



## Configuring IPv6 Unicast Routing

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### Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and 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 feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

### Information About Configuring IPv6 Host Functions

This chapter describes how to configure IPv6 host functions on the Catalyst 2960, 2960-S, and 2960-C.



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**Note**

To use IPv6 Host Functions, the switch must be running the LAN Base image.

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For information about configuring IPv6 Multicast Listener Discovery (MLD) snooping, see *Configuring MLD Snooping*.

To enable dual stack environments (supporting both IPv4 and IPv6) on a Catalyst 2960 switch, you must configure the switch to use the a dual IPv4 and IPv6 switch database management (SDM) template. See the ["Dual IPv4 and IPv6 Protocol Stacks"](#) section. This template is not required on Catalyst 2960-S switches.



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**Note**

For complete syntax and usage information for the commands used in this chapter, see the Cisco IOS documentation referenced in the procedures.

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## Understanding IPv6

IPv4 users can move to IPv6 and receive services such as end-to-end security, quality of service (QoS), and globally unique addresses. The IPv6 address space reduces the need for private addresses and Network Address Translation (NAT) processing by border routers at network edges.

For information about how Cisco Systems implements IPv6, go to:

[http://www.cisco.com/en/US/products/ps6553/products\\_ios\\_technology\\_home.html](http://www.cisco.com/en/US/products/ps6553/products_ios_technology_home.html)

For information about IPv6 and other features in this chapter

- See the *Cisco IOS IPv6 Configuration Library*.
- Use the Search field on Cisco.com to locate the Cisco IOS software documentation. For example, if you want information about static routes, you can enter *Implementing Static Routes for IPv6* in the search field to learn about static routes.

## IPv6 Addresses

The switch supports only IPv6 unicast addresses. It does not support site-local unicast addresses, or anycast addresses.

The IPv6 128-bit addresses are represented as a series of eight 16-bit hexadecimal fields separated by colons in the format: n:n:n:n:n:n:n:n. This is an example of an IPv6 address:

```
2031:0000:130F:0000:0000:09C0:080F:130B
```

For easier implementation, leading zeros in each field are optional. This is the same address without leading zeros:

```
2031:0:130F:0:0:9C0:80F:130B
```

You can also use two colons (::) to represent successive hexadecimal fields of zeros, but you can use this short version only once in each address:

```
2031:0:130F::09C0:080F:130B
```

For more information about IPv6 address formats, address types, and the IPv6 packet header, see the "Implementing IPv6 Addressing and Basic Connectivity" chapter of *Cisco IOS IPv6 Configuration Library* on Cisco.com.

In the "Implementing Addressing and Basic Connectivity" chapter, these sections apply to the Catalyst 2960, 2960-S, 2960-C, 2960-X, 2960-CX and 3560-CX switches:

- IPv6 Address Formats
- IPv6 Address Type: Multicast
- IPv6 Address Output Display
- Simplified IPv6 Packet Header

## Supported IPv6 Unicast Routing Features

These sections describe the IPv6 protocol features supported by the switch:

## 128-Bit Wide Unicast Addresses

The switch supports aggregatable global unicast addresses and link-local unicast addresses. It does not support site-local unicast addresses.

- Aggregatable global unicast addresses are IPv6 addresses from the aggregatable global unicast prefix. The address structure enables strict aggregation of routing prefixes and limits the number of routing table entries in the global routing table. These addresses are used on links that are aggregated through organizations and eventually to the Internet service provider.

These addresses are defined by a global routing prefix, a subnet ID, and an interface ID. Current global unicast address allocation uses the range of addresses that start with binary value 001 (2000::/3). Addresses with a prefix of 2000::/3(001) through E000::/3(111) must have 64-bit interface identifiers in the extended unique identifier (EUI)-64 format.

- Link local unicast addresses can be automatically configured on any interface by using the link-local prefix FE80::/10(1111 1110 10) and the interface identifier in the modified EUI format. Link-local addresses are used in the neighbor discovery protocol (NDP) and the stateless autoconfiguration process. Nodes on a local link use link-local addresses and do not require globally unique addresses to communicate. IPv6 routers do not forward packets with link-local source or destination addresses to other links.

For more information, see the section about IPv6 unicast addresses in the “Implementing IPv6 Addressing and Basic Connectivity” chapter in the *Cisco IOS IPv6 Configuration Library* on Cisco.com.

## DNS for IPv6

IPv6 supports Domain Name System (DNS) record types in the DNS name-to-address and address-to-name lookup processes. The DNS AAAA resource record types support IPv6 addresses and are equivalent to an A address record in IPv4. The switch supports DNS resolution for IPv4 and IPv6.

## ICMPv6

The Internet Control Message Protocol (ICMP) in IPv6 generates error messages, such as ICMP destination unreachable messages, to report errors during processing and other diagnostic functions. In IPv6, ICMP packets are also used in the neighbor discovery protocol and path MTU discovery.

## Neighbor Discovery

The switch supports NDP for IPv6, a protocol running on top of ICMPv6, and static neighbor entries for IPv6 stations that do not support NDP. The IPv6 neighbor discovery process uses ICMP messages and solicited-node multicast addresses to determine the link-layer address of a neighbor on the same network (local link), to verify the reachability of the neighbor, and to keep track of neighboring routers.

The switch supports ICMPv6 redirect for routes with mask lengths less than 64 bits. ICMP redirect is not supported for host routes or for summarized routes with mask lengths greater than 64 bits.

Neighbor discovery throttling ensures that the switch CPU is not unnecessarily burdened while it is in the process of obtaining the next hop forwarding information to route an IPv6 packet. The switch drops any additional IPv6 packets whose next hop is the same neighbor that the switch is actively trying to resolve. This drop avoids further load on the CPU.

## IPv6 Stateless Autoconfiguration and Duplicate Address Detection

The switch uses stateless autoconfiguration to manage link, subnet, and site addressing changes, such as management of host and mobile IP addresses. A host autonomously configures its own link-local address, and booting nodes send router solicitations to request router advertisements for configuring interfaces.

For more information about autoconfiguration and duplicate address detection, see the “Implementing IPv6 Addressing and Basic Connectivity” chapter of *Cisco IOS IPv6 Configuration Library* on Cisco.com.

## IPv6 Applications

The switch has IPv6 support for these applications:

- Ping, traceroute, and Telnet
- Secure Shell (SSH) over an IPv6 transport
- HTTP server access over IPv6 transport
- DNS resolver for AAAA over IPv4 transport
- Cisco Discovery Protocol (CDP) support for IPv6 addresses

For more information about managing these applications, see the *Cisco IOS IPv6 Configuration Library* on Cisco.com.

## SNMP and Syslog Over IPv6

To support both IPv4 and IPv6, IPv6 network management requires both IPv6 and IPv4 transports. Syslog over IPv6 supports address data types for these transports.

SNMP and syslog over IPv6 provide these features:

- Support for both IPv4 and IPv6
- IPv6 transport for SNMP and to modify the SNMP agent to support traps for an IPv6 host
- SNMP- and syslog-related MIBs to support IPv6 addressing
- Configuration of IPv6 hosts as trap receivers

For support over IPv6, SNMP modifies the existing IP transport mapping to simultaneously support IPv4 and IPv6. These SNMP actions support IPv6 transport management:

- Opens User Datagram Protocol (UDP) SNMP socket with default settings
- Provides a new transport mechanism called *SR\_IPV6\_TRANSPORT*
- Sends SNMP notifications over IPv6 transport
- Supports SNMP-named access lists for IPv6 transport
- Supports SNMP proxy forwarding using IPv6 transport
- Verifies SNMP Manager feature works with IPv6 transport

For information on SNMP over IPv6, including configuration procedures, see the “Managing Cisco IOS Applications over IPv6” chapter in the *Cisco IOS IPv6 Configuration Library* on Cisco.com.

For information about syslog over IPv6, including configuration procedures, see the “Implementing IPv6 Addressing and Basic Connectivity” chapter in the *Cisco IOS IPv6 Configuration Library* on Cisco.com.

### HTTP(S) Over IPv6

The HTTP client sends requests to both IPv4 and IPv6 HTTP servers, which respond to requests from both IPv4 and IPv6 HTTP clients. URLs with literal IPv6 addresses must be specified in hexadecimal using 16-bit values between colons.

The accept socket call chooses an IPv4 or IPv6 address family. The accept socket is either an IPv4 or IPv6 socket. The listening socket continues to listen for both IPv4 and IPv6 signals that indicate a connection. The IPv6 listening socket is bound to an IPv6 wildcard address.

The underlying TCP/IP stack supports a dual-stack environment. HTTP relies on the TCP/IP stack and the sockets for processing network-layer interactions.

Basic network connectivity (**ping**) must exist between the client and the server hosts before HTTP connections can be made.

For more information, see the “Managing Cisco IOS Applications over IPv6” chapter in the *Cisco IOS IPv6 Configuration Library* on Cisco.com.

## Default IPv6 Configuration

**Table 1: Default IPv6 Configuration**

Feature	Default Setting
SDM template	Advance desktop. Default is advanced template
IPv6 addresses	None configured

## Configuring IPv6 Addressing and Enabling IPv6 Routing

This section describes how to assign IPv6 addresses to individual Layer 3 interfaces and to globally forward IPv6 traffic on the switch.

Before configuring IPv6 on the switch, consider these guidelines:

- In the **ipv6 address** interface configuration command, you must enter the *ipv6-address* and *ipv6-prefix* variables with the address specified in hexadecimal using 16-bit values between colons. The *prefix-length* variable (preceded by a slash [/]) is a decimal value that shows how many of the high-order contiguous bits of the address comprise the prefix (the network portion of the address).

To forward IPv6 traffic on an interface, you must configure a global IPv6 address on that interface. Configuring an IPv6 address on an interface automatically configures a link-local address and activates IPv6 for the interface. The configured interface automatically joins these required multicast groups for that link:

- solicited-node multicast group FF02:0:0:0:1:ff00::/104 for each unicast address assigned to the interface (this address is used in the neighbor discovery process.)
- all-nodes link-local multicast group FF02::1
- all-routers link-local multicast group FF02::2

For more information about configuring IPv6 routing, see the “Implementing Addressing and Basic Connectivity for IPv6” chapter in the *Cisco IOS IPv6 Configuration Library* on Cisco.com.

Beginning in privileged EXEC mode, follow these steps to assign an IPv6 address to a Layer 3 interface and enable IPv6 forwarding:

## SUMMARY STEPS

1. **configure terminal**
2. **ipv6 unicast-routing**
3. **interface *interface-id***
4. Use one of the following:
  - **ipv6 address *ipv6-prefix/prefix length* *eui-64***
  - **ipv6 address *ipv6-address/prefix length***
  - **ipv6 address *ipv6-address* **link-local****
  - **ipv6 enable**
5. **exit**
6. **end**
7. **show ipv6 interface *interface-id***
8. **copy running-config startup-config**

## DETAILED STEPS

	Command or Action	Purpose
Step 1	<b>configure terminal</b>  <b>Example:</b> Switch# <b>configure terminal</b>	Enters global configuration mode.
Step 2	<b>ipv6 unicast-routing</b>  <b>Example:</b> Switch(config)# <b>ipv6 unicast-routing</b>	Enables unicast routing for IPv6.

	Command or Action	Purpose
<b>Step 3</b>	<b>interface</b> <i>interface-id</i>  <b>Example:</b> <pre>Switch(config)# interface gigabitethernet 1/0/1</pre>	Enters interface configuration mode, and specifies the Layer 3 interface to configure.
<b>Step 4</b>	Use one of the following: <ul style="list-style-type: none"> <li>• <b>ipv6 address</b> <i>ipv6-prefix/prefix length eui-64</i></li> <li>• <b>ipv6 address</b> <i>ipv6-address/prefix length</i></li> <li>• <b>ipv6 address</b> <i>ipv6-address link-local</i></li> <li>• <b>ipv6 enable</b></li> </ul> <b>Example:</b> <pre>Switch(config-if)# ipv6 address 2001:0DB8:c18:1::/64 eui 64  Switch(config-if)# ipv6 address 2001:0DB8:c18:1::/64  Switch(config-if)# ipv6 address 2001:0DB8:c18:1:: link-local  Switch(config-if)# ipv6 enable</pre>	<ul style="list-style-type: none"> <li>• Specifies a global IPv6 address with an extended unique identifier (EUI) in the low-order 64 bits of the IPv6 address. Specify only the network prefix; the last 64 bits are automatically computed from the switch MAC address. This enables IPv6 processing on the interface.</li> <li>• Manually configures an IPv6 address on the interface.</li> <li>• Specifies a link-local address on the interface to be used instead of the link-local address that is automatically configured when IPv6 is enabled on the interface. This command enables IPv6 processing on the interface.</li> <li>• Automatically configures an IPv6 link-local address on the interface, and enables the interface for IPv6 processing. The link-local address can only be used to communicate with nodes on the same link.</li> </ul>
<b>Step 5</b>	<b>exit</b>  <b>Example:</b> <pre>Switch(config-if)# exit</pre>	Returns to global configuration mode.
<b>Step 6</b>	<b>end</b>  <b>Example:</b> <pre>Switch(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 7</b>	<b>show ipv6 interface</b> <i>interface-id</i>  <b>Example:</b> <pre>Switch# show ipv6 interface gigabitethernet 1/0/1</pre>	Verifies your entries.
<b>Step 8</b>	<b>copy running-config startup-config</b>  <b>Example:</b> <pre>Switch# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Configuring IPv6 ICMP Rate Limiting (CLI)

ICMP rate limiting is enabled by default with a default interval between error messages of 100 milliseconds and a bucket size (maximum number of tokens to be stored in a bucket) of 10.

Beginning in privileged EXEC mode, follow these steps to change the ICMP rate-limiting parameters:

### DETAILED STEPS

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Switch# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>ipv6 icmp error-interval <i>interval</i> [<i>bucketsize</i>]</b>  <b>Example:</b> Switch(config)# <b>ipv6 icmp error-interval 50 20</b>	Configures the interval and bucket size for IPv6 ICMP error messages: <ul style="list-style-type: none"> <li>• <i>interval</i>—The interval (in milliseconds) between tokens being added to the bucket. The range is from 0 to 2147483647 milliseconds.</li> <li>• <i>bucketsize</i>—(Optional) The maximum number of tokens stored in the bucket. The range is from 1 to 200.</li> </ul>
<b>Step 3</b>	<b>end</b>  <b>Example:</b> Switch(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 4</b>	<b>show ipv6 interface [<i>interface-id</i>]</b>  <b>Example:</b> Switch# <b>show ipv6 interface gigabitethernet 1/0/1</b>	Verifies your entries.
<b>Step 5</b>	<b>copy running-config startup-config</b>  <b>Example:</b> Switch# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.



## Configuring Static Routing for IPv6 (CLI)

Before configuring a static IPv6 route, you must enable routing by using the **ip routing** global configuration command, enable the forwarding of IPv6 packets by using the **ipv6 unicast-routing** global configuration command, and enable IPv6 on at least one Layer 3 interface by configuring an IPv6 address on the interface.



**Note** The switch supports 16 IPv6 static routes.

For more information about configuring static IPv6 routing, see the “Implementing Static Routes for IPv6” chapter in the *Cisco IOS IPv6 Configuration Library* on Cisco.com.

### DETAILED STEPS

	Command or Action	Purpose
Step 1	<p><b>configure terminal</b></p> <p><b>Example:</b></p> <pre>Switch# configure terminal</pre>	Enters global configuration mode.
Step 2	<p><b>ipv6 route</b> <i>ipv6-prefix/prefix length</i>  <i>{ipv6-address   interface-id</i>  <i>[ipv6-address]}</i> <i>[administrative distance]</i></p> <p><b>Example:</b></p> <pre>Switch(config)# ipv6 route 2001:0DB8::/32 gigabitethernet2/0/1 130</pre>	<p>Configures a static IPv6 route.</p> <ul style="list-style-type: none"> <li>• <i>ipv6-prefix</i>—The IPv6 network that is the destination of the static route. It can also be a hostname when static host routes are configured.</li> <li>• <i>/prefix length</i>—The length of the IPv6 prefix. A decimal value that shows how many of the high-order contiguous bits of the address comprise the prefix (the network portion of the address). A slash mark must precede the decimal value.</li> <li>• <i>ipv6-address</i>—The IPv6 address of the next hop that can be used to reach the specified network. The IPv6 address of the next hop need not be directly connected; recursion is done to find the IPv6 address of the directly connected next hop. The address must be in the form documented in RFC 2373, specified in hexadecimal using 16-bit values between colons.</li> <li>• <i>interface-id</i>—Specifies direct static routes from point-to-point and broadcast interfaces. With point-to-point interfaces, there is no need to specify the IPv6 address of the next hop. With broadcast interfaces, you should always specify the IPv6 address of the next hop, or ensure that the specified prefix is assigned to the link, specifying a link-local address as the next hop. You can optionally specify the IPv6 address of the next hop to which packets are sent.</li> </ul> <p><b>Note</b> You must specify an <i>interface-id</i> when using a link-local address as the next hop (the link-local next hop must also be an adjacent router).</p> <ul style="list-style-type: none"> <li>• <i>administrative distance</i>—(Optional) An administrative distance. The range is 1 to 254; the default value is 1, which gives static routes precedence over any other type of route except connected routes. To configure a floating</li> </ul>

	Command or Action	Purpose
		static route, use an administrative distance greater than that of the dynamic routing protocol.
<b>Step 3</b>	<b>end</b>  <b>Example:</b> Switch(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 4</b>	Use one of the following: <ul style="list-style-type: none"> <li>• <b>show ipv6 static</b> [ <i>ipv6-address</i>   <i>ipv6-prefix/prefix length</i> ] [ <b>interface</b> <i>interface-id</i> ] [ <b>detail</b> ] [ <b>recursive</b> ] [ <b>detail</b> ]</li> <li>• <b>show ipv6 route static</b> [ <i>updated</i> ]</li> </ul> <b>Example:</b> Switch# <b>show ipv6 static</b> 2001:0DB8::/32 <b>interface</b> gigabitethernet2/0/1  OR Switch# <b>show ipv6 route static</b>	Verifies your entries by displaying the contents of the IPv6 routing table. <ul style="list-style-type: none"> <li>• <b>interface</b> <i>interface-id</i>—(Optional) Displays only those static routes with the specified interface as an egress interface.</li> <li>• <b>recursive</b>—(Optional) Displays only recursive static routes. The <b>recursive</b> keyword is mutually exclusive with the <b>interface</b> keyword, but it can be used with or without the IPv6 prefix included in the command syntax.</li> <li>• <b>detail</b>—(Optional) Displays this additional information: <ul style="list-style-type: none"> <li>◦ For valid recursive routes, the output path set, and maximum resolution depth.</li> <li>◦ For invalid routes, the reason why the route is not valid.</li> </ul> </li> </ul>
<b>Step 5</b>	<b>copy running-config startup-config</b>  <b>Example:</b> Switch# <b>copy running-config</b> <b>startup-config</b>	(Optional) Saves your entries in the configuration file.

## Displaying IPv6

For complete syntax and usage information on these commands, see the Cisco IOS command reference publications.

**Table 2: Command for Monitoring IPv6**

Command	Purpose
<b>show ipv6 access-list</b>	Displays a summary of access lists.
<b>show ipv6 cef</b>	Displays Cisco Express Forwarding for IPv6.

Command	Purpose
<b>show ipv6 interface</b> <i>interface-id</i>	Displays IPv6 interface status and configuration.
<b>show ipv6 mtu</b>	Displays IPv6 MTU per destination cache.
<b>show ipv6 neighbors</b>	Displays IPv6 neighbor cache entries.
<b>show ipv6 prefix-list</b>	Displays a list of IPv6 prefix lists.
<b>show ipv6 protocols</b>	Displays a list of IPv6 routing protocols on the switch.
<b>show ipv6 rip</b>	Displays IPv6 RIP routing protocol status.
<b>show ipv6 route</b>	Displays IPv6 route table entries.
<b>show ipv6 static</b>	Displays IPv6 static routes.
<b>show ipv6 traffic</b>	Displays IPv6 traffic statistics.

## Configuration Examples for IPv6 Unicast Routing

### Configuring IPv6 Addressing and Enabling IPv6 Routing: Example

This example shows how to enable IPv6 with both a link-local address and a global address based on the IPv6 prefix 2001:0DB8:c18:1::/64. The EUI-64 interface ID is used in the low-order 64 bits of both addresses. Output from the **show ipv6 interface** EXEC command is included to show how the interface ID (20B:46FF:FE2F:D940) is appended to the link-local prefix FE80::/64 of the interface.

```
Switch(config)# ipv6 unicast-routing
Switch(config)# interface gigabitethernet1/0/11

Switch(config-if)# ipv6 address 2001:0DB8:c18:1::/64 eui 64
Switch(config-if)# end
Switch# show ipv6 interface gigabitethernet1/0/11
GigabitEthernet1/0/11 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::20B:46FF:FE2F:D940
  Global unicast address(es):
    2001:0DB8:c18:1:20B:46FF:FE2F:D940, subnet is 2001:0DB8:c18:1::/64 [EUI]
  Joined group address(es):
    FE02::1
    FE02::2
    FE02::1:FF2F:D940
  MTU is 1500 bytes
  ICMP error messages limited to one every 100 milliseconds
  ICMP redirects are enabled
  ND DAD is enabled, number of DAD attempts: 1
  ND reachable time is 30000 milliseconds
  ND advertised reachable time is 0 milliseconds
  ND advertised retransmit interval is 0 milliseconds
  ND router advertisements are sent every 200 seconds
  ND router advertisements live for 1800 seconds
```

Hosts use stateless autoconfig for addresses.

## Configuring IPv6 ICMP Rate Limiting: Example

This example shows how to configure an IPv6 ICMP error message interval of 50 milliseconds and a bucket size of 20 tokens.

```
Switch(config)#ipv6 icmp error-interval 50 20
```

## Configuring Static Routing for IPv6: Example

This example shows how to configure a floating static route to an interface with an administrative distance of 130:

```
Switch(config)# ipv6 route 2001:0DB8::/32 gigabitethernet2/0/1 130
```

## Displaying IPv6: Example

This is an example of the output from the **show ipv6 interface** privileged EXEC command:

```
Switch# show ipv6 interface
Vlan1 is up, line protocol is up
IPv6 is enabled, link-local address is FE80::20B:46FF:FE2F:D940
Global unicast address(es):
  3FFE:C000:0:1:20B:46FF:FE2F:D940, subnet is 3FFE:C000:0:1::/64 [EUI]
Joined group address(es):
  FF02::1
  FF02::2
  FF02::1:FF2F:D940
MTU is 1500 bytes
ICMP error messages limited to one every 100 milliseconds
ICMP redirects are enabled
ND DAD is enabled, number of DAD attempts: 1
ND reachable time is 30000 milliseconds
ND advertised reachable time is 0 milliseconds
ND advertised retransmit interval is 0 milliseconds
ND router advertisements are sent every 200 seconds
ND router advertisements live for 1800 seconds
<output truncated>
```