IPv6 Addressing

IPv6 addressing is based on hexadecimal notation with values from numbers 0-9 and A to F. Each address is comprised of eight groups with four hexadecimal values of 4 bits each. There are as a result 16 bits per group and with eight groups per IPv6 address equals 128 bits.

Figure 1 IPv6 Address Structure

Figure 1-17 illustrates the structure of a standard IPv6 address. There is a 64-bit network portion and 64-bit host identifier. The 64-bit network prefix is further comprised of a 48-bit routing prefix and 16-bit local subnet ID.

The network prefix is similar to the IPv4 network address portion. The host identifier is similar to the IPv4 host portion. The subnet ID allows for subnetting with variable-length subnet masks (VLSM). IPv6 addresses are allocated by a Regional Internet Registry (RIR).

The primary reason for migrating to or enabling support for IPv6 is scalability. The IPv4 public routable address space is near depleted. In addition there is increasing demand for public addresses resulting from new cloud services and mobile devices.

Enabling IPv6 support now will ease migration over so that public routable addresses will be available for internet connectivity. IPv6 decreases network traffic by eliminating broadcast messages with multicasting technique. Ease of management with address autoconfiguration is an advantage as well.

Advantages of IPv6 Addressing

- Scalability with larger address space that is assignable.
- Dual stack IPv4/IPv6 for easy migration and transition.
- Better performance with multicasts instead of broadcasts.
- Easier address auto-configuration option.
- Multiple IPv6 addresses are assignable per interface.

IPv6 Addressing Rules

- Double colon **::** summarizes consecutive zeros for multiple groups.
- Only one double colon is permitted per IPv6 address.
- Multiple zeros can be summarized with a single zero per group.
- Leading zeros in a single group can be deleted.
- No less than eight groups including zero groups are required.
- Any address with less than eight groups must have double colon to summarize consecutive zero groups.

Example 1

What is the alternate equivalent notation for the following IPv6 address?
2001:25D3:0000:0000:009F:CD2A:0000:332E

A. 2001:25D3:9F::CD2A:0000:332E

B. 2001:25D3:9F:CD2A:0:332E

C. 2001:25D3::9F:CD2A:0:332E

D. 2001:25D3:0:009F:CD2A:332E

Answer: C

IPv6 address **2001:25D3::9F:CD2A:0:332E** does the following:

1. Minimizes multiple zero groups (group 3 and 4) to a double colon **::**
2. Deletes leading zeros from a single group (group 5)
3. Minimizes a single group with all zeros to single zero **:0:** (group 7)

A. 2001:25D3:9F::CD2A:0000:332E
(There is a double colon **::** in the wrong location to summarize group 3 and group 4. and group 7 not summarized to a single zero).

B. 2001:25D3:9F:CD2A:0:332E
Summarize zero groups 3 and group 4 to a double colon **::**

D. 2001:25D3:0:009F:CD2A:332E
Summarize group 3 and group 4 to a double colon **::** and not a single zero. Delete group 5 leading zeros and use a single zero for group 7.

Example 2

Select the valid IPv6 address from the following list?

A. 2001:0000:12D4::043D::1

B. 2001:1234:4567:AD:12DE:1

C. FEC0:ABCD:9WCD:0067::2A4

D. 2001:AD:654C:1234::9

Answer: D

Options A, B and C have features that are not valid with IPv6 addressing. The following explains the issues with each address:

A. 2001:0000:12D4::043D::1

There are double colons **::** occurring twice. The double colon is only permitted once per IPv6 address.

B. 2001:1234:4567:AD:12DE:1

There are only 6 groups. IPv6 requires 8 groups (8 x 16 bits = 128 bits). Any IPv6 address with less than 8 groups must have double colon to summarize zero groups.

C. FEC0:ABCD:9**W**CD:0067::2A4

There is an illegal value (W). IPv6 is based on hexadecimal notation with values from 0 to F only.

IPv6 Addressing Configuration

The global configuration command **ipv6 unicast-routing** enables IPv6 packet forwarding**.** It is the standard first command to enable before assigning IPv6 addresses. The command only enables IPv6 services and does not provide routing services.

There are a variety of dynamic addressing options available with IPv6. Each have different features for configuring IPv6 parameters to clients. They are alternatives to static IP parameter configuration. The following methods assign IPv6 addresses that is not statically configured

Stateful DHCPv6

Stateful DHCPv6 is most similar to DHCPv4 for IPv4 addressing. The IPv6 client sends a broadcast request to the nearest DHCPv6 server for IP address configuration. The DHCPv6 server assigns the IPv6 address and any additional required addressing configuration such as default gateway and DNS server.

Stateless DHCPv6

Stateless DHCPv6 feature uses Stateless Address Autoconfiguration (SLAAC) to assign an IPv6 address and default gateway to clients. The feature does require a DHCPv6 server for sending a variety of additional IP configuration settings including DNS server address to clients.

Stateless Address Autoconfiguration (SLAAC)

IPv6 makes addressing easier when auto-configuration (SLAAC) is enabled. There is a unique link-local address assigned automatically to each network interface. SLAAC does not however send DNS server address to clients. It only provides IP address and default gateway address to clients. SLAAC does not require configuration of **ipv6 enable** command. The following IOS commands enable IPv6 packet forwarding globally and autoconfiguration on a network interface.

```
router(config)# ipv6 unicast-routing
router(config)# interface gigabitethernet1/0
router(config-if)# ipv6 address autoconfig
```

Stateless Autoconfiguration generates a unique link-local address based on EUI-64 format. The IPv6 address is based on the network prefix sent in Router Advertisement (RA) from the local router. SLAAC obtains the default gateway from RA messages to configure clients. IPv6 processing is automatically enabled on an interface as soon as an IPv6 address is assigned to the interface. The IPv6 interface state is the status based on an autoconfiguration address request.

Tentative - Address is being verified with duplicate address detection.

Valid - Address can send and receive unicast traffic.

Preferred - Address can send and receive unicast traffic.

Deprecated - Address can send/receive unicasts (not recommended).

Invalid - Address cannot be used to send or receive unicast traffic.

IPv6 Static Address Configuration

The following IOS interface command manually assigns an IPv6 address to a network interface. The **ipv6 enable** command is not required when an IPv6 address is already assigned to an interface.

ipv6 address 2001:AF42:1212:4F32::1/64

The following IOS command will display the operational status of an IPv6 enabled interface, link-local address and global unicast addressing.

show ipv6 interface

Table 1 IPv6 Address Types

global unicast	internet routable with global routing prefix 2000::/3
multicast address	prefix FF00::/8 (send to group members)
unique local address	private global network, not internet routable, starts with FD00::/8
link-local address	mandatory, auto-configured, local subnet only, used for routing adjacency, prefix FE80::/64
loopback address	universal address, assigned to every interface, prefix ::1/128
modified eui-64	IPv6 host interface identifier, EUI-64 + msb 7th bit inverted
unspecified address	source address for initializing host, :1/128

The IPv6 link-local address always start with the FE80::/64 prefix. It is a mandatory address that is only routable within the local network segment where it is assigned. Every IPv6 enabled interface must have a link-local address even where there are routable IPv6 addresses assigned.

IPv6 Duplicate Address Detection

IPv6 duplicate address detection is enabled on all IPv6 addresses assigned to an interface. The detection starts with Stateless Address Autoconfiguration assigning an IPv6 link-local address to a node.

The network interface state is tentative during the detection process. The network administrator can enable duplicate address detection again by assigning a new IPv6 address. There are a variety of IPv6 address states based on the operational status of the interface and duplicate address detection. The IPv6 address state is pending while the associated network interface is administratively down. The following statements describe what happens when a router detects an IPv6 duplicate address.

- Duplicate global addresses are not used on interfaces where assigned.
- IPv6 forwarding disabled on interface with duplicate link-local address.
- IPv6 addresses are all disabled on any interface with a duplicate link-local address until it is resolved.

Hexadecimal to Binary Conversion

IPv6 addressing is based on hexadecimal format instead of IPv4 octets. The IPv6 address is comprised of 32 hexadecimal values of 4 bits each. Each hexadecimal number has 16 possible values that range from 0 to F derived from the lower 4 bits of an octet. The same values from 0-9 are used for IPv4 and IPv6 binary to decimal conversion.

Table 2 Hexadecimal Conversion

Hexadecimal	Decimal	Binary
A	10	1010
B	11	1011
C	12	1100
D	13	1101
E	14	1110
F	15	1111

Example 1: Hexadecimal Conversion

1 0 **1** 0
8 4 **2** 0 = 8 + 0 + 2 + 0 = 10 = A

1 **1** 0 **1**
8 **4** 0 **1** = 8 + 4 + 1 = 13 = D

Example 2: Hexadecimal Conversion

Convert FDA4 Hex to Binary = **1111 1101 1**010 0**1**00

F D A 4

IPv6 supports multiple IPv6 address types per interface. There is at least one loopback address (**::1**) and link-local address assigned to each interface. Unique local addresses are only routable across the company private network. The leftmost 64 bits of an IPv6 address represent the prefix with subnet mask.

Modified EUI-64 Address Format

IPv6 autoconfiguration configures EUI-64 modified address format as a default. The interface identifier is the host portion of an IPv6 address comprised of the rightmost 64 bits. It is uniquely derived from the MAC address assigned to network interface. The host divides its MAC address into two 24-bits components. The 16-bit hexadecimal value 0xFFFE is inserted between the MAC address halves. The most significant bit 7 is then inverted.

Table 3 IPv6 Route Types

network prefix	/64
default route	ipv6 route ::/0 2001:DB8:3C4D:2::1
point-to-point address	/126
floating static route	ipv6 route 2001:DB8::/32 Fa 1/0 200
static route	ipv6 route 2001:DB8:3C4D::/64 Fa 1/0 FE80::2
host route	/128
directly connected static route	ipv6 route 2001:DB8::/32 serial 1/0

* Egress interface must be specified for static route when the next hop is link-local address.