# IPv6 Addressing

📕 CCNA1v7 Module 12 IPv6 Addressing
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# Need for IPv6

- **IPv4 depletion**
  All RIRs (Regional Internet Registries) have exhausted their address pools, except those reserved for IPv6 transition.
- **Enhancements over IPv4**
  The development of IPv6 also included fixes for IPv4 limitations and other enhancements, with subnetting in mind.

# IPv4 and IPv6 Coexistence

## Protocols and tools to help network admins migrate to IPv6

- **Dual Stack**
  The devices run both IPv4 and IPv6 protocol stacks simultaneously.
- **Tunneling**
  The IPv6 packet is encapsulated inside an IPv4 packet.
- **Translation**
  Network Address Translation 64 (NAT64) allows IPv6-enabled devices to communicate with IPv4-enabled devices using a translation technique similar to NAT for IPv4

# IPv6 Addressing Format

- **Length:** 128 bits
- **Representation:** Hexadecimal
- **Format:** `xxxx:xxxx:xxxx:xxxx:xxxx:xxxx:xxxx:xxxx`
- **IPv6 ➡️ 8 hextets**

  1 hextet = 16 bit segment = 4 hexadecimal values

> **Example:**
>
> 2001:0db8:acad:1111:abde:cafe:010f:1234

# IPv6 Compression

## Rule 1 – Omit Hextets Leading Zero

> **Example:**
> Preferred: `2001:0db8:0000:1111:0000:0000:0000:0200`
> No leading zeros: `2001:db8:0:1111:0:0:0:200`

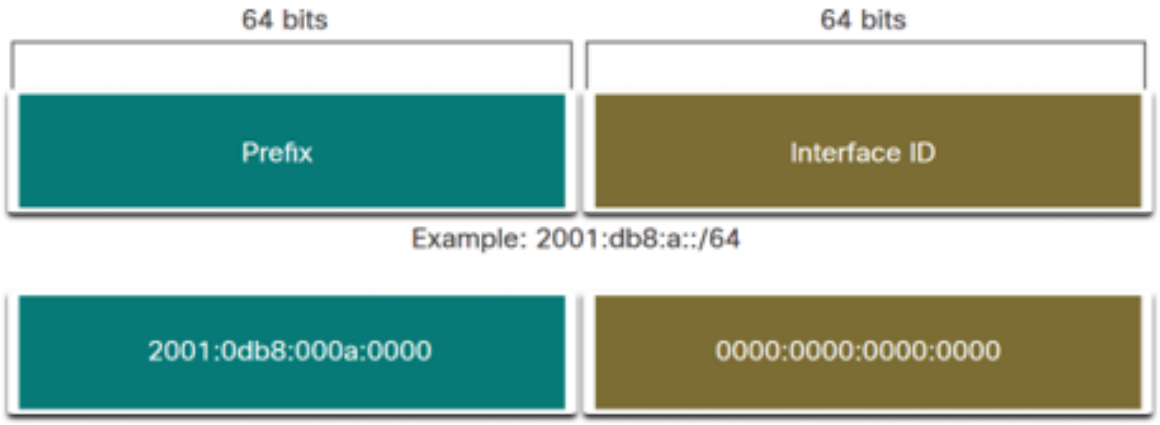
## Rule 2 – Replace contiguous zero hextets with ::

### ⚠️ We can only use `::` once!

> **Example:**
> No leading zeros: `2001:db8:0:1111:0:0:0:200`
> Compressed: `2001:db8:0:1111::200`

# IPv6 Prefix Length

- Used to indicate the **network portion** of an IPv6 address
- **Recommended Prefix length:** /64

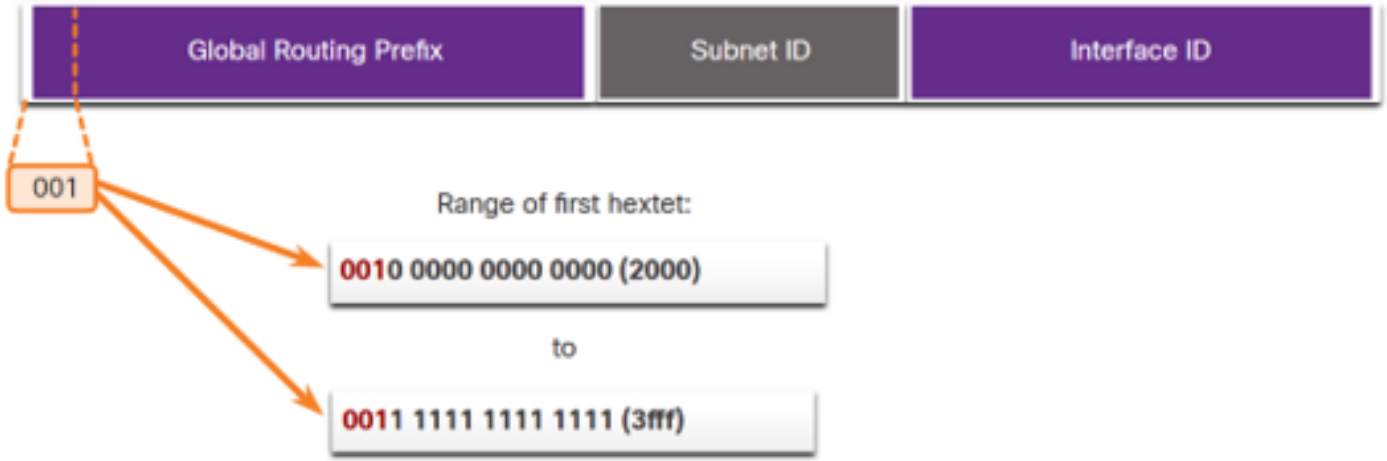


# IPv6 Unicast Addresses

- **Global Unicast Address (GUA)**
  - Similar to public IPv4 addresses.
  - Globally unique, **internet-routable addresses**.
- **Link-Local Address (LLA)**
  - Used to communicate to other devices on the same local link.
  - **Not routable, confined to a single link**.
- **Loopback** `::1/128`
- **Unspecified Address** `::/128`
- **Unique local** `fc00::/7 - fdff::/7`
  Similar to IPv4 private addresses.

# IPv6 GUA

- **Currently Range:** `2000::/3` <--> `3fff::/3`
- **Global Routing Prefix** (48bits): **Network portion.** Assigned by provider.
- **Subnet ID** (16bits): **Subnet.** To identy subnets within its site.
- **Interface ID** (64bits): **Host portion.**
- **Static GUA on a Router:** `ipv6 address 2001:db8:acada:1::1/64`



# IPv6 LLA

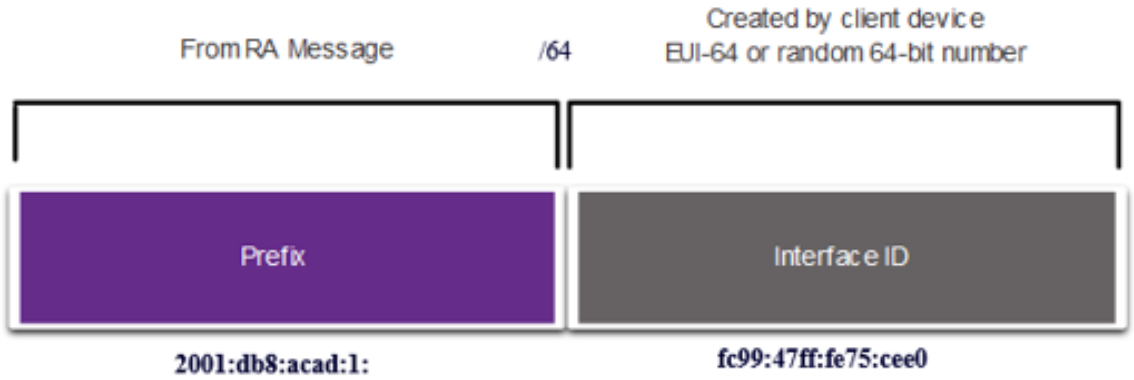
- **Range:** `fe80::/10`
- An IPv6 LLA enables a device to communicate with other IPv6-enabled devices on the same link and only on that link (subnet).
- **Cannot be routed.**
- Every IPv6-enabled network interface must have an LLA.
- **If an LLA is not configured manually on an interface, the device will automatically create one.**
- **Static LLA on a Router:** `ipv6 address fe80::1/64 link-local`

# Dynamic Addressing for IPv6 GUAs

- Devices obtain addresses dynamically through **ICMPv6 messages**:
  - **Router Solicitation (RS) messages**
    - Sent by host devices to discover IPv6 routers
  - **Router Advertisement (RA) messages**
    - Sent by routers to inform hosts on how to obtain an IPv6 GUA/LLA.
  - 3 methods for configuring IPv6 GUA:
    1. SLAAC
    2. SLAAC with Stateless DHCPv6 server
    3. Stateful DHCPv6 (no SLAAC)

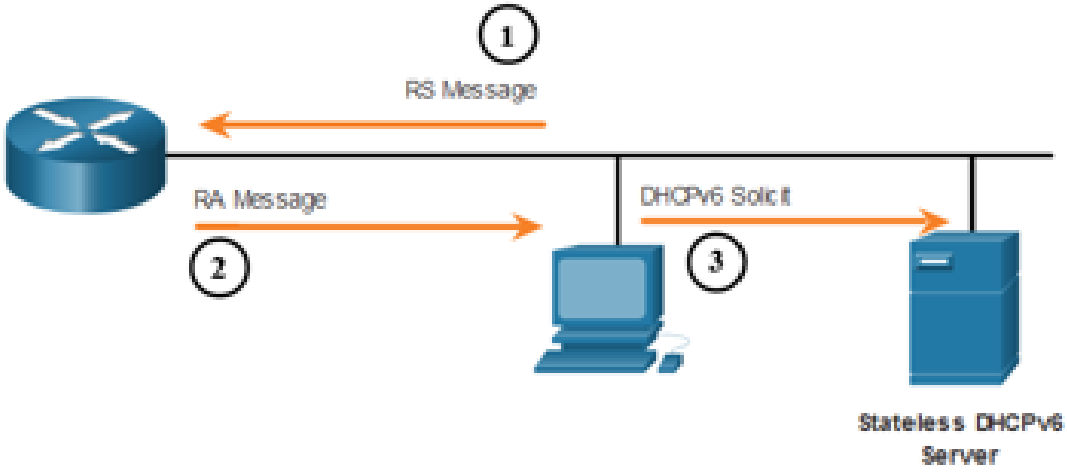
# Method 1: SLAAC

- Devices configure a GUA without the services of DHCPv6, obtaining the necessary information from the ICMPv6 RA messages of the local router.
- **Prefix:** provided by the RA message
- **Interface ID:** created by the device using one of these 2 methods:
  - EUI-64
  - Random generation



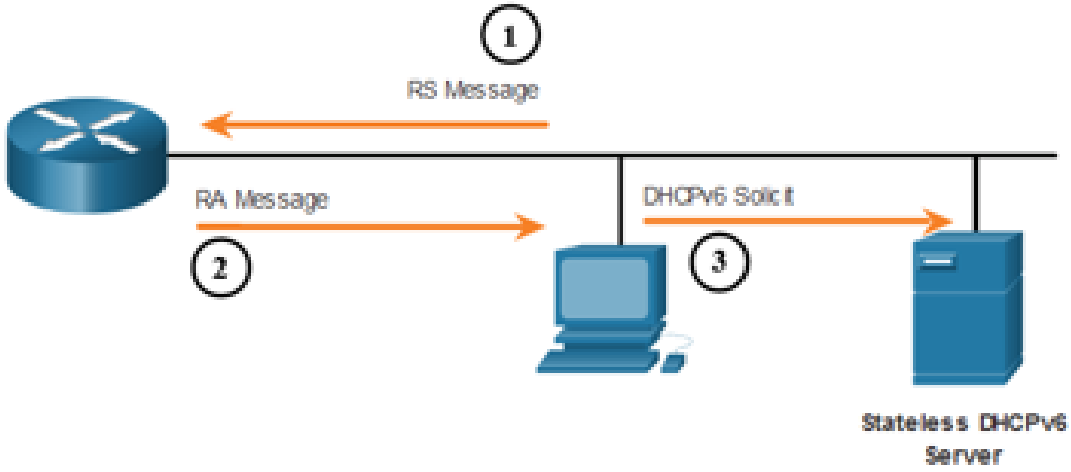
# Method 2: SLAAC with Stateless DHCPv6 server

- **IPv6 GUA:** SLAAC
- **Default gateway:** Router LLA (RA source IPv6 address)
- **DNS Server and domain name:** obtained from an stateless DHCPv6 server



# Method 3: Stateful DHCPv6

- Similar to DHCPv4
- **IPv6 GUA, prefix length, DNS server and domain:** From Stateful DHCPv6 server
- **Default gateway:** Router LLA (RA source IPv6 address)



# Auto Generated Interface ID: EUI-64 Process

- Used by Linux and CISCO devices

1️⃣ Split Ethernet MAC address of the client (48bits): OUI ↔️ Serial Number
2️⃣ Insert `ff:fe` into the middle (64bits)
3️⃣ Reverse from binary 0 to 1 the 7th bit

> **Example:**
> MAC: `fc:99:47:75:ce:e0`
> EUI-64 Interface ID: `fe:99:47:ff:fe:75:ce:e0`

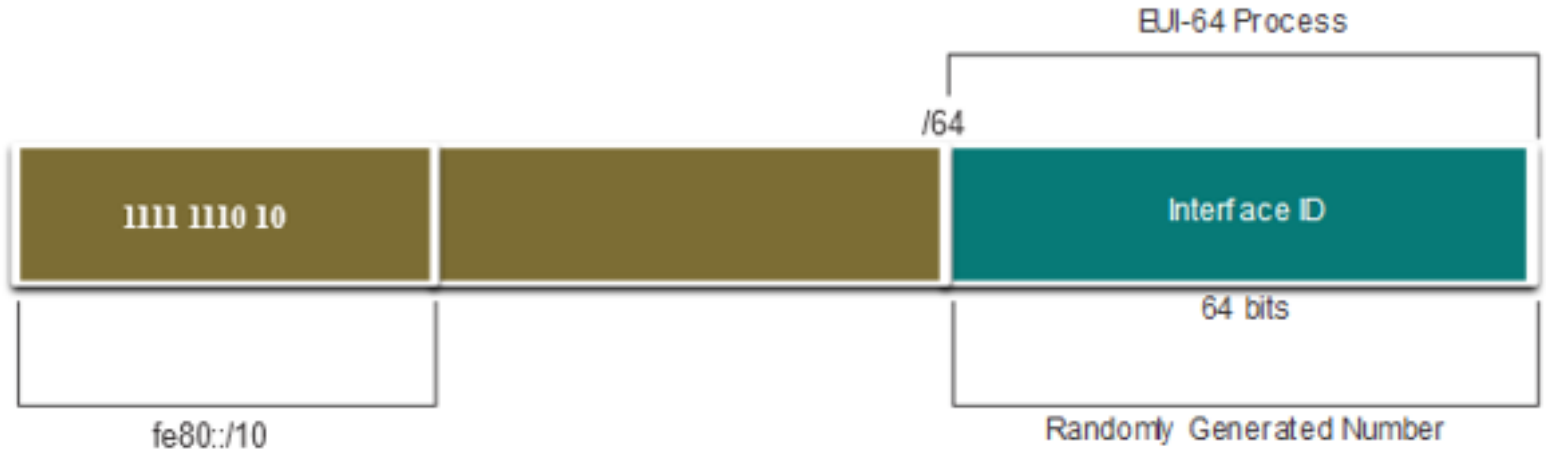
## Randomly Generated Interface ID

- Used by Windows
- **Interface ID:** Random number

⚠️ Client may use DAD (Duplicate Address Detection) to ensure the uniqueness of the generated IPv6. No reply => unique.

# Dynamic LLA

- **Interface ID:**
  - Created by the device using one of these 2 methods:
    - EUI-64
    - Random generation



# IPv6 Multicast

- **Prefix:** `ff00::/8`. 2 types:
  - **Well-known multicast addresses**
    - `ff02::1` **All-nodes multicast group**: All IPv6-enabled devices join
    - `ff02::2` **All-routers multicast group**: All IPv6 routers join
  - **Solicited node multicast addresses**
    - Similar to the all-nodes multicast address.

# IPv6 Anycast

- Any IPv6 unicast address that can be assigned to multiple devices.
- Routed to the nearest device having that address.

# IPv6 Subnetting

- A separate **Subnet ID** field in the IPv6 GUA is used to create subnets.
- Subnet ID: **4th hextext**