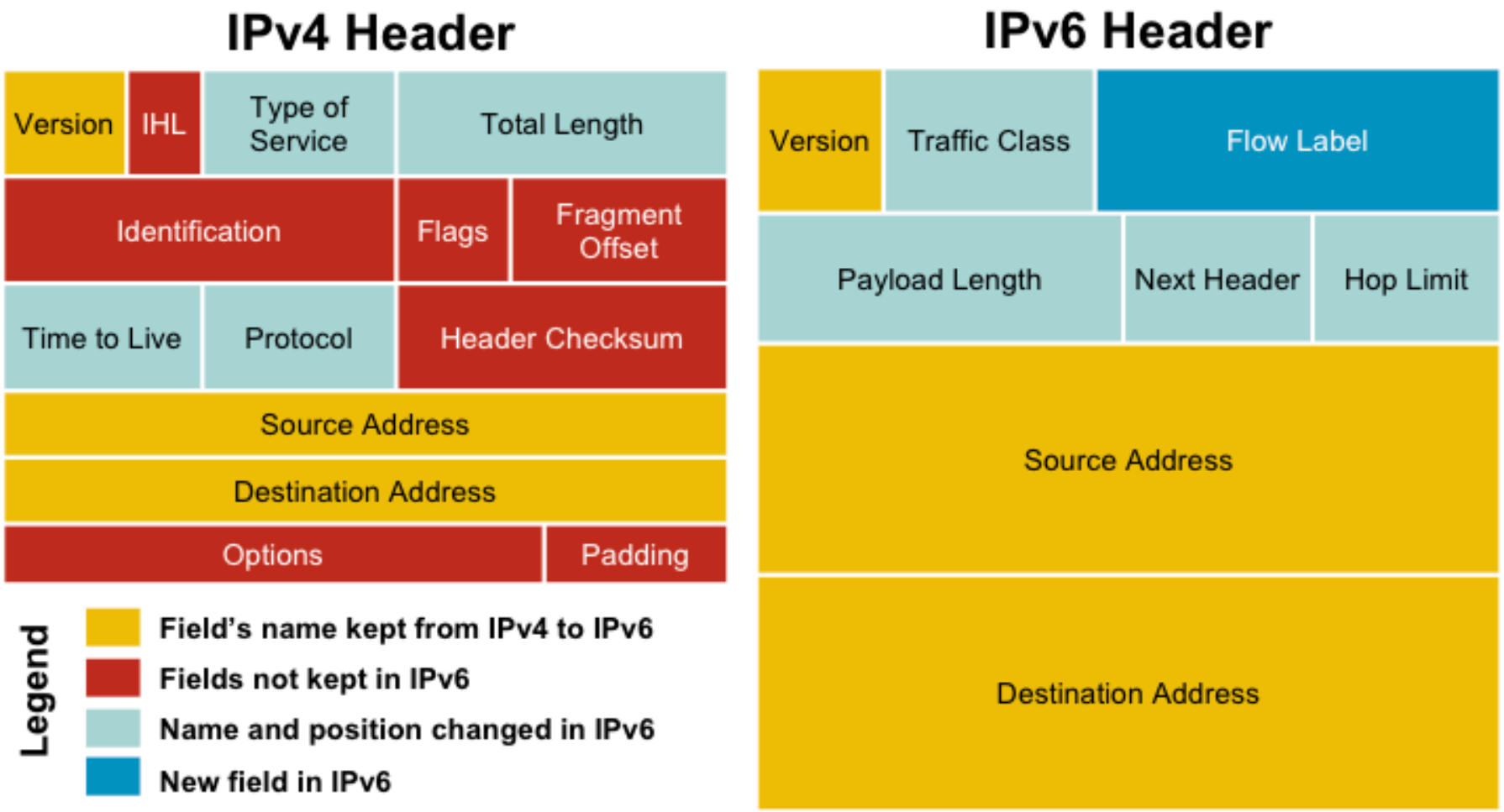
IPv6 Address Format

- 128 bits or 16 bytes long
  - 2^128 or 3.4E+38 possible addresses
  - 5*E+28 address per person on earth
- 128 binary bit is reduced down to 32 hex bit
- 16 bit number is converted to a 4 digit hexadecimal number in each field separated by colon (:)
  - “Coloned Hex” format: X:X:X:X:X:X:X:X (X = 16 bit hexadecimal field)
- Case-insensitive for hexadecimal digits A-F

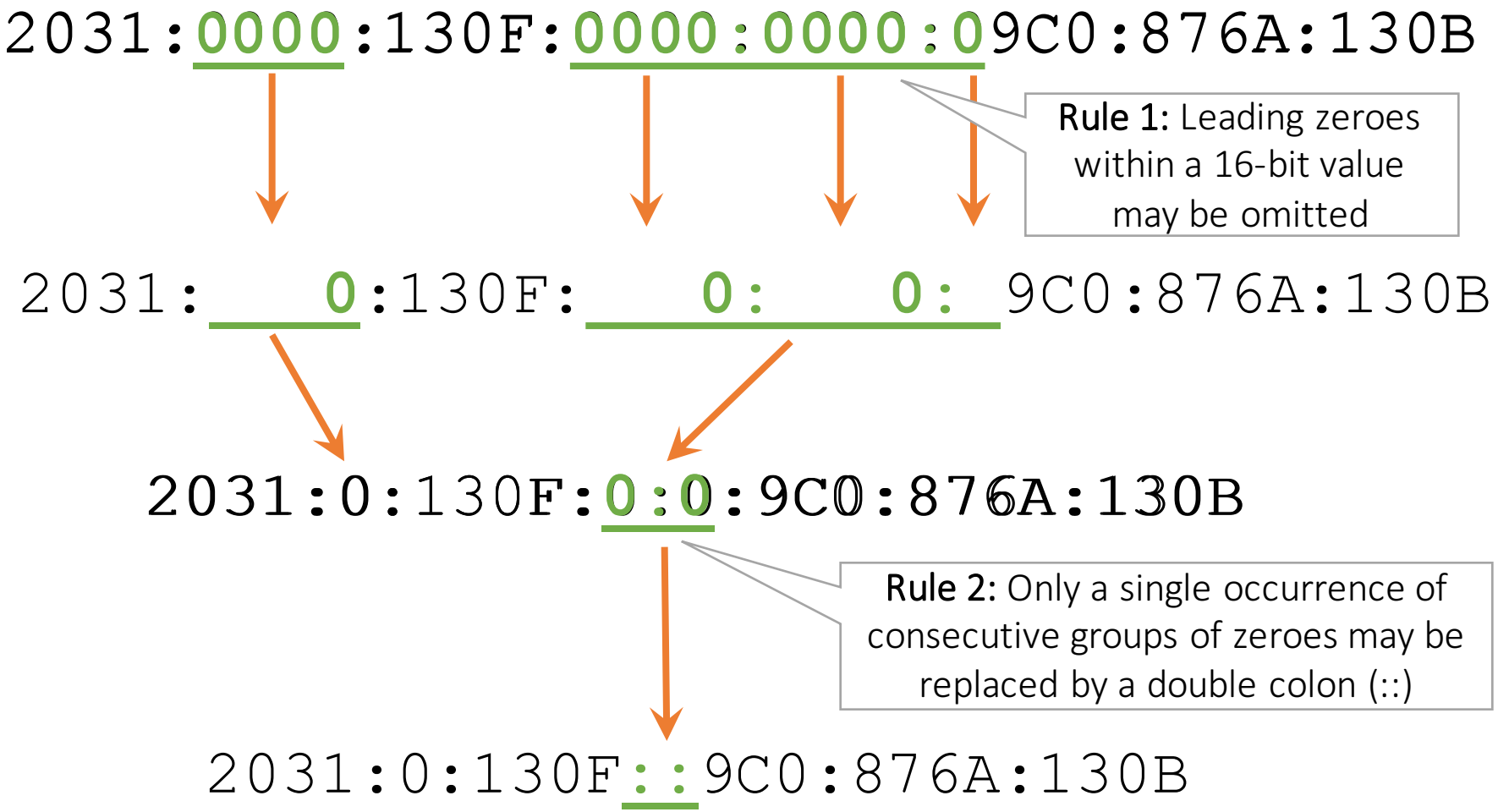
IPv4 and IPv6 comparison

IPv4	IPv6
32 Bit	128 Bit
2^32 possible IPv4 addresses	2^128 possible IPv6 addresses
Represented in Decimal	Represented in Hexadecimal
Grouped in 8-bit *Octet*	Grouped in 16-bit *Hextet*. (Each Hextet actually has 4 Hexadecimal Digit also known as "*Nibble*")
4 Octets separated by dot (.) hence called *dotted decimal format*	8 Hextets separated by colon (:) hence called *coloned hexadecimal format*

Protocol Header Comparison



IPv6 Address Representation



IPv6 Address Examples

FF01:0000:0000:0000:0000:0000:0000:1

FF01:0:0:0:0:0:0:1 = FF01::1

E3D7:0000:0000:0000:51F4:00C8:C0A8:6420

= E3D7::51F4:C8:C0A8:6420

3FFE:0501:0008:0000:0260:97FF:FE40:EFAB

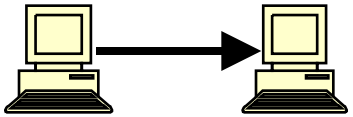
= 3FFE:501:8:0:260:97FF:FE40:EFAB

= 3FFE:501:8::260:97FF:FE40:EFAB

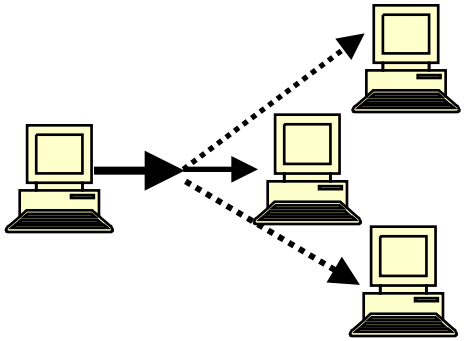
IPv6 Addressing Model

RFC 4291

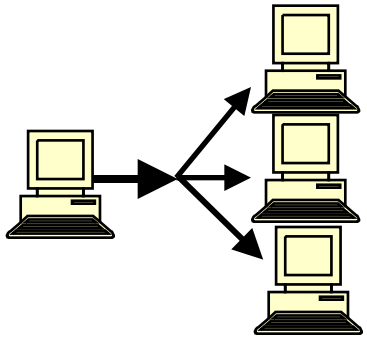
- IPv6 Address type
  - Unicast
  - An identifier for a single interface



- Anycast
  - An identifier for a set of interfaces



- Multicast
  - An identifier for a group of nodes

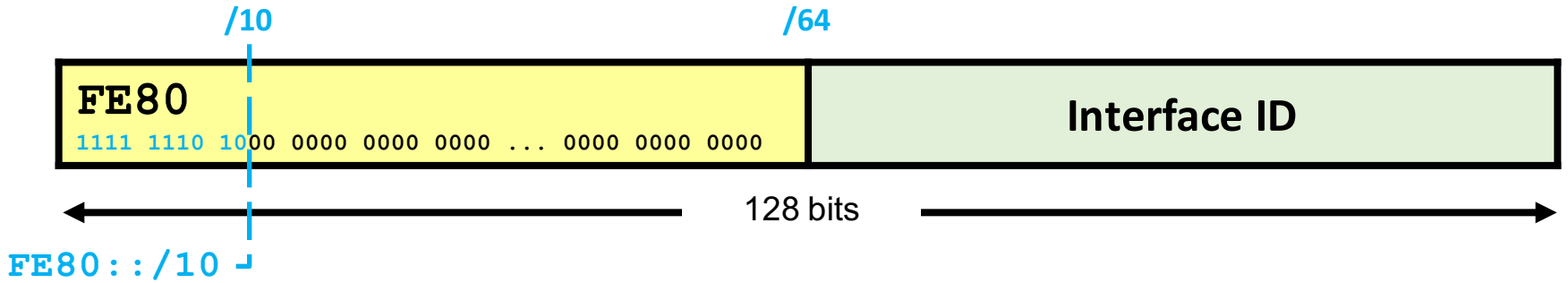


Different IPv6 Addresses

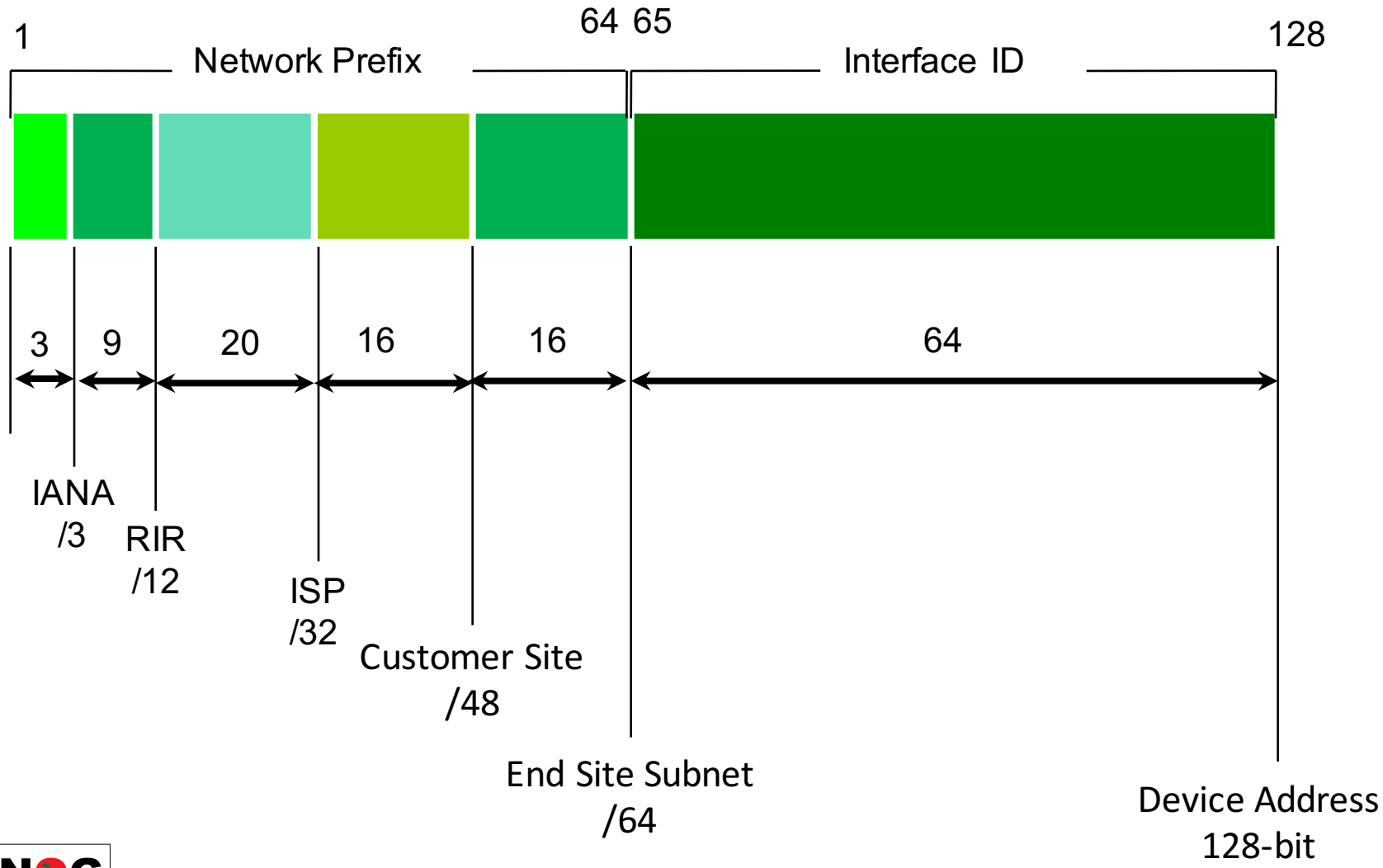
IPv6 Address	Description
::/0	• All routes and used when specifying a default static route. • It is equivalent to the IPv4 quad-zero (0.0.0.0).
::/128	• Unspecified address and is initially assigned to a host when it first resolves its local link address.
::1/128	• Loopback address of local host. • Equivalent to 127.0.0.1 in IPv4.
FE80::/10	• Link-local unicast address. • Similar to the Windows autoconfiguration IP address of 169.254.x.x.
FF00::/8	• Multicast addresses.
All other addresses	• Global unicast address.

Link-local Address

- Used for automatic address configuration, neighbor discovery, router discovery, and by many routing protocols.
- Dynamically created using a link-local prefix of **FE80::/10** and a 64-bit interface identifier.
- Link-local packets are unique only on the link, and are not routable off the link.



IPv6 Global Unicast Address

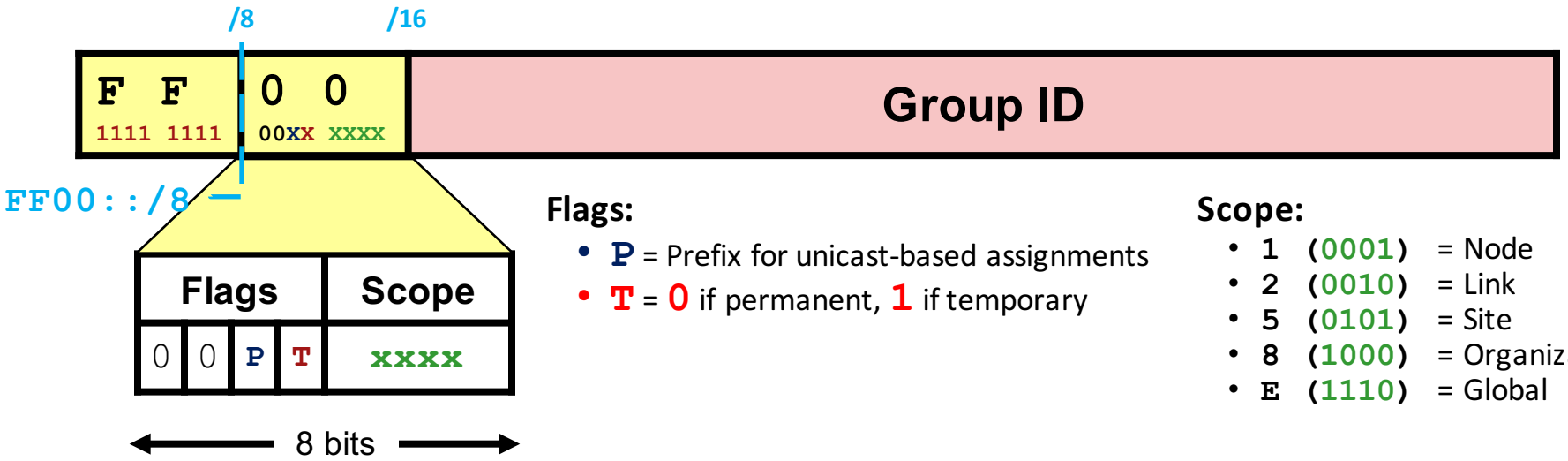


IPv6 Global Unicast Address

- IPV6 Global Unicast Address
  - 0010 2000::/3
  - 0011 3000::/3
- All five RIRs are given a /12 from the /3 to further distribute within the RIR region
  - APNIC 2400:0000::/12
  - ARIN 2600:0000::/12
  - LACNIC 2800:0000::/12
  - AfriNIC 2C00:0000::/12
  - RIPE 2A00:0000::/12

IPv6 Multicast Address

- Multicasting is at the core of many IPv6 functions and it is a replacement for the broadcast address.
- They are defined by the prefix **FF00::/8**.
  - An interface may belong to any number of multicast groups.
  - **FF00::** to **FF0F::** have the **T** flag = **0** means permanent and reserved.



Flags:

- **P** = Prefix for unicast-based assignments
- **T** = **0** if permanent, **1** if temporary

Scope:

- **1** (0001) = Node
- **2** (0010) = Link
- **5** (0101) = Site
- **8** (1000) = Organization
- **E** (1110) = Global

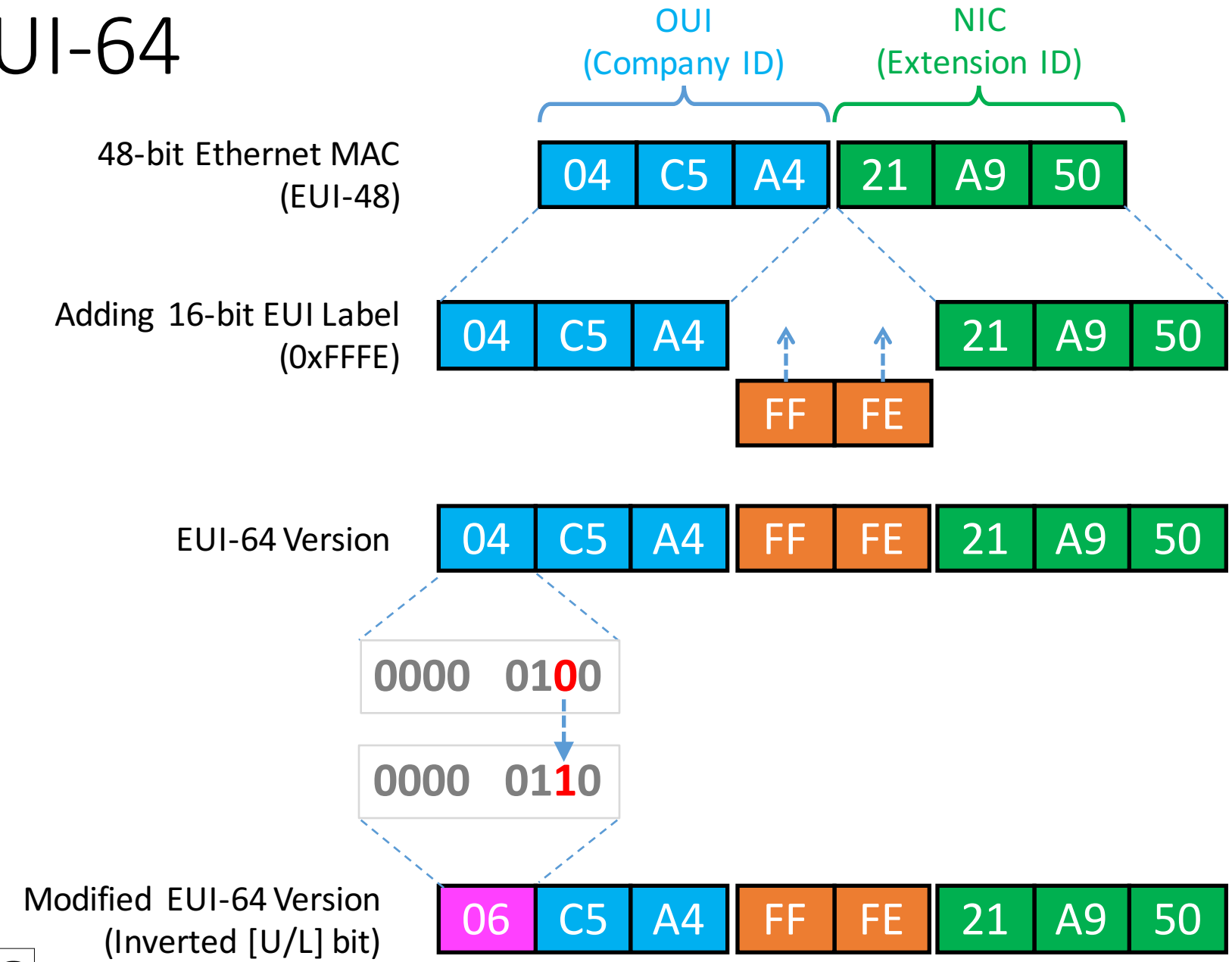
Reserved IPv6 Multicast Address

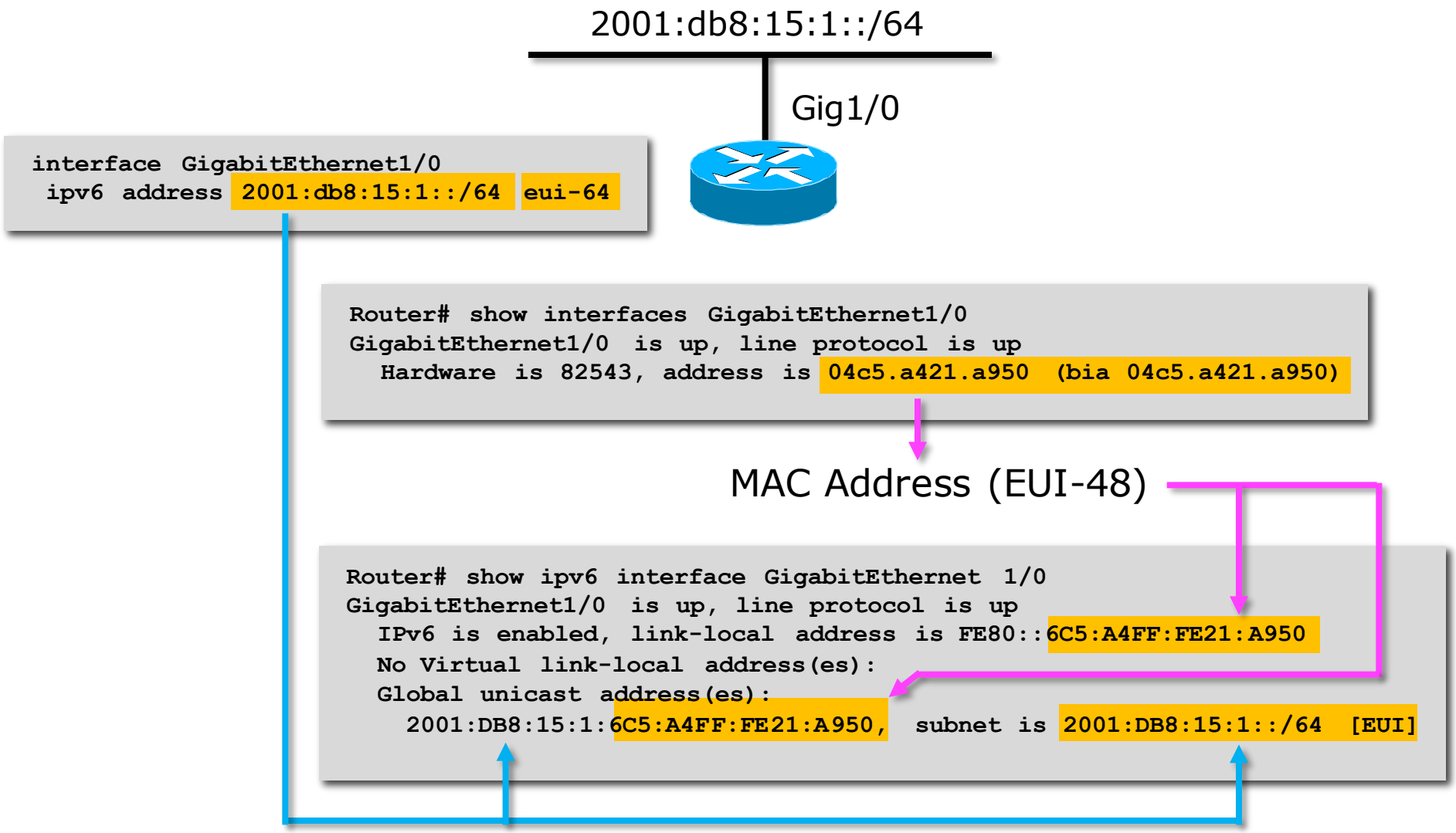
Multicast Address	Description
FF02::1	• All nodes on a link (link-local scope).
FF02::2	• All routers on a link.
FF02::9	• All routing information protocol (RIP) routers on a link.
FF02::1:FFxx:xxxx	• All solicited-node multicast addresses used for host autoconfiguration and neighbor discovery (similar to ARP in IPv4). • The xx:xxxx is the far right 24 bits of the corresponding unicast or anycast address of the node.
FF05::101	• All Network Time Protocol (NTP) servers.

Interface ID

- The lowest-order 64-bit field addresses may be assigned in several different ways:
  - Auto-configured from a 48-bit MAC address expanded into a 64-bit EUI-64
  - Assigned via DHCP
  - Manually configured
  - Auto-generated pseudo-random number
  - Possibly other methods in the future

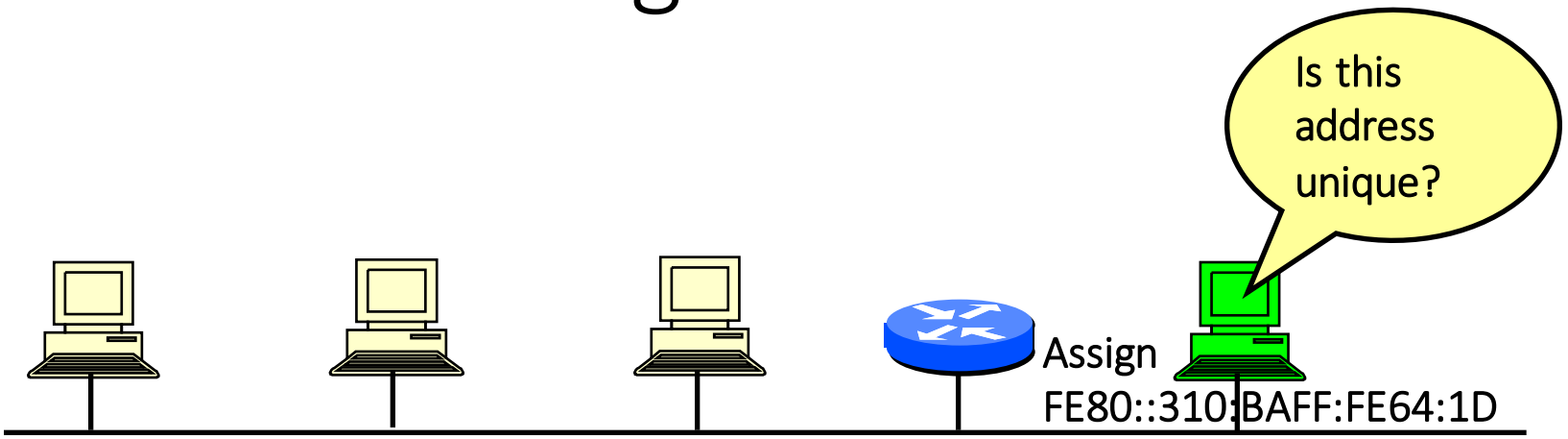
EUI-64


OUI
(Company ID)
NIC
(Extension ID)
48-bit Ethernet MAC
(EUI-48)
04 C5 A4 21 A9 50
Adding 16-bit EUI Label
(0xFFFE)
04 C5 A4 FF FE 21 A9 50
EUI-64 Version
04 C5 A4 FF FE 21 A9 50
0000 0100
0000 0110
Modified EUI-64 Version
(Inverted [U/L] bit)
06 C5 A4 FF FE 21 A9 50


2001:db8:15:1::/64
Gig1/0
interface GigabitEthernet1/0
ipv6 address 2001:db8:15:1::/64 eui-64
Router# show interfaces GigabitEthernet1/0
GigabitEthernet1/0 is up, line protocol is up
Hardware is 82543, address is 04c5.a421.a950 (bia 04c5.a421.a950)
MAC Address (EUI-48)
Router# show ipv6 interface GigabitEthernet 1/0
GigabitEthernet1/0 is up, line protocol is up
IPv6 is enabled, link-local address is FE80::6C5:A4FF:FE21:A950
No Virtual link-local address(es):
Global unicast address(es):
2001:DB8:15:1:6C5:A4FF:FE21:A950, subnet is 2001:DB8:15:1::/64 [EUI]

IPv6 Autoconfiguration

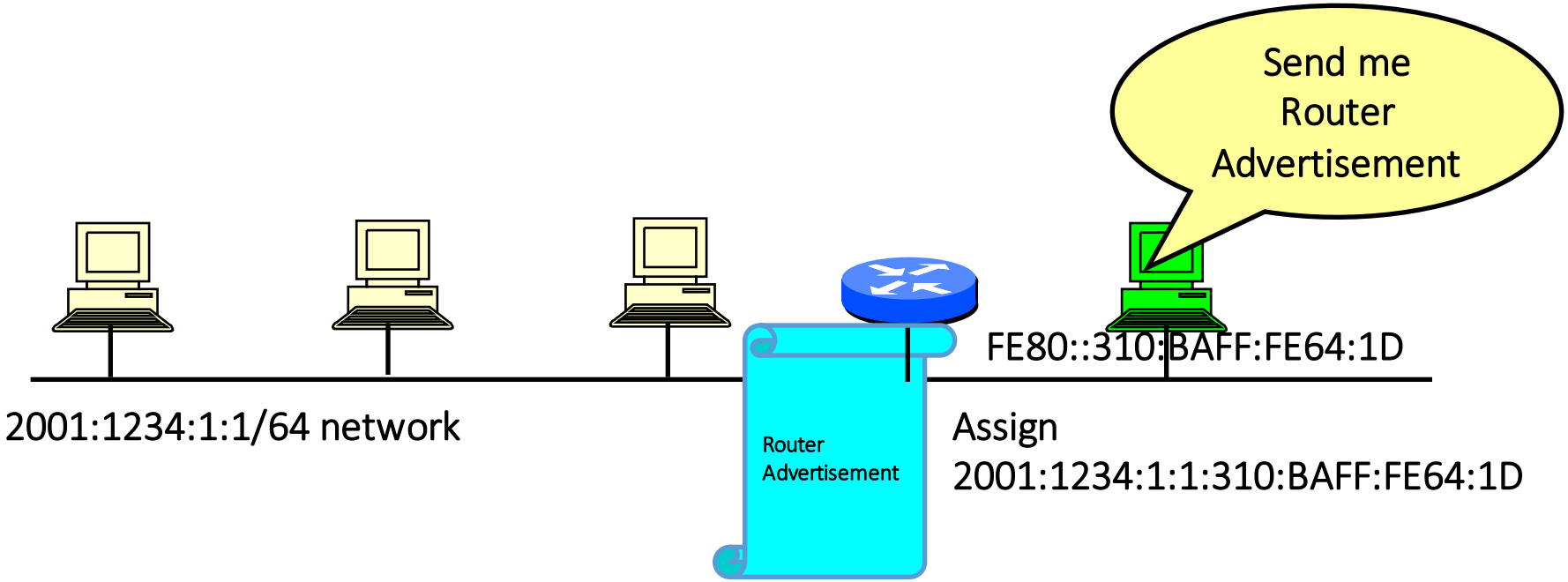
IPv6 Autoconfiguration



Tentative address (link-local address)
Well-known link local prefix +Interface ID (EUI-64)
Ex: FE80::310:BAFF:FE64:1D

1. A new host is turned on.
2. Tentative address will be assigned to the new host.
3. Duplicate Address Detection (DAD) is performed. First the host transmit a Neighbor Solicitation (NS) message to the solicited node multicast address (FF02::1:FF64:001D) corresponding to its to be used address
5. If no Neighbor Advertisement (NA) message comes back then the address is unique.
6. FE80::310:BAFF:FE64:1D will be assigned to the new host.

IPv6 Autoconfiguration



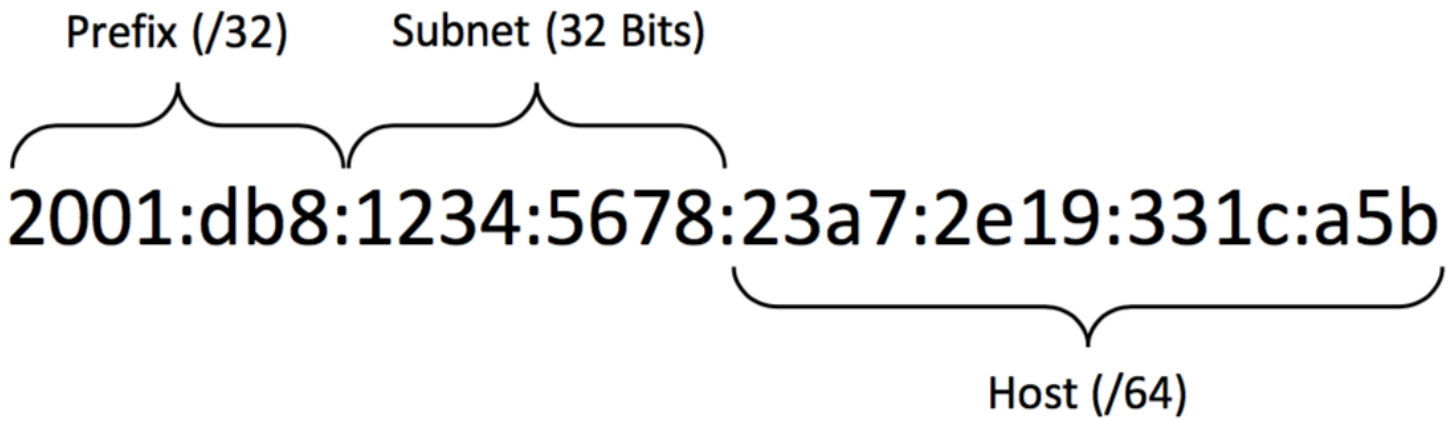
1. The new host will send Router Solicitation (RS) request to the all-routers multicast group (FF02::2).
2. The router will reply Routing Advertisement (RA).
3. The new host will learn the network prefix. E.g, 2001:1234:1:1/64
4. The new host will assigned a new address Network prefix+Interface ID
   E.g, 2001:1234:1:1:310:BAFF:FE64:1D

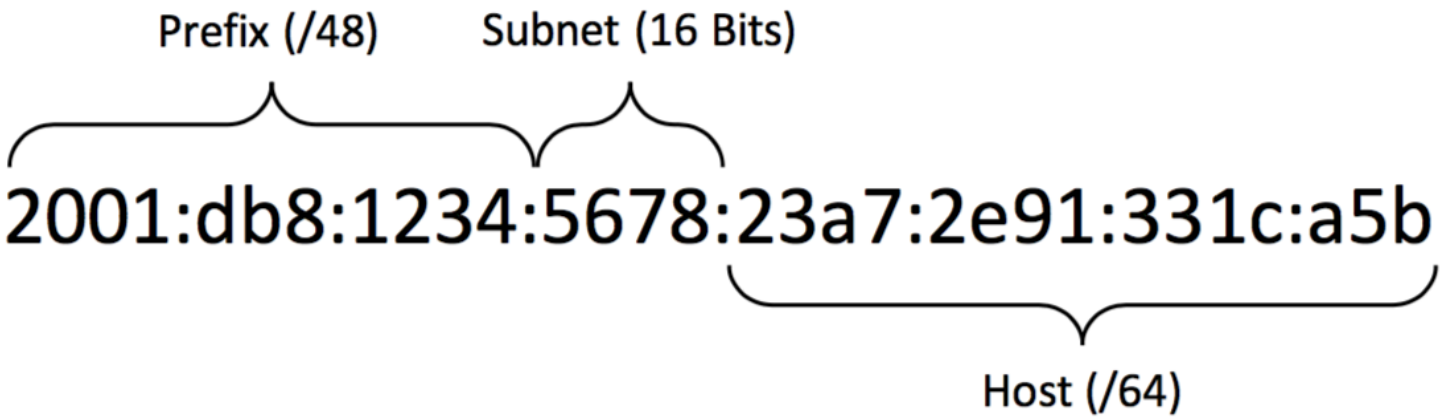
IPv6 Subnetting

Remember IPv4 Subnetting?

- 192.168.1.0/24
  - What are the second and fifth /28 subnets?
- 10.10.0.0/18
  - What are the first and third /21 subnets?

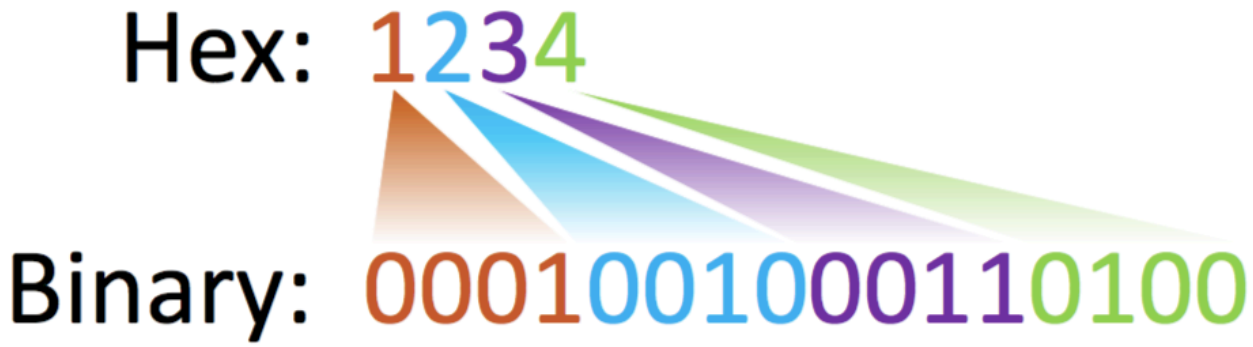
IPv6 Prefix


Prefix (/32)
Subnet (32 Bits)
2001:db8:1234:5678:23a7:2e19:331c:a5b
Host (/64)

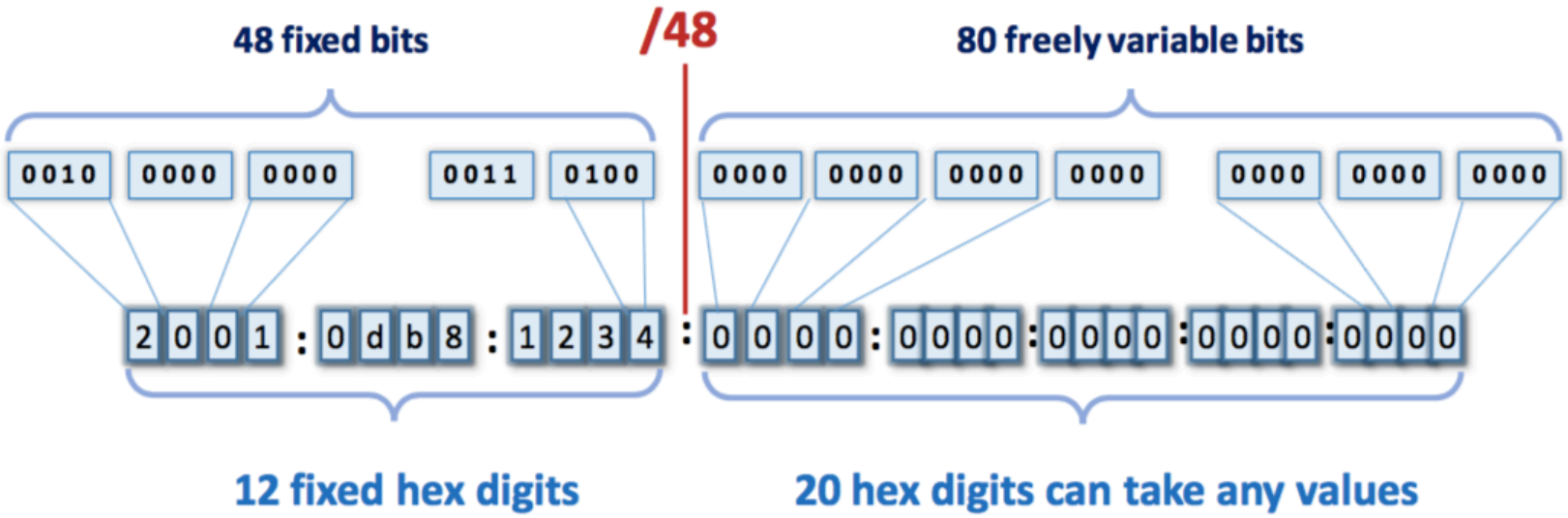

Prefix (/48)
Subnet (16 Bits)
2001:db8:1234:5678:23a7:2e91:331c:a5b
Host (/64)

“Nibble” Boundaries

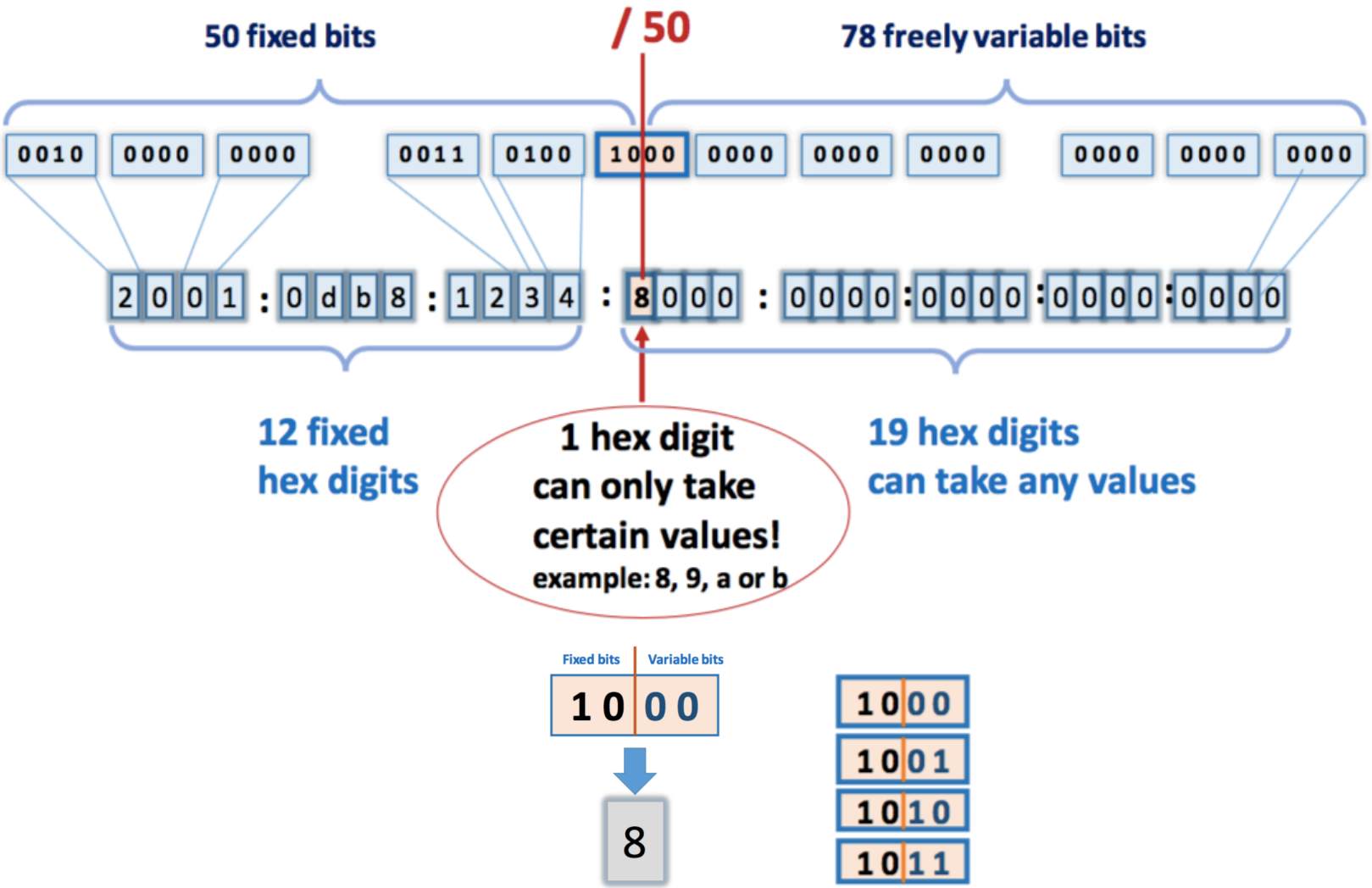
- A "nibble" is one hexadecimal digit (or 4 bits)
- You don't have to subnet based on nibbles. You can use other prefixes, ex. /49, /51, /55 etc.
- But it is MUCH easier to identify addresses if you do



If /x is a multiple of 4



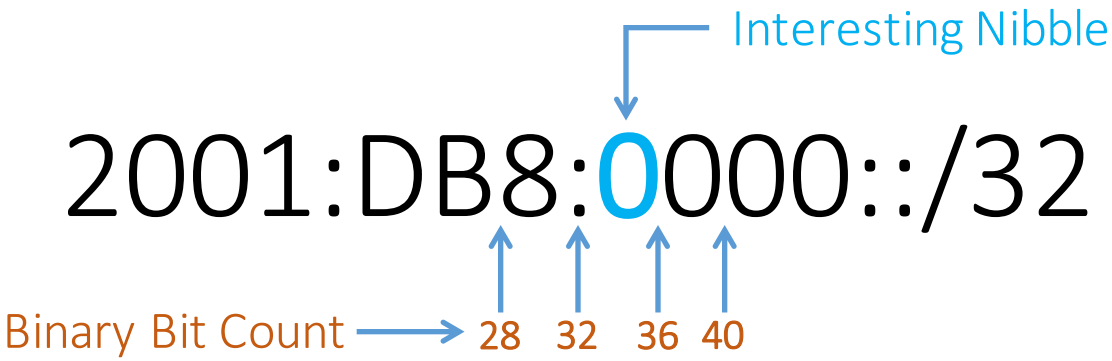
If /x is not a multiple of 4



IPv6 Subnetting

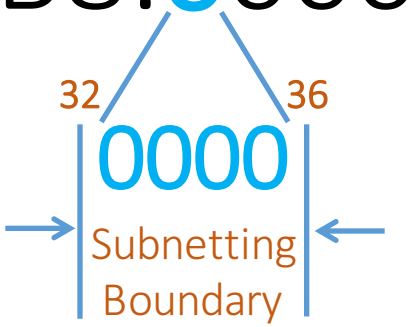
- Identify the first four /36 address blocks out of 2001:db8::/32
- Identify the first four /38 address blocks out of 2001:db8::/32

IPv6 Subnetting: Example 1



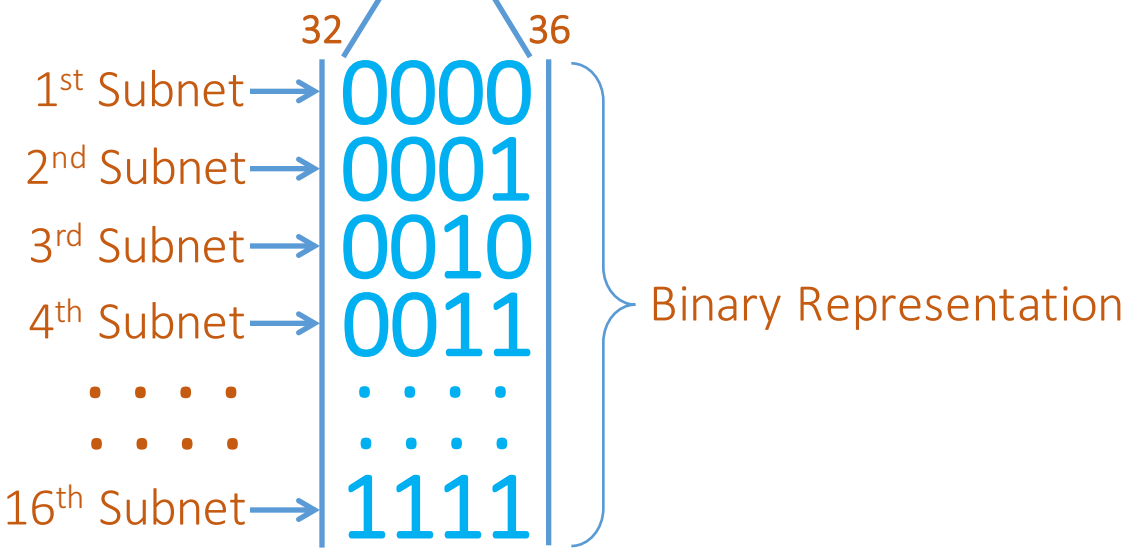
IPv6 Subnetting: Example 1

2001:DB8:0000::/32



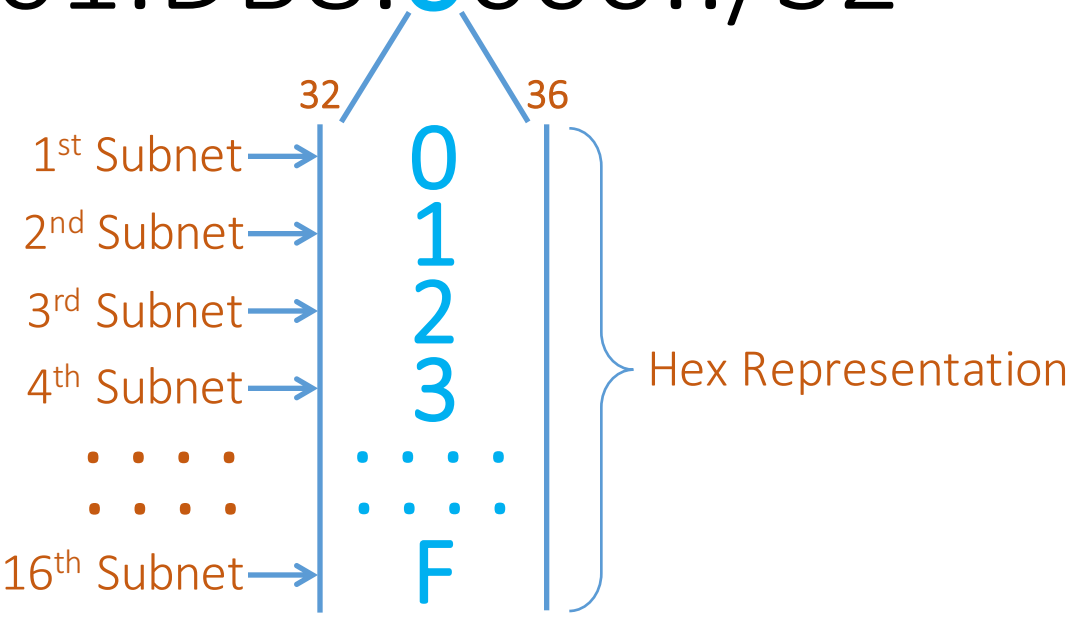
IPv6 Subnetting: Example 1

2001:DB8:0000::/32



IPv6 Subnetting: Example 1

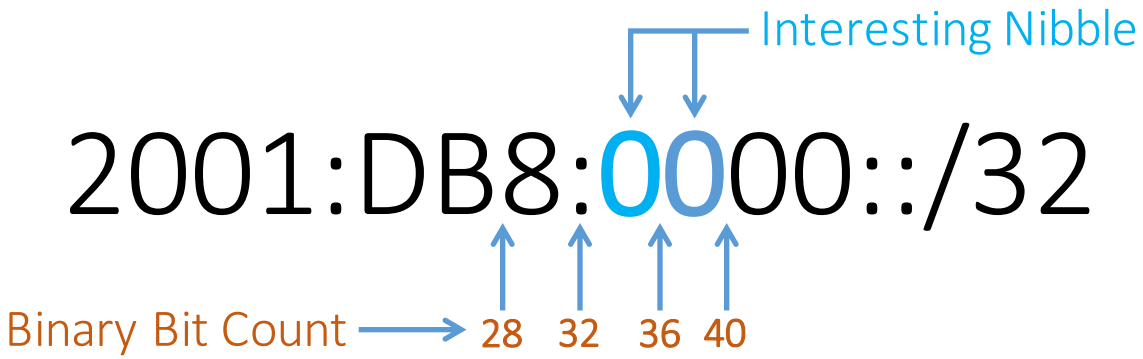
2001:DB8:0000::/32



IPv6 Subnetting: Example 1

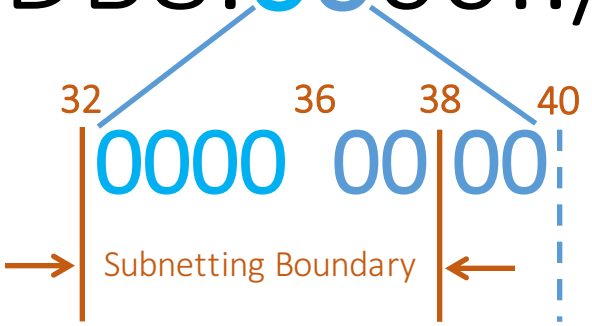
1st Subnet → 2001:DB8:0000::/36
2nd Subnet → 2001:DB8:1000::/36
3rd Subnet → 2001:DB8:2000::/36
4th Subnet → 2001:DB8:3000::/36
. . . .
. . . .
16th Subnet → 2001:DB8:F000::/36

IPv6 Subnetting: Example 2



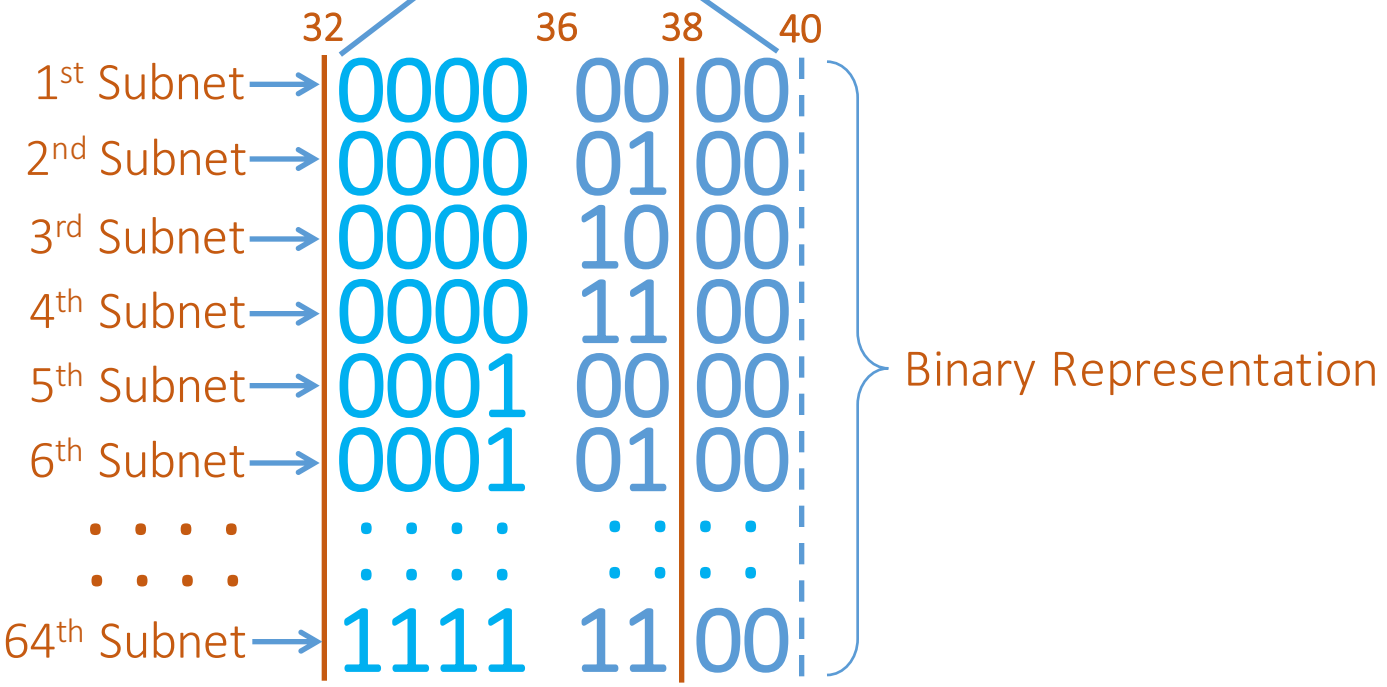
IPv6 Subnetting: Example 2

2001:DB8:0000::/32

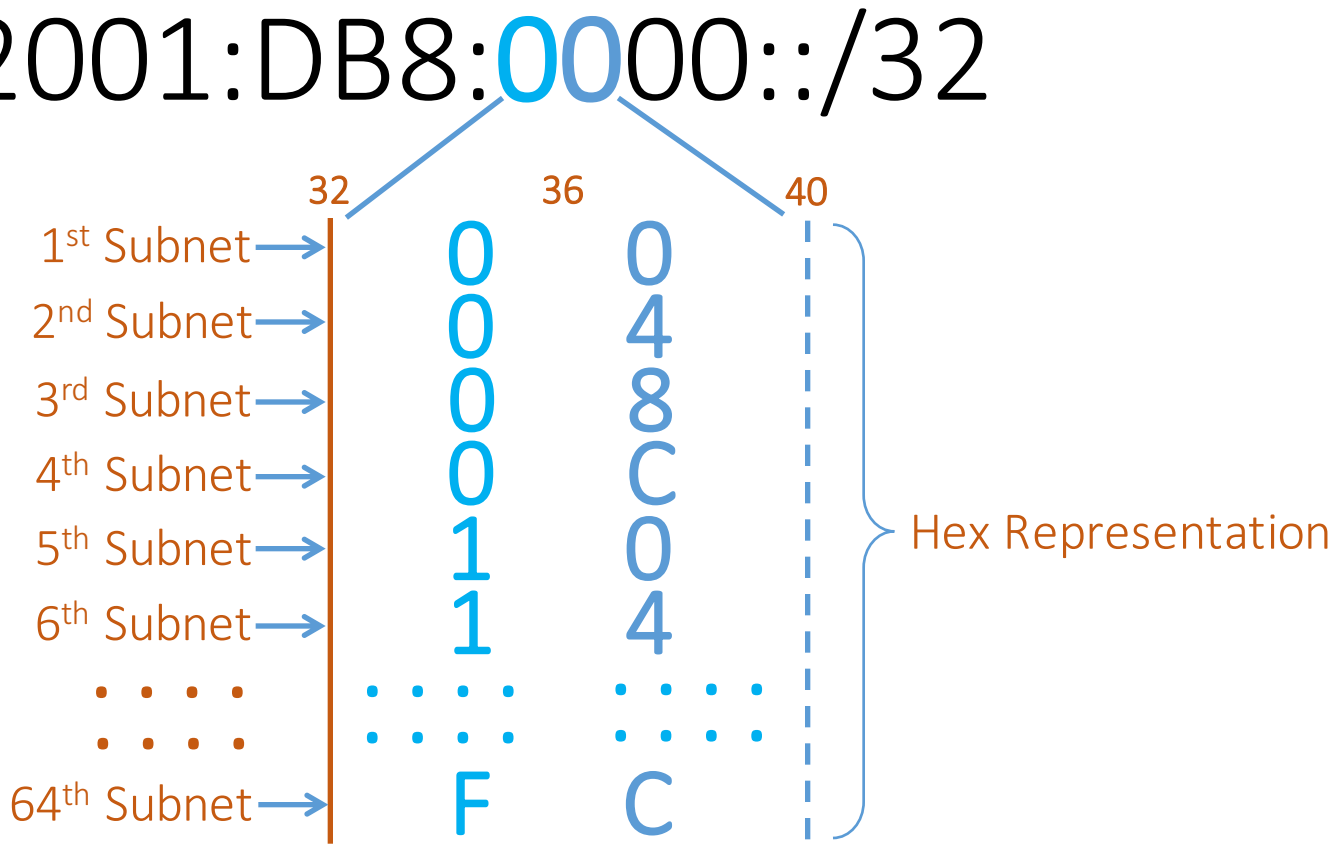


IPv6 Subnetting: Example 2

2001:DB8:0000::/32



IPv6 Subnetting: Example 2



IPv6 Subnetting: Example 2

1st Subnet → 2001:DB8:0000::/38
2nd Subnet → 2001:DB8:0400::/38
3rd Subnet → 2001:DB8:0800::/38
4th Subnet → 2001:DB8:0C00::/38
5th Subnet → 2001:DB8:1000::/38
6th Subnet → 2001:DB8:1400::/38
. . . .
. . . .
64th Subnet → 2001:DB8:FC00::/38

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Questions?