



Implementing OSPF for IPv6

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The *Implementing OSPF for IPv6* module expands on Open Shortest Path First (OSPF) to provide support for IPv6 routing prefixes. This module describes the concepts and tasks you need to implement OSPF for IPv6 on your network.

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest feature information and caveats, see 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 for Implementing OSPF for IPv6”](#) section on page 32.

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

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Prerequisites for Implementing OSPF for IPv6

Before you enable OSPF for IPv6 on an interface, you must do the following:

- Complete the OSPF network strategy and planning for your IPv6 network. For example, you must decide whether multiple areas are required.
- Enable IPv6 unicast routing.
- Enable IPv6 on the interface.
- Configure the IP Security (IPsec) secure socket application program interface (API) on OSPF for IPv6 in order to enable authentication and encryption.

This document assumes that you are familiar with IPv4. Refer to the publications referenced in the “[Related Documents](#)” section for IPv4 configuration and command reference information.

Restrictions for Implementing OSPF for IPv6

- When running a dual-stack IP network with OSPF version 2 for IPv4 and OSPF for IPv6, be careful when changing the defaults for commands used to enable OSPF for IPv6. Changing these defaults may affect your OSPF for IPv6 network, possibly adversely.
- Authentication is supported as of Cisco IOS Release 12.3(4)T.
- ESP authentication and encryption are supported as of Cisco IOS Release 12.4(9)T.
- A packet will be rejected on a router if the packet is coming from an IPv6 address that is found on any interface on the same router.

Information About Implementing OSPF for IPv6

To implement OSPF for IPv6, you need to understand the following concepts:

- [How OSPF for IPv6 Works, page 3](#)
- [Comparison of OSPF for IPv6 and OSPF Version 2, page 3](#)
- [LSA Types for IPv6, page 3](#)
- [Force SPF in OSPF for IPv6, page 5](#)
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- [Load Balancing in OSPF for IPv6, page 5](#)
- [Address Import into OSPF for IPv6, page 6](#)
- [OSPF for IPv6 Customization, page 6](#)
- [OSPF for IPv6 Authentication Support with IPsec, page 6](#)
- [OSPFv3 Graceful Restart, page 9](#)
- [BFD Support for OSPFv3, page 10](#)

How OSPF for IPv6 Works

OSPF is a routing protocol for IP. It is a link-state protocol, as opposed to a distance-vector protocol. Think of a link as being an interface on a networking device. A link-state protocol makes its routing decisions based on the states of the links that connect source and destination machines. The state of a link is a description of that interface and its relationship to its neighboring networking devices. The interface information includes the IPv6 prefix of the interface, the network mask, the type of network it is connected to, the routers connected to that network, and so on. This information is propagated in various type of link-state advertisements (LSAs).

A router's collection of LSA data is stored in a link-state database. The contents of the database, when subjected to the Dijkstra algorithm, result in the creation of the OSPF routing table. The difference between the database and the routing table is that the database contains a complete collection of raw data; the routing table contains a list of shortest paths to known destinations via specific router interface ports.

OSPF version 3, which is described in RFC 2740, supports IPv6.

Comparison of OSPF for IPv6 and OSPF Version 2

Much of the OSPF for IPv6 feature is the same as in OSPF version 2. OSPF version 3 for IPv6, which is described in RFC 2740, expands on OSPF version 2 to provide support for IPv6 routing prefixes and the larger size of IPv6 addresses.

In OSPF for IPv6, a routing process does not need to be explicitly created. Enabling OSPF for IPv6 on an interface will cause a routing process, and its associated configuration, to be created.

In OSPF for IPv6, each interface must be enabled using commands in interface configuration mode. This feature is different from OSPF version 2, in which interfaces are indirectly enabled using the router configuration mode.

When using a nonbroadcast multiaccess (NBMA) interface in OSPF for IPv6, users must manually configure the router with the list of neighbors. Neighboring routers are identified by their router ID.

In IPv6, users can configure many address prefixes on an interface. In OSPF for IPv6, all address prefixes on an interface are included by default. Users cannot select some address prefixes to be imported into OSPF for IPv6; either all address prefixes on an interface are imported, or no address prefixes on an interface are imported.

Unlike OSPF version 2, multiple instances of OSPF for IPv6 can be run on a link.

In OSPF for IPv6, it is possible that no IPv4 addresses will be configured on any interface. In this case, the user must use the **router-id** command to configure a router ID before the OSPF process will be started. A router ID is a 32-bit opaque number. OSPF version 2 takes advantage of the 32-bit IPv4 address to pick an IPv4 address as the router ID. If an IPv4 address does exist when OSPF for IPv6 is enabled on an interface, then that IPv4 address is used for the router ID. If more than one IPv4 address is available, a router ID is chosen using the same rules as for OSPF version 2.

OSPF automatically prefers a loopback interface over any other kind, and it chooses the highest IP address among all loopback interfaces. If no loopback interfaces are present, the highest IP address in the router is chosen. You cannot tell OSPF to use any particular interface.

LSA Types for IPv6

The following list describes LSA types, each of which has a different purpose:

- Router LSAs (Type 1)—Describes the link state and costs of a router's links to the area. These LSAs are flooded within an area only. The LSA indicates if the router is an Area Border Router (ABR) or Autonomous System Boundary Router (ASBR), and if it is one end of a virtual link. Type 1 LSAs are also used to advertise stub networks. In OSPF for IPv6, these LSAs have no address information and are network-protocol-independent. In OSPF for IPv6, router interface information may be spread across multiple router LSAs. Receivers must concatenate all router LSAs originated by a given router when running the SPF calculation.
- Network LSAs (Type 2)—Describes the link-state and cost information for all routers attached to the network. This LSA is an aggregation of all the link-state and cost information in the network. Only a designated router tracks this information and can generate a network LSA. In OSPF for IPv6, network LSAs have no address information and are network-protocol-independent.
- Interarea-prefix LSAs for ABRs (Type 3)—Advertises internal networks to routers in other areas (interarea routes). Type 3 LSAs may represent a single network or a set of networks summarized into one advertisement. Only ABRs generate summary LSAs. In OSPF for IPv6, addresses for these LSAs are expressed as *prefix, prefix length* instead of *address, mask*. The default route is expressed as a prefix with length 0.
- Interarea-router LSAs for ASBRs (Type 4)—Advertise the location of an ASBR. Routers that are trying to reach an external network use these advertisements to determine the best path to the next hop. ASBRs generate Type 4 LSAs.
- Autonomous system external LSAs (Type 5)—Redistributes routes from another AS, usually from a different routing protocol into OSPF. In OSPF for IPv6, addresses for these LSAs are expressed as *prefix, prefix length* instead of *address, mask*. The default route is expressed as a prefix with length 0.
- Link LSAs (Type 8)—Have local-link flooding scope and are never flooded beyond the link with which they are associated. Link LSAs provide the link-local address of the router to all other routers attached to the link, inform other routers attached to the link of a list of IPv6 prefixes to associate with the link, and allow the router to assert a collection of Options bits to associate with the network LSA that will be originated for the link.
- Intra-Area-Prefix LSAs (Type 9)—A router can originate multiple intra-area-prefix LSAs for each router or transit network, each with a unique link-state ID. The link-state ID for each intra-area-prefix LSA describes its association to either the router LSA or the network LSA and contains prefixes for stub and transit networks.

An address prefix occurs in almost all newly defined LSAs. The prefix is represented by three fields: PrefixLength, PrefixOptions, and Address Prefix. In OSPF for IPv6, addresses for these LSAs are expressed as *prefix, prefix length* instead of *address, mask*. The default route is expressed as a prefix with length 0. Type 3 and Type 9 LSAs carry all IPv6 prefix information that, in IPv4, is included in router LSAs and network LSAs. The Options field in certain LSAs (router LSAs, network LSAs, interarea-router LSAs, and link LSAs) has been expanded to 24 bits to provide support for OSPF in IPv6.

In OSPF for IPv6, the sole function of link-state ID in interarea-prefix LSAs, interarea-router LSAs, and autonomous-system external LSAs is to identify individual pieces of the link-state database. All addresses or router IDs that are expressed by the link-state ID in OSPF version 2 are carried in the body of the LSA in OSPF for IPv6.

The link-state ID in network LSAs and link LSAs is always the interface ID of the originating router on the link being described. For this reason, network LSAs and link LSAs are now the only LSAs whose size cannot be limited. A network LSA must list all routers connected to the link, and a link LSA must list all of the address prefixes of a router on the link.

NBMA in OSPF for IPv6

On NBMA networks, the designated router (DR) or backup DR (BDR) performs the LSA flooding. On point-to-point networks, flooding simply goes out an interface directly to a neighbor.

Routers that share a common segment (Layer 2 link between two interfaces) become neighbors on that segment. OSPF uses the Hello protocol, periodically sending hello packets out each interface. Routers become neighbors when they see themselves listed in the neighbor's hello packet. After two routers become neighbors, they may proceed to exchange and synchronize their databases, which creates an adjacency. Not all neighboring routers have an adjacency.

On point-to-point and point-to-multipoint networks, the software floods routing updates to immediate neighbors. There is no DR or BDR; all routing information is flooded to each networking device.

On broadcast or NBMA segments only, OSPF minimizes the amount of information being exchanged on a segment by choosing one router to be a DR and one router to be a BDR. Thus, the routers on the segment have a central point of contact for information exchange. Instead of each router exchanging routing updates with every other router on the segment, each router exchanges information with the DR and BDR. The DR and BDR relay the information to the other routers.

The software looks at the priority of the routers on the segment to determine which routers will be the DR and BDR. The router with the highest priority is elected the DR. If there is a tie, then the router with the higher router ID takes precedence. After the DR is elected, the BDR is elected the same way. A router with a router priority set to zero is ineligible to become the DR or BDR.

When using NBMA in OSPF for IPv6, you cannot automatically detect neighbors. On an NBMA interface, you must configure your neighbors manually using interface configuration mode.

Force SPF in OSPF for IPv6

When the **process** keyword is used with the **clear ipv6 ospf** command, the OSPF database is cleared and repopulated, and then the SPF algorithm is performed. When the **force-spf** keyword is used with the **clear ipv6 ospf** command, the OSPF database is not cleared before the SPF algorithm is performed.

Fast Convergence—LSA and SPF Throttling

The OSPF for IPv6 LSA and SPF throttling feature provides a dynamic mechanism to slow down link-state advertisement updates in OSPF during times of network instability. It also allows faster OSPF convergence by providing LSA rate limiting in milliseconds.

Previously, OSPF for IPv6 used static timers for rate-limiting SPF calculation and LSA generation. Although these timers are configurable, the values used are specified in seconds, which poses a limitation on OSPF for IPv6 convergence. LSA and SPF throttling achieves subsecond convergence by providing a more sophisticated SPF and LSA rate-limiting mechanism that is able to react quickly to changes and also provide stability and protection during prolonged periods of instability.

Load Balancing in OSPF for IPv6

When a router learns multiple routes to a specific network via multiple routing processes (or routing protocols), it installs the route with the lowest administrative distance in the routing table. Sometimes the router must select a route from among many learned via the same routing process with the same

administrative distance. In this case, the router chooses the path with the lowest cost (or metric) to the destination. Each routing process calculates its cost differently and the costs may need to be manipulated in order to achieve load balancing.

OSPF performs load balancing automatically in the following way. If OSPF finds that it can reach a destination through more than one interface and each path has the same cost, it installs each path in the routing table. The only restriction on the number of paths to the same destination is controlled by the **maximum-paths** command. The default maximum paths is 16, and the range is from 1 to 64.

Address Import into OSPF for IPv6

When importing the set of addresses specified on an interface on which OSPF for IPv6 is running into OSPF for IPv6, users cannot select specific addresses to be imported. Either all addresses are imported, or no addresses are imported.

OSPF for IPv6 Customization

You can customize OSPF for IPv6 for your network, but you likely will not need to do so. The defaults for OSPF in IPv6 are set to meet the requirements of most customers and features. If you must change the defaults, refer to the IPv6 command reference to find the appropriate syntax.



Caution

Be careful when changing the defaults. Changing defaults will affect your OSPF for IPv6 network, possibly adversely.

OSPF for IPv6 Authentication Support with IPsec

In order to ensure that OSPF for IPv6 packets are not altered and re-sent to the router, causing the router to behave in a way not desired by its managers, OSPF for IPv6 packets must be authenticated. OSPF for IPv6 uses the IP Security (IPsec) secure socket application program interface (API) to add authentication to OSPF for IPv6 packets. This API has been extended to provide support for IPv6.

OSPF for IPv6 requires the use of IPsec to enable authentication. Crypto images are required to use authentication, because only crypto images include the IPsec API needed for use with OSPF for IPv6.

In OSPF for IPv6, authentication fields have been removed from OSPF headers. When OSPF runs on IPv6, OSPF requires the IPv6 authentication header (AH) or IPv6 ESP header to ensure integrity, authentication, and confidentiality of routing exchanges. IPv6 AH and ESP extension headers can be used to provide authentication and confidentiality to OSPF for IPv6.

To use the IPsec AH, you must enable the **ipv6 ospf authentication** command. To use the IPsec ESP, you must enable the **ipv6 ospf encryption** command. The ESP header may be applied alone or in combination with the AH, and when ESP is used, both encryption and authentication are provided. Security services can be provided between a pair of communicating hosts, between a pair of communicating security gateways, or between a security gateway and a host.

To configure IPsec, users configure a security policy, which is a combination of the security policy index (SPI) and the key (the key is used to create and validate the hash value). IPsec for OSPF for IPv6 can be configured on an interface or on an OSPF area. For higher security, users should configure a different policy on each interface configured with IPsec. If a user configures IPsec for an OSPF area, the policy is applied to all of the interfaces in that area, except for the interfaces that have IPsec configured directly. Once IPsec is configured for OSPF for IPv6, IPsec is invisible to the user.

The secure socket API is used by applications to secure traffic. The API needs to allow the application to open, listen, and close secure sockets. The binding between the application and the secure socket layer also allows the secure socket layer to inform the application of changes to the socket, such as connection open and close events. The secure socket API is able to identify the socket; that is, it can identify the local and remote addresses, masks, ports, and protocol that carry the traffic requiring security.

Each interface has a secure socket state, which can be one of the following:

- **NULL:** Do not create a secure socket for the interface if authentication is configured for the area.
- **DOWN:** IPsec has been configured for the interface (or the area that contains the interface), but OSPF for IPv6 either has not requested IPsec to create a secure socket for this interface, or there is an error condition.
- **GOING UP:** OSPF for IPv6 has requested a secure socket from IPsec and is waiting for a CRYPTO_SS_SOCKET_UP message from IPsec.
- **UP:** OSPF has received a CRYPTO_SS_SOCKET_UP message from IPsec.
- **CLOSING:** The secure socket for the interface has been closed. A new socket may be opened for the interface, in which case the current secure socket makes the transition to the DOWN state. Otherwise, the interface will become UNCONFIGURED.
- **UNCONFIGURED:** Authentication is not configured on the interface.

OSPF will not send or accept packets while in the DOWN state.

For further information on IPsec, refer to the [Implementing IPsec in IPv6 Security](#) document.

OSPF for IPv6 Virtual Links

For each virtual link, a master security information datablock is created for the virtual link. Because a secure socket must be opened on each interface, there will be a corresponding security information datablock for each interface in the transit area. The secure socket state is kept in the interface's security information datablock. The state field in the master security information datablock reflects the status of all of the secure sockets opened for the virtual link. If all of the secure sockets are UP, then the security state for the virtual link will be set to UP.

Packets sent on a virtual link with IPsec must use predetermined source and destination addresses. The first local area address found in the router's intra-area-prefix LSA for the area is used as the source address. This source address is saved in the area data structure and used when secure sockets are opened and packets sent over the virtual link. The virtual link will not transition to the point-to-point state until a source address is selected. Also, when the source or destination address changes, the previous secure sockets must be closed and new secure sockets opened.

OSPF Cost Calculation

Because cost components can change rapidly, it might be necessary to dampen the volume of changes to reduce network-wide churn. The recommended values for S2, S3, and S4 are based on network simulations that may reduce the rate of network changes. The recommended value for S1 is zero to eliminate this variable from the route cost calculation.

The overall link cost is computed using the following formula shown in [Figure 1](#).

Figure 1 Overall Link Cost Formula



Table 1 defines the symbols used in the OSPF cost calculation.

Table 1 OSPF Cost Calculation Definitions

Cost Component	Component Definition
OC	The “default OSPF cost.” Calculated from reference bandwidth using $reference_bw / (MDR * 1000)$, where $reference_bw = 10^8$.
A through D	Various radio-specific data-based formulas that produce results in the 0 through 64,000 range.
A	CDR- and MDR-related formula: $(2^{16} * (100 - (CDR * 100 / MDR))) / 100$
B	Resources related formula: $((100 - RESOURCES)^3 * 2^{16} / 10^6)$
C	Latency as reported by the radio, already in the 0 through 64K range when reported (LATENCY).
D	RLF-related formula: $((100 - RLF) * 2^{16}) / 100$
S1 through S4	Scalar weighting factors input from the command-line interface (CLI). These scalars scale down the values as computed by A through D. The value of 0 disables and value of 100 enables full 0 through 64,000 range for one component.

Because each network might have unique characteristics that require different settings to optimize actual network performance, these are recommended values intended as a starting point for optimizing an OSPFv3 network. Table 2 lists the recommended value settings for OSPF cost metrics.

Table 2 Recommended Value Settings for OSPF Cost Metrics

Setting	Metric Description	Default Value	Recommended Value
S1	ipv6 ospf dynamic weight throughout	100	0
S2	ipv6 ospf dynamic weight resources	100	29
S3	ipv6 ospf dynamic weight latency	100	29
S4	ipv6 ospf dynamic weight L2 factor	100	29

The default path costs were calculated using this formula, as noted in the following list. If these values do not suit your network, you can use your own method of calculating path costs.

- 56-kbps serial link—Default cost is 1785.
- 64-kbps serial link—Default cost is 1562.
- T1 (1.544-Mbps serial link)—Default cost is 64.
- E1 (2.048-Mbps serial link)—Default cost is 48.
- 4-Mbps Token Ring—Default cost is 25.
- Ethernet—Default cost is 10.
- 16-Mbps Token Ring—Default cost is 6.
- FDDI—Default cost is 1.
- X25—Default cost is 5208.
- Asynchronous—Default cost is 10,000.
- ATM—Default cost is 1.

To illustrate these settings, the following example shows how OSPF cost metrics might be defined for a VMI interface:

```
interface vmi1
  ipv6 ospf cost dynamic weight throughout 0
  ipv6 ospf cost dynamic weight resources 29
  ipv6 ospf cost dynamic weight latency 29
  ipv6 ospf cost dynamic weight L2-factor 29
```

OSPFv3 Graceful Restart

The graceful restart feature in OSPFv3 allows nonstop data forwarding along routes that are already known while the OSPFv3 routing protocol information is being restored. A router can participate in graceful restart either in restart mode (such as in a graceful-restart-capable router) or in helper mode (such as in a graceful-restart-aware router).

To perform the graceful restart function, a router must be in high availability (HA) stateful switchover (SSO) mode (that is, dual RP). A router capable of graceful restart will perform the graceful restart function when the following failures occur:

- A Route Processor (RP) failure that results in switchover to standby RP
- A planned RP switchover to standby RP

The graceful restart feature requires that neighboring routers be graceful-restart aware.

For further information about SSO and nonstop forwarding (NSF), see the [Stateful Switchover](#) and [Cisco Nonstop Forwarding](#) documents.

BFD Support for OSPFv3

Bidirectional Forwarding Detection (BFD) supports OSPFv3. For information on how to configure BFD for OSPFv3, see the [Implementing Bidirectional Forwarding Detection for IPv6](#) module.

How to Implement OSPF for IPv6

This section contains the following procedures:

- [Enabling OSPF for IPv6 on an Interface, page 10](#) (required)
- [Defining an OSPF for IPv6 Area Range, page 11](#) (optional)
- [Configuring IPsec on OSPF for IPv6, page 12](#) (optional)
- [Configuring NBMA Interfaces in OSPF for IPv6, page 17](#) (optional)
- [Configuring LSA and SPF Throttling for OSPF for IPv6 Fast Convergence, page 18](#) (optional)
- [Enabling OSPFv3 Graceful Restart, page 21](#) (optional)
- [Forcing an SPF Calculation, page 23](#) (optional)
- [Verifying OSPF for IPv6 Configuration and Operation, page 23](#) (optional)

Enabling OSPF for IPv6 on an Interface

This task explains how to enable OSPF for IPv6 routing and configure OSPF for IPv6 on each interface. By default, OSPF for IPv6 routing is disabled and OSPF for IPv6 is not configured on an interface.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number*
4. **ipv6 ospf** *process-id* **area** *area-id* [**instance** *instance-id*]

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Router> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> Enter your password if prompted.
Step 2	configure terminal Example: Router# configure terminal	Enters global configuration mode.
Step 3	interface <i>type number</i> Example: Router(config)# interface ethernet 0/0	Specifies an interface type and number, and places the router in interface configuration mode.
Step 4	ipv6 ospf <i>process-id area area-id [instance instance-id]</i> Example: Router(config-if)# ipv6 ospf 1 area 0	Enables OSPF for IPv6 on an interface.

Defining an OSPF for IPv6 Area Range

The cost of the summarized routes will be the highest cost of the routes being summarized. For example, if the following routes are summarized:

```
OI 2001:0DB8:0:0:7::/64 [110/20]
   via FE80::A8BB:CCFF:FE00:6F00, Ethernet0/0
OI 2001:0DB8:0:0:8::/64 [110/100]
   via FE80::A8BB:CCFF:FE00:6F00, Ethernet0/0
OI 2001:0DB8:0:0:9::/64 [110/20]
   via FE80::A8BB:CCFF:FE00:6F00, Ethernet0/0
```

They become one summarized route, as follows:

```
OI 2001:0DB8::/48 [110/100]
   via FE80::A8BB:CCFF:FE00:6F00, Ethernet0/0
```

This task explains how to consolidate or summarize routes for an OSPF area.

Prerequisites

OSPF for IPv6 routing must be enabled.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ipv6 router ospf** *process-id*

4. `area area-id range ipv6-prefix/prefix-length [advertise | not-advertise] [cost cost]`

DETAILED STEPS

	Command or Action	Purpose
Step 1	<code>enable</code> Example: Router> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> Enter your password if prompted.
Step 2	<code>configure terminal</code> Example: Router# configure terminal	Enters global configuration mode.
Step 3	<code>ipv6 router ospf process-id</code> Example: Router(config)# ipv6 router ospf 1	Enables OSPF router configuration mode.
Step 4	<code>area area-id range ipv6-prefix/prefix-length [advertise not-advertise] [cost cost]</code> Example: Router(config-rtr)# area 1 range 2001:0DB8::/48	Consolidates and summarizes routes at an area boundary.

Configuring IPsec on OSPF for IPv6

Once you have configured OSPF for IPv6 and decided on your authentication, you must define the security policy on each of the routers within the group. The security policy consists of the combination of the key and the SPI. To define a security policy, you must define an SPI and a key.

You can configure an authentication or encryption policy either on an interface or for an OSPF area. When you configure for an area, the security policy is applied to all of the interfaces in the area. For higher security, use a different policy on each interface.

You can configure authentication and encryption on virtual links.

The following tasks explain how to configure authentication and encryption on an interface or in an OSPF area, and on virtual links.

- [Defining Authentication on an Interface, page 12](#)
- [Defining Encryption on an Interface, page 13](#)
- [Defining Authentication in an OSPF Area, page 14](#)
- [Defining Encryption in an OSPF Area, page 15](#)
- [Defining Authentication and Encryption for a Virtual Link in an OSPF Area, page 16](#)

Defining Authentication on an Interface

This task explains how to define authentication on an interface.

Prerequisites

Before you configure IPsec on an interface, you must configure OSPF for IPv6 on that interface.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number*
4. **ipv6 ospf authentication ipsec spi** *spi md5* [*key-encryption-type* {*key* | **null**}]

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Router> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> • Enter your password if prompted.
Step 2	configure terminal Example: Router# configure terminal	Enters global configuration mode.
Step 3	interface <i>type number</i> Example: Router(config)# interface ethernet 0/0	Specifies an interface type and number, and places the router in interface configuration mode.
Step 4	ipv6 ospf authentication ipsec spi <i>spi md5</i> [<i>key-encryption-type</i> { <i>key</i> null }] Example: Router(config-if)# ipv6 ospf authentication ipsec spi 500 md5 1234567890abcdef1234567890abcdef	Specifies the authentication type for an interface.

Defining Encryption on an Interface

This task describes how to define encryption on an interface.

Prerequisites

Before you configure IPsec on an interface, you must configure OSPF for IPv6 on that interface.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number*

4. **ipv6 ospf encryption** {**ipsec spi spi esp encryption-algorithm** [[*key-encryption-type*] *key*] *authentication-algorithm* [*key-encryption-type*] *key* | **null**}

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Router> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> • Enter your password if prompted.
Step 2	configure terminal Example: Router# configure terminal	Enters global configuration mode.
Step 3	interface <i>type number</i> Example: Router(config)# interface ethernet 0/0	Specifies an interface type and number, and places the router in interface configuration mode.
Step 4	ipv6 ospf encryption { ipsec spi spi esp encryption-algorithm [[<i>key-encryption-type</i>] <i>key</i>] <i>authentication-algorithm</i> [<i>key-encryption-type</i>] <i>key</i> null }	Specifies the encryption type for an interface.
	Example: Router(config-if) ipv6 ospf encryption ipsec spi 1001 esp null sha1 123456789A123456789B123456789C123456789D	

Defining Authentication in an OSPF Area

This task explains how to define authentication in an OSPF area.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ipv6 router ospf** *process-id*
4. **area** *area-id* **authentication ipsec spi spi md5** [*key-encryption-type*] *key*

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Router> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> Enter your password if prompted.
Step 2	configure terminal Example: Router# configure terminal	Enters global configuration mode.
Step 3	ipv6 router ospf process-id Example: Router(config)# ipv6 router ospf 1	Enables OSPF router configuration mode.
Step 4	area area-id authentication ipsec spi spi md5 [key-encryption-type] key Example: Router(config-rtr)# area 1 authentication ipsec spi 678 md5 1234567890ABCDEF1234567890ABCDEF	Enables authentication in an OSPF area.

Defining Encryption in an OSPF Area

This task describes how to define encryption in an OSPF area.

SUMMARY STEPS

- enable**
- configure terminal**
- ipv6 router ospf process-id**
- area area-id encryption ipsec spi spi esp encryption-algorithm** [[key-encryption-type] key] authentication-algorithm [key-encryption-type] key

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Router> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> Enter your password if prompted.
Step 2	configure terminal Example: Router# configure terminal	Enters global configuration mode.

	Command or Action	Purpose
Step 3	ipv6 router ospf <i>process-id</i> Example: Router(config)# ipv6 router ospf 1	Enables OSPF router configuration mode.
Step 4	area <i>area-id</i> encryption ipsec spi spi esp <i>encryption-algorithm</i> [<i>key-encryption-type</i>] <i>key</i> authentication-algorithm [<i>key-encryption-type</i>] <i>key</i> Example: Router(config-rtr)# area 1 encryption ipsec spi 500 esp null md5 1aaa2bbb3ccc4ddd5eee6fff7aaa8bbb	Enables encryption in an OSPF area.

Defining Authentication and Encryption for a Virtual Link in an OSPF Area

The following task describes how to define authentication and encryption for virtual links in an OSPF area.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ipv6 router ospf** *process-id*
4. **area** *area-id* **virtual-link** *router-id* **authentication ipsec spi spi authentication-algorithm** [*key-encryption-type*] *key*
5. **area** *area-id* **virtual-link** *router-id* **encryption ipsec spi spi esp encryption-algorithm** [*key-encryption-type*] *key* **authentication-algorithm** [*key-encryption-type*] *key*

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Router> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> • Enter your password if prompted.
Step 2	configure terminal Example: Router# configure terminal	Enters global configuration mode.
Step 3	ipv6 router ospf <i>process-id</i> Example: Router(config)# ipv6 router ospf 1	Enables OSPF router configuration mode.

	Command or Action	Purpose
Step 4	<pre>area area-id virtual-link router-id authentication ipsec spi spi authentication-algorithm [key-encryption-type] key</pre> <p>Example:</p> <pre>Router(config-rtr)# area 1 virtual-link 10.0.0.1 authentication ipsec spi 940 md5 1234567890ABCDEF1234567890ABCDEF</pre>	Enables authentication for virtual links in an OSPF area.
Step 5	<pre>area area-id virtual-link router-id encryption ipsec spi spi esp encryption-algorithm [[key-encryption-type] key] authentication-algorithm [key-encryption-type] key</pre> <p>Example:</p> <pre>Router(config-rtr)# area 1 virtual-link 10.1.0.1 hello-interval 2 dead-interval 10 encryption ipsec spi 3944 esp null sha1 123456789A123456789B123456789C123456789D</pre>	Enables encryption for virtual links in an OSPF area.

Configuring NBMA Interfaces in OSPF for IPv6

You can customize OSPF for IPv6 in your network to use NBMA interfaces. OSPF for IPv6 cannot automatically detect neighbors over NBMA interfaces. On an NBMA interface, you must configure your neighbors manually using interface configuration mode. This task explains how to configure NBMA interfaces.

Prerequisites

Before you configure NBMA interfaces, you must perform the following tasks:

- Configure your network to be an NBMA network
- Identify each neighbor

Restrictions

- You cannot automatically detect neighbors when using NBMA interfaces. You must manually configure your router to detect neighbors when using an NBMA interface.
- When configuring the **ipv6 ospf neighbor** command, the IPv6 address used must be the link-local address of the neighbor.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number*

4. **frame-relay map ipv6** *ipv6-address dlc* [**broadcast**] [**cisco**] [**ietf**] [**payload-compression** {**packet-by-packet** | **frf9 stac** [*hardware-options*] | **data-stream stac** [*hardware-options*]}]
5. **ipv6 ospf neighbor** *ipv6-address* [**priority number**] [**poll-interval seconds**] [**cost number**] [**database-filter all out**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Router> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> • Enter your password if prompted.
Step 2	configure terminal Example: Router# configure terminal	Enters global configuration mode.
Step 3	interface <i>type number</i> Example: Router(config)# interface serial 0	Specifies an interface type and number, and places the router in interface configuration mode.
Step 4	frame-relay map ipv6 <i>ipv6-address dlc</i> [broadcast] [cisco] [ietf] [payload-compression { packet-by-packet frf9 stac [<i>hardware-options</i>] data-stream stac [<i>hardware-options</i>]}] Example: Router(config-if)# frame-relay map ipv6 FE80::A8BB:CCFF:FE00:C01 120	Defines the mapping between a destination IPv6 address and the data-link connection identifier (DLCI) used to connect to the destination address. <ul style="list-style-type: none"> • In this example, the NBMA link is frame relay. For other kinds of NBMA links, different mapping commands are used.
Step 5	ipv6 ospf neighbor <i>ipv6-address</i> [priority number] [poll-interval seconds] [cost number] [database-filter all out] Example: Router(config-if) ipv6 ospf neighbor FE80::A8BB:CCFF:FE00:C01	Configures an OSPF for IPv6 neighboring router.

Configuring LSA and SPF Throttling for OSPF for IPv6 Fast Convergence

This task explains how to configure LSA and SPF throttling for the OSPF for IPv6 Fast Convergence feature.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ipv6 router ospf** *process-id*

4. **timers throttle spf** *spf-start spf-hold spf-max-wait*
5. **timers throttle lsa** *start-interval hold-interval max-interval*
6. **timers lsa arrival** *milliseconds*
7. **timers pacing flood** *milliseconds*

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Router> enable	Enables privileged EXEC mode. <ul style="list-style-type: none">• Enter your password if prompted.
Step 2	configure terminal Example: Router# configure terminal	Enters global configuration mode.
Step 3	ipv6 router ospf <i>process-id</i> Example: Router(config)# ipv6 router ospf 1	Enables OSPF router configuration mode.
Step 4	timers throttle spf <i>spf-start spf-hold spf-max-wait</i> Example: Router(config-rtr)# timers throttle spf 200 200 200	Turns on SPF throttling.
Step 5	timers throttle lsa <i>start-interval hold-interval max-interval</i> Example: Router(config-rtr)# timers throttle lsa 300 300 300	Sets rate-limiting values for OSPF for IPv6 LSA generation.
Step 6	timers lsa arrival <i>milliseconds</i> Example: Router(config-rtr)# timers lsa arrival 300	Sets the minimum interval at which the software accepts the same LSA from OSPF neighbors.
Step 7	timers pacing flood <i>milliseconds</i> Example: Router(config-rtr)# timers pacing flood 30	Configures LSA flood packet pacing.

Enabling Event Logging for LSA and SPF Rate Limiting

An OSPF for IPv6 event log is kept for each OSPF for IPv6 instance. This task explains how to enable event logging for the LSA and SPF rate-limiting function.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ipv6 router ospf *process-id***
4. **event-log [size [*number of events*]] [one-shot] [pause]**

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Router> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> • Enter your password if prompted.
Step 2	configure terminal Example: Router# configure terminal	Enters global configuration mode.
Step 3	ipv6 router ospf <i>process-id</i> Example: Router(config)# ipv6 router ospf 1	Enables OSPF router configuration mode.
Step 4	event-log [size [<i>number of events</i>]] [one-shot] [pause] Example: Router(config-rtr)# event-log size 10000 one-shot	Enables event logging.

Clearing the Content of an Event Log

This task explains how to clear the content of an event log.

SUMMARY STEPS

1. **enable**
2. **clear ipv6 ospf [*process-id*] events**

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Router> enable	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	clear ipv6 ospf [process-id] events Example: Router# clear ipv6 ospf 1 events	Clears the OSPF for IPv6 event log content based on the OSPF routing process ID.

Enabling OSPFv3 Graceful Restart

The graceful restart feature may be enabled on graceful-restart-capable routers and on graceful-restart-aware routers. The following sections describe how to enable OSPFv3 graceful restart:

- [Enabling OSPFv3 Graceful Restart on a Graceful-Restart-Capable Router, page 21](#)
- [Enabling OSPFv3 Graceful Restart on a Graceful-Restart-Aware Router, page 22](#)

Enabling OSPFv3 Graceful Restart on a Graceful-Restart-Capable Router

This task describes how to enable OSPFv3 graceful restart on a graceful-restart-capable router.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ipv6 router ospf process-id**
4. **graceful-restart [restart-interval interval]**

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Router> enable	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	configure terminal Example: Router# configure terminal	Enters global configuration mode.

	Command or Action	Purpose
Step 3	<code>ipv6 router ospf process-id</code> Example: Router(config)# ipv6 router ospf 1	Enables OSPF router configuration mode.
Step 4	<code>graceful-restart [restart-interval interval]</code> Example: Router(config-rtr)# graceful-restart	Enables the OSPFv3 graceful restart feature on a graceful-restart-capable router.

Enabling OSPFv3 Graceful Restart on a Graceful-Restart-Aware Router

This task describes how to enable OSPFv3 graceful restart on a graceful-restart-aware router.

SUMMARY STEPS

1. `enable`
2. `configure terminal`
3. `ipv6 router ospf process-id`
4. `graceful-restart helper {disable | strict-lsa-checking}`

DETAILED STEPS

	Command or Action	Purpose
Step 1	<code>enable</code> Example: Router> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> • Enter your password if prompted.
Step 2	<code>configure terminal</code> Example: Router# configure terminal	Enters global configuration mode.
Step 3	<code>ipv6 router ospf process-id</code> Example: Router(config)# ipv6 router ospf 1	Enables OSPF router configuration mode.
Step 4	<code>graceful-restart helper {disable strict-lsa-checking}</code> Example: Router(config-rtr)# graceful-restart helper strict-lsa-checking	Enables the OSPFv3 graceful restart feature on a graceful-restart-aware router.

Forcing an SPF Calculation

This task explains how to start the SPF algorithm without first clearing the OSPF database.

SUMMARY STEPS

1. **enable**
2. **clear ipv6 ospf** [*process-id*] {**process** | **force-spf** | **redistribution**}

	Command or Action	Purpose
Step 1	enable Example: Router> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> • Enter your password if prompted.
Step 2	clear ipv6 ospf [<i>process-id</i>] { process force-spf redistribution } Example: Router# clear ipv6 ospf force-spf	Clears the OSPF state based on the OSPF routing process ID, and forces the start of the SPF algorithm.

Verifying OSPF for IPv6 Configuration and Operation

This task explains how to display information to verify the configuration and operation of OSPF for IPv6.

SUMMARY STEPS

1. **enable**
2. **show ipv6 ospf** [*process-id*] [*area-id*] **interface** [*interface-type interface-number*]
3. **show ipv6 ospf** [*process-id*] [*area-id*]
4. **show crypto ipsec policy** [*name policy-name*]
5. **show crypto ipsec sa** [*map map-name* | **address** | **identity** | **interface** *type number* | **peer** [*vrf fvrf-name*] **address** | **vrf** *ivrf-name* | **ipv6** [*interface-type interface-number*]] [**detail**]
6. **show ipv6 ospf** [*process-ID*] **event** [**generic** | **interface** | **lsa** | **neighbor** | **reverse** | **rib** | **spf**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Router> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> Enter your password if prompted.
Step 2	show ipv6 ospf [<i>process-id</i>] [<i>area-id</i>] interface [<i>interface-type interface-number</i>] Example: Router# show ipv6 ospf interface	Displays OSPF-related interface information.
Step 3	show ipv6 ospf [<i>process-id</i>] [<i>area-id</i>] Example: Router# show ipv6 ospf	Displays general information about OSPF routing processes.
Step 4	show crypto ipsec policy [<i>name policy-name</i>] Example: Router# show crypto ipsec policy	Displays the parameters for each IPsec parameter.
Step 5	show crypto ipsec sa [<i>map map-name</i> address identity interface type number peer [<i>vrf fvrf-name</i>] address vrf ivrf-name ipv6 [<i>interface-type interface-number</i>]] [detail] Example: Router# show crypto ipsec sa ipv6	Displays the settings used by current security associations (SAs).
Step 6	show ipv6 ospf [<i>process-ID</i>] event [generic interface lsa neighbor reverse rib spf] Example: Router# show ipv6 ospf event spf	Displays detailed information about OSPF for IPv6 events.

Examples

This section provides the following output examples:

- [Sample Output from the show ipv6 ospf interface Command, page 24](#)
- [Sample Output from the show ipv6 ospf Command, page 26](#)
- [Sample Output from the show crypto ipsec policy Command, page 26](#)
- [Sample Output from the show crypto ipsec sa ipv6 Command, page 27](#)
- [Sample Output from the show ipv6 ospf graceful-restart Command, page 27](#)

Sample Output from the show ipv6 ospf interface Command

The following is sample output from the **show ipv6 ospf interface** command with regular interfaces and a virtual link that are protected by encryption and authentication:

```

Router# show ipv6 ospf interface

OSPFv3_VL1 is up, line protocol is up
  Interface ID 69
  Area 0, Process ID 1, Instance ID 0, Router ID 10.0.0.1
  Network Type VIRTUAL_LINK, Cost: 64
  Configured as demand circuit.
  Run as demand circuit.
  DoNotAge LSA allowed.
  NULL encryption SHA-1 auth SPI 3944, secure socket UP (errors: 0)
  Transmit Delay is 1 sec, State POINT_TO_POINT,
  Timer intervals configured, Hello 2, Dead 10, Wait 40, Retransmit 5
    Hello due in 00:00:00
  Index 1/3/5, flood queue length 0
  Next 0x0(0)/0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1, Adjacent neighbor count is 1
    Adjacent with neighbor 10.2.0.1 (Hello suppressed)
  Suppress hello for 1 neighbor(s)
OSPFv3_VL0 is up, line protocol is up
  Interface ID 67
  Area 0, Process ID 1, Instance ID 0, Router ID 10.0.0.1
  Network Type VIRTUAL_LINK, Cost: 128
  Configured as demand circuit.
  Run as demand circuit.
  DoNotAge LSA allowed.
  MD5 authentication SPI 940, secure socket UP (errors: 0)
  Transmit Delay is 1 sec, State POINT_TO_POINT,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:09
  Index 1/2/4, flood queue length 0
  Next 0x0(0)/0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 10
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1, Adjacent neighbor count is 1
    Adjacent with neighbor 10.1.0.1 (Hello suppressed)
  Suppress hello for 1 neighbor(s)
Ethernet1/0 is up, line protocol is up
  Link Local Address FE80::A8BB:CCFF:FE00:6601, Interface ID 6
  Area 0, Process ID 1, Instance ID 0, Router ID 10.0.0.1
  Network Type BROADCAST, Cost: 10
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 10.0.0.1, local address FE80::A8BB:CCFF:FE00:6601
  No backup designated router on this network
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:09
  Index 1/1/1, flood queue length 0
  Next 0x0(0)/0x0(0)/0x0(0)
  Last flood scan length is 0, maximum is 0
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 0, Adjacent neighbor count is 0
  Suppress hello for 0 neighbor(s)
Serial12/0 is up, line protocol is up
  Link Local Address FE80::A8BB:CCFF:FE00:6600, Interface ID 50
  Area 1, Process ID 1, Instance ID 0, Router ID 10.0.0.1
  Network Type POINT_TO_POINT, Cost: 64
  AES-CBC encryption SHA-1 auth SPI 2503, secure socket UP (errors: 0)
  authentication NULL
  Transmit Delay is 1 sec, State POINT_TO_POINT,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:09
  Index 1/2/3, flood queue length 0
  Next 0x0(0)/0x0(0)/0x0(0)

```

```

Last flood scan length is 1, maximum is 5
Last flood scan time is 0 msec, maximum is 0 msec
Neighbor Count is 1, Adjacent neighbor count is 1
  Adjacent with neighbor 10.2.0.1
  Suppress hello for 0 neighbor(s)
Serial11/0 is up, line protocol is up
Link Local Address FE80::A8BB:CCFF:FE00:6600, Interface ID 46
Area 1, Process ID 1, Instance ID 0, Router ID 10.0.0.1
Network Type POINT_TO_POINT, Cost: 64
MD5 authentication (Area) SPI 500, secure socket UP (errors: 0)
Transmit Delay is 1 sec, State POINT_TO_POINT,
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
  Hello due in 00:00:09
Index 1/1/2, flood queue length 0
Next 0x0(0)/0x0(0)/0x0(0)
Last flood scan length is 1, maximum is 5
Last flood scan time is 0 msec, maximum is 0 msec
Neighbor Count is 1, Adjacent neighbor count is 1
  Adjacent with neighbor 10.0.0.1
  Suppress hello for 0 neighbor(s)

```

Sample Output from the show ipv6 ospf Command

The following is sample output from the **show ipv6 ospf** command:

```

Router# show ipv6 ospf

Routing Process "ospfv3 1" with ID 172.16.3.3
It is an autonomous system boundary router
Redistributing External Routes from,
  static
SPF schedule delay 5 secs, Hold time between two SPFs 10 secs
Minimum LSA interval 5 secs. Minimum LSA arrival 1 secs
LSA group pacing timer 240 secs
Interface flood pacing timer 33 msecs
Retransmission pacing timer 66 msecs
Number of external LSA 1. Checksum Sum 0x218D
Number of areas in this router is 1. 1 normal 0 stub 0 nssa
  Area 1
    Number of interfaces in this area is 2
    SPF algorithm executed 9 times
    Number of LSA 15. Checksum Sum 0x67581
    Number of DCbitless LSA 0
    Number of indication LSA 0
    Number of DoNotAge LSA 0
    Flood list length 0

```

Sample Output from the show crypto ipsec policy Command

The following is sample output from the **show crypto ipsec policy** command:

```

Router# show crypto ipsec policy

Crypto IPsec client security policy data

Policy name:      OSPFv3-1-1000
Policy refcount: 1
Inbound  AH SPI: 1000 (0x3E8)
Outbound AH SPI: 1000 (0x3E8)
Inbound  AH Key: 1234567890ABCDEF1234567890ABCDEF
Outbound AH Key: 1234567890ABCDEF1234567890ABCDEF
Transform set:   ah-md5-hmac

```

Sample Output from the show crypto ipsec sa ipv6 Command

The following is sample output from the **show crypto ipsec sa ipv6** command:

```
Router# show crypto ipsec sa ipv6

IPv6 IPsec SA info for interface Ethernet0/0

protected policy name:OSPFv3-1-1000
IPsec created ACL name:Ethernet0/0-ipsecv6-ACL

local ident (addr/prefixlen/proto/port):(FE80::/10/89/0)
remote ident (addr/prefixlen/proto/port):(::/0/89/0)
current_peer::
  PERMIT, flags={origin_is_acl,}
  #pkts encaps:21, #pkts encrypt:0, #pkts digest:21
  #pkts decaps:20, #pkts decrypt:0, #pkts verify:20
  #pkts compressed:0, #pkts decompressed:0
  #pkts not compressed:0, #pkts compr. failed:0
  #pkts not decompressed:0, #pkts decompress failed:0
  #send errors 0, #recv errors 0

local crypto endpt. ::, remote crypto endpt. ::
path mtu 1500, media mtu 1500
current outbound spi:0x3E8(1000)

inbound ESP SAs:

inbound AH SAs:
spi:0x3E8(1000)
  transform:ah-md5-hmac ,
  in use settings ={Transport, }
  slot:0, conn_id:2000, flow_id:1, crypto map:N/R
  no sa timing (manual-keyed)
  replay detection support:N

inbound PCP SAs:

outbound ESP SAs:

outbound AH SAs:
spi:0x3E8(1000)
  transform:ah-md5-hmac ,
  in use settings ={Transport, }
  slot:0, conn_id:2001, flow_id:2, crypto map:N/R
  no sa timing (manual-keyed)
  replay detection support:N

outbound PCP SAs:
```

Sample Output from the show ipv6 ospf graceful-restart Command

The following is sample output from the **show crypto ipsec sa ipv6** command:

```
Router# show ipv6 ospf graceful-restart

Routing Process "ospf 1"
Graceful Restart enabled
  restart-interval limit: 120 sec, last restart 00:00:15 ago (took 36 secs)
Graceful Restart helper support enabled
Router status : Active
Router is running in SSO mode
OSPF restart state : NO_RESTART
Router ID 10.1.1.1, checkpoint Router ID 10.0.0.0
```

Configuration Examples for Implementing OSPF for IPv6

This section provides the following configuration examples:

- [Enabling OSPF for IPv6 on an Interface Configuration: Example, page 28](#)
- [Defining an OSPF for IPv6 Area Range: Example, page 28](#)
- [Defining Authentication on an Interface: Example, page 28](#)
- [Defining Authentication in an OSPF Area: Example, page 29](#)
- [Configuring NBMA Interfaces Configuration: Example, page 29](#)
- [Configuring LSA and SPF Throttling for OSPF for IPv6 Fast Convergence: Example, page 29](#)
- [Forcing SPF Configuration: Example, page 29](#)

Enabling OSPF for IPv6 on an Interface Configuration: Example

The following example configures an OSPF routing process 109 to run on the interface and puts it in area 1:

```
ipv6 ospf 109 area 1
```

Defining an OSPF for IPv6 Area Range: Example

The following example specifies an OSPF for IPv6 area range:

```
interface Ethernet7/0
  ipv6 address 2001:0DB8:0:0:7::/64 eui-64
  ipv6 enable
  ipv6 ospf 1 area 1
!
interface Ethernet8/0
  ipv6 address 2001:0DB8:0:0:8::/64 eui-64
  ipv6 enable
  ipv6 ospf 1 area 1
!
interface Ethernet9/0
  ipv6 address 2001:0DB8:0:0:9::/64 eui-64
  ipv6 enable
  ipv6 ospf 1 area 1
!
ipv6 router ospf 1
  router-id 10.11.11.1
  area 1 range 2001:0DB8::/48
```

Defining Authentication on an Interface: Example

The following example defines authentication on the Ethernet 0/0 interface:

```
interface Ethernet0/0
  ipv6 enable
  ipv6 ospf 1 area 0
  ipv6 ospf authentication ipsec spi 500 md5 1234567890ABCDEF1234567890ABCDEF

interface Ethernet0/0
  ipv6 enable
```

```
ipv6 ospf authentication null
ipv6 ospf 1 area 0
```

Defining Authentication in an OSPF Area: Example

The following example defines authentication on OSPF area 0:

```
ipv6 router ospf 1
router-id 10.11.11.1
area 0 authentication ipsec spi 1000 md5 1234567890ABCDEF1234567890ABCDEF
```

Configuring NBMA Interfaces Configuration: Example

The following example configures an OSPF neighboring router with the IPv6 address of FE80::A8BB:CCFF:FE00:C01.

```
interface serial 0
ipv6 enable
ipv6 ospf 1 area 0
encapsulation frame-relay
frame-relay map ipv6 FE80::A8BB:CCFF:FE00:C01 120
ipv6 ospf neighbor FE80::A8BB:CCFF:FE00:C0
```

Configuring LSA and SPF Throttling for OSPF for IPv6 Fast Convergence: Example

The following example displays the configuration values for SPF and LSA throttling timers:

```
Router# show ipv6 ospf

Routing Process "ospfv3 1" with ID 10.9.4.1
Event-log enabled, Maximum number of events: 1000, Mode: cyclic
It is an autonomous system boundary router
Redistributing External Routes from,
  ospf 2
Initial SPF schedule delay 5000 msec
Minimum hold time between two consecutive SPF's 10000 msec
Maximum wait time between two consecutive SPF's 10000 msec
Minimum LSA interval 5 secs
Minimum LSA arrival 1000 msec
```

Forcing SPF Configuration: Example

The following example triggers SPF to redo the SPF and repopulate the routing tables:

```
clear ipv6 ospf force-spf
```

Additional References

The following sections provide additional references related to the Implementing OSPF for IPv6 feature.

Related Documents

Related Topic	Document Title
Configuring a router ID in OSPF	<ul style="list-style-type: none"> “Configuring OSPF,” <i>Cisco IOS IP Routing Protocols Configuration Guide</i> Cisco IOS IP Routing Protocols Command Reference
OSPF for IPv6 commands	Cisco IOS IPv6 Command Reference
IPv6 supported feature list	“ Start Here: Cisco IOS Software Release Specifics for IPv6 Features ,” <i>Cisco IOS IPv6 Configuration Guide</i>
Implementing basic IPv6 connectivity	“ Implementing IPv6 Addressing and Basic Connectivity ,” <i>Cisco IOS IPv6 Configuration Guide</i>
IPsec for IPv6	“ Implementing IPsec for IPv6 Security ,” <i>Cisco IOS IPv6 Configuration Guide</i>
Stateful switchover	“ Stateful Switchover ,” <i>Cisco IOS High Availability Configuration Guide</i>
Cisco nonstop forwarding	“ Cisco Nonstop Forwarding ,” <i>Cisco IOS High Availability Configuration Guide</i>
OSPF for IPv4 tasks	“ Configuring OSPF ,” <i>Cisco IOS IP Routing Protocols Configuration Guide</i>
OSPF for IPv4 commands	Cisco IOS IP Routing Protocols Command Reference
Security configuration tasks (IPv4)	Cisco IOS Security Configuration Guide
LSA throttling	“ OSPF Link-State Advertisement (LSA) Throttling ,” <i>Cisco IOS IP Routing Protocols Configuration Guide</i>
Security commands: complete command syntax, command mode, defaults, usage guidelines, and examples (IPv4)	Cisco IOS Security Command Reference

Standards

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

MIBs

MIBs	MIBs Link
<ul style="list-style-type: none"> CISCO-IETF-IP-FORWARD-MIB CISCO-IETF-IP-MIB 	<p>To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:</p> <p>http://www.cisco.com/go/mibs</p>

RFCs

RFCs	Title
RFC 2401	<i>Security Architecture for the Internet Protocol</i>
RFC 2402	<i>IP Authentication Header</i>
RFC 2406	<i>IP Encapsulating Security Payload (ESP)</i>
RFC 2740	<i>OSPF for IPv6</i>
RFC 4552	<i>Authentication/Confidentiality for OSPFv3</i>
RFC 5187	<i>OSPFv3 Graceful Restart</i>

Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<p>http://www.cisco.com/techsupport</p>

Feature Information for Implementing OSPF for IPv6

Table 3 lists the features in this module and provides links to specific configuration information. Only features that were introduced or modified in Cisco IOS Release 12.0(24)S or a later release appear in the table.

For information on a feature in this technology that is not documented here, see [Start Here: Cisco IOS Software Release Specifics for IPv6 Features](#).

Not all commands may be available in your Cisco IOS software release. For release information about a specific command, see the command reference documentation.

Use Cisco Feature Navigator to find information about platform support and software image support. Cisco Feature Navigator enables you to determine which Cisco IOS and Catalyst OS software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.


Note

Table 3 lists only the Cisco IOS software release that introduced support for a given feature in a given Cisco IOS software release train. Unless noted otherwise, subsequent releases of that Cisco IOS software release train also support that feature.

Table 3 Feature Information for Implementing OSPF for IPv6

Feature Name	Releases	Feature Information
IPv6 routing: OSPF for IPv6 (OSPFv3)	12.0(24)S 12.2(18)S 12.2(28)SB 12.2(25)SG 12.2(33)SRA 12.2(15)T 12.3 12.3(2)T 12.4 12.4(2)T 15.0(1)M	OSPF version 3 for IPv6 expands on OSPF version 2 to provide support for IPv6 routing prefixes and the larger size of IPv6 addresses. This entire document provides information about this feature.
IPv6 routing: LSA types in OSPF for IPv6	12.0(24)S 12.2(18)S 12.2(28)SB 12.2(15)T 12.3 12.3(2)T 12.4 12.4(2)T	A router's collection of LSA data is stored in a link-state database. The contents of the database, when subjected to the Dijkstra algorithm, result in the creation of the OSPF routing table. The following sections provide information about this feature: <ul style="list-style-type: none"> • How OSPF for IPv6 Works, page 3 • LSA Types for IPv6, page 3

Table 3 *Feature Information for Implementing OSPF for IPv6 (continued)*

Feature Name	Releases	Feature Information
IPv6 routing: Fast Convergence—LSA and SPF throttling	12.2(33)SB 12.2(33)SRC 15.0(1)M	<p>The OSPF for IPv6 LSA and SPF throttling feature provides a dynamic mechanism to slow down link-state advertisement updates in OSPF during times of network instability.</p> <p>The following sections provide information about this feature:</p> <ul style="list-style-type: none"> • Fast Convergence—LSA and SPF Throttling, page 5 • Configuring LSA and SPF Throttling for OSPF for IPv6 Fast Convergence, page 18 • Enabling Event Logging for LSA and SPF Rate Limiting, page 19 • Clearing the Content of an Event Log, page 20 • Configuring LSA and SPF Throttling for OSPF for IPv6 Fast Convergence: Example, page 29
IPv6 routing: NBMA interfaces in OSPF for IPv6	12.0(24)S 12.2(18)S 12.2(28)SB 12.2(15)T 12.3 12.3(2)T 12.4 12.4(2)T	<p>On NBMA networks, the DR or backup DR performs the LSA flooding.</p> <p>The following sections provide information about this feature:</p> <ul style="list-style-type: none"> • NBMA in OSPF for IPv6, page 5 • Configuring NBMA Interfaces in OSPF for IPv6, page 17
IPv6 routing: Force SPF in OSPF for IPv6	12.0(24)S 12.2(18)S 12.2(28)SB 12.2(15)T 12.3 12.3(2)T 12.4 12.4(2)T	<p>This feature enables the OSPF database to be cleared and repopulated, and then the SPF algorithm is performed.</p> <p>The following sections provide information about this feature:</p> <ul style="list-style-type: none"> • Force SPF in OSPF for IPv6, page 5 • Enabling OSPFv3 Graceful Restart, page 21
IPv6 routing: Load balancing in OSPF for IPv6	12.0(24)S 12.2(18)S 12.2(28)SB 12.2(15)T 12.3 12.3(2)T 12.4 12.4(2)T	<p>OSPF for IPv6 performs load balancing automatically.</p> <p>The following section provides information about this feature:</p> <ul style="list-style-type: none"> • Load Balancing in OSPF for IPv6, page 5

Table 3 Feature Information for Implementing OSPF for IPv6 (continued)

Feature Name	Releases	Feature Information
IPv6 routing: OSPF for IPv6 authentication support with IPsec	12.3(4)T 12.4 12.4(2)T	<p>OSPF for IPv6 uses the IPsec secure socket API to add authentication to OSPF for IPv6 packets.</p> <p>The following sections provide information about this feature:</p> <ul style="list-style-type: none"> • OSPF for IPv6 Authentication Support with IPsec, page 6 • Configuring IPsec on OSPF for IPv6, page 12 • Defining Authentication on an Interface, page 12 • Defining Authentication in an OSPF Area, page 14
IPv6 routing: OSPF IPv6 (OSPFv3) IPsec ESP encryption and authentication	12.4(9)T	<p>IPv6 ESP extension headers can be used to provide authentication and confidentiality to OSPF for IPv6.</p> <p>The following sections provide information about this feature:</p> <ul style="list-style-type: none"> • Restrictions for Implementing OSPF for IPv6, page 2 • OSPF for IPv6 Authentication Support with IPsec, page 6 • Defining Encryption on an Interface, page 13 • Defining Encryption in an OSPF Area, page 15 • Defining Authentication and Encryption for a Virtual Link in an OSPF Area, page 16
OSPFv3 dynamic interface cost support	12.4(15)T	<p>OSPFv3 dynamic interface cost support provides enhancements to the OSPF for IPv6 cost metric for supporting mobile ad hoc networking.</p> <p>The following section provides information about this feature:</p> <ul style="list-style-type: none"> • OSPF Cost Calculation, page 7
OSPFv3 graceful restart	12.2(33)SRE 15.0(1)M	<p>The graceful restart feature in OSPFv3 allows nonstop data forwarding along routes that are already known while the OSPFv3 routing protocol information is being restored.</p> <p>The following sections provide information about this feature:</p> <ul style="list-style-type: none"> • OSPFv3 Graceful Restart, page 9 • Enabling OSPFv3 Graceful Restart, page 21
OSPFv3 for BFD	12.2(33)SRE	<p>BFD supports the dynamic routing protocol OSPF for IPv6 (OSPFv3).</p> <p>The following section provides information about this feature:</p> <ul style="list-style-type: none"> • BFD Support for OSPFv3, page 10

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