Configuring IPv6

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Finding Feature Information

Your software release might not support all the features documented in this module. For the latest caveats and feature information, see the Bug Search Tool at https://bst.cloudapps.cisco.com/bugsearch and the release notes for your software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the "New and Changed Information"chapter or the Feature History table in this chapter.

Information About IPv6

IPv6, which is designed to replace IPv4, increases the number of network address bits from 32 bits (in IPv4) to 128 bits. IPv6 is based on IPv4 but it includes a much larger address space and other improvements such as a simplified main header and extension headers.

The larger IPv6 address space allows networks to scale and provide global reachability. The simplified IPv6 packet header format handles packets more efficiently. The flexibility of the IPv6 address space reduces the need for private addresses and the use of Network Address Translation (NAT), which translates private (not globally unique) addresses into a limited number of public addresses. IPv6 enables new application protocols that do not require special processing by border routers at the edge of networks.

IPv6 functionality, such as prefix aggregation, simplified network renumbering, and IPv6 site multihoming capabilities, enable more efficient routing. IPv6 supports Routing Information Protocol (RIP), Integrated Intermediate System-to-Intermediate System (IS-IS), Open Shortest Path First (OSPF) for IPv6, and multiprotocol Border Gateway Protocol (BGP).

IPv6 Address Formats

An IPv6 address has 128 bits or 16 bytes. The address is divided into eight, 16-bit hexadecimal blocks separated by colons (:) in the format x:x:x:x:x:x:x:x.

Two examples of IPv6 addresses are as follows:

```
2001:0DB8:7654:3210:FEDC:BA98:7654:3210
```

```
2001:0DB8:0:0:8:800:200C:417A
```

IPv6 addresses contain consecutive zeros within the address. You can use two colons (::) at the beginning, middle, or end of an IPv6 address to replace the consecutive zeros.

Note You can use two colons (::) only once in an IPv6 address to replace the longest string of consecutive zeros within the address.

You can use a double colon as part of the IPv6 address when consecutive 16-bit values are denoted as zero. You can configure multiple IPv6 addresses per interface but only one link-local address.

The hexadecimal letters in IPv6 addresses are not case sensitive.

Table 1: Compressed IPv6 Address Formats

IPv6 Address Type	Preferred Format	Compressed Format
Unicast	2001:0:0:0:0:DB8:800:200C:417A	2001::0DB8:800:200C:417A
Multicast	FF01:0:0:0:0:0:0:101	FF01::101
Loopback	0:0:0:0:0:0:0:1	::1
Unspecified	0:0:0:0:0:0:0:0	::

A node may use the loopback address listed in the table to send an IPv6 packet to itself. The loopback address in IPv6 is the same as the loopback address in IPv4.

Note You cannot assign the IPv6 loopback address to a physical interface. A packet that contains the IPv6 loopback address as its source or destination address must remain within the node that created the packet. IPv6 routers do not forward packets that have the IPv6 loopback address as their source or destination address.

You cannot assign an IPv6 unspecified address to an interface. You should not use the unspecified IPv6 addresses as destination addresses in IPv6 packets or the IPv6 routing header.

The IPv6-prefix is in the form documented in RFC 2373 where the IPv6 address is specified in hexadecimal using 16-bit values between colons. The prefix length is a decimal value that indicates how many of the

high-order contiguous bits of the address comprise the prefix (the network portion of the address). For example, 2001:0DB8:8086:6502::/32 is a valid IPv6 prefix.

IPv6 Unicast Addresses

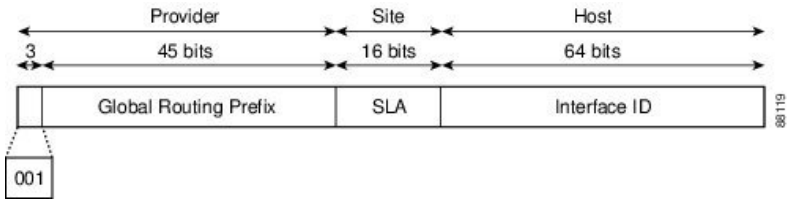
An IPv6 unicast address is an identifier for a single interface on a single node. A packet that is sent to a unicast address is delivered to the interface identified by that address.

Aggregatable Global Addresses

An aggregatable global address is an IPv6 address from the aggregatable global unicast prefix. The structure of aggregatable global unicast addresses enables strict aggregation of routing prefixes that limits the number of routing table entries in the global routing table. Aggregatable global addresses are used on links that are aggregated upward through organizations and eventually to the Internet service providers (ISPs).

Aggregatable global IPv6 addresses are defined by a global routing prefix, a subnet ID, and an interface ID. Except for addresses that start with binary 000, all global unicast addresses have a 64-bit interface ID. The IPv6 global unicast address allocation uses the range of addresses that start with binary value 001 (2000::/3). The figure shows the structure of an aggregatable global address.

Figure 1: Aggregatable Global Addresses



Addresses with a prefix of 2000::/3 (001) through E000::/3 (111) are required to have 64-bit interface identifiers in the extended universal identifier (EUI)-64 format. The Internet Assigned Numbers Authority (IANA) allocates the IPv6 address space in the range of 2000::/16 to regional registries.

The aggregatable global address consists of a 48-bit global routing prefix and a 16-bit subnet ID or Site-Level Aggregator (SLA). In the IPv6 aggregatable global unicast address format document (RFC 2374), the global routing prefix included two other hierarchically structured fields called Top-Level Aggregator (TLA) and Next-Level Aggregator (NLA). The IETF decided to remove the TLS and NLA fields from the RFCs because these fields are policy based. Some existing IPv6 networks deployed before the change might still use networks that are on the older architecture.

A subnet ID, which is a 16-bit subnet field, can be used by individual organizations to create a local addressing hierarchy and to identify subnets. A subnet ID is similar to a subnet in IPv4, except that an organization with an IPv6 subnet ID can support up to 65,535 individual subnets.

An interface ID identifies interfaces on a link. The interface ID is unique to the link. In many cases, an interface ID is the same as or based on the link-layer address of an interface. Interface IDs used in aggregatable global unicast and other IPv6 address types have 64 bits and are in the modified EUI-64 format.

Interface IDs are in the modified EUI-64 format in one of the following ways:

- For all IEEE 802 interface types (for example, Ethernet, and Fiber Distributed Data interfaces), the first three octets (24 bits) are the Organizationally Unique Identifier (OUI) of the 48-bit link-layer address (MAC address) of the interface, the fourth and fifth octets (16 bits) are a fixed hexadecimal value of FFFE, and the last three octets (24 bits) are the last three octets of the MAC address. The Universal/Local

(U/L) bit, which is the seventh bit of the first octet, has a value of 0 or 1. Zero indicates a locally administered identifier; 1 indicates a globally unique IPv6 interface identifier.

- For all other interface types (for example, serial, loopback, ATM, Frame Relay, and tunnel interface types-except tunnel interfaces used with IPv6 overlay tunnels), the interface ID is similar to the interface ID for IEEE 802 interface types; however, the first MAC address from the pool of MAC addresses in the router is used as the identifier (because the interface does not have a MAC address).
- For tunnel interface types that are used with IPv6 overlay tunnels, the interface ID is the IPv4 address assigned to the tunnel interface with all zeros in the high-order 32 bits of the identifier

Note For interfaces that use the Point-to-Point Protocol (PPP), where the interfaces at both ends of the connection might have the same MAC address, the interface identifiers at both ends of the connection are negotiated (picked randomly and, if necessary, reconstructed) until both identifiers are unique. The first MAC address in the router is used as the identifier for interfaces using PPP.

If no IEEE 802 interface types are in the router, link-local IPv6 addresses are generated on the interfaces in the router in the following sequence:

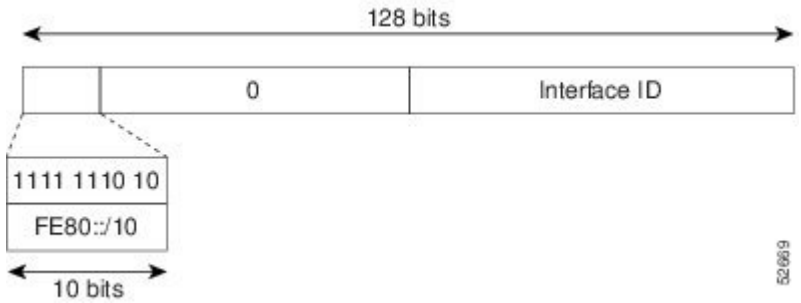
1. The router is queried for MAC addresses (from the pool of MAC addresses in the router).
2. If no MAC addresses are available in the router, the serial number of the router is used to form the link-local addresses.
3. If the serial number of the router cannot be used to form the link-local addresses, the router uses a Message Digest 5 (MD5) hash to determine the MAC address of the router from the hostname of the router.

Link-Local Addresses

A link-local address is an IPv6 unicast address that can be automatically configured on any interface using the link-local prefix FE80::/10 (1111 1110 10) and the interface identifier in the modified EUI-64 format. Link-local addresses are used in the Neighbor Discovery Protocol (NDP) and the stateless autoconfiguration process. Nodes on a local link can use link-local addresses to communicate; the nodes do not need globally unique addresses to communicate.

IPv6 routers cannot forward packets that have link-local source or destination addresses to other links.

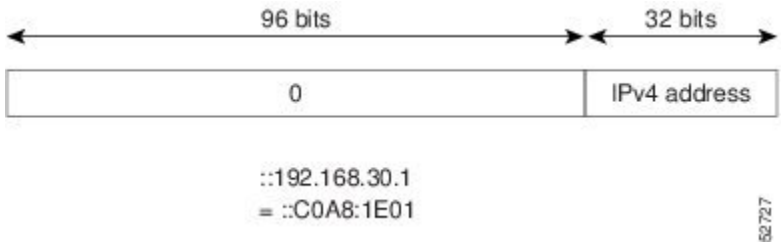
Figure 2: Link-Local Address Format



IPv4-Compatible IPv6 Addresses

An IPv4-compatible IPv6 address is an IPv6 unicast address that has zeros in the high-order 96 bits of the address and an IPv4 address in the low-order 32 bits of the address. The format of an IPv4-compatible IPv6 address is 0:0:0:0:0:0:A.B.C.D or ::A.B.C.D. The entire 128-bit IPv4-compatible IPv6 address is used as the IPv6 address of a node and the IPv4 address embedded in the low-order 32 bits is used as the IPv4 address of the node. IPv4-compatible IPv6 addresses are assigned to nodes that support both the IPv4 and IPv6 protocol stacks and are used in automatic tunnels.

Figure 3: IPv4-Compatible IPv6 Address Format



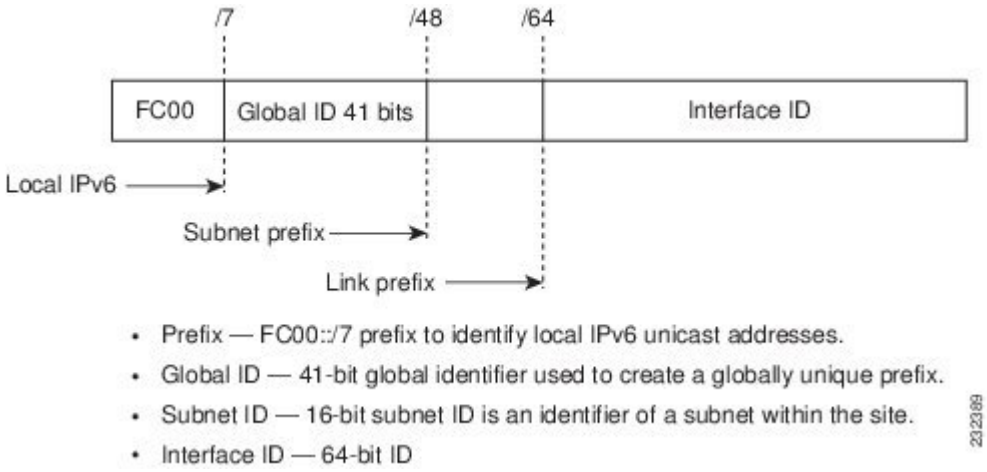
Unique Local Addresses

A unique local address is an IPv6 unicast address that is globally unique and is intended for local communications. It is not expected to be routable on the global Internet and is routable inside of a limited area, such as a site, and it may be routed between a limited set of sites. Applications may treat unique local addresses like global scoped addresses.

A unique local address has the following characteristics:

- It has a globally unique prefix (it has a high probability of uniqueness).
- It has a well-known prefix to allow for easy filtering at site boundaries
- It allows sites to be combined or privately interconnected without creating any address conflicts or requiring renumbering of interfaces that use these prefixes.
- It is ISP-independent and can be used for communications inside of a site without having any permanent or intermittent Internet connectivity.
- If it is accidentally leaked outside of a site through routing or the Domain Name Server (DNS), there is no conflict with any other addresses.

Figure 4: Unique Local Address Structure



Site Local Addresses

Because RFC 3879 deprecates the use of site-local addresses, you should follow the recommendations of unique local addressing (ULA) in RFC 4193 when you configure private IPv6 addresses.

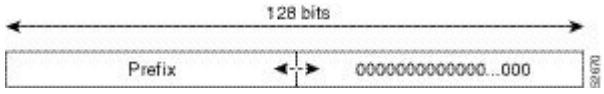
IPv6 Anycast Addresses

An anycast address is an address that is assigned to a set of interfaces that belong to different nodes. A packet sent to an anycast address is delivered to the closest interface-as defined by the routing protocols in use-identified by the anycast address. Anycast addresses are syntactically indistinguishable from unicast addresses because anycast addresses are allocated from the unicast address space. Assigning a unicast address to more than one interface turns a unicast address into an anycast address. You must configure the nodes to which the anycast address to recognize that the address is an anycast address.

Note Anycast addresses can be used only by a router, not a host. Anycast addresses cannot be used as the source address of an IPv6 packet.

The following figure shows the format of the subnet router anycast address; the address has a prefix concatenated by a series of zeros (the interface ID). The subnet router anycast address can be used to reach a router on the link that is identified by the prefix in the subnet router anycast address.

Figure 5: Subnet Router Anycast Address Format

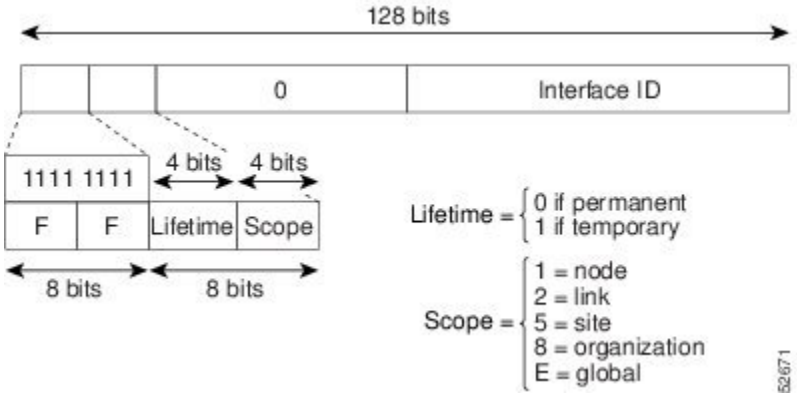


IPv6 Multicast Addresses

An IPv6 multicast address is an IPv6 address that has a prefix of FF00::/8 (1111 1111). An IPv6 multicast address is an identifier for a set of interfaces that belong to different nodes. A packet sent to a multicast address

is delivered to all interfaces identified by the multicast address. The second octet following the prefix defines the lifetime and scope of the multicast address. A permanent multicast address has a lifetime parameter equal to 0; a temporary multicast address has a lifetime parameter equal to 1. A multicast address that has the scope of a node, link, site, or organization, or a global scope, has a scope parameter of 1, 2, 5, 8, or E, respectively. For example, a multicast address with the prefix FF02::/16 is a permanent multicast address with a link scope.

Figure 6: IPv6 Multicast Address Format



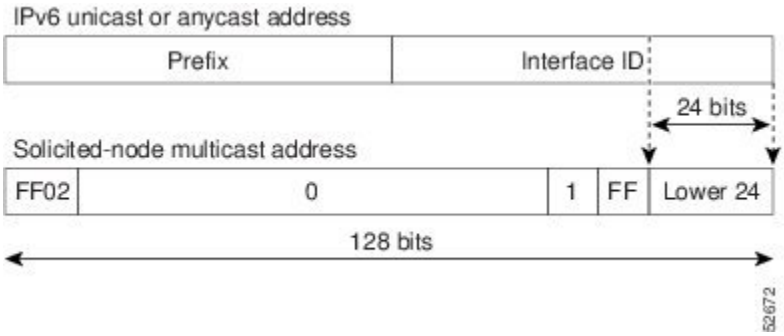
IPv6 nodes (hosts and routers) are required to join (where received packets are destined for) the following multicast groups:

- All-nodes multicast group FF02:0:0:0:0:0:0:1 (the scope is link-local)
- Solicited-node multicast group FF02:0:0:0:0:1:FF00:0000/104 for each of its assigned unicast and anycast addresses

IPv6 routers must also join the all-routers multicast group FF02:0:0:0:0:0:0:2 (the scope is link-local).

The solicited-node multicast address is a multicast group that corresponds to an IPv6 unicast or anycast address. IPv6 nodes must join the associated solicited-node multicast group for every unicast and anycast address to which it is assigned. The IPv6 solicited-node multicast address has the prefix FF02:0:0:0:0:1:FF00:0000/104 concatenated with the 24 low-order bits of a corresponding IPv6 unicast or anycast address. For example, the solicited-node multicast address that corresponds to the IPv6 address 2037::01:800:200E:8C6C is FF02::1:FF0E:8C6C. Solicited-node addresses are used in neighbor solicitation messages.

Figure 7: Pv6 Solicited-Node Multicast Address Format

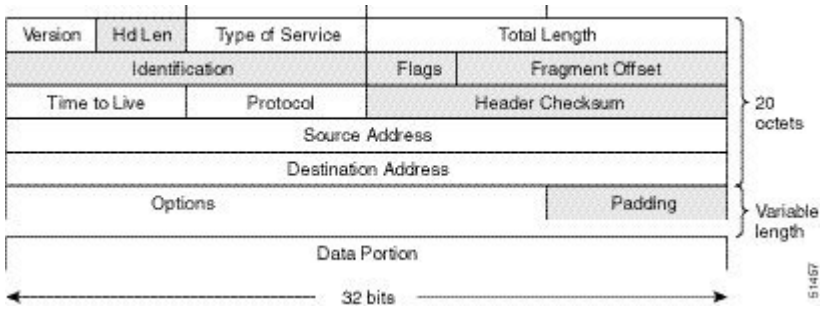


Note IPv6 has no broadcast addresses. IPv6 multicast addresses are used instead of broadcast addresses.

IPv4 Packet Header

The base IPv4 packet header has 12 fields with a total size of 20 octets (160 bits). The 12 fields may be followed by an Options field, which is followed by a data portion that is usually the transport-layer packet. The variable length of the Options field adds to the total size of the IPv4 packet header. The shaded fields of the IPv4 packet header are not included in the IPv6 packet header.

Figure 8: IPv4 Packet Header Format



Simplified IPv6 Packet Header

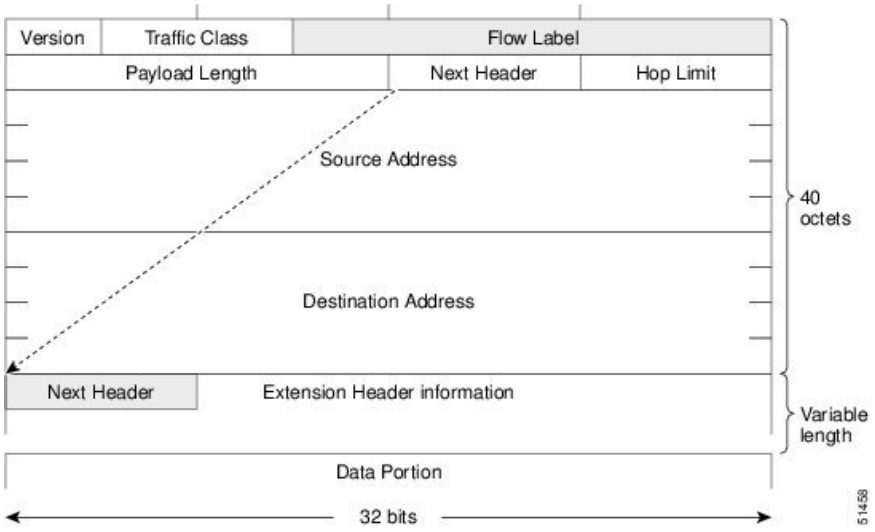
The base IPv6 packet header has 8 fields with a total size of 40 octets (320 bits). Fragmentation is handled by the source of a packet and checksums at the data link layer and transport layer are used. The User Datagram Protocol (UDP) checksum checks the integrity of the inner packet and the base IPv6 packet header and Options field are aligned to 64 bits, which can facilitate the processing of IPv6 packets.

Table 2: Base IPv6 Packet Header Fields

Field	Description
Version	Similar to the Version field in the IPv4 packet header, except that the field lists number 6 for IPv6 instead of number 4 for IPv4.
Traffic Class	Similar to the Type of Service field in the IPv4 packet header. The Traffic Class field tags packets with a traffic class that is used in differentiated services.
Flow Label	New field in the IPv6 packet header. The Flow Label field tags packets with a specific flow that differentiates the packets at the network layer.
Payload Length	Similar to the Total Length field in the IPv4 packet header. The Payload Length field indicates the total length of the data portion of the packet.

Field	Description
Next Header	Similar to the Protocol field in the IPv4 packet header. The value of the Next Header field determines the type of information that follows the base IPv6 header. The type of information that follows the base IPv6 header can be a transport-layer packet, for example, a TCP or UDP packet, or an Extension Header.
Hop Limit	Similar to the Time to Live field in the IPv4 packet header. The value of the Hop Limit field specifies the maximum number of routers that an IPv6 packet can pass through before the packet is considered invalid. Each router decrements the value by one. Because no checksum is in the IPv6 header, the router can decrement the value without needing to recalculate the checksum, which saves processing resources.
Source Address	Similar to the Source Address field in the IPv4 packet header, except that the field contains a 128-bit source address for IPv6 instead of a 32-bit source address for IPv4.
Destination Address	Similar to the Destination Address field in the IPv4 packet header, except that the field contains a 128-bit destination address for IPv6 instead of a 32-bit destination address for IPv4.

Figure 9: IPv6 Packet Header Format



Optional extension headers and the data portion of the packet are after the eight fields of the base IPv6 packet header. If present, each extension header is aligned to 64 bits. There is no fixed number of extension headers in an IPv6 packet. Each extension header is identified by the Next Header field of the previous header. Typically, the final extension header has a Next Header field of a transport-layer protocol, such as TCP or UDP.

Figure 10: IPv6 Extension Header Format

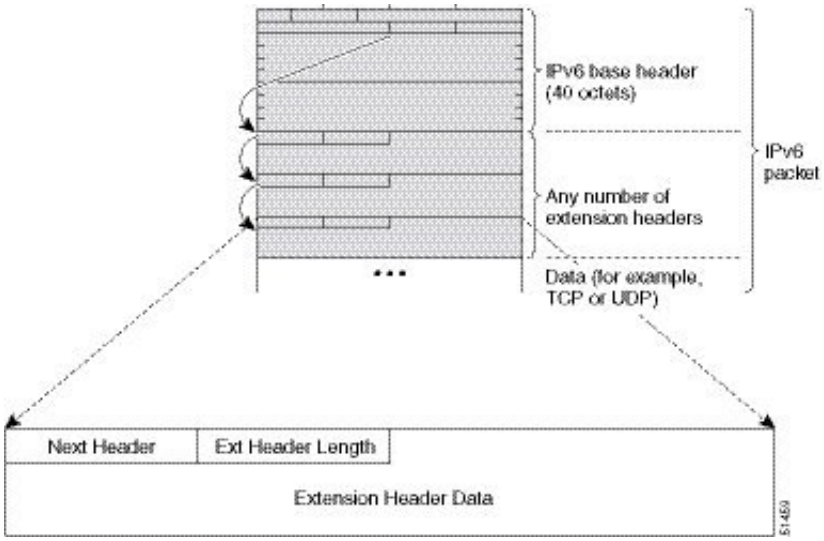


Table 3: IPv6 Extension Header Types

Header Type	Next Header Value	Description
Hop-by-Hop options header	0	Header that is processed by all hops in the path of a packet. When present, the hop-by-hop options header always follows immediately after the base IPv6 packet header.
Destination Header Options	60	Header that can follow any hop-by-hop options header. The header is processed at the final destination and at each visited address specified by a routing header. Alternatively, the destination options header can follow any Encapsulating Security Payload (ESP) header. The destination options header is processed only at the final destination.
Routing Header	43	Header that is used for source routing.

Header Type	Next Header Value	Description
Fragment Header	44	Header that is used when a source fragments a packet that is larger than the maximum transmission unit (MTU) for the path between itself and a destination. The Fragment header is used in each fragmented packet.
Upper-Layer Headers	6 (TCP) 17 (UDP)	Headers that are used inside a packet to transport the data. The two main transport protocols are TCP and UDP.

DNS for IPv6

IPv6 supports DNS record types that are supported in the DNS name-to-address and address-to-name lookup processes. The DNS record types support IPv6 addresses.

Note IPv6 also supports the reverse mapping of IPv6 addresses to DNS names.

Table 4: IPv6 DNS Record Types

Record Type	Description	Format
AAAA	Maps a hostname to an IPv6 address. (Equivalent to an A record in IPv4.)	www.abc.test AAAA 3FFE:YYYY:C18:1::2
PTR	Maps an IPv6 address to a hostname. (Equivalent to a PTR record in IPv4.)	2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.1.0.0.0.8.1.c.0.y.y.y.y.e.f.f.3.ip6.int PTR www.abc.test

Path MTU Discovery for IPv6

As in IPv4, you can use path MTU discovery in IPv6 to allow a host to dynamically discover and adjust to differences in the MTU size of every link along a data path. In IPv6, however, fragmentation is handled by the source of a packet when the path MTU of one link along a given data path is not large enough to accommodate the size of the packets. Having IPv6 hosts handle packet fragmentation saves IPv6 router processing resources and helps IPv6 networks run more efficiently. Once the path MTU is reduced by the arrival of an ICMP Too Big message, Cisco NX-OS retains the lower value. The connection does not increase the segment size to gauge the throughput.

Note In IPv6, the minimum link MTU is 1280 octets. We recommend that you use an MTU value of 1500 octets for IPv6 links.

CDP IPv6 Address Support

You can use the Cisco Discovery Protocol (CDP) IPv6 address support for the neighbor information feature to transfer IPv6 addressing information between two Cisco devices. Cisco Discovery Protocol support for IPv6 addresses provides IPv6 information to network management products and troubleshooting tools.

ICMP for IPv6

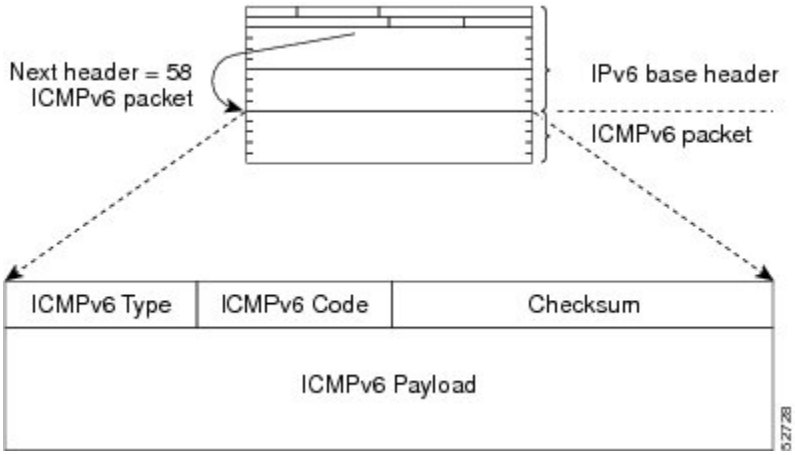
You can use ICMP in IPv6 to provide information about the health of the network. ICMPv6, the version that works with IPv6, reports errors if packets cannot be processed correctly and sends informational messages about the status of the network. For example, if a router cannot forward a packet because it is too large to be sent out on another network, the router sends out an ICMPv6 message to the originating host. Additionally, ICMP packets in IPv6 are used in IPv6 neighbor discovery and path MTU discovery. The path MTU discovery process ensures that a packet is sent using the largest possible size that is supported on a specific route.

A value of 58 in the Next Header field of the base IPv6 packet header identifies an IPv6 ICMP packet. The ICMP packet follows all the extension headers and is the last piece of information in the IPv6 packet.Within the IPv6 ICMP packets, the ICMPv6 Type and ICMPv6 Code fields identify IPv6 ICMP packet specifics, such as the ICMP message type. The value in the Checksum field is computed by the sender and checked by the receiver from the fields in the IPv6 ICMP packet and the IPv6 pseudo header.

Note The IPv6 header does not have a checksum. But a checksum on the transport layer can determine if packets have not been delivered correctly. All checksum calculations that include the IP address in the calculation must be modified for IPv6 to accommodate the new 128-bit address. A checksum is generated using a pseudo header.

The ICMPv6 Payload field contains error or diagnostic information that relates to IP packet processing.

Figure 11: IPv6 ICMP Packet Header Format



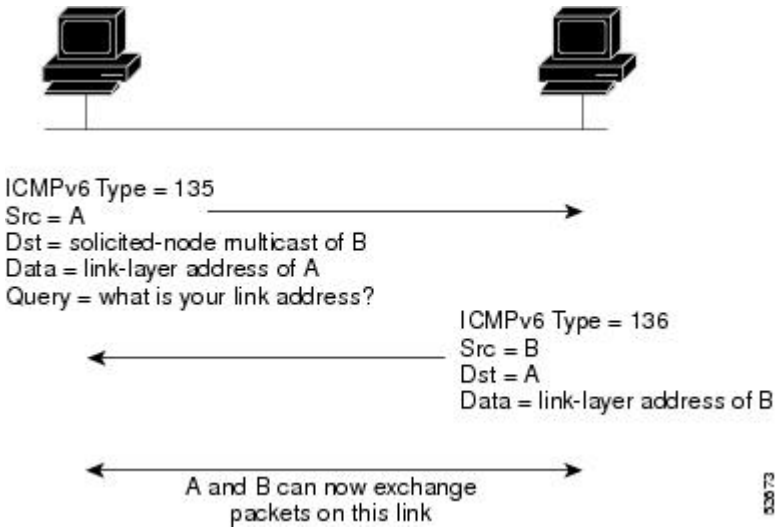
IPv6 Neighbor Discovery

You can use the IPv6 Neighbor Discovery Protocol (NDP) to determine whether a neighboring router is reachable. IPv6 nodes use neighbor discovery to determine the addresses of nodes on the same network (local link), to find neighboring routers that can forward their packets, to verify whether neighboring routers are reachable or not, and to detect changes to link-layer addresses. NDP uses ICMP messages to detect whether packets are sent to neighboring routers that are unreachable.

IPv6 Neighbor Solicitation Message

A node sends a neighbor solicitation message, which has a value of 135 in the Type field of the ICMP packet header, on the local link when it wants to determine the link-layer address of another node on the same local link. The source address is the IPv6 address of the node that sends the neighbor solicitation message. The destination address is the solicited-node multicast address that corresponds to the IPv6 address of the destination node. The neighbor solicitation message also includes the link-layer address of the source node.

Figure 12: IPv6 Neighbor Discovery-Neighbor Solicitation Message



After receiving the neighbor solicitation message, the destination node replies by sending a neighbor advertisement message, which has a value of 136 in the Type field of the ICMP packet header, on the local link. The source address is the IPv6 address of the node (the IPv6 address of the node interface that sends the neighbor advertisement message). The destination address is the IPv6 address of the node that sends the neighbor solicitation message. The data portion includes the link-layer address of the node that sends the neighbor advertisement message.

After the source node receives the neighbor advertisement, the source node and destination node can communicate.

Neighbor solicitation messages can verify the reachability of a neighbor after a node identifies the link-layer address of a neighbor. When a node wants to verify the reachability of a neighbor, it uses the destination address in a neighbor solicitation message as the unicast address of the neighbor.

Neighbor advertisement messages are also sent when there is a change in the link-layer address of a node on a local link. When there is a change, the destination address for the neighbor advertisement is the all-nodes multicast address.

Neighbor unreachability detection identifies the failure of a neighbor or the failure of the forward path to the neighbor and is used for all paths between hosts and neighboring nodes (hosts or routers). Neighbor unreachability detection is performed for neighbors to which only unicast packets are being sent and is not performed for neighbors to which multicast packets are being sent.

A neighbor is considered reachable when a positive acknowledgment is returned from the neighbor (indicating that packets previously sent to the neighbor have been received and processed). A positive acknowledgment-from an upper-layer protocol (such as TCP)-indicates that a connection is making forward progress (reaching its destination). If packets are reaching the peer, they are also reaching the next-hop neighbor of the source. Forward progress is also a confirmation that the next-hop neighbor is reachable.

For destinations that are not on the local link, forward progress implies that the first-hop router is reachable. When acknowledgments from an upper-layer protocol are not available, a node probes the neighbor using unicast neighbor solicitation messages to verify that the forward path is still working. The return of a solicited neighbor advertisement message from the neighbor is a positive acknowledgment that the forward path is still working (neighbor advertisement messages that have the solicited flag set to a value of 1 are sent only in response to a neighbor solicitation message). Unsolicited messages confirm only the one-way path from the

source to the destination node; solicited neighbor advertisement messages indicate that a path is working in both directions.

Note A neighbor advertisement message that has the solicited flag set to a value of 0 is not considered as a positive acknowledgment that the forward path is still working.

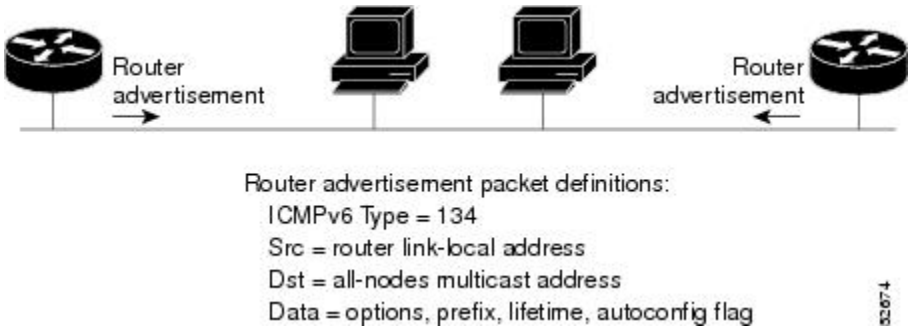
Neighbor solicitation messages are also used in the stateless autoconfiguration process to verify the uniqueness of unicast IPv6 addresses before the addresses are assigned to an interface. Duplicate address detection is performed first on a new, link-local IPv6 address before the address is assigned to an interface (the new address remains in a tentative state while duplicate address detection is performed). A node sends a neighbor solicitation message with an unspecified source address and a tentative link-local address in the body of the message. If another node is already using that address, the node returns a neighbor advertisement message that contains the tentative link-local address. If another node is simultaneously verifying the uniqueness of the same address, that node also returns a neighbor solicitation message. If no neighbor advertisement messages are received in response to the neighbor solicitation message and no neighbor solicitation messages are received from other nodes that are attempting to verify the same tentative address, the node that sent the original neighbor solicitation message considers the tentative link-local address to be unique and assigns the address to the interface.

IPv6 Router Advertisement Message

Router advertisement (RA) messages, which have a value of 134 in the Type field of the ICMP packet header, are periodically sent out to each configured interface of an IPv6 router. For stateless autoconfiguration to work properly, the advertised prefix length in RA messages must always be 64 bits.

The RA messages are sent to the all-nodes multicast address.

Figure 13: Neighbor Discovery—RA Message



RA messages typically include the following information:

- One or more onlink IPv6 prefixes that nodes on the local link can use to automatically configure their IPv6 addresses
- Life-time information for each prefix included in the advertisement
- Sets of flags that indicate the type of autoconfiguration (stateless or stateful) that can be completed
- Default router information (whether the router sending the advertisement should be used as a default router and, if so, the amount of time in seconds that the router should be used as a default router)

- Additional information for hosts, such as the hop limit and MTU that a host should use in packets that it originates

RAs are also sent in response to router solicitation messages. Router solicitation messages, which have a value of 133 in the Type field of the ICMP packet header, are sent by hosts at system startup so that the host can immediately autoconfigure without needing to wait for the next scheduled RA message. The source address is usually the unspecified IPv6 address (0:0:0:0:0:0:0:0). If the host has a configured unicast address, the unicast address of the interface that sends the router solicitation message is used as the source address in the message. The destination address is the all-routers multicast address with a scope of the link. When an RA is sent in response to a router solicitation, the destination address in the RA message is the unicast address of the source of the router solicitation message.

You can configure the following RA message parameters:

- The time interval between periodic RA messages
- The router life-time value, which indicates the usefulness of a router as the default router (for use by all nodes on a given link)
- The network prefixes in use on a given link
- The time interval between neighbor solicitation message retransmissions (on a given link)
- The amount of time that a node considers a neighbor reachable (for use by all nodes on a given link)

The configured parameters are specific to an interface. The sending of RA messages (with default values) is automatically enabled on Ethernet interfaces. For other interface types, you must enter the **no ipv6 nd suppress-ra** command to send RA messages. You can disable the RA message feature on individual interfaces by entering the **ipv6 nd suppress-ra** command.

IPv6 Router Advertisement Options for DNS Configuration

Most of the internet services are identified by a Domain Name Server (DNS) name. Cisco NX-OS IPv6 Router Advertisement (RA) provides the following two options to allow IPv6 hosts to perform automatic DNS configuration:

- Recursive DNS Server (RDNSS)
- DNS Search List (DNSSL)

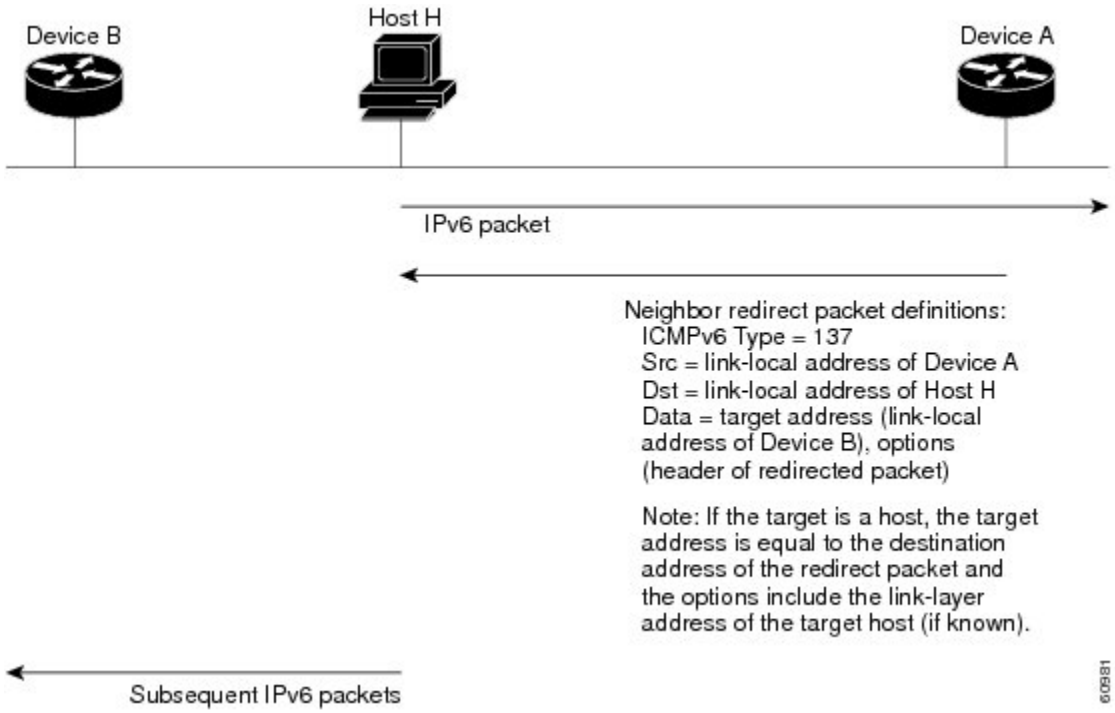
RDNSS contains the address of recursive DNS servers that help in DNS name resolution in IPv6 hosts. DNS Search List is a list of DNS suffix domain names used by IPv6 hosts when they perform DNS query searches.

For more information on RA options for DNS configuration, refer IETF RFC 6106.

IPv6 Neighbor Redirect Message

Routers send neighbor redirect messages to inform hosts of better first-hop nodes on the path to a destination. A value of 137 in the Type field of the ICMP packet header identifies an IPv6 neighbor redirect message.

Figure 14: IPv6 Neighbor Discovery—Neighbor Redirect Message



Note A router must be able to determine the link-local address for each of its neighboring routers in order to ensure that the target address (the final destination) in a redirect message identifies the neighbor router by its link-local address. For static routing, you should specify the address of the next-hop router using the link-local address of the router. For dynamic routing, you must configure all IPv6 routing protocols to exchange the link-local addresses of neighboring routers.

After forwarding a packet, a router sends a redirect message to the source of the packet under the following circumstances:

- The destination address of the packet is not a multicast address.
- The packet was not addressed to the router.
- The packet is about to be sent out the interface on which it was received.
- The router determines that a better first-hop node for the packet resides on the same link as the source of the packet.
- The source address of the packet is a global IPv6 address of a neighbor on the same link or a link-local address.

Virtualization Support for IPv6

IPv6 supports virtual routing and forwarding (VRF) instances. VRFs exist within virtual device contexts (VDCs). By default, Cisco NX-OS places you in the default VDC and default VRF unless you specifically configure another VDC and VRF. For more information, see the *Cisco Nexus 7000 Series NX-OS Virtual Device Context Configuration Guide*.

Prerequisites for IPv6

IPv6 has the following prerequisites:

- You must be familiar with IPv6 basics such as IPv6 addressing, IPv6 header information, ICMPv6, and the IPv6 Neighbor Discovery (ND) Protocol.
- Ensure that you follow the memory/processing guidelines when you make a device a dual-stack device (IPv4/IPv6).

Guidelines and Limitations for Configuring IPv6

IPv6 has the following configuration guidelines and limitations:

- In the absence of routes within a VRF, the bulk IPv6 consistency check will not function as expected due to a known software limitation.
- IPv6 packets are transparent to Layer 2 LAN switches because the switches do not examine Layer 3 packet information before forwarding IPv6 frames. IPv6 hosts can be directly attached to Layer 2 LAN switches.
- You can configure multiple IPv6 global addresses within the same prefix on an interface. However, multiple IPv6 link-local addresses on an interface are not supported.
- It supports contiguous masks only for both IPv4 and IPv6 addresses and does not support discontiguous masks IPv6 and IPv4 filters.
- Each interface can be configured with a maximum of 255 global IPv6 addresses and a maximum of 255 anycast IPv6 addresses.
- Because RFC 3879 deprecates the use of site-local addresses, you should configure private IPv6 addresses according to the recommendations of unique local addressing (ULA) in RFC 4193.
- F2 Series modules do not support IPv6 tunnels.
- On F2 Series modules, you must disable IGMP optimized multicast flooding (OMF) on any VLANs that require any IPv6 packet forwarding (unicast or multicast). IPv6 neighbor discovery functions correctly only in a VLAN with the OMF feature disabled. To disable OMF, use the **no ip igmp snooping optimised-multicast-flood** command in VLAN configuration mode. With OMF disabled, unknown IPv4 multicast traffic (as well as all IPv6 multicast traffic) is flooded to all ports in the VLAN. Note that unknown multicast traffic refers to multicast packets with an active source but no receivers (and therefore no group forwarding entry in the hardware) in the ingress VLAN.
- IPv6 static route next hop link-local address cannot be configured at any local interface.

Default Settings for IPv6

Parameters	Default
ND reachable time	0 milliseconds
neighbor solicitation retransmit interval	1000 milliseconds

By default, IPv6 source routing is enabled on the switch. To disable IPv6 source routing configure no **ipv6 source-route** command on the switch.

Configuring IPv6

Configuring IPv6 Addressing

You must configure an IPv6 address on an interface so that the interface can forward IPv6 traffic. When you configure a global IPv6 address on an interface, it automatically configures a link-local address and activates IPv6 for that interface.

Note Each interface can be configured with a maximum of 255 global IPv6 addresses and a maximum of 255 anycast IPv6 addresses.

Before you begin

Ensure that you are in the correct VDC (or use the **switchto vdc** command).

Procedure

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters global configuration mode.
Step 2	switch(config)# **interface ethernet** *number*	Enters interface configuration mode.
Step 3	switch(config-if)# **ipv6 address** {*address* [**eui64**] [**route-preference** *preference*] [**secondary**] **tag** *tag-id*] or switch(config-if)# **ipv6 address** *ipv6-address* **use-link-local-only**	Specifies an IPv6 address assigned to the interface and enables IPv6 processing on the interface. Entering the **ipv6 address** command configures global IPv6 addresses with an interface identifier (ID) in the low-order 64 bits of the IPv6 address. Only the 64-bit network prefix for the address needs to be specified; the last 64 bits are automatically computed from the interface ID. Entering the **ipv6 address use-link-local-only**command configures a link-local address on the interface that is used instead of the link-local address that is automatically configured when IPv6 is enabled on the interface.

	Command or Action	Purpose
		This command enables IPv6 processing on an interface without configuring an IPv6 address.
Step 4	(Optional) switch(config-if)# **show ip interface**	Displays interfaces configured for IPv4.
Step 5	(Optional) switch(config)# **copy running-config startup-config**	Saves the change persistently through reboots and restarts by copying the running configuration to the startup configuration.

Example

This example shows how to assign an IPv6 address:

```
switch# configure terminal
switch(config)# interface ethernet 2/3
switch(config-if)# ipv6 address 2001:db8::/64 eui64
switch(config-if)# copy running-config startup-config
switch(config-if)#
```

This example shows how to display an IPv6 interface:

```
switch# configure terminal
switch(config)# show ipv6 interface ethernet 3/1
Ethernet3/1, Interface status: protocol-down/link-down/admin-down, iod: 36
IPv6 address: 0dc3:0dc3:0000:0000:0218:baff:fed8:239d
IPv6 subnet:  0dc3:0dc3:0000:0000:0000:0000:0000:0000/64
IPv6 link-local address: fe80::0218:baff:fed8:239d (default)
IPv6 multicast routing: disabled
IPv6 multicast groups locally joined:
ff02::0001:ffd8:239d  ff02::0002  ff02::0001  ff02::0001:ffd8:239d
IPv6 multicast (S,G) entries joined: none
IPv6 MTU: 1500 (using link MTU)
IPv6 RP inbound packet-filtering policy: none
IPv6 RP outbound packet-filtering policy: none
IPv6 inbound packet-filtering policy: none
IPv6 outbound packet-filtering policy: none
IPv6 interface statistics last reset: never
IPv6 interface RP-traffic statistics: (forwarded/originated/consumed)
Unicast packets: 0/0/0
Unicast bytes: 0/0/0
Multicast packets: 0/0/0
Multicast bytes: 0/0/0
```

Configuring IPv6 Neighbor Discovery

You can configure IPv6 neighbor discovery on the router. Neighbor Discovery (ND) enables IPv6 nodes and routers to determine the link-layer address of a neighbor on the same link, find neighboring routers, and keep track of neighbors.

Before you begin

Ensure that you are in the correct VDC (or use the **switchto vdc** command).

Procedure

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters global configuration mode.
Step 2	switch(config)# **interface ethernet** *number*	Enters interface configuration mode.
Step 3	switch(config-if)# **ipv6 nd** [**hop-limit** *hop-limit* | **managed-config-flag** | **mtu** *mtu* | **ns-interval** *interval* | **other-config-flag** | **prefix** | **ra-interval** *interval* | **ra-lifetime** *lifetime* | **reachable-time** *time* | **redirects** | **retrans-timer** *time* | **suppress-ra**]	Specifies an IPv6 address assigned to the interface and enables IPv6 processing on the interface. • **hop-limit** *hop-limit*— Advertises the hop limit in IPv6 neighbor discovery packets. The range is from 0 to 255. • **managed-config-flag**— Advertises in ICMPv6 router-advertisement messages to use stateful address auto-configuration to obtain address information. • **mtu** *mtu*—Advertises the maximum transmission unit (MTU) in ICMPv6 router-advertisement messages on this link. The range is from 1280 to 65535 bytes. • **ns-interval** *interval*—Configures the retransmission interval between IPv6 neighbor solicitation messages. The range is from 1000 to 3600000 milliseconds. • **other-config-flag**—Indicates in ICMPv6 router-advertisement messages that hosts use stateful auto-configuration to obtain nonaddress related information. • **prefix**—Advertises the IPv6 prefix in the router-advertisement messages. • **ra-interval** *interval*—Configures the interval between sending ICMPv6 router-advertisement messages. The range is from 4 to 1800 seconds. • **ra-lifetime** *lifetime*—Advertises the lifetime of a default router in ICMPv6 router-advertisement messages. The range is from 0 to 9000 seconds. • **reachable-time** *time*—Advertises the time when a node considers a neighbor up after receiving a reachability confirmation in ICMPv6 router-advertisement messages. The range is from 0 to 9000 seconds. • **redirects**—Enables sending ICMPv6 redirect messages. • **retrans-timer** *time*—Advertises the time between neighbor-solicitation messages in ICMPv6

	Command or Action	Purpose
		router-advertisement messages. The range is from 0 to 9000 seconds. • **suppress-ra**— Disables sending ICMPv6 router-advertisement messages.
Step 4	Required: switch(config-if)# **ipv6 nd prefix** {*ipv6-address/prefix-length* | **default**} {**valid-lifetime** | **infinite** | **no-advertise**} {**preferred-lifetime** | **infinite**} [**no-autoconfig**] [**no-onlink**] [**off-link**]	Advertises the IPv6 prefix in the router advertisement messages. • *valid-lifetime*—The amount of time (in seconds) that the specified IPv6 prefix is advertised as being valid. • **infinite**—Specifies that the valid lifetime is infinite. • **no-advertise**—Specifies that the prefix is not advertised. • *preferred-lifetime*—The amount of time (in seconds) that the specified IPv6 prefix is advertised as being preferred. • **no-autoconfig**—Indicates to hosts on the local link that the specified prefix cannot be used for IPv6 autoconfiguration. The prefix will be advertised with the A-bit clear. • **no-onlink**—Configures the specified prefix as not on-link. The prefix will be advertised with the L-bit clear. • **off-link**—Configures the specified prefix as off-link. The prefix will be advertised with the L-bit clear. The prefix will not be inserted into the routing table as a connected prefix. If the prefix is already present in the routing table as a connected prefix (for example, because the prefix was also configured using the **ipv6 address** command), it will be removed.
Step 5	(Optional) switch(config-if)# **show ip nd interface**	Displays interfaces configured for IPv6 neighbor discovery.
Step 6	(Optional) switch(config)# **copy running-config startup-config**	Saves the change persistently through reboots and restarts by copying the running configuration to the startup configuration.

Example

This example shows how to configure IPv6 neighbor discovery reachable time:

```
switch# configure terminal
switch(config)# interface ethernet 3/1
switch(config-if)# ipv6 nd reachable-time 10
switch(config-if)# copy running-config startup-config
switch(config-if)#
```

This example shows how to display an IPv6 interface:

```
switch# configure terminal
switch(config)# show ipv6 nd interface ethernet 3/1

ICMPv6 ND Interfaces for VRF "default"
Ethernet3/1, Interface status: protocol-down/link-down/admin-down
IPv6 address: 0dc3:0dc3:0000:0000:0218:baff:fed8:239d
ICMPv6 active timers:
Last Neighbor-Solicitation sent: never
Last Neighbor-Advertisement sent: never
Last Router-Advertisement sent:never
Next Router-Advertisement sent in: 0.000000
Router-Advertisement parameters:
Periodic interval: 200 to 600 seconds
Send "Managed Address Configuration" flag: false
Send "Other Stateful Configuration" flag: false
Send "Current Hop Limit" field: 64
Send "MTU" option value: 1500
Send "Router Lifetime" field: 1800 secs
Send "Reachable Time" field: 10 ms
Send "Retrans Timer" field: 0 ms
Neighbor-Solicitation parameters:
NS retransmit interval: 1000 ms
ICMPv6 error message parameters:
Send redirects: false
Send unreachables: false
```

This example shows how to include the IPv6 prefix 2001:0DB8::/35 in router advertisements that are sent out Ethernet interface 0/0 with a valid lifetime of 1000 seconds and a preferred lifetime of 900 seconds:

```
switch(config)# interface ethernet 0/0
switch(config-if)# ipv6 nd prefix 2001:0DB8::/35 1000 900
```

Configuring Optional IPv6 Neighbor Discovery

You can use the following optional IPv6 neighbor discovery commands:

Command	Purpose
ipv6 nd cache limit *max-nd-adj* [**syslog** *syslogs-per-second*]	Configures the maximum number of entries in the neighbor adjacency table. The range is from 1 to 409600. The **syslog** keyword configures the number of system logs per second. The range is from 1 to 1000. If you configure a limit for IPv6 neighbor discovery entries, system logs appear if you try to add an adjacency after reaching the configured limit. **Note** You cannot unconfigure the cache limit until the total number of current adjacencies is less than 131,072.

Command	Purpose
ipv6 nd dad attempts *number*	Sets the number of consecutive neighbor solicitation messages that the device sends from the IPv6 interface for duplicate address detection (DAD) validation. The default value is 1 attempt.
ipv6 nd fast-path	Improves the performance of glean packets by reducing the processing of the packets in the supervisor. It applies to glean packets where the destination IP address is part of the same subnet and does not apply to packets where the destination IP address is in a different subnet. The default is enabled.
ipv6 nd hop-limit	Configures the maximum number of hops used in router advertisements and all IPv6 packets that are originated by the router.
ipv6 nd managed-config-flag	Sets the managed address configuration flag in IPv6 router advertisements.
ipv6 nd mtu	Sets the maximum transmission unit (MTU) size of IPv6 packets sent on an interface.
ipv6 nd ns-interval	Configures the interval between IPv6 neighbor solicitation retransmissions on an interface.
ipv6 nd other-config-flag	Configures the other stateful configuration flag in IPv6 router advertisements.
ipv6 nd ra-interval	Configures the interval between IPv6 router advertisement (RA) transmissions on an interface.
ipv6 nd ra-lifetime	Configures the router lifetime value in IPv6 router advertisements on an interface.
ipv6 nd reachable-time	Configures the amount of time that a remote IPv6 node is considered reachable after some reachability confirmation event has occurred.
ipv6 nd redirects	Enables ICMPv6 redirect messages to be sent.
ipv6 nd retrans-timer	Configures the advertised time between neighbor solicitation messages in router advertisements.
ipv6 nd suppress-ra	Suppresses IPv6 router advertisement transmissions on a LAN interface.

Configuring Recursive DNS Server (RDNSS)

You can configure up to eight DNS servers to advertise with Router Advertisement. You can also remove one or more DNS servers from the advertising list by using the **no** form of the command.

Before you begin

Ensure that you are in the correct VDC (or use the **switchto vdc** command).

Procedure

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters the global configuration mode.
Step 2	switch(config)#**interface ethernet** *number*	Enters interface configuration mode.
Step 3	switch(config-if)# **ipv6 nd ra dns server** *ipv6-addr* [*rdnss-life* | **infinite**] **sequence** *sequence-num*	Configures the recursive DNS server. You can specify the life time and the sequence of the server.
Step 4	switch(config-if)# **show ipv6 nd ra dns server** [**interface** *interface*]	(Optional) Displays the configured RDNSS list.
Step 5	switch(config-if)# **ipv6 nd ra dns server suppress**	(Optional) Disables the configured server list.
Step 6	switch(config-if)# **no ipv6 nd ra dns server** *ipv6-addr* [*rdnss-life* | **infinite**] **sequence** *sequence-num*	Removes a server from the RDNSS list.

Example

The following example shows how to configure Recursive DNS Server list on Ethernet 3/3 and verify the same.

```
switch# configure terminal
switch(config)# interface ethernet 3/3
switch(config-if)# ipv6 nd ra dns server 1::1 1000 sequence 0
switch(config-if)# ipv6 nd ra dns server 2::1 infinite sequence 1

switch(config)# show ipv6 nd ra dns server

Recursive DNS Server List on: mgmt0
Suppress DNS Server List: No
Recursive DNS Server List on: Ethernet3/3
  Suppress DNS Server List: No
  DNS Server 1: 1::1 Lifetime:1000 seconds Sequence:0
  DNS Server 2: 2::1 Infinite Sequence:1
```

Configuring DNS Search List (DNSSL)

You can configure up to eight DNS search lists to advertise with Router Advertisement. You can also remove one or more DNS search lists from the advertising list by using the **no** form of the command.

Before you begin

Ensure that you are in the correct VDC (or use the **switchto vdc** command).

Procedure

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters the global configuration mode.
Step 2	switch(config)#**interface ethernet** *number*	Enters interface configuration mode.
Step 3	switch(config-if)# **ipv6 nd ra dns search-list** *list* [*dnssl-life* | **infinite**] **sequence** *sequence-num*	Configures the DNS search list. You can specify the life time and the sequence of the search list.
Step 4	switch(config-if)# **show ipv6 nd ra dns search-list** [**interface** *interface*]	(Optional) Displays the configured DNS search list.
Step 5	switch(config-if)# **ipv6 nd ra dns search-list suppress**	(Optional) Disables the configured search list.
Step 6	switch(config-if)# **no ipv6 nd ra dns search-list** *list* [*dnssl-life* | **infinite**] **sequence** *sequence-num*	(Optional) Removes a search list from the RA.

Example

The following example shows how to configure DNS Search list on Ethernet 3/3 and verify the same.

```
switch# configure terminal
switch(config)# interface ethernet 3/3
switch(config-if)# ipv6 nd ra dns search-list cisco.com 100 sequence 1
switch(config-if)# ipv6 nd ra dns search-list ind.cisco.com 100 sequence 2

switch(config)# show ipv6 nd ra dns search-list

DNS Search List on: mgmt0
Suppress DNS Search List: No
 DNS Search List on: Ethernet3/3
  Suppress DNS Search List: No
  DNS Server 1:cisco.com 100 Sequence:1
  DNS Server 2:ind.cisco.com 100 Sequence:2
```

Configuring IPv6 Packet Verification

Cisco NX-OS supports an Intrusion Detection System (IDS) that checks for IPv6 packet verification. You can enable or disable these IDS checks.

Procedure

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters global configuration mode.
Step 2	switch(config)# **hardware ip verify address** {**destination zero** | **identical** | **reserved** | **source multicast**}	Performs the following IDS checks on the IPv6 address: • destination zero—Drops IPv6 packets if the destination IP address is ::.

	Command or Action	Purpose
		• identical—Drops IPv6 packets if the source IPv6 address is identical to the destination IPv6 address. • reserved—Drops IPv6 packets if the IPv6 address is ::1. • source multicast—Drops IPv6 packets if the IPv6 source address is in the FF00::/8 range (multicast).
Step 3	switch(config)# **hardware ip verify length** {**consistent** | **maximum** {**max-frag** | **max-tcp** | **udp**}}	Performs the following IDS checks on the IPv6 address: • consistent—Drops IPv6 packets where the Ethernet frame size is greater than or equal to the IPv6 packet length plus the Ethernet header. • maximum max-frag—Drops IPv6 packets if the formula (IPv6 Payload Length - IPv6 Extension Header Bytes) + (Fragment Offset * 8) is greater than 65536.. • maximum max-tcp—Drops IPv6 packets if the TCP length is greater than the IP payload length. • maximum max-udp—Drops IPv6 packets if the TCP length is less than the UDP packet length.
Step 4	switch(config)# **hardware ipv6 verify tcp tiny-frag**	Drops TCP packets if the IPv6 fragment offset is 1, or if the IPv6 fragment offset is 0 and the IP payload length is less than 16.
Step 5	switch(config)# **hardware ipv6 verify version**	Drops TCP packets if the EtherType is not set to 6 (IPv6).
Step 6	switch(config)# **show hardware forwarding ip verify**	Displays the IPv6 packet verification configuration.
Step 7	switch(config)# **copy running-config startup-config**	(Optional) Saves the change persistently through reboots and restarts by copying the running configuration to the startup configuration.

Verifying the IPv6 Configuration

Use one of the following commands to verify the configuration:

Command	Purpose
show hardware forwarding ip verify	Shows the IPv4 and IPv6 packet verification configuration.
show ipv6 interface	Displays IPv6-related interface information.
show ipv6 adjacency	Displays the adjacency table.
show ipv6 icmp	Displays ICMP IPv6 information.

Command	Purpose
show ipv6 nd	Displays IPv6 neighbor discovery information.
show ipv6 neighbor	Displays IPv6 neighbor entry.

Configuration Example for IPv6

```
switch# configure terminal
switch(config)# interface ethernet 3/1
switch(config-if)# ipv6 address 2001:db8::/64 eui64
switch(config-if)# ipv6 nd reachable-time 10
switch(config-if)#
```

Related Documents for IPv6

For more information related to IP CLI commands, see the *Cisco Nexus 7000 Series NX-OS Unicast Routing Command Reference.*

Standards for IPv6

No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.

Feature History for IPv6

This table includes only the updates for those releases that have resulted in additions or changes to the feature.

Table 5: Feature History for IPv6

Feature Name	Release	Feature Information
Duplicate address detection	6.2(2)	Added the ability to set the number of consecutive neighbor solicitation messages that the device sends from the IPv6 interface.
Glean optimization	6.2(2)	Added the **fast-path** keyword to the **ipv6 nd** command to improve the performance of glean packets by reducing the processing of the packets in the supervisor.
IPv6	6.2(2)	Added the ability to configure the maximum number of neighbor discovery entries in the neighbor adjacency table.
IPv6	6.0(1)	Updated for F2 Series modules.
IPv6	5.0(2)	Added support for IPv6 path MTU discovery.

Feature Name	Release	Feature Information
IPv6	4.1(3)	Changed **platform** {**ip** | **ipv6**} **verify** command to the **hardware** {**ip** | **ipv6**} **verify** command.
IPv6	4.0(3)	Added the **tag** keyword to the**ipv6 address** command.
IPv6	4.0(1)	This feature was introduced.