

IPv6 Addressing

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

- 🐱 **Dual Stack:** devices run both IPv4 and IPv6 protocol stacks simultaneously.
- 🚂 **Tunneling:** 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)
- Prefix Length: Indicate the **network portion** (recommended /64)

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`

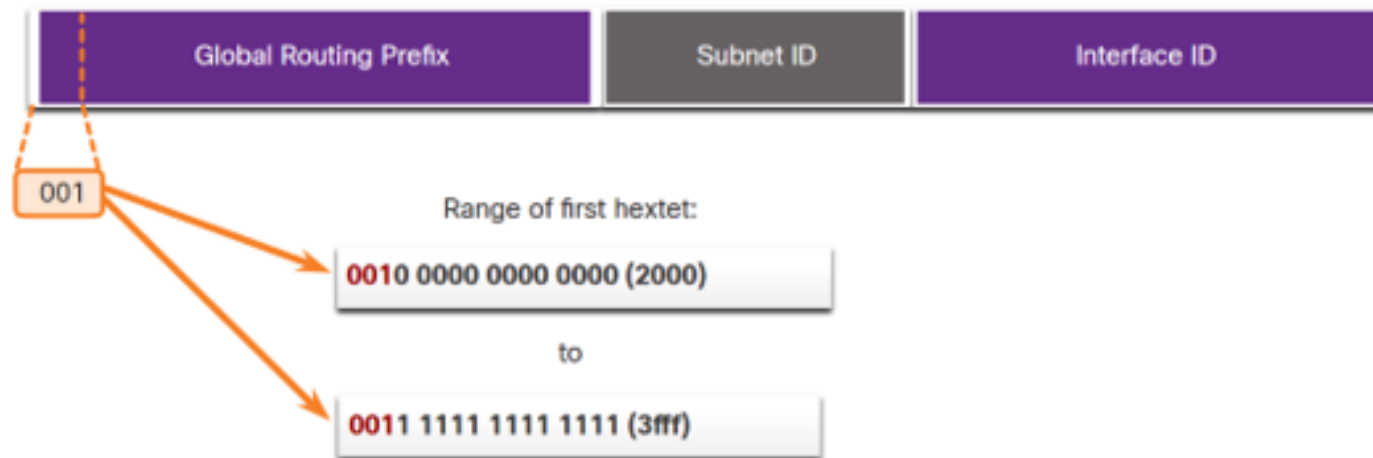
Compressed: `2001:db8:0:1111::200`

IPv6 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 identify subnets within its site.
- **Interface ID (64bits): Host portion.**
- **Static GUA on a Router:** `ipv6 address 2001:db8:acad:1::1/64`



IPv6 LLA

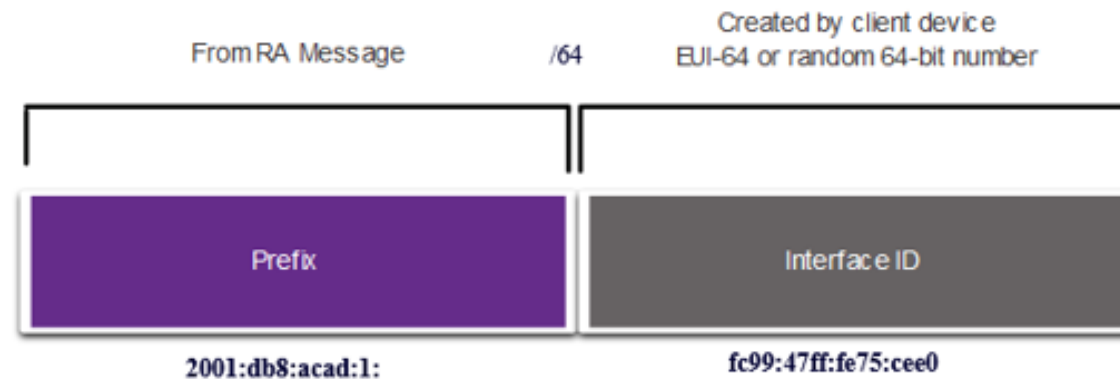
- **Range:** `fe80::/10`
- An IPv6 LLA enables a device to communicate with other IPv6-enabled devices on the same link and only on that link (subnet).
- **⚠ Cannot be routed.**
- Every IPv6-enabled network interface must have an LLA.
- **If an LLA is not configured manually on an interface, the device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

Dynamic Addressing for IPv6 GUAs

- Devices obtain addresses dynamically through **ICMPv6 messages**:
 - **Router Solicitation (RS) messages**: Sent by hosts 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)

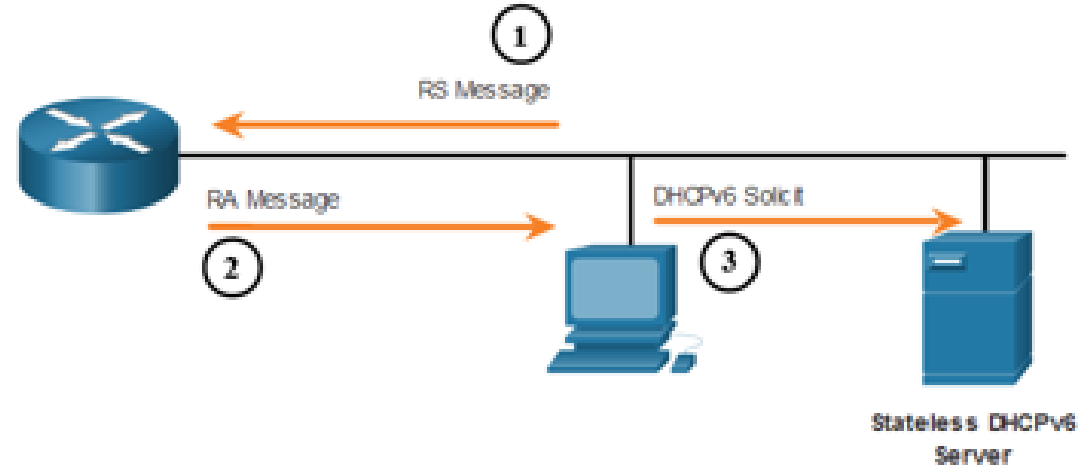
Method **1**: SLAAC

- 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



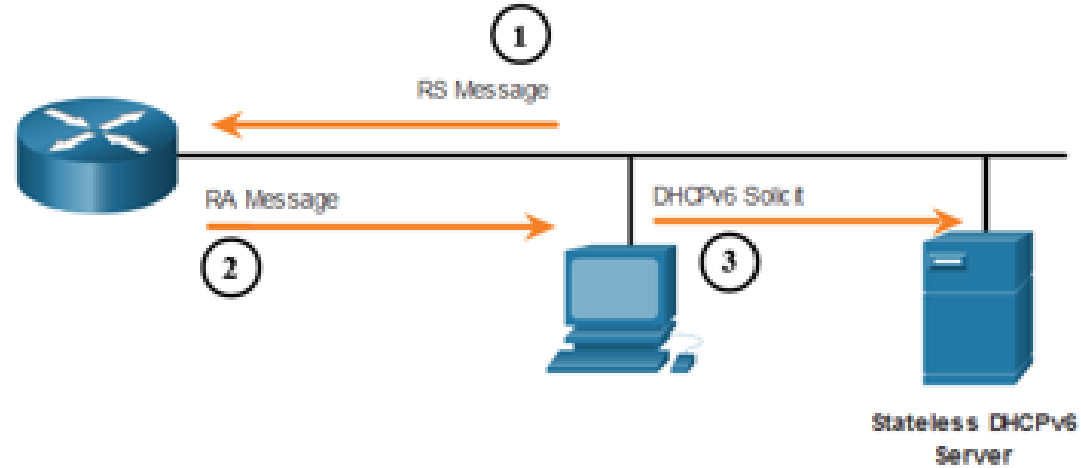
Method **2**: SLAAC with Stateless DHCPv6 server

- 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

- 1 Split Ethernet MAC address of the client (48bits): OUI ↔ Serial Number
- 2 Insert `ff:fe` into the middle (64bits)
- 3 Flip 7th bit (0 → 1, 1 → 0)

Example: MAC: `fc:99:47:75:ce:e0`

EUI-64 Interface ID: `fe:99:47:ff:fe:75:ce:e0`

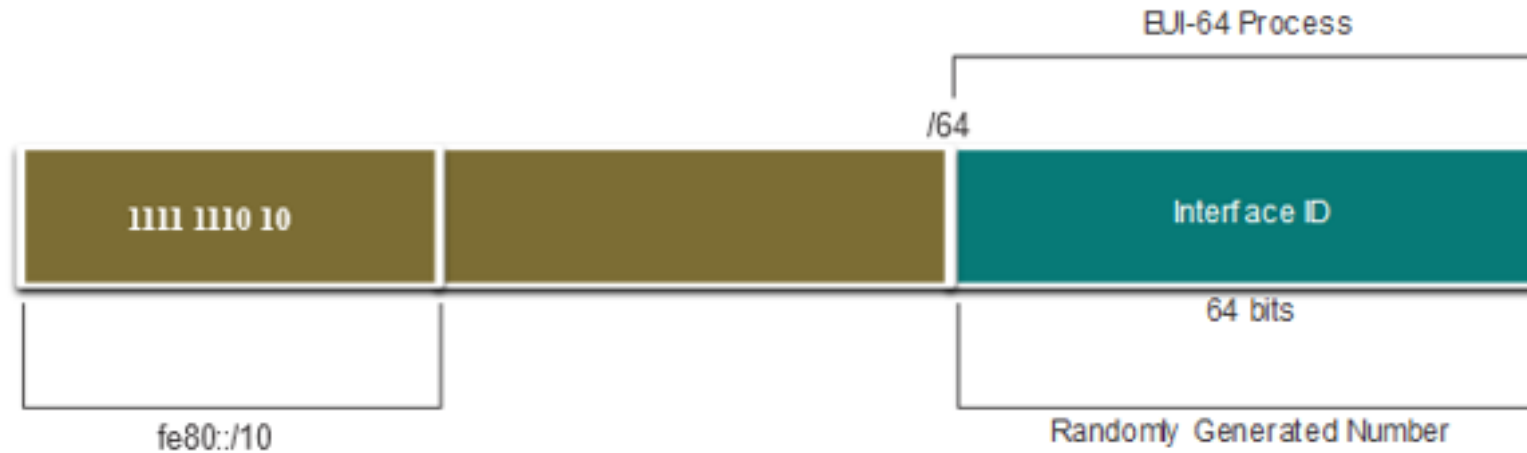
Randomly Generated Interface ID

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**

