Implementing OSPF

Open Shortest Path First (OSPF) is an Interior Gateway Protocol (IGP) developed by the OSPF working group of the Internet Engineering Task Force (IETF). Designed expressly for IP networks, OSPF supports IP subnetting and tagging of externally derived routing information. OSPF also allows packet authentication and uses IP multicast when sending and receiving packets.

OSPF Version 3 (OSPFv3) expands on OSPF Version 2, providing support for IPv6 routing prefixes.

This module describes the concepts and tasks you need to implement both versions of OSPF on your Cisco ASR 9000 Series Router . The term “OSPF" implies both versions of the routing protocol, unless otherwise noted.

Note For more information about OSPF on Cisco IOS XR software and complete descriptions of the OSPF commands listed in this module, see the Related Documents, on page 127 section of this module. To locate documentation for other commands that might appear during execution of a configuration task, search online in the *Cisco ASR 9000 Series Aggregation Services Router Commands Master List*

Feature History for Implementing OSPF

Release	Modification
Release 3.7.2	This feature was introduced.
Release 3.9.0	Support was added for the following features: • OSPFv2 SPF Prefix Prioritization. • IP fast reroute loop-free alternates computation • Warm Standby for OSPF Version 3
Release 4.2.0	Support was added for the following features: • OSPFv2 Fast Re-route Per-Prefix Computation • OSPFv3 Non-stop Routing (NSR)

Release	Modification
Release 4.3.0	Support was added for the following features: • OSPFv2 VRF Lite • OSPFv3 Timers Update
Release 5.3.0	Support was added for the following features: • OSPFv2 Segment Routing Topology Independent Fast Reroute • 64 ECMP for ASR 9000 Enhanced Ethernet Line Card
Release 5.3.2	Support was added for the following features: • OSPF strict-mode Support for BFD Dampening • OSPF FIB Download Notification

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Prerequisites for Implementing OSPF

The following are prerequisites for implementing OSPF on Cisco IOS XR software:

- You must be in a user group associated with a task group that includes the proper task IDs. The command reference guides include the task IDs required for each command. If you suspect user group assignment is preventing you from using a command, contact your AAA administrator for assistance.
- Configuration tasks for OSPFv3 assume that you are familiar with IPv6 addressing and basic configuration. See the *Implementing Network Stack IPv4 and IPv6 on* Cisco ASR 9000 Series Router module of the *IP Addresses and Services Configuration Guide for Cisco ASR 9000 Series Routers* for information on IPv6 routing and addressing.
- Before you enable OSPFv3 on an interface, you must perform the following tasks:
  - Complete the OSPF network strategy and planning for your IPv6 network. For example, you must decide whether multiple areas are required.
  - Enable IPv6 on the interface.

- Configuring authentication (IP Security) is an optional task. If you choose to configure authentication, you must first decide whether to configure plain text or Message Digest 5 (MD5) authentication, and whether the authentication applies to an entire area or specific interfaces.

Information About Implementing OSPF

To implement OSPF you need to understand the following concepts:

OSPF Functional Overview

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

A router stores the collection of received LSA data in a link-state database. This database includes LSA data for the links of the router. The contents of the database, when subjected to the Dijkstra algorithm, extract data to create an 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 through specific router interface ports.

OSPF is the IGP of choice because it scales to large networks. It uses areas to partition the network into more manageable sizes and to introduce hierarchy in the network. A router is attached to one or more areas in a network. All of the networking devices in an area maintain the same complete database information about the link states in their area only. They do not know about all link states in the network. The agreement of the database information among the routers in the area is called convergence.

At the intradomain level, OSPF can import routes learned using Intermediate System-to-Intermediate System (IS-IS). OSPF routes can also be exported into IS-IS. At the interdomain level, OSPF can import routes learned using Border Gateway Protocol (BGP). OSPF routes can be exported into BGP.

Unlike Routing Information Protocol (RIP), OSPF does not provide periodic routing updates. On becoming neighbors, OSPF routers establish an adjacency by exchanging and synchronizing their databases. After that, only changed routing information is propagated. Every router in an area advertises the costs and states of its links, sending this information in an LSA. This state information is sent to all OSPF neighbors one hop away. All the OSPF neighbors, in turn, send the state information unchanged. This flooding process continues until all devices in the area have the same link-state database.

To determine the best route to a destination, the software sums all of the costs of the links in a route to a destination. After each router has received routing information from the other networking devices, it runs the shortest path first (SPF) algorithm to calculate the best path to each destination network in the database.

The networking devices running OSPF detect topological changes in the network, flood link-state updates to neighbors, and quickly converge on a new view of the topology. Each OSPF router in the network soon has the same topological view again. OSPF allows multiple equal-cost paths to the same destination. Since all link-state information is flooded and used in the SPF calculation, multiple equal cost paths can be computed and used for routing.

On broadcast and nonbroadcast multiaccess (NBMA) networks, the designated router (DR) or backup DR performs the LSA flooding. On point-to-point networks, flooding simply exits an interface directly to a neighbor.

OSPF runs directly on top of IP; it does not use TCP or User Datagram Protocol (UDP). OSPF performs its own error correction by means of checksums in its packet header and LSAs.

In OSPFv3, the fundamental concepts are the same as OSPF Version 2, except that support is added for the increased address size of IPv6. New LSA types are created to carry IPv6 addresses and prefixes, and the protocol runs on an individual link basis rather than on an individual IP-subnet basis.

OSPF typically requires coordination among many internal routers: Area Border Routers (ABRs), which are routers attached to multiple areas, and Autonomous System Border Routers (ASBRs) that export reroutes from other sources (for example, IS-IS, BGP, or static routes) into the OSPF topology. At a minimum, OSPF-based routers or access servers can be configured with all default parameter values, no authentication, and interfaces assigned to areas. If you intend to customize your environment, you must ensure coordinated configurations of all routers.

After the router boots up, it sends OSPFv2 traps only after two dead intervals have passed to prevent flooding caused by frequent state changes.

Key Features Supported in the Cisco IOS XR Software OSPF Implementation

The Cisco IOS XR Software implementation of OSPF conforms to the OSPF Version 2 and OSPF Version 3 specifications detailed in the Internet RFC 2328 and RFC 2740, respectively.

The following key features are supported in the Cisco IOS XR Software implementation:

- Hierarchy—CLI hierarchy is supported.
- Inheritance—CLI inheritance is supported.
- Stub areas—Definition of stub areas is supported.
- NSF—Nonstop forwarding is supported.
- SPF throttling—Shortest path first throttling feature is supported.
- LSA throttling—LSA throttling feature is supported.
- Fast convergence—SPF and LSA throttle timers are set, configuring fast convergence. The OSPF LSA throttling feature provides a dynamic mechanism to slow down LSA updates in OSPF during network instability. LSA throttling also allows faster OSPF convergence by providing LSA rate limiting in milliseconds.
- Route redistribution—Routes learned using any IP routing protocol can be redistributed into any other IP routing protocol.
- Authentication—Plain text and MD5 authentication among neighboring routers within an area is supported.
- Routing interface parameters—Configurable parameters supported include interface output cost, retransmission interval, interface transmit delay, router priority, router “dead” and hello intervals, and authentication key.
- Virtual links—Virtual links are supported.
- Not-so-stubby area (NSSA)—RFC 1587 is supported.

- OSPF over demand circuit—RFC 1793 is supported.

Comparison of Cisco IOS XR Software OSPFv3 and OSPFv2

Much of the OSPFv3 protocol is the same as in OSPFv2. OSPFv3 is described in RFC 2740.

The key differences between the Cisco IOS XR Software OSPFv3 and OSPFv2 protocols are as follows:

- OSPFv3 expands on OSPFv2 to provide support for IPv6 routing prefixes and the larger size of IPv6 addresses.
- When using an NBMA interface in OSPFv3, users must manually configure the router with the list of neighbors. Neighboring routers are identified by the link local address of the attached interface of the neighbor.
- Unlike in OSPFv2, multiple OSPFv3 processes can be run on a link.
- LSAs in OSPFv3 are expressed as “prefix and prefix length” instead of “address and mask.”
- The router ID is a 32-bit number with no relationship to an IPv6 address.

OSPF Hierarchical CLI and CLI Inheritance

Cisco IOS XR Software introduces new OSPF configuration fundamentals consisting of hierarchical CLI and CLI inheritance.

Hierarchical CLI is the grouping of related network component information at defined hierarchical levels such as at the router, area, and interface levels. Hierarchical CLI allows for easier configuration, maintenance, and troubleshooting of OSPF configurations. When configuration commands are displayed together in their hierarchical context, visual inspections are simplified. Hierarchical CLI is intrinsic for CLI inheritance to be supported.

With CLI inheritance support, you need not explicitly configure a parameter for an area or interface. In Cisco IOS XR Software, the parameters of interfaces in the same area can be exclusively configured with a single command, or parameter values can be inherited from a higher hierarchical level—such as from the area configuration level or the router ospf configuration levels.

For example, the hello interval value for an interface is determined by this precedence “IF” statement:

If the **hello interval** command is configured at the interface configuration level, then use the interface configured value, else

If the **hello interval** command is configured at the area configuration level, then use the area configured value, else

If the **hello interval** command is configured at the router ospf configuration level, then use the router ospf configured value, else

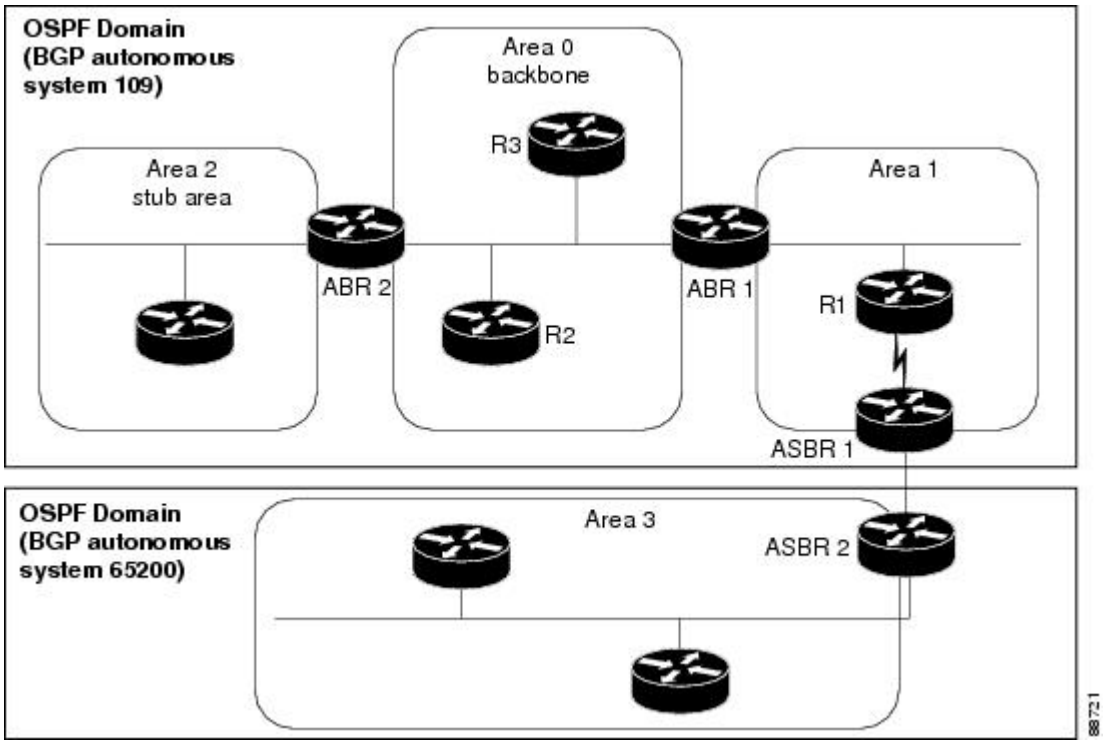
Use the default value of the command.

OSPF Routing Components

Before implementing OSPF, you must know what the routing components are and what purpose they serve. They consist of the autonomous system, area types, interior routers, ABRs, and ASBRs.

Figure 1: OSPF Routing Components

This figure illustrates the routing components in an OSPF network topology.



Autonomous Systems

The autonomous system is a collection of networks, under the same administrative control, that share routing information with each other. An autonomous system is also referred to as a routing domain. Figure 1: OSPF Routing Components, on page 6 shows two autonomous systems: 109 and 65200. An autonomous system can consist of one or more OSPF areas.

Areas

Areas allow the subdivision of an autonomous system into smaller, more manageable networks or sets of adjacent networks. As shown in Figure 1: OSPF Routing Components, on page 6, autonomous system 109 consists of three areas: Area 0, Area 1, and Area 2.

OSPF hides the topology of an area from the rest of the autonomous system. The network topology for an area is visible only to routers inside that area. When OSPF routing is within an area, it is called *intra-area routing*. This routing limits the amount of link-state information flood into the network, reducing routing traffic. It also reduces the size of the topology information in each router, conserving processing and memory requirements in each router.

Also, the routers within an area cannot see the detailed network topology outside the area. Because of this restricted view of topological information, you can control traffic flow between areas and reduce routing traffic when the entire autonomous system is a single routing domain.

Backbone Area

A backbone area is responsible for distributing routing information between multiple areas of an autonomous system. OSPF routing occurring outside of an area is called *interarea routing*.

The backbone itself has all properties of an area. It consists of ABRs, routers, and networks only on the backbone. As shown in Figure 1: OSPF Routing Components, on page 6, Area 0 is an OSPF backbone area. Any OSPF backbone area has a reserved area ID of 0.0.0.0.

Stub Area

A stub area is an area that does not accept route advertisements or detailed network information external to the area. A stub area typically has only one router that interfaces the area to the rest of the autonomous system. The stub ABR advertises a single default route to external destinations into the stub area. Routers within a stub area use this route for destinations outside the area and the autonomous system. This relationship conserves LSA database space that would otherwise be used to store external LSAs flooded into the area. In Figure 1: OSPF Routing Components, on page 6, Area 2 is a stub area that is reached only through ABR 2. Area 0 cannot be a stub area.

Not-so-Stubby Area

A Not-so-Stubby Area (NSSA) is similar to the stub area. NSSA does not flood Type 5 external LSAs from the core into the area, but can import autonomous system external routes in a limited fashion within the area.

NSSA allows importing of Type 7 autonomous system external routes within an NSSA area by redistribution. These Type 7 LSAs are translated into Type 5 LSAs by NSSA ABRs, which are flooded throughout the whole routing domain. Summarization and filtering are supported during the translation.

Use NSSA to simplify administration if you are a network administrator that must connect a central site using OSPF to a remote site that is using a different routing protocol.

Before NSSA, the connection between the corporate site border router and remote router could not be run as an OSPF stub area because routes for the remote site could not be redistributed into a stub area, and two routing protocols needed to be maintained. A simple protocol like RIP was usually run and handled the redistribution. With NSSA, you can extend OSPF to cover the remote connection by defining the area between the corporate router and remote router as an NSSA. Area 0 cannot be an NSSA.

Routers

The OSPF network is composed of ABRs, ASBRs, and interior routers.

Area Border Routers

An area border routers (ABR) is a router with multiple interfaces that connect directly to networks in two or more areas. An ABR runs a separate copy of the OSPF algorithm and maintains separate routing data for each area that is attached to, including the backbone area. ABRs also send configuration summaries for their attached areas to the backbone area, which then distributes this information to other OSPF areas in the autonomous system. In Figure 1: OSPF Routing Components, on page 6, there are two ABRs. ABR 1 interfaces Area 1 to the backbone area. ABR 2 interfaces the backbone Area 0 to Area 2, a stub area.

Autonomous System Boundary Routers (ASBR)

An autonomous system boundary router (ASBR) provides connectivity from one autonomous system to another system. ASBRs exchange their autonomous system routing information with boundary routers in other autonomous systems. Every router inside an autonomous system knows how to reach the boundary routers for its autonomous system.

ASBRs can import external routing information from other protocols like BGP and redistribute them as AS-external (ASE) Type 5 LSAs to the OSPF network. If the Cisco IOS XR router is an ASBR, you can configure it to advertise VIP addresses for content as autonomous system external routes. In this way, ASBRs flood information about external networks to routers within the OSPF network.

ASBR routes can be advertised as a Type 1 or Type 2 ASE. The difference between Type 1 and Type 2 is how the cost is calculated. For a Type 2 ASE, only the external cost (metric) is considered when multiple paths to the same destination are compared. For a Type 1 ASE, the combination of the external cost and cost to reach the ASBR is used. Type 2 external cost is the default and is always more costly than an OSPF route and used only if no OSPF route exists.

Interior Routers

An interior router (such as R1 in Figure 1: OSPF Routing Components, on page 6) is attached to one area (for example, all the interfaces reside in the same area).

OSPF Process and Router ID

An OSPF process is a logical routing entity running OSPF in a physical router. This logical routing entity should not be confused with the logical routing feature that allows a system administrator (known as the Cisco IOS XR Software Owner) to partition the physical box into separate routers.

A physical router can run multiple OSPF processes, although the only reason to do so would be to connect two or more OSPF domains. Each process has its own link-state database. The routes in the routing table are calculated from the link-state database. One OSPF process does not share routes with another OSPF process unless the routes are redistributed.

Each OSPF process is identified by a router ID. The router ID must be unique across the entire routing domain. OSPF obtains a router ID from the following sources, in order of decreasing preference:

- By default, when the OSPF process initializes, it checks if there is a router-id in the checkpointing database.
- The 32-bit numeric value specified by the OSPF router-id command in router configuration mode. (This value can be any 32-bit value. It is not restricted to the IPv4 addresses assigned to interfaces on this router, and need not be a routable IPv4 address.)
- The ITAL selected router-id.
- The primary IPv4 address of an interface over which this OSPF process is running. The first interface address in the OSPF interface is selected.

We recommend that the router ID be set by the **router-id** command in router configuration mode. Separate OSPF processes could share the same router ID, in which case they cannot reside in the same OSPF routing domain.

Supported OSPF Network Types

OSPF classifies different media into the following types of networks:

- NBMA networks
- Point-to-point networks (POS)
- Broadcast networks (Gigabit Ethernet)

- Point-to-multipoint

You can configure your Cisco IOS XR network as either a broadcast or an NBMA network. Using this feature, you can configure broadcast networks as NBMA networks when, for example, you have routers in your network that do not support multicast addressing.

Route Authentication Methods for OSPF

OSPF Version 2 supports two types of authentication: plain text authentication and MD5 authentication. By default, no authentication is enabled (referred to as null authentication in RFC 2178).

OSPF Version 3 supports all types of authentication except key rollover.

Plain Text Authentication

Plain text authentication (also known as Type 1 authentication) uses a password that travels on the physical medium and is easily visible to someone that does not have access permission and could use the password to infiltrate a network. Therefore, plain text authentication does not provide security. It might protect against a faulty implementation of OSPF or a misconfigured OSPF interface trying to send erroneous OSPF packets.

MD5 Authentication

MD5 authentication provides a means of security. No password travels on the physical medium. Instead, the router uses MD5 to produce a message digest of the OSPF packet plus the key, which is sent on the physical medium. Using MD5 authentication prevents a router from accepting unauthorized or deliberately malicious routing updates, which could compromise your network security by diverting your traffic.

Note MD5 authentication supports multiple keys, requiring that a key number be associated with a key.

See OSPF Authentication Message Digest Management, on page 37.

Authentication Strategies

Authentication can be specified for an entire process or area, or on an interface or a virtual link. An interface or virtual link can be configured for only one type of authentication, not both. Authentication configured for an interface or virtual link overrides authentication configured for the area or process.

If you intend for all interfaces in an area to use the same type of authentication, you can configure fewer commands if you use the **authentication** command in the area configuration submode (and specify the **message-digest** keyword if you want the entire area to use MD5 authentication and HMAC SHA 256 authentication). This strategy requires fewer commands than specifying authentication for each interface.

Key Rollover

To support the changing of an MD5 key in an operational network without disrupting OSPF adjacencies (and hence the topology), a key rollover mechanism is supported. As a network administrator configures the new key into the multiple networking devices that communicate, some time exists when different devices are using both a new key and an old key. If an interface is configured with a new key, the software sends two copies of the same packet, each authenticated by the old key and new key. The software tracks which devices start using the new key, and the software stops sending duplicate packets after it detects that all of its neighbors

are using the new key. The software then discards the old key. The network administrator must then remove the old key from each the configuration file of each router.

Neighbors and Adjacency for OSPF

Routers that share a segment (Layer 2 link between two interfaces) become neighbors on that segment. OSPF uses the hello protocol as a neighbor discovery and keep alive mechanism. The hello protocol involves receiving and periodically sending hello packets out each interface. The hello packets list all known OSPF neighbors on the interface. Routers become neighbors when they see themselves listed in the hello packet of the neighbor. After two routers are neighbors, they may proceed to exchange and synchronize their databases, which creates an adjacency. On broadcast and NBMA networks all neighboring routers have an adjacency.

OSPF strict-mode Support for BFD Dampening

Strict-mode is an OSPF BFD operation mode which keeps the neighbor in a down state until the BFD session is up. The status of the neighbor node shows as awaiting BFD session up in the output of the **show ospf neighbor** command. This will ensure that client protocols do not operate independent of the declared state of BFD.

Restrictions

- Strict-mode and non-strict-mode modes of operation are incompatible and will cause OSPF to never form a neighbor relationship. Strict-mode can not be configured on one node and default/non-strict mode on the other. Both BFD neighbors must run IOS-XR images that support strict-mode. However, if by design the additional BFD clients have already initiated the BFD session and OSPF is not the only initiator, then they may form a neighbor relationship.
- Due to the dependency on BFD, OSPF operating in strict-mode may experience delayed neighbor establishment and full adjacency.

Enabling strict-mode

Strict-mode can be enabled at different levels - process, area and interface. The following procedure describes how to enable BFD strict-mode for Open Shortest Path First (OSPF) on an interface:

SUMMARY STEPS

1. **configure**
2. **router ospf** *process-name*
3. **area** *area-id*
4. **interface** *type interface-path-id*
5. **bfd fast-detect strict-mode**
6. **commit**
7. **show ospf interface** *type interface-path-id*

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**router ospf** *process-name* **Example:** `RP/0/RSP0/CPU0:router(config)# router ospf 1`	Enters OSPF configuration mode, allowing you to configure the OSPF routing process. Use the **show ospf** command in EXEC configuration mode to obtain the process-name for the current router.
Step 3	**area** *area-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# area 0`	Configures an Open Shortest Path First (OSPF) area. Replace *area-id* with the OSPF area identifier.
Step 4	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf-ar)# interface gigabitEthernet 0/3/0/1`	Enters interface configuration mode and specifies the interface name and notation *rack/slot/module/port*. The example indicates a Gigabit Ethernet interface in modular services card slot 3.
Step 5	**bfd fast-detect strict-mode** **Example:** `RP/0/RSP0/CPU0:router(config-ospf-ar-if)# bfd fast-detect strict-mode`	Enables strict-mode to hold down neighbor session until BFD session is up.
Step 6	**commit**	Commits the changes to the running configuration.
Step 7	**show ospf interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf-ar-if)#show ospf interface gigabitEthernet 0/3/0/1`	Verify that strict-mode is enabled on the appropriate interface.

BFD strict-mode: Example

The following example shows how to enable BFD strict-mode for OSPF on a Gigabit Ethernet interface and check the OSPF interface information. The value of **Mode** displays as **Strict** when BFD strict-mode is enabled. By default, the value of **Mode** displays as **Default**.

```
RP/0/RSP0/CPU0:router#configure
RP/0/RSP0/CPU0:router(config)#router ospf 0
RP/0/RSP0/CPU0:router(config-ospf)#area 0
RP/0/RSP0/CPU0:router(config-ospf-ar)#interface gigabitEthernet 0/3/0/1
RP/0/RSP0/CPU0:router(config-ospf-ar-if)#bfd fast-detect strict-mode
RP/0/RSP0/CPU0:router(config-ospf-ar-if)#commit
```

```
RP/0/RSP0/CPU0:router(config-ospf-ar-if)#end
RP/0/RSP0/CPU0:router#show ospf interface gigabitEthernet 0/3/0/1

GigabitEthernet0/3/0/1 is up, line protocol is up
  Internet Address 10.1.1.2/24, Area 0
  Process ID 1, Router ID 2.2.2.2, Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State DR, Priority 1, MTU 1500, MaxPktSz 1500
  BFD enabled, BFD interval 150 msec, BFD multiplier 3, Mode: Strict
  Designated Router (ID) 2.2.2.2, Interface address 10.1.1.2
  No backup designated router on this network
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:07:358
  Index 1/1, flood queue length 0
  Next 0(0)/0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  LS Ack List: current length 0, high water mark 1
  Neighbor Count is 1, Adjacent neighbor count is 0
  Suppress hello for 0 neighbor(s)
  Multi-area interface Count is 0
```

The following example shows the output of the **show ospf neighbor** command. # indicates that the neighbor is waiting for the BFD session to come up.

```
RP/0/RSP0/CPU0:router#show ospf neighbor

Neighbors for OSPF 1

Neighbor ID     Pri   State           Dead Time   Address         Interface
192.0.2.1         0    DOWN/DROTHER    00:00:33    10.1.1.3/24       GigabitEthernet0/3/0/1#


Total neighbor count: 1
```

OSPF FIB Download Notification

OSPF FIB Download Notification feature minimizes the ingress traffic drop for a prolonged period of time after the line card reloads and this feature is enabled by default.

Open Shortest Path First (OSPF) registers with Routing Information Base (RIB) through Interface Table Attribute Library (ITAL) which keeps the interface down until all the routes are downloaded to Forwarding Information Base (FIB). OSPF gets the Interface Up notification when all the routes on the reloaded line card are downloaded through RIB/FIB.

RIB provides notification to registered clients when a:

- Node is lost.
- Node is created.
- Node's FIB upload is completed.

Designated Router (DR) for OSPF

On point-to-point and point-to-multipoint networks, the Cisco IOS XR software floods routing updates to immediate neighbors. No DR or backup DR (BDR) exists; all routing information is flooded to each router.

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. On broadcast network segments the number of OSPF packets is further reduced by the DR and BDR sending such OSPF updates to a multicast IP address that all OSPF routers on the network segment are listening on.

The software looks at the priority of the routers on the segment to determine which routers are 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.

Default Route for OSPF

Type 5 (ASE) LSAs are generated and flooded to all areas except stub areas. For the routers in a stub area to be able to route packets to destinations outside the stub area, a default route is injected by the ABR attached to the stub area.

The cost of the default route is 1 (default) or is determined by the value specified in the **default-cost** command.

Link-State Advertisement Types for OSPF Version 2

Each of the following LSA types has a different purpose:

- Router LSA (Type 1)—Describes the links that the router has within a single area, and the cost of each link. These LSAs are flooded within an area only. The LSA indicates if the router can compute paths based on quality of service (QoS), whether it is an ABR or ASBR, and if it is one end of a virtual link. Type 1 LSAs are also used to advertise stub networks.
- Network LSA (Type 2)—Describes the link state and cost information for all routers attached to a multiaccess network segment. This LSA lists all the routers that have interfaces attached to the network segment. It is the job of the designated router of a network segment to generate and track the contents of this LSA.
- Summary LSA 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 aggregated into one prefix. Only ABRs generate summary LSAs.
- Summary LSA for ASBRs (Type 4)—Advertises an ASBR and the cost to reach it. Routers that are trying to reach an external network use these advertisements to determine the best path to the next hop. ABRs generate Type 4 LSAs.
- Autonomous system external LSA (Type 5)—Redistributes routes from another autonomous system, usually from a different routing protocol into OSPF.
- Autonomous system external LSA (Type 7)—Provides for carrying external route information within an NSSA. Type 7 LSAs may be originated by and advertised throughout an NSSA. NSSAs do not receive or originate Type 5 LSAs. Type 7 LSAs are advertised only within a single NSSA. They are not flooded into the backbone area or into any other area by border routers.
- Intra-area-prefix LSAs (Type 9)—A router can originate multiple intra-area-prefix LSAs for every 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 network LSA and contains prefixes for stub and transit networks.

- Area local scope (Type 10)—Opaque LSAs are not flooded past the borders of their associated area.
- Link-state (Type 11)—The LSA is flooded throughout the AS. The flooding scope of Type 11 LSAs are equivalent to the flooding scope of AS-external (Type 5) LSAs. Similar to Type 5 LSAs, the LSA is rejected if a Type 11 opaque LSA is received in a stub area from a neighboring router within the stub area. Type 11 opaque LSAs have these attributes:
  - LSAs are flooded throughout all transit areas.
  - LSAs are not flooded into stub areas from the backbone.
  - LSAs are not originated by routers into their connected stub areas.

Link-State Advertisement Types for OSPFv3

Each of the following LSA types has a different purpose:

- Router LSA (Type 1)—Describes the link state and costs of a the router link to the area. These LSAs are flooded within an area only. The LSA indicates whether the router is an ABR or ASBR and if it is one end of a virtual link. Type 1 LSAs are also used to advertise stub networks. In OSPFv3, these LSAs have no address information and are network protocol independent. In OSPFv3, router interface information may be spread across multiple router LSAs. Receivers must concatenate all router LSAs originated by a given router before running the SPF calculation.
- Network LSA (Type 2)—Describes the link state and cost information for all routers attached to a multiaccess network segment. This LSA lists all OSPF routers that have interfaces attached to the network segment. Only the elected designated router for the network segment can generate and track the network LSA for the segment. In OSPFv3, network LSAs have no address information and are network-protocol-independent.
- Interarea-prefix LSA for ABRs (Type 3)—Advertises internal networks to routers in other areas (interarea routes). Type 3 LSAs may represent a single network or set of networks aggregated into one prefix. Only ABRs generate Type 3 LSAs. In OSPFv3, addresses for these LSAs are expressed as “prefix and prefix length” instead of “address and mask.” The default route is expressed as a prefix with length 0.
- Interarea-router LSA for ASBRs (Type 4)—Advertises an ASBR and the cost to reach it. Routers that are trying to reach an external network use these advertisements to determine the best path to the next hop. ABRs generate Type 4 LSAs.
- Autonomous system external LSA (Type 5)—Redistributes routes from another autonomous system, usually from a different routing protocol into OSPF. In OSPFv3, addresses for these LSAs are expressed as “prefix and prefix length” instead of “address and mask.” The default route is expressed as a prefix with length 0.
- Autonomous system external LSA (Type 7)—Provides for carrying external route information within an NSSA. Type 7 LSAs may be originated by and advertised throughout an NSSA. NSSAs do not receive or originate Type 5 LSAs. Type 7 LSAs are advertised only within a single NSSA. They are not flooded into the backbone area or into any other area by border routers.
- Link LSA (Type 8)—Has link-local flooding scope and is never flooded beyond the link with which it is associated. Link LSAs provide the link-local address of the router to all other routers attached to the

link or network segment, 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 is originated for the link.

- Intra-area-prefix LSAs (Type 9)—A router can originate multiple intra-area-prefix LSAs for every 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 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: Prefix Length, Prefix Options, and Address Prefix. In OSPFv3, addresses for these LSAs are expressed as "prefix and prefix length" instead of "address and mask." The default route is expressed as a prefix with length 0.

Inter-area-prefix and intra-area-prefix 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 OSPFv3, 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 OSPFv3.

Virtual Link and Transit Area for OSPF

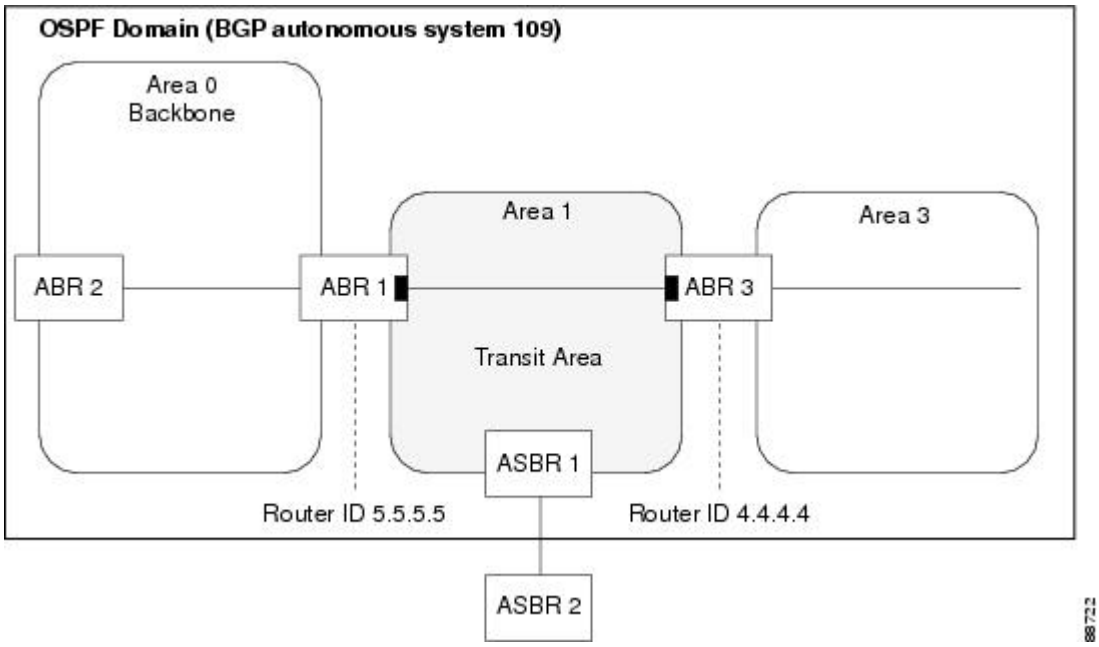
In OSPF, routing information from all areas is first summarized to the backbone area by ABRs. The same ABRs, in turn, propagate such received information to their attached areas. Such hierarchical distribution of routing information requires that all areas be connected to the backbone area (Area 0). Occasions might exist for which an area must be defined, but it cannot be physically connected to Area 0. Examples of such an occasion might be if your company makes a new acquisition that includes an OSPF area, or if Area 0 itself is partitioned.

In the case in which an area cannot be connected to Area 0, you must configure a virtual link between that area and Area 0. The two endpoints of a virtual link are ABRs, and the virtual link must be configured in both routers. The common nonbackbone area to which the two routers belong is called a transit area. A virtual link specifies the transit area and the router ID of the other virtual endpoint (the other ABR).

A virtual link cannot be configured through a stub area or NSSA.

Figure 2: Virtual Link to Area 0

This figure illustrates a virtual link from Area 3 to Area 0.



Passive Interface

Setting an interface as passive disables the sending of routing updates for the neighbors, hence adjacencies will not be formed in OSPF. However, the particular subnet will continue to be advertised to OSPF neighbors. Use the **passive** command in appropriate mode to suppress the sending of OSPF protocol operation on an interface.

It is recommended to use passive configuration on interfaces that are connecting LAN segments with hosts to the rest of the network, but are not meant to be transit links between routers.

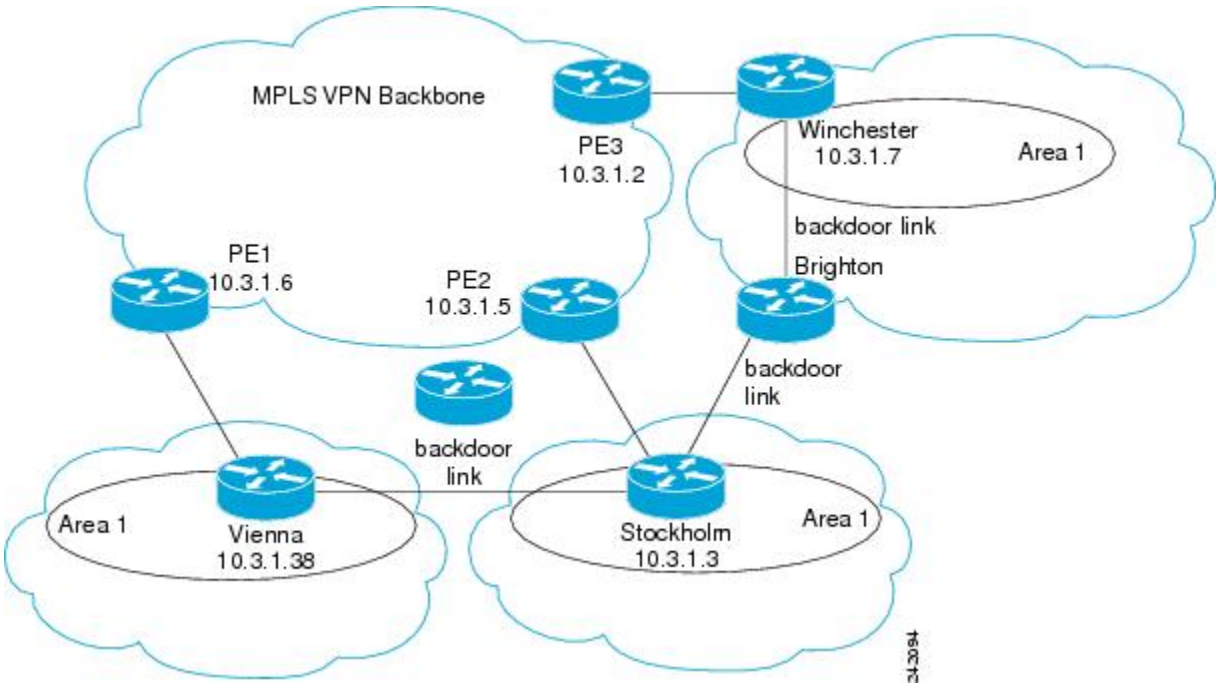
OSPFv2 Sham Link Support for MPLS VPN

In an MPLS VPN environment, several VPN client sites can be connected in the same OSPF area. If these sites are connected over a backdoor link (intra-area link) and connected over the VPN backbone, all traffic passes over the backdoor link instead of over the VPN backbone, because provider edge routers advertise OSPF routes learned over the VPN backbone as inter-area or external routes that are less preferred than intra-area routes advertised over backdoor links.

To correct this default OSPF behavior in an MPLS VPN, configure a sham link between two provider edge (PE) routers to connect the sites through the MPLS VPN backbone. A sham link represents an intra-area (unnumbered point-to-point) connection between PE routers. All other routers in the area see the sham link and use it to calculate intra-area shortest path first (SPF) routes to the remote site. A cost must be configured with each sham link to determine whether traffic is sent over the backdoor link or sham link.

Configured source and destination addresses serve as the endpoints of the sham link. The source and destination IP addresses must belong to the VRF and must be advertised by Border Gateway Protocol (BGP) as host routes to remote PE routers. The sham-link endpoint addresses should not be advertised by OSPF.

Figure 3: Backdoor Paths Between OSPF Client Sites



For example, Figure 3: Backdoor Paths Between OSPF Client Sites , on page 17 shows three client sites, each with backdoor links. Because each site runs OSPF within Area 1 configuration, all routing between the sites follows the intra-area path across the backdoor links instead of over the MPLS VPN backbone.

If the backdoor links between the sites are used only for backup purposes, default route selection over the backbone link is not acceptable as it creates undesirable traffic flow. To establish the desired path selection over the MPLS backbone, an additional OSPF intra-area (sham link) link between the ingress and egress PErouters must be created.

A sham link is required between any two VPN sites that belong to the same OSPF area and share an OSPF backdoor link. If no backdoor link exists between sites, no sham link is required.

Figure 4: Sham Link Between PE Routers to Connected OSPF Client Sites

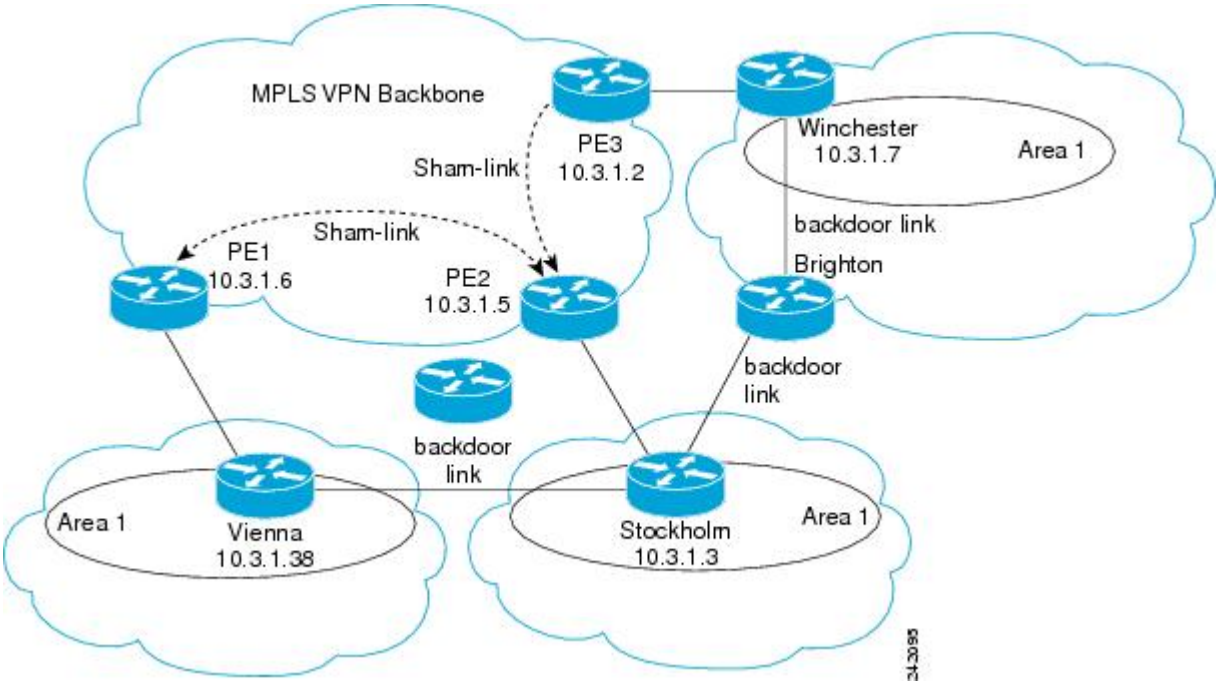


Figure 4: Sham Link Between PE Routers to Connected OSPF Client Sites , on page 18 shows an MPLS VPN topology where a sham link configuration is necessary. A VPN client has three sites, each with a backdoor link. Two sham links are configured, one between PE-1 and PE-2 and another between PE-2 and PE-3. A sham link is not required between PE-1 and PE-3, because there is no backdoor link between these sites.

When a sham link is configured between the PE routers, the PE routers can populate the virtual routing and forwarding (VRF) table with the OSPF routes learned over the sham link. These OSPF routes have a larger administrative distance than BGP routes. If BGP routes are available, they are preferred over these OSPF routes with the high administrative distance.

OSPFv3 Sham Link Support for MPLS VPN

OSPFv3 sham link represents the VPN backbone as a single point-to-point connection between the two PEs. OSPFv3 treats the sham link as a point-to-point unnumbered interface, similar to virtual-link. When OSPFv3 sham link is configured, ensure that the route to the remote endpoint of the sham-link exists in the VRF RIB.

If the route to the remote endpoint exists, sham link interface is brought up. If the route to the remote endpoint of the sham-link is removed from the VRF RIB, OSPFv3 receives redistribution callback and brings the sham link down.

Graceful Restart Procedure over the Sham-link

OSPFv3 treats the sham link as any other interface during the switch-over or process restart. OSPFv3 assumes that all the configured sham links are UP and tries to form an adjacency over them.

If the sham link is down prior to the switch-over, OSPFv3 sends the Hello packets to the remote endpoint. Once the final convergence signal is received from the RIB, OSPFv3 keeps the sham link either up or down based on the BGP route for each configured sham link in the RIB.

OSPFv3 installs the high AD routes over the sham link only after the BGP convergence is complete.

ECMP and OSPFv3 Sham-link

Equal Cost Multipath (ECMP) mechanism is used to load-balance traffic on the Sham-link if there are multiple iBGP path for a prefix. If the sham link path and the backdoor path have the same cost, ECMP between the sham link path and backdoor path is not supported.

OSPF SPF Prefix Prioritization

The OSPF SPF Prefix Prioritization feature enables an administrator to converge, in a faster mode, important prefixes during route installation.

When a large number of prefixes must be installed in the Routing Information Base (RIB) and the Forwarding Information Base (FIB), the update duration between the first and last prefix, during SPF, can be significant.

In networks where time-sensitive traffic (for example, VoIP) may transit to the same router along with other traffic flows, it is important to prioritize RIB and FIB updates during SPF for these time-sensitive prefixes.

The OSPF SPF Prefix Prioritization feature provides the administrator with the ability to prioritize important prefixes to be installed, into the RIB during SPF calculations. Important prefixes converge faster among prefixes of the same route type per area. Before RIB and FIB installation, routes and prefixes are assigned to various priority batch queues in the OSPF local RIB, based on specified route policy. The RIB priority batch queues are classified as "critical," "high," "medium," and "low," in the order of decreasing priority.

When enabled, prefix alters the sequence of updating the RIB with this prefix priority:

Critical > High > Medium > Low

As soon as prefix priority is configured, /32 prefixes are no longer preferred by default; they are placed in the low-priority queue, if they are not matched with higher-priority policies. Route policies must be devised to retain /32s in the higher-priority queues (high-priority or medium-priority queues).

Priority is specified using route policy, which can be matched based on IP addresses or route tags. During SPF, a prefix is checked against the specified route policy and is assigned to the appropriate RIB batch priority queue.

These are examples of this scenario:

- If only high-priority route policy is specified, and no route policy is configured for a medium priority:
  - Permitted prefixes are assigned to a high-priority queue.
  - Unmatched prefixes, including /32s, are placed in a low-priority queue.
- If both high-priority and medium-priority route policies are specified, and no maps are specified for critical priority:
  - Permitted prefixes matching high-priority route policy are assigned to a high-priority queue.
  - Permitted prefixes matching medium-priority route policy are placed in a medium-priority queue.
  - Unmatched prefixes, including /32s, are moved to a low-priority queue.
- If both critical-priority and high-priority route policies are specified, and no maps are specified for medium priority:
  - Permitted prefixes matching critical-priority route policy are assigned to a critical-priority queue.

- Permitted prefixes matching high-priority route policy are assigned to a high-priority queue.
- Unmatched prefixes, including /32s, are placed in a low-priority queue.

- If only medium-priority route policy is specified and no maps are specified for high priority or critical priority:
  - Permitted prefixes matching medium-priority route policy are assigned to a medium-priority queue.
  - Unmatched prefixes, including /32s, are placed in a low-priority queue.

  Use the **[no] spf prefix-priority route-policy** *rpl* command to prioritize OSPF prefix installation into the global RIB during SPF.

  SPF prefix prioritization is disabled by default. In disabled mode, /32 prefixes are installed into the global RIB, before other prefixes. If SPF prioritization is enabled, routes are matched against the route-policy criteria and are assigned to the appropriate priority queue based on the SPF priority set. Unmatched prefixes, including /32s, are placed in the low-priority queue.

  If all /32s are desired in the high-priority queue or medium-priority queue, configure this single route map:

```
prefix-set ospf-medium-prefixes
  0.0.0.0/0 ge 32
  end-set
```

Route Redistribution for OSPF

Redistribution allows different routing protocols to exchange routing information. This technique can be used to allow connectivity to span multiple routing protocols. It is important to remember that the **redistribute** command controls redistribution *into* an OSPF process and not from OSPF. See Configuration Examples for Implementing OSPF , on page 117 for an example of route redistribution for OSPF.

OSPF Shortest Path First Throttling

OSPF SPF throttling makes it possible to configure SPF scheduling in millisecond intervals and to potentially delay SPF calculations during network instability. SPF is scheduled to calculate the Shortest Path Tree (SPT) when there is a change in topology. One SPF run may include multiple topology change events.

The interval at which the SPF calculations occur is chosen dynamically and based on the frequency of topology changes in the network. The chosen interval is within the boundary of the user-specified value ranges. If network topology is unstable, SPF throttling calculates SPF scheduling intervals to be longer until topology becomes stable.

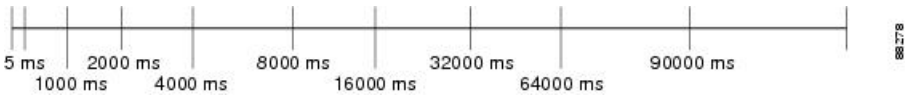
SPF calculations occur at the interval set by the **timers throttle spf** command. The wait interval indicates the amount of time to wait until the next SPF calculation occurs. Each wait interval after that calculation is twice as long as the previous interval until the interval reaches the maximum wait time specified.

The SPF timing can be better explained using an example. In this example, the start interval is set at 5 milliseconds (ms), initial wait interval at 1000 ms, and maximum wait time at 90,000 ms.

```
timers spf 5 1000 90000
```

Figure 5: SPF Calculation Intervals Set by the timers spf Command

This figure shows the intervals at which the SPF calculations occur as long as at least one topology change event is received in a given wait interval.

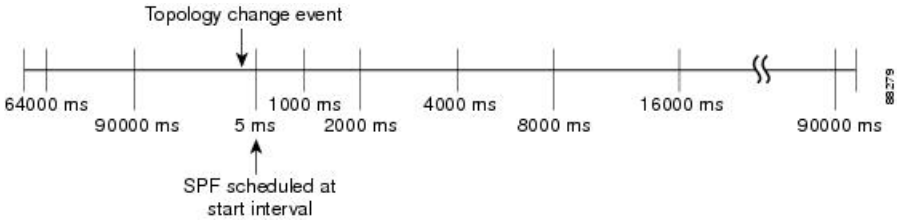


Notice that the wait interval between SPF calculations doubles when at least one topology change event is received during the previous wait interval. After the maximum wait time is reached, the wait interval remains the same until the topology stabilizes and no event is received in that interval.

If the first topology change event is received after the current wait interval, the SPF calculation is delayed by the amount of time specified as the start interval. The subsequent wait intervals continue to follow the dynamic pattern.

If the first topology change event occurs after the maximum wait interval begins, the SPF calculation is again scheduled at the start interval and subsequent wait intervals are reset according to the parameters specified in the **timers throttle spf** command. Notice in Figure 6: Timer Intervals Reset After Topology Change Event, on page 21that a topology change event was received after the start of the maximum wait time interval and that the SPF intervals have been reset.

Figure 6: Timer Intervals Reset After Topology Change Event



Nonstop Forwarding for OSPF Version 2

Cisco IOS XR Software NSF for OSPF Version 2 allows for the forwarding of data packets to continue along known routes while the routing protocol information is being restored following a process restart or failover. With NSF, peer networking devices do not experience routing flaps. During process restart or failover, data traffic is forwarded through intelligent line cards while the standby Route Processor (RP) assumes control from the failed RP. The ability of line cards to remain up through a process restart, and to be kept current with the Forwarding Information Base (FIB) on the active RP is key to Cisco IOS XR Software NSF operation.

Routing protocols, such as OSPF, run only on the active RP or DRP and receive routing updates from their neighbor routers. When an OSPF NSF-capable router performs a process restart, it must perform two tasks to resynchronize its link-state database with its OSPF neighbors. First, it must relearn the available OSPF neighbors on the network without causing a reset of the neighbor relationship. Second, it must reacquire the contents of the link-state database for the network.

As quickly as possible after an RP failover or process restart, the NSF-capable router sends an OSPF NSF signal to neighboring NSF-aware devices. This signal is in the form of a link-local LSA generated by the failed-over router. Neighbor networking devices recognize this signal as a cue that the neighbor relationship with this router should not be reset. As the NSF-capable router receives signals from other routers on the network, it can begin to rebuild its neighbor list.

After neighbor relationships are reestablished, the NSF-capable router begins to resynchronize its database with all of its NSF-aware neighbors. At this point, the routing information is exchanged between the OSPF neighbors. After this exchange is completed, the NSF-capable device uses the routing information to remove stale routes, update the RIB, and update the FIB with the new forwarding information. OSPF on the router and the OSPF neighbors are now fully converged.

Graceful Shutdown for OSPFv3

The OSPFv3 Graceful Shutdown feature preserves the data plane capability in these circumstances:

- RP failure resulting in a switch-over to the backup processor
- Planned OSPFv3 process restart, such as a restart resulting from a software upgrade or downgrade
- Unplanned OSPFv3 process restart, such as a restart resulting from a process crash

In addition, OSPFv3 will unilaterally shutdown and enter the exited state when a critical memory event, indicating the processor is critically low on available memory, is received from the sysmon watch dog process.

This feature supports nonstop data forwarding on established routes while the OSPFv3 routing protocol restarts. Therefore, this feature enhances high availability of IPv6 forwarding.

Modes of Graceful Restart Operation

The operational modes that a router can be in for this feature are restart mode, helper mode, and protocol shutdown mode.

Restart Mode

When the OSPFv3 process starts up, it determines whether it must attempt a graceful restart. The determination is based on whether graceful restart was previously enabled. (OSPFv3 does not attempt a graceful restart upon the first-time startup of the router.) When OSPFv3 graceful restart is enabled, it changes the purge timer in the RIB to a nonzero value. See Configuring OSPFv3 Graceful Restart, on page 72,for descriptions of how to enable and configure graceful restart.

During a graceful restart, the router does not populate OSPFv3 routes in the RIB. It tries to bring up full adjacencies with the fully adjacent neighbors that OSPFv3 had before the restart. Eventually, the OSPFv3 process indicates to the RIB that it has converged, either for the purpose of terminating the graceful restart (for any reason) or because it has completed the graceful restart.

The following are general details about restart mode. More detailed information on behavior and certain restrictions and requirements appears in Graceful Restart Requirements and Restrictions, on page 24 section.

- If OSPFv3 attempts a restart too soon after the most recent restart, the OSPFv3 process is most likely crashing repeatedly, so the new graceful restart stops running. To control the period between allowable graceful restarts, use the **graceful-restart interval** command.
- When OSFPv3 starts a graceful restart with the first interface that comes up, a timer starts running to limit the duration (or lifetime) of the graceful restart. You can configure this period with the **graceful-restart lifetime** command. On each interface that comes up, a *grace* LSA (Type 11) is flooded to indicate to the neighboring routers that this router is attempting graceful restart. The neighbors enter into helper mode.
- The designated router and backup designated router check of the hello packet received from the restarting neighbor is bypassed, because it might not be valid.

Helper Mode

Helper mode is enabled by default. When a (helper) router receives a grace LSA (Type 11) from a router that is attempting a graceful restart, the following events occur:

- If helper mode has been disabled through the **graceful-restart helper disable** command, the router drops the LSA packet.
- If helper mode is enabled, the router enters helper mode if all of the following conditions are met:
  - The local router itself is not attempting a graceful restart.
  - The local (helping) router has full adjacency with the sending neighbor.
  - The value of *lsage* (link state age) in the received LSA is less than the requested grace period.
  - The sender of the grace LSA is the same as the originator of the grace LSA.
- Upon entering helper mode, a router performs its helper function for a specific period of time. This time period is the lifetime value from the router that is in restart mode—minus the value of *lsage* in the received grace LSA. If the graceful restart succeeds in time, the helper's timer is stopped before it expires. If the helper's timer does expire, the adjacency to the restarting router is brought down, and normal OSPFv3 functionality resumes.
- The dead timer is not honored by the router that is in helper mode.
- A router in helper mode ceases to perform the helper function in any of the following cases:
  - The helper router is able to bring up a FULL adjacency with the restarting router.
  - The local timer for the helper function expires.

Protocol Shutdown Mode

In this mode the OSPFv3 operation is completely disabled. This is accomplished by flushing self-originated link state advertisements (LSAs), immediately bringing down local OSPFv3-supported interfaces, and clearing the Link State Database (LSDB). The non-local LSDB entries are removed by OSPFv3, These are not flooded (MaxAged).

The protocol shutdown mode can be invoked either manually through the **protocol shutdown** command that disables the protocol instance or when the OSPFv3 process runs out of memory. These events occur when protocol shut down is performed:

- The local Router LSA and all local Link LSAs are flushed. All other LSAs are eventually aged out by other OSPFv3 routers in the domain.
- OSPFv3 neighbors not yet in Full state with the local router are brought down with the Kill_Nbr event.
- After a three second delay, empty Hello packets are immediately sent to each neighbor that has an active adjacency.
  - An empty Hello packet is sent periodically until the dead_interval has elapsed.
  - When the dead_interval elapses, Hello packets are no longer sent.

After a Dead Hello interval delay (4 X Hello Interval), the following events are then performed:

- The LSA database from that OSPFv3 instance is cleared.

- All routes from RIB that were installed by OSPFv3 are purged.

The router will not respond to any OSPF control packets it receives from neighbors while in protocol shutdown state.

Protocol Restoration

The method of restoring the protocol is dependent on the trigger that originally invoked the shut down. If the OSPFv3 was shut down using the **protocol shutdown** command, then use the **no protocol shutdown** command to restore OSPFv3 back to normal operation. If the OSPFv3 was shutdown due to a Critical Memory message from the sysmon, then a Normal Memory message from sysmon, which indicates that sufficient memory has been restored to the processor, restores the OSPFv3 protocol to resume normal operation. When OSPFv3 is shutdown due to the Critical Memory trigger, it must be manually restarted when normal memory levels are restored on the route processor. It will not automatically restore itself.

These events occur when the OSPFv3 is restored:

1. All OSPFv3 interfaces are brought back up using the Hello packets and database exchange.
2. The local router and link LSAs are rebuilt and advertised.
3. The router replies normally to all OSPFv3 control messages received from neighbors.
4. Routes learned from other OSPFv3 routers are installed in RIB.

Graceful Restart Requirements and Restrictions

The requirements for supporting the Graceful Restart feature include:

- Cooperation of a router's neighbors during a graceful restart. In relation to the router on which OSPFv3 is restarting, each router is called a *helper*.
- All neighbors of the router that does a graceful restart must be capable of doing a graceful restart.
- A graceful restart does not occur upon the first-time startup of a router.
- OSPFv3 neighbor information and database information are not check-pointed.
- An OSPFv3 process rebuilds adjacencies after it restarts.
- To ensure consistent databases after a restart, the OSPFv3 configuration must be identical to the configuration before the restart. (This requirement applies to self-originated information in the local database.) A graceful restart can fail if configurations change during the operation. In this case, data forwarding would be affected. OSPFv3 resumes operation by regenerating all its LSAs and resynchronizing its database with all its neighbors.
- Although IPv6 FIB tables remain unchanged during a graceful restart, these tables eventually mark the routes as stale through the use of a holddown timer. Enough time is allowed for the protocols to rebuild state information and converge.
- The router on which OSPFv3 is restarting must send OSPFv3 hellos within the dead interval of the process restart. Protocols must be able to retain adjacencies with neighbors before the adjacency dead timer expires. The default for the dead timer is 40 seconds. If hellos do not arrive on the adjacency before the dead timer expires, the router takes down the adjacency. The OSPFv3 Graceful Restart feature does not function properly if the dead timer is configured to be less than the time required to send hellos after the OSPFv3 process restarts.

- Simultaneous graceful restart sessions on multiple routers are not supported on a single network segment. If a router determines that multiple routers are in restart mode, it terminates any local graceful restart operation.
- This feature utilizes the available support for changing the purge time of existing OSPFv3 routes in the Routing Information Base (RIB). When graceful restart is enabled, the purge timer is set to 90 seconds by default. If graceful restart is disabled, the purge timer setting is 0.
- This feature has an associated *grace* LSA. This link-scope LSA is type11.
- According to the RFC, the OSPFv3 process should flush all old, self-originated LSAs during a restart. With the Graceful Restart feature, however, the router delays this flushing of unknown self-originated LSAs during a graceful restart. OSPFv3 can learn new information and build new LSAs to replace the old LSAs. When the delay is over, all old LSAs are flushed.
- If graceful restart is enabled, the adjacency creation time of all the neighbors is saved in the system database (SysDB). The purpose for saving the creation time is so that OSPFv3 can use the original adjacency creation time to display the uptime for that neighbor after the restart.

Warm Standby and Nonstop Routing for OSPF Version 2

OSPFv2 warm standby provides high availability across RP switchovers. With warm standby extensions, each process running on the active RP has a corresponding standby process started on the standby RP. A standby OSPF process can send and receive OSPF packets with no performance impact to the active OSPF process.

Nonstop routing (NSR) allows an RP failover, process restart, or in-service upgrade to be invisible to peer routers and ensures that there is minimal performance or processing impact. Routing protocol interactions between routers are not impacted by NSR. NSR is built on the warm standby extensions. NSR alleviates the requirement for Cisco NSF and IETF graceful restart protocol extensions.

NSR is enabled by default for OSPF. To disable NSR, use the **nsr disable** command in the OSPF configuration mode.

Note It is recommended to set the hello timer interval to the default of 10 seconds. OSPF sessions may flap during switchover if hello-interval timer configured is less then default value.

Warm Standby for OSPF Version 3

This feature helps OSPFv3 to initialize itself prior to Fail over (FO) and be ready to function before the failure occurs. It reduces the downtime during switchover. By default, the router sends hello packets every 40 seconds.

With warm standby process for each OSPF process running on the Active Route Processor, the corresponding OSPF process must start on the Standby RP. There are no changes in configuration for this feature.

Warm-Standby is always enabled. This is an advantage for the systems running OSPFv3 as their IGP when they do RP failover.

Multicast-Intact Support for OSPF

The multicast-intact feature provides the ability to run multicast routing (PIM) when IGP shortcuts are configured and active on the router. Both OSPFv2 and IS-IS support the multicast-intact feature.

You can enable multicast-intact in the IGP when multicast routing protocols (PIM) are configured and IGP shortcuts are configured on the router. IGP shortcuts are MPLS tunnels that are exposed to IGP. The IGP routes IP traffic over these tunnels to destinations that are downstream from the egress router of the tunnel (from an SPF perspective). PIM cannot use IGP shortcuts for propagating PIM joins, because reverse path forwarding (RPF) cannot work across a unidirectional tunnel.

When you enable multicast-intact on an IGP, the IGP publishes a parallel or alternate set of equal-cost next hops for use by PIM. These next hops are called *mcast-intact* next hops. The mcast-intact next hops have the following attributes:

- They are guaranteed not to contain any IGP shortcuts.
- They are not used for unicast routing but are used only by PIM to look up an IPv4 next-hop to a PIM source.
- They are not published to the FIB.
- When multicast-intact is enabled on an IGP, all IPv4 destinations that were learned through link-state advertisements are published with a set equal-cost mcast-intact next hops to the RIB. This attribute applies even when the native next hops have no IGP shortcuts.

In OSPF, the max-paths (number of equal-cost next hops) limit is applied separately to the native and mcast-intact next hops. The number of equal cost mcast-intact next hops is the same as that configured for the native next hops.

Load Balancing in OSPF Version 2 and OSPFv3

When a router learns multiple routes to a specific network by using 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 by using 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; the costs may need to be manipulated to achieve load balancing.

OSPF performs load balancing automatically. 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** (OSPF) command.

The range for maximum paths is from 1 to 8 and the default number of maximum paths is 8.

Configure Prefix Suppression for OSPF

Transit-only networks that connect two routers are usually configured with routing IP addresses that are advertised in the Links State Advertisements (LSAs). However, these prefixes are not needed for data traffic. Suppressing these prefixes would reduce the number of links in LSAs, thereby improving convergence and also reducing the vulnerability of potential remote attacks.

Prefixes can be suppressed for an OSPF process, an OSPF area, or for specific interfaces of a router.

Configure Prefix Suppression for a Router Running OSPF

Use the procedure in this section to configure prefix suppression for an OSPF process on a router.

Note

- If you suppress prefixes for an OSPF process on a router, the suppression is valid for all interfaces and areas associated with the router.
- When prefix suppression is configured on an NSSA ASBR, all interfaces on the routers have their prefixes suppressed, and the Type 7 LSAs have a forwarding address of 0. This stops the translation of Type 7 LSAs to Type 5 by the NSSA ABR. The workaround for this is to configure at least one loopback interface in the NSSA area, or one interface with prefix suppression disabled, so that the interface address is selected as the forwarding address for all the Type 7 LSAs.

1. Enter the global configuration mode and configure the interfaces of the router.

```
RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# interface GigabitEthernet 0/0/0/1
RP/0/RSP0/CPU0:router(config-if)# ipv4 address 10.1.1.1 255.255.255.0
RP/0/RSP0/CPU0:router(config-if)# no shut
RP/0/RSP0/CPU0:router(config-if)# exit
RP/0/RSP0/CPU0:router(config)# interface Loopback 0
RP/0/RSP0/CPU0:router(config-if)# ipv4 address 10.10.10.10 255.255.255.255
RP/0/RSP0/CPU0:router(config-if)# no shut
RP/0/RSP0/CPU0:router(config-if)# exit
```

2. Configure the OSPF process with prefix suppression.

```
RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# router ospf pfx
RP/0/RSP0/CPU0:router(config-ospf)# router-id 10.10.10.10
RP/0/RSP0/CPU0:router(config-ospf)# prefix-suppression
```

3. Add the configured interfaces to the OSPF area.

```
RP/0/RSP0/CPU0:router(config-ospf)# area 0
RP/0/RSP0/CPU0:router(config-ospf-ar)# interface Loopback 0
RP/0/RSP0/CPU0:router(config-ospf-ar-if)# exit
RP/0/RSP0/CPU0:router(config-ospf-ar)# interface GigabitEthernet 0/0/0/1
RP/0/RSP0/CPU0:router(config-ospf-ar-if)# network point-to-point
```

4. Exit the OSPF area configuration mode and commit your configuration.

```
RP/0/RSP0/CPU0:router(config-ospf-ar-if)# exit
RP/0/RSP0/CPU0:router(config-ospf-ar)# exit
RP/0/RSP0/CPU0:router(config-ospf)# exit
RP/0/RSP0/CPU0:router(config)# commit
RP/0/RSP0/CPU0:router(config)# exit
```

5. Confirm your configuration.

```
RP/0/RSP0/CPU0:router# show running-configuration
...
interface Loopback0
 ipv4 address 10.10.10.10 255.255.255.255
!
interface GigabitEthernet0/0/0/1
 ipv4 address 10.1.1.1 255.255.255.0
!
router ospf pfx
```

```
 router-id 10.10.10.10
 prefix-suppression
 area 0
  interface GigabitEthernet0/0/0/1
   network point-to-point
  !
 !
!
```

6. Verify whether prefix suppression is enabled.

```
RP/0/RSP0/CPU0:router# show ospf interface
Fri Jun 17 15:13:08.470 IST

Interfaces for OSPF 1

GigabitEthernet0/0/0/1 is up, line protocol is up
  Internet Address 10.1.1.1/24, Area 0
  Process ID 1, Router ID 10.10.10.10, Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State BDR, Priority 1, MTU 1500, MaxPktSz 1500
  Designated Router (ID) 10.10.10.20, Interface address 10.1.1.2
  Backup Designated router (ID) 10.10.10.30, Interface address 10.1.1.3
  Primary addresses not advertised
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:06:898
  Index 2/2, flood queue length 0
  Next 0(0)/0(0)
  Last flood scan length is 2, maximum is 2
  Last flood scan time is 0 msec, maximum is 0 msec
  LS Ack List: current length 0, high water mark 2
  Neighbor Count is 1, Adjacent neighbor count is 1
    Adjacent with neighbor 10.10.10.30  (Designated Router)
  Suppress hello for 0 neighbor(s)
  Multi-area interface Count is 0
```

If your output verifies that primary addresses are not advertised, then you have successfully configured prefix suppression for the OSPF process on the router.

Configure Prefix Suppression for an OSPF Area

Use the procedure in this section to configure prefix suppression for an OSPF area.

Note If you suppress prefixes on an area, the suppression is valid for all interfaces associated with the area.

1. Enter the global configuration mode and configure the interfaces of the router.

```
RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# interface GigabitEthernet 0/0/0/1
RP/0/RSP0/CPU0:router(config-if)# ipv4 address 10.1.1.1 255.255.255.0
RP/0/RSP0/CPU0:router(config-if)# no shut
RP/0/RSP0/CPU0:router(config-if)# exit
RP/0/RSP0/CPU0:router(config)# interface Loopback 0
RP/0/RSP0/CPU0:router(config-if)# ipv4 address 10.10.10.10 255.255.255.255
RP/0/RSP0/CPU0:router(config-if)# no shut
RP/0/RSP0/CPU0:router(config-if)# exit
```

2. Configure the OSPF area with prefix suppression.

```
RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# router ospf pfx
```

```
RP/0/RSP0/CPU0:router(config-ospf)# router-id 10.10.10.10
RP/0/RSP0/CPU0:router(config-ospf)# area 0
RP/0/RSP0/CPU0:router(config-ospf-ar)# prefix-suppression
```

3. Add the configured interfaces to the OSPF area.

```
RP/0/RSP0/CPU0:router(config-ospf-ar)# interface Loopback 0
RP/0/RSP0/CPU0:router(config-ospf-ar-if)# exit
RP/0/RSP0/CPU0:router(config-ospf-ar)# interface GigabitEthernet 0/0/0/1
RP/0/RSP0/CPU0:router(config-ospf-ar-if)# network point-to-point
```

4. Exit the OSPF area configuration mode and commit your configuration.

```
RP/0/RSP0/CPU0:router(config-ospf-ar-if)# exit
RP/0/RSP0/CPU0:router(config-ospf-ar)# exit
RP/0/RSP0/CPU0:router(config-ospf)# exit
RP/0/RSP0/CPU0:router(config)# commit
RP/0/RSP0/CPU0:router(config)# exit
```

5. Confirm your configuration.

```
RP/0/RSP0/CPU0:router# show running-configuration
...
interface Loopback0
 ipv4 address 10.10.10.10 255.255.255.255
!
interface GigabitEthernet0/0/0/1
 ipv4 address 10.1.1.1 255.255.255.0
!
router ospf pfx
 router-id 10.10.10.10
 area 0
  prefix-suppression
  interface GigabitEthernet0/0/0/1
   network point-to-point
  !
 !
!
```

6. Verify if prefix suppression is enabled.

```
RP/0/RSP0/CPU0:router# show ospf interface
Fri Jun 17 15:13:08.470 IST

Interfaces for OSPF 1

GigabitEthernet0/0/0/1 is up, line protocol is up
  Internet Address 10.1.1.1/24, Area 0
  Process ID 1, Router ID 10.10.10.10, Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State BDR, Priority 1, MTU 1500, MaxPktSz 1500
  Designated Router (ID) 10.10.10.20, Interface address 10.1.1.2
  Backup Designated router (ID) 10.10.10.30, Interface address 10.1.1.3
  Primary addresses not advertised
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:06:898
  Index 2/2, flood queue length 0
  Next 0(0)/0(0)
  Last flood scan length is 2, maximum is 2
  Last flood scan time is 0 msec, maximum is 0 msec
  LS Ack List: current length 0, high water mark 2
  Neighbor Count is 1, Adjacent neighbor count is 1
    Adjacent with neighbor 10.10.10.30  (Designated Router)
  Suppress hello for 0 neighbor(s)
  Multi-area interface Count is 0
```

If your output verifies that primary addresses are not advertised, then you have successfully configured prefix suppression for the OSPF area.

Configure Prefix Suppression for an OSPF Interface

Use the procedure in this section to configure prefix suppression for an OSPF interface.

Note If you suppress prefixes on an interface, suppression is valid only on that interface, and all other interfaces must be configured separately with prefix suppression.

1. Enter the global configuration mode and configure the interfaces of the router.

```
RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# interface GigabitEthernet 0/0/0/1
RP/0/RSP0/CPU0:router(config-if)# ipv4 address 10.1.1.1 255.255.255.0
RP/0/RSP0/CPU0:router(config-if)# no shut
RP/0/RSP0/CPU0:router(config-if)# exit
RP/0/RSP0/CPU0:router(config)# interface Loopback 0
RP/0/RSP0/CPU0:router(config-if)# ipv4 address 10.10.10.10 255.255.255.255
RP/0/RSP0/CPU0:router(config-if)# no shut
RP/0/RSP0/CPU0:router(config-if)# exit
```

2. Configure the OSPF area.

```
RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# router ospf pfx
RP/0/RSP0/CPU0:router(config-ospf)# router-id 10.10.10.10
RP/0/RSP0/CPU0:router(config-ospf)# area 0
```

3. Add the configured interfaces to the OSPF area, and configure prefix suppression on the required interface.

```
RP/0/RSP0/CPU0:router(config-ospf-ar)# interface Loopback 0
RP/0/RSP0/CPU0:router(config-ospf-ar-if)# exit
RP/0/RSP0/CPU0:router(config-ospf-ar)# interface GigabitEthernet 0/0/0/1
RP/0/RSP0/CPU0:router(config-ospf-ar-if)# network point-to-point
RP/0/RSP0/CPU0:router(config-ospf-ar-if)# prefix-suppression
```

4. Exit the OSPF area configuration mode and commit your configuration.

```
RP/0/RSP0/CPU0:router(config-ospf-ar-if)# exit
RP/0/RSP0/CPU0:router(config-ospf-ar)# exit
RP/0/RSP0/CPU0:router(config-ospf)# exit
RP/0/RSP0/CPU0:router(config)# commit
RP/0/RSP0/CPU0:router(config)# exit
```

5. Confirm your configuration.

```
RP/0/RSP0/CPU0:router# show running-configuration
...
interface Loopback0
 ipv4 address 10.10.10.10 255.255.255.255
!
interface GigabitEthernet0/0/0/1
 ipv4 address 10.1.1.1 255.255.255.0
!
router ospf pfx
 router-id 10.10.10.10
 area 0
  interface GigabitEthernet0/0/0/1
```

```
   network point-to-point
   prefix-suppression
  !
 !
!
```

6. Verify if prefix suppression is enabled.

```
RP/0/RSP0/CPU0:router# show ospf interface
Fri Jun 17 15:13:08.470 IST

Interfaces for OSPF 1

GigabitEthernet0/0/0/1 is up, line protocol is up
  Internet Address 10.1.1.1/24, Area 0
  Process ID 1, Router ID 10.10.10.10, Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State BDR, Priority 1, MTU 1500, MaxPktSz 1500
  Designated Router (ID) 10.10.10.20, Interface address 10.1.1.2
  Backup Designated router (ID) 10.10.10.30, Interface address 10.1.1.3
  Primary addresses not advertised
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:06:898
  Index 2/2, flood queue length 0
  Next 0(0)/0(0)
  Last flood scan length is 2, maximum is 2
  Last flood scan time is 0 msec, maximum is 0 msec
  LS Ack List: current length 0, high water mark 2
  Neighbor Count is 1, Adjacent neighbor count is 1
    Adjacent with neighbor 10.10.10.30  (Designated Router)
  Suppress hello for 0 neighbor(s)
  Multi-area interface Count is 0
```

If your output verifies that primary addresses are not advertised, then you have successfully configured prefix suppression on the interface.

Configure Prefix Suppression for OSPFv3

Transit-only networks that connect two routers are usually configured with routing IP addresses that are advertised in the Links State Advertisements (LSAs). However, these prefixes are not needed for data traffic. Suppressing these prefixes would reduce the number of links in LSAs, thereby improving convergence and also reducing the vulnerability of potential remote attacks.

Prefixes can be suppressed for an OSPF process, an OSPF area, or for specific interfaces of a router.

Configure Prefix Suppression for a Router Running OSPFv3

Use the procedure in this section to configure prefix suppression for an OSPFv3 process on a router.

Note

- If you suppress prefixes for an OSPF process on a router, the suppression is valid for all interfaces and areas associated with the router.
- When prefix suppression is configured on an NSSA ASBR, all interfaces on the routers have their prefixes suppressed, and the Type 7 LSAs have a forwarding address of 0. This stops the translation of Type 7 LSAs to Type 5 by the NSSA ABR. The workaround for this is to configure at least one loopback interface in the NSSA area, or one interface with prefix suppression disabled, so that the interface address is selected as the forwarding address for all the Type 7 LSAs.

1. Enter the global configuration mode and configure the interfaces of the router.

```
RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# interface GigabitEthernet 0/0/0/1
RP/0/RSP0/CPU0:router(config-if)# ipv6 address 2008:DB8::1/64
RP/0/RSP0/CPU0:router(config-if)# no shut
RP/0/RSP0/CPU0:router(config-if)# exit
RP/0/RSP0/CPU0:router(config)# interface Loopback 0
RP/0/RSP0/CPU0:router(config-if)# ipv6 address ::1/128
RP/0/RSP0/CPU0:router(config-if)# no shut
RP/0/RSP0/CPU0:router(config-if)# exit
```

2. Configure the OSPFv3 process with prefix suppression.

```
RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# router ospfv3 pfx
RP/0/RSP0/CPU0:router(config-ospfv3)# router-id 10.10.10.10
RP/0/RSP0/CPU0:router(config-ospfv3)# prefix-suppression
```

3. Add the configured interfaces to the OSPFv3 area.

```
RP/0/RSP0/CPU0:router(config-ospfv3)# area 0
RP/0/RSP0/CPU0:router(config-ospfv3-ar)# interface Loopback 0
RP/0/RSP0/CPU0:router(config-ospfv3-ar-if)# exit
RP/0/RSP0/CPU0:router(config-ospfv3-ar)# interface GigabitEthernet 0/0/0/1
RP/0/RSP0/CPU0:router(config-ospfv3-ar-if)# network point-to-point
```

4. Exit the OSPFv3 area configuration mode and commit your configuration.

```
RP/0/RSP0/CPU0:router(config-ospfv3-ar-if)# exit
RP/0/RSP0/CPU0:router(config-ospfv3-ar)# exit
RP/0/RSP0/CPU0:router(config-ospfv3)# exit
RP/0/RSP0/CPU0:router(config)# commit
RP/0/RSP0/CPU0:router(config)# exit
```

5. Confirm your configuration.

```
RP/0/RSP0/CPU0:router# show running-configuration
...
interface Loopback0
 ipv6 address ::1/128
!
interface GigabitEthernet0/0/0/1
 ipv6 address 2008:DB8::1/64
!
router ospfv3 pfx
 router-id 10.10.10.10
 prefix-suppression
 area 0
  interface GigabitEthernet0/0/0/1
   network point-to-point
  !
 !
!
```

6. Verify whether prefix suppression is enabled.

```
RP/0/RSP0/CPU0:router# show ospfv3 interface
Fri Jun 17 15:13:08.470 IST
GigabitEthernet0/0/0/2 is up, line protocol is up
  Link Local address fe80::45:caff:feaf:72af, Interface ID 5
  Area 0, Process ID pfx, Instance ID 0, Router ID 10.10.10.10
  Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State DOWN, Priority 1
  No designated router on this network
```

```
No backup designated router on this network
Addresses not advertised
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
Index 0/1/1, flood queue length 0
Next 0(0)/0(0)/0(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)
Reference count is 0
```

If your output verifies that primary addresses are not advertised, then you have successfully configured prefix suppression for the OSPFv3 process on the router.

Configure Prefix Suppression for an OSPFv3 Area

Use the procedure in this section to configure prefix suppression for an OSPFv3 area.

Note If you suppress prefixes on an area, the suppression is valid for all interfaces associated with the area.

1. Enter the global configuration mode and configure the interfaces of the router.

```
RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# interface GigabitEthernet 0/0/0/1
RP/0/RSP0/CPU0:router(config-if)# ipv6 address 2008:DB8::1/64
RP/0/RSP0/CPU0:router(config-if)# no shut
RP/0/RSP0/CPU0:router(config-if)# exit
RP/0/RSP0/CPU0:router(config)# interface Loopback 0
RP/0/RSP0/CPU0:router(config-if)# ipv6 address ::1/128
RP/0/RSP0/CPU0:router(config-if)# no shut
RP/0/RSP0/CPU0:router(config-if)# exit
```

2. Configure the OSPFv3 area with prefix suppression.

```
RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# router ospfv3 pfx
RP/0/RSP0/CPU0:router(config-ospfv3)# router-id 10.10.10.10
RP/0/RSP0/CPU0:router(config-ospfv3)# area 0
RP/0/RSP0/CPU0:router(config-ospfv3-ar)# prefix-suppression
```

3. Add the configured interfaces to the OSPFv3 area.

```
RP/0/RSP0/CPU0:router(config-ospfv3-ar)# interface Loopback 0
RP/0/RSP0/CPU0:router(config-ospfv3-ar-if)# exit
RP/0/RSP0/CPU0:router(config-ospfv3-ar)# interface GigabitEthernet 0/0/0/1
RP/0/RSP0/CPU0:router(config-ospfv3-ar-if)# network point-to-point
```

4. Exit the OSPFv3 area configuration mode and commit your configuration.

```
RP/0/RSP0/CPU0:router(config-ospfv3-ar-if)# exit
RP/0/RSP0/CPU0:router(config-ospfv3-ar)# exit
RP/0/RSP0/CPU0:router(config-ospfv3)# exit
RP/0/RSP0/CPU0:router(config)# commit
RP/0/RSP0/CPU0:router(config)# exit
```

5. Confirm your configuration.

```
RP/0/RSP0/CPU0:router# show running-configuration
...
interface Loopback0
```

```
 ipv6 address ::1/128
!
interface GigabitEthernet0/0/0/1
 ipv6 address 2008:DB8::1/64
!
router ospfv3 pfx
 router-id 10.10.10.10
 area 0
  prefix-suppression
  interface GigabitEthernet0/0/0/1
   network point-to-point
  !
 !
!
```

6. Verify if prefix suppression is enabled.

```
RP/0/RSP0/CPU0:router# show ospfv3 interface
Fri Jun 17 15:13:08.470 IST
GigabitEthernet0/0/0/2 is up, line protocol is up
  Link Local address fe80::45:caff:feaf:72af, Interface ID 5
  Area 0, Process ID pfx, Instance ID 0, Router ID 10.10.10.10
  Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State DOWN, Priority 1
  No designated router on this network
  No backup designated router on this network
  Addresses not advertised
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
  Index 0/1/1, flood queue length 0
  Next 0(0)/0(0)/0(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)
  Reference count is 0
```

If your output verifies that primary addresses are not advertised, then you have successfully configured prefix suppression for the OSPFv3 area.

Configure Prefix Suppression for an OSPFv3 Interface

Use the procedure in this section to configure prefix suppression for an OSPFv3 interface.

Note If you suppress prefixes on an interface, suppression is valid only on that interface, and all other interfaces must be configured separately with prefix suppression.

1. Enter the global configuration mode and configure the interfaces of the router.

```
RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# interface GigabitEthernet 0/0/0/1
RP/0/RSP0/CPU0:router(config-if)# ipv6 address 2008:DB8::1/64
RP/0/RSP0/CPU0:router(config-if)# no shut
RP/0/RSP0/CPU0:router(config-if)# exit
RP/0/RSP0/CPU0:router(config)# interface loopback 0
RP/0/RSP0/CPU0:router(config-if)# ipv6 address ::1/128
RP/0/RSP0/CPU0:router(config-if)# no shut
RP/0/RSP0/CPU0:router(config-if)# exit
```

2. Configure the OSPFv3 area.

```
RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# router ospfv3 pfx
RP/0/RSP0/CPU0:router(config-ospfv3)# router-id 10.10.10.10
RP/0/RSP0/CPU0:router(config-ospfv3)# area 0
```

3. Add the configured interfaces to the OSPFv3 area, and configure prefix suppression on the required interface.

```
RP/0/RSP0/CPU0:router(config-ospfv3-ar)# interface Loopback 0
RP/0/RSP0/CPU0:router(config-ospfv3-ar-if)# exit
RP/0/RSP0/CPU0:router(config-ospfv3-ar)# interface GigabitEthernet 0/0/0/1
RP/0/RSP0/CPU0:router(config-ospfv3-ar-if)# network point-to-point
RP/0/RSP0/CPU0:router(config-ospfv3-ar-if)# prefix-suppression
```

4. Exit the OSPFv3 area configuration mode and commit your configuration.

```
RP/0/RSP0/CPU0:router(config-ospfv3-ar-if)# exit
RP/0/RSP0/CPU0:router(config-ospfv3-ar)# exit
RP/0/RSP0/CPU0:router(config-ospfv3)# exit
RP/0/RSP0/CPU0:router(config)# commit
RP/0/RSP0/CPU0:router(config)# exit
```

5. Confirm your configuration.

```
RP/0/RSP0/CPU0:router# show running-configuration
...
interface Loopback0
 ipv4 address 10.10.10.10 255.255.255.255
!
interface GigabitEthernet0/0/0/1
 ipv4 address 10.1.1.1 255.255.255.0
!
router ospfv3 pfx
 router-id 10.10.10.10
 area 0
  interface GigabitEthernet0/0/0/1
   network point-to-point
   prefix-suppression
  !
 !
!
```

6. Verify if prefix suppression is enabled.

```
RP/0/RSP0/CPU0:router# show ospfv3 interface
Fri Jun 17 15:13:08.470 IST
GigabitEthernet0/0/0/2 is up, line protocol is up
  Link Local address fe80::45:caff:feaf:72af, Interface ID 5
  Area 0, Process ID pfx, Instance ID 0, Router ID 10.10.10.10
  Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State DOWN, Priority 1
  No designated router on this network
  No backup designated router on this network
  Addresses not advertised
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
  Index 0/1/1, flood queue length 0
  Next 0(0)/0(0)/0(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)
  Reference count is 0
```

If your output verifies that primary addresses are not advertised, then you have successfully configured prefix suppression on the interface.

Multi-Area Adjacency for OSPF Version 2

The multi-area adjacency feature for OSPFv2 allows a link to be configured on the primary interface in more than one area so that the link could be considered as an intra-area link in those areas and configured as a preference over more expensive paths.

This feature establishes a point-to-point unnumbered link in an OSPF area. A point-to-point link provides a topological path for that area, and the primary adjacency uses the link to advertise the link consistent with draft-ietf-ospf-multi-area-adj-06.

The following are multi-area interface attributes and limitations:

- Exists as a logical construct over an existing primary interface for OSPF; however, the neighbor state on the primary interface is independent of the multi-area interface.
- Establishes a neighbor relationship with the corresponding multi-area interface on the neighboring router. A mixture of multi-area and primary interfaces is not supported.
- Advertises an unnumbered point-to-point link in the router link state advertisement (LSA) for the corresponding area when the neighbor state is full.
- Created as a point-to-point network type. You can configure multi-area adjacency on any interface where only two OSF speakers are attached. In the case of native broadcast networks, the interface must be configured as an OPSF point-to-point type using the **network point-to-point** command to enable the interface for a multi-area adjacency.
- Inherits the Bidirectional Forwarding Detection (BFD) characteristics from its primary interface. BFD is not configurable under a multi-area interface; however, it is configurable under the primary interface.

The multi-area interface inherits the interface characteristics from its primary interface, but some interface characteristics can be configured under the multi-area interface configuration mode as shown below:

```
RP/0/RSP0/CPU0:router(config-ospf-ar)# multi-area-interface GigabitEthernet 0/1/0/3
RP/0/RSP0/CPU0:router(config-ospf-ar-mif)# ?
  authentication       Enable authentication
  authentication-key   Authentication password (key)
  cost                 Interface cost
  cost-fallback        Cost when cumulative bandwidth goes below the theshold
  database-filter      Filter OSPF LSA during synchronization and flooding
  dead-interval        Interval after which a neighbor is declared dead
  distribute-list      Filter networks in routing updates
  hello-interval       Time between HELLO packets
  message-digest-key   Message digest authentication password (key)
  mtu-ignore           Enable/Disable ignoring of MTU in DBD packets
  packet-size          Customize size of OSPF packets upto MTU
  retransmit-interval  Time between retransmitting lost link state advertisements
  transmit-delay       Estimated time needed to send link-state update packet

RP/0/RSP0/CPU0:router(config-ospf-ar-mif)#
```

Label Distribution Protocol IGP Auto-configuration for OSPF

Label Distribution Protocol (LDP) Interior Gateway Protocol (IGP) auto-configuration simplifies the procedure to enable LDP on a set of interfaces used by an IGP instance, such as OSPF. LDP IGP auto-configuration can be used on a large number of interfaces (for example, when LDP is used for transport in the core) and on multiple OSPF instances simultaneously.

This feature supports the IPv4 unicast address family for the default VPN routing and forwarding (VRF) instance.

LDP IGP auto-configuration can also be explicitly disabled on an individual interface basis under LDP using the **igp auto-config disable** command. This allows LDP to receive all OSPF interfaces minus the ones explicitly disabled.

See *MPLS Configuration Guide for Cisco ASR 9000 Series Routers* for information on configuring LDP IGP auto-configuration.

OSPF Authentication Message Digest Management

All OSPF routing protocol exchanges are authenticated and the method used can vary depending on how authentication is configured. When using cryptographic authentication, the OSPF routing protocol uses the Message Digest 5 (MD5) authentication algorithm to authenticate packets transmitted between neighbors in the network. For each OSPF protocol packet, a key is used to generate and verify a message digest that is appended to the end of the OSPF packet. The message digest is a one-way function of the OSPF protocol packet and the secret key. Each key is identified by the combination of interface used and the key identification. An interface may have multiple keys active at any time.

To manage the rollover of keys and enhance MD5 authentication for OSPF, you can configure a container of keys called a *keychain* with each key comprising the following attributes: generate/accept time, key identification, and authentication algorithm.

GTSM TTL Security Mechanism for OSPF

OSPF is a link state protocol that requires networking devices to detect topological changes in the network, flood Link State Advertisement (LSA) updates to neighbors, and quickly converge on a new view of the topology. However, during the act of receiving LSAs from neighbors, network attacks can occur, because there are no checks that unicastor multicast packets are originating from a neighbor that is one hop away or multiple hops away over virtual links.

For virtual links, OSPF packets travel multiple hops across the network; hence, the TTL value can be decremented several times. For these type of links, a minimum TTL value must be allowed and accepted for multiple-hop packets.

To filter network attacks originating from invalid sources traveling over multiple hops, the Generalized TTL Security Mechanism (GTSM), RFC 3682, is used to prevent the attacks. GTSM filters link-local addresses and allows for only one-hop neighbor adjacencies through the configuration of TTL value 255. The TTL value in the IP header is set to 255 when OSPF packets are originated, and checked on the received OSPF packets against the default GTSM TTL value 255 or the user configured GTSM TTL value, blocking unauthorized OSPF packets originated from TTL hops away.

Path Computation Element for OSPFv2

A PCE is an entity (component, application, or network node) that is capable of computing a network path or route based on a network graph and applying computational constraints.

PCE is accomplished when a PCE address and client is configured for MPLS-TE. PCE communicates its PCE address and capabilities to OSPF then OSPF packages this information in the PCE Discovery type-length-value (TLV) (Type 2) and reoriginates the RI LSA. OSPF also includes the Router Capabilities TLV (Type 1) in

all its RI LSAs. The PCE Discovery TLV contains the PCE address sub-TLV (Type 1) and the Path Scope Sub-TLV (Type 2).

The PCE Address Sub-TLV specifies the IP address that must be used to reach the PCE. It should be a loop-back address that is always reachable, this TLV is mandatory, and must be present within the PCE Discovery TLV. The Path Scope Sub-TLV indicates the PCE path computation scopes, which refers to the PCE ability to compute or participate in the computation of intra-area, inter-area, inter-AS or inter-layer TE LSPs.

PCE extensions to OSPFv2 include support for the Router Information Link State Advertisement (RI LSA). OSPFv2 is extended to receive all area scopes (LSA Types 9, 10, and 11). However, OSPFv2 originates only area scope Type 10.

For detailed information for the Path Computation Element feature see the *Implementing MPLS Traffic Engineering on* Cisco ASR 9000 Series Router module of the *MPLS Configuration Guide for Cisco ASR 9000 Series Routers* and the following IETF drafts:

- draft-ietf-ospf-cap-09
- draft-ietf-pce-disco-proto-ospf-00

OSPF IP Fast Reroute Loop Free Alternate

The OSPF IP Fast Reroute (FRR) Loop Free Alternate (LFA) computation supports these:

- Fast rerouting capability by using IP forwarding and routing
- Handles failure in the line cards in minimum time
- Supports OSPFv2 and OSPFv3 IP FRR functionality in non-default VRFs.

Management Information Base (MIB) for OSPFv3

Cisco IOS XR supports full MIBs and traps for OSPFv3, as defined in RFC 5643. The RFC 5643 defines objects of the Management Information Base (MIB) for use with the Open Shortest Path First (OSPF) Routing Protocol for IPv6 (OSPF version 3).

The OSPFv3 MIB implementation is based on the IETF draft *Management Information Base for OSPFv3 (draft-ietf-ospf-ospfv3-mib-8)*. Users need to update the NMS application to pick up the new MIB when upgraded to RFC 5643.

Refer to the *Cisco ASR 9000 Series Aggregation Services Router MIB Specification Guide* for more information on Cisco IOS XR MIB support.

Multiple OSPFv3 Instances

SNMPv3 supports "contexts" that can be used to implement MIB views on multiple OSPFv3 instances, in the same system.

VRF-lite Support for OSPFv2

VRF-lite capability is enabled for OSPF version 2 (OSPFv2). VRF-lite is the virtual routing and forwarding (VRF) deployment without the BGP/MPLS based backbone. In VRF-lite, individual provider edge (PE)

routers are directly connected using VRF interfaces. To enable VRF-lite in OSPFv2, configure the **capability vrf-lite** command in VRF configuration mode. When VRF-lite is configured, the DN bit processing and the automatic Area Border Router (ABR) status setting are disabled.

OSPFv3 Timers Link-state Advertisements and Shortest Path First Throttle Default Values Update

The Open Shortest Path First version 3 (OSPFv3) timers link-state advertisements (LSAs) and shortest path first (SPF) throttle default values are updated to:

- **timers throttle lsa all**—*start-interval*: 50 milliseconds and *hold-interval*: 200 milliseconds
- **timers throttle spf** —*spf-start*: 50 milliseconds, *spf-hold*: 200 milliseconds, *spf-max-wait*: 5000 milliseconds

IGP link state

IGP Link-State Database Distribution

A given BGP node may have connections to multiple, independent routing domains. IGP link-state database distribution into BGP-LS is supported for both OSPF and IS-IS protocols in order to distribute this information on to controllers or applications that desire to build paths spanning or including these multiple domains.

To distribute OSPFv2 link-state data using BGP-LS, use the **distribute link-state** command in router configuration mode.

```
Router# configure
Router(config)# router ospf 100
Router(config-ospf)# distribute link-state instance-id 32
```

OSPF Link State

With OSPF link state configured (as given above), the entire link-state data is advertised by BGPLS to the controllers. But the controllers might not be interested in the bulk of LS information and unwanted information might be dropped by them. A selective filtering in this case would reduce their burden. You can now filter the unwanted summary LSAs by the LSLIB and selectively allow only some of the PE's prefixes to LSLIB consumers. This selective filtering helps in reducing the burden of the controllers.

There are several ways in which you can filter:

- Filtering based on a route policy at OSPF instance level.
  - Set of prefixes as destination attribute.
  - Route-type attribute
- Option to exclude all external LSAs at OSPF instance level.
- Option to disable link-state information from a selected OSPF area.
- Option to exclude all summary LSAs at OSPF area level.
- Option to exclude all NSSA LSAs at OSPF area level.

Configuration Example

You can use the **distribute link state** command to selectively filter the LSAs.

```
Router(config)#router ospf 1
Router(config-ospf)#distribute link-state ?
  allow-prefix   Selectively allow prefixes from route policy
  excl-external  Filter advertisement of external prefixes
  instance-id    Set distribution process instance identifier
  throttle       Throttle time between successive LSA updates
```

You can also filter based on a route policy at OSPF instance level.

```
Router(config-ospf)#distribute link-state allow-prefix ?
  route-policy  Specify the route-policy to allow a set of prefixes

Router(config-ospf)#distribute link-state allow-prefix route-policy ?
  ospf-bgpls-rpl1     Name of the policy
  ospf-bgpls-rpl2     Name of the policy
  WORD  Name of the policy

Router#distribute link-state allow-prefix route-policy ospf-bgpls-rpl1  ?
  (              Specify parameter values for the policy
  excl-external  Filter advertisement of external prefixes
  instance-id    Set distribution process instance identifier
  throttle       Throttle time between successive LSA updates
```

Filter option to exclude all external LSAs at OSPF instance level.

```
RP/0/0/CPU0:ios(config-ospf)#distribute link-state excl-external ?
  allow-prefix  Selectively allow prefixes from route policy
  instance-id   Set distribution process instance identifier
  throttle      Throttle time between successive LSA updates
  <cr>
RP/0/0/CPU0:ios(config-ospf)#
```

The following example shows how to filter syntax at OSPF area level:

```
Router(config-ospf)#area 1
Router(config-ospf-ar)#distribute link-state ?
  disable       Disable link-state advertisement of this area
  excl-nssa     Filter advertisement of NSSA prefixes
  excl-summary  Filter advertisement of summary prefixes
```

The following example shows the option to disable link-state information from a selected OSPF area.

```
Router(config-ospf-ar)#distribute link-state disable ?
  excl-nssa     Filter advertisement of NSSA prefixes
  excl-summary  Filter advertisement of summary prefixes
```

The following example shows option to exclude all summary LSAs at OSPF area level.

```
Router(config-ospf-ar)#distribute link-state excl-nssa ?
  disable       Disable link-state advertisement of this area
  excl-summary  Filter advertisement of summary prefixes
```

The following example shows option to exclude all NSSA LSAs at OSPF area level.

```
Router(config-ospf-ar)#distribute link-state excl-summary ?
  disable    Disable link-state advertisement of this area
  excl-nssa  Filter advertisement of NSSA prefixes
```

Verification

The following example shows sample RPLs and prefix-set.

```
Router#do show running-config prefix-set pe_list

prefix-set pe_list
  100.0.0.0/24 ge 24,
  101.0.0.0/24 ge 24
end-set
!

Router#do show running-config route-policy ospf-bgpls-rpl1
route-policy ospf-bgpls-rpl1
  if destination in pe_list then
    pass
  endif
end-policy
!

Router(config)#do show running-config route-policy ospf-bgpls-rpl2
route-policy ospf-bgpls-rpl2
  if route-type is ospf-external-type-2 then
    drop
  else
    pass
  endif
end-policy
!
```

Note You can refer to BGP Link state document for BGP configurations.

Unequal Cost Multipath Load-balancing for OSPF

The unequal cost multipath (UCMP) load-balancing adds the capability with Open Shortest Path First (OSPF) to load-balance traffic proportionally across multiple paths, with different cost. Without UCMP enabled, only the best cost paths are discovered by OSPF (ECMP) and alternate higher cost paths are not computed.

Generally, higher bandwidth links have lower IGP metrics configured, so that they form the shortest IGP paths. With the UCMP load-balancing enabled, IGP can use even lower bandwidth links or higher cost links for traffic, and can install these paths to the forwarding information base (FIB). OSPF installs multiple paths to the same destination in FIB, but each path will have a 'load metric/weight' associated with it. FIB uses this load metric/weight to decide the amount of traffic that needs to be sent on a higher bandwidth path and the amount of traffic that needs to be sent on a lower bandwidth path.

The UCMP computation is provided under OSPF VRF context, enabling UCMP computation for a particular VRF. For default VRF the configuration is done under the OSPF global mode. The UCMP configuration is also provided with a prefix-list option, which would limit the UCMP computation only for the prefixes present in the prefix-list. If prefix-list option is not provided, UCMP computation is done for the reachable prefixes in OSPF. The number of UCMP paths to be considered and installed is controlled using the **variance** configuration. Variance value identifies the range for the UCMP path metric to be considered for installation into routing information base (RIB/FIB) and is defined in terms of a percentage of the primary path metric. Total number of paths, including ECMP and UCMP paths together is limited by the max-path configuration or by the max-path capability of the platform.

There is an option to exclude an interface from being used for UCMP computation. If it is desired that a particular interface should not be considered as a UCMP nexthop, for any prefix, then use the UCMP **exclude interface** command to configure the interface to be excluded from UCMP computation.

Enabling the UCMP configuration indicates that OSPF should perform UCMP computation for the all the reachable OSPF prefixes or all the prefixes permitted by the prefix-list, if the prefix-list option is used. The UCMP computation happens only after the primary SPF and route calculation is completed. There would be a configurable delay (default delay is 100 ms) from the time primary route calculation is completed and UCMP computation is started. Use the UCMP **delay-interval** command to configure the delay between primary SPF completion and start of UCMP computation. UCMP computation will be done during the fast re-route computation (IPFRR does not need to be enabled for UCMP computation to be performed). If IPFRR is enabled, the fast re-route backup paths will be calculated for both the primary equal cost multipath (ECMP) paths and the UCMP paths.

To manually adjust UCMP ratio, use any command that changes the metric of the link.

- By using the bandwidth command in interface configuration mode
- By adjusting the OSPF interface cost on the link

More than 32 ECMP and UCMP paths are not supported for these features:

- LI
- GRE
- BVI
- NetFlow
- Satellite
- MCAST
- SPAN
- PWHE
- ABF
- P2MP
- MVPN
- VPLS
- L2TPv3
- LISP
- VIDMON
- PBR

How to Implement OSPF

This section contains the following procedures:

Enabling OSPF

This task explains how to perform the minimum OSPF configuration on your router that is to enable an OSPF process with a router ID, configure a backbone or nonbackbone area, and then assign one or more interfaces on which OSPF runs.

Before you begin

Although you can configure OSPF before you configure an IP address, no OSPF routing occurs until at least one IP address is configured.

SUMMARY STEPS

1. **configure**
2. Do one of the following:
   - **router ospf** *process-name*
   - **router ospfv3** *process-name*
3. **router-id** { *router-id* }
4. **area** *area-id*
5. **interface** *type interface-path-id*
6. Repeat Step 5 for each interface that uses OSPF.
7. **log adjacency changes** [**detail**] [**disable**]
8. Use the **commit** or **end** command.

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.

Step 2	Do one of the following:
	• **router ospf** *process-name*
	• **router ospfv3** *process-name*
	Example:
	`RP/0/RSP0/CPU0:router(config)# router ospf 1`
	or
	`RP/0/RSP0/CPU0:router(config)# router ospfv3 1`
		Enables OSPF routing for the specified routing process and places the router in router configuration mode.
		or
		Enables OSPFv3 routing for the specified routing process and places the router in router ospfv3 configuration mode.
		Note
		The *process-name* argument is any alphanumeric string no longer than 40 characters.

Step 3	**router-id** { *router-id* } **Example:**	Configures a router ID for the OSPF process. **Note**

	Command or Action	Purpose
	`RP/0/RSP0/CPU0:router(config-ospf)# router-id 192.168.4.3`	We recommend using a stable IP address as the router ID.
Step 4	**area** *area-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# area 0`	Enters area configuration mode and configures an area for the OSPF process. • Backbone areas have an area ID of 0. • Nonbackbone areas have a nonzero area ID. • The *area-id* argument can be entered in dotted-decimal or IPv4 address notation, such as area 1000 or area 0.0.3.232. However, you must choose one form or the other for an area. We recommend using the IPv4 address notation.
Step 5	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf-ar)# interface GigabitEthernet 0/1/0/3`	Enters interface configuration mode and associates one or more interfaces for the area configured in Step 4.
Step 6	Repeat Step 5 for each interface that uses OSPF.	—
Step 7	**log adjacency changes** [**detail**] [**disable**] **Example:** `RP/0/RSP0/CPU0:router(config-ospf-ar-if)# log adjacency changes detail`	(Optional) Requests notification of neighbor changes. • By default, this feature is enabled. • The messages generated by neighbor changes are considered notifications, which are categorized as severity Level 5 in the **logging console** command. The **logging console** command controls which severity level of messages are sent to the console. By default, all severity level messages are sent.
Step 8	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Configuring Stub and Not-So-Stubby Area Types

This task explains how to configure the stub area and the NSSA for OSPF.

SUMMARY STEPS

1. **configure**
2. Do one of the following:
   - **router ospf** *process-name*
   - **router ospfv3** *process-name*
3. **router-id** { *router-id* }
4. **area** *area-id*
5. Do one of the following:
   - **stub** [**no-summary**]
   - **nssa** [**no-redistribution**] [**default-information-originate**] [**no-summary**] [**translate**] [**translate always**]
6. Do one of the following:
   - **stub**
   - **nssa**
7. **default-cost** *cost*
8. Use the **commit** or **end** command.
9. Repeat this task on all other routers in the stub area or NSSA.

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.

Step 2	Do one of the following:
	• **router ospf** *process-name*
	• **router ospfv3** *process-name*
	Example:
	`RP/0/RSP0/CPU0:router(config)# router ospf 1`
	or
	`RP/0/RSP0/CPU0:router(config)# router ospfv3 1`
		Enables OSPF routing for the specified routing process and places the router in router configuration mode.
		or
		Enables OSPFv3 routing for the specified routing process and places the router in router ospfv3 configuration mode.
		Note
		The *process-name* argument is any alphanumeric string no longer than 40 characters.

Step 3	**router-id** { *router-id* } **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# router-id 192.168.4.3`	Configures a router ID for the OSPF process. **Note** We recommend using a stable IP address as the router ID.

	Command or Action	Purpose
Step 4	**area** *area-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# area 1`	Enters area configuration mode and configures a nonbackbone area for the OSPF process. • The *area-id* argument can be entered in dotted-decimal or IPv4 address notation, such as area 1000 or area 0.0.3.232. However, you must choose one form or the other for an area. We recommend using the IPv4 address notation.

Step 5	Do one of the following:
	• **stub** [**no-summary**]
	• **nssa** [**no-redistribution**] [**default-information-originate**] [**no-summary**] [**translate**] [**translate always**]
	Example:
	`RP/0/RSP0/CPU0:router(config-ospf-ar)# stub no summary`
	or
	`RP/0/RSP0/CPU0:router(config-ospf-ar)# nssa no-redistribution`
	or
	`RP/0/RSP0/CPU0:router(config-ospf-ar)# nssa translate <type number> always`
		Defines the nonbackbone area as a stub area.
		• Specify the **no-summary** keyword to further reduce the number of LSAs sent into a stub area. This keyword prevents the ABR from sending summary link-state advertisements (Type 3) in the stub area.
		or
		Defines an area as an NSSA.

Step 6	Do one of the following:
	• **stub**
	• **nssa**
	Example:
	`RP/0/RSP0/CPU0:router(config-ospf-ar)# stub`
	or
	`RP/0/RSP0/CPU0:router(config-ospf-ar)# nssa`
		(Optional) Turns off the options configured for stub and NSSA areas.
		• If you configured the stub and NSSA areas using the optional keywords (**no-summary** , **no-redistribution** , **default-information-originate** , and **translate**) in Step 5, you must now reissue the **stub** and **nssa** commands without the keywords—rather than using the **no** form of the command.
		• For example, the **no nssa default-information-originate** form of the command changes the NSSA area into a normal area that inadvertently brings down the existing adjacencies in that area.

Step 7	**default-cost** *cost* **Example:** `RP/0/RSP0/CPU0:router(config-ospf-ar)#default-cost 15`	(Optional) Specifies a cost for the default summary route sent into a stub area or an NSSA. • Use this command only on ABRs attached to the NSSA. Do not use it on any other routers in the area. • The default cost is 1.

	Command or Action	Purpose
Step 8	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.
Step 9	Repeat this task on all other routers in the stub area or NSSA.	—

Configuring Neighbors for Nonbroadcast Networks

This task explains how to configure neighbors for a nonbroadcast network. This task is optional.

Before you begin

Configuring NBMA networks as either broadcast or nonbroadcast assumes that there are virtual circuits from every router to every router or fully meshed network.

SUMMARY STEPS

1. **configure**
2. Do one of the following:
   - **router ospf** *process-name*
   - **router ospfv3** *process-name*
3. **router-id** { *router-id* }
4. **area** *area-id*
5. **network** { **broadcast** | **non-broadcast** | { **point-to-multipoint** [**non-broadcast**] | **point-to-point** } }
6. **dead-interval** *seconds*
7. **hello-interval** *seconds*
8. **interface** *type interface-path-id*
9. Do one of the following:
   - **neighbor** *ip-address* [**priority** *number*] [**poll-interval** *seconds*][**cost** *number*]
   - **neighbor** *ipv6-link-local-address* [**priority** *number*] [**poll-interval** *seconds*][**cost** *number*] [**database-filter** [**all**]]
10. Repeat Step 9 for all neighbors on the interface.
11. exit
12. Use the **commit** or **end** command.

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.

Step 2	Do one of the following:
	• **router ospf** *process-name*
	• **router ospfv3** *process-name*
	Example:
	`RP/0/RSP0/CPU0:router(config)# router ospf 1`
	or
	`RP/0/RSP0/CPU0:router(config)# router ospfv3 1`
		Enables OSPF routing for the specified routing process and places the router in router configuration mode.
		or
		Enables OSPFv3 routing for the specified routing process and places the router in router ospfv3 configuration mode.
		Note
		The *process-name* argument is any alphanumeric string no longer than 40 characters.

Step 3	**router-id** { *router-id* } **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# router-id 192.168.4.3`	Configures a router ID for the OSPF process. **Note** We recommend using a stable IP address as the router ID.
Step 4	**area** *area-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# area 0`	Enters area configuration mode and configures an area for the OSPF process. • The example configures a backbone area. • The *area-id* argument can be entered in dotted-decimal or IPv4 address notation, such as area 1000 or area 0.0.3.232. However, you must choose one form or the other for an area. We recommend using the IPv4 address notation.
Step 5	**network** { **broadcast** | **non-broadcast** | { **point-to-multipoint** [**non-broadcast**] | **point-to-point** } } **Example:** `RP/0/RSP0/CPU0:router(config-ospf-ar)# network non-broadcast`	Configures the OSPF network type to a type other than the default for a given medium. • The example sets the network type to NBMA.
Step 6	**dead-interval** *seconds* **Example:**	(Optional) Sets the time to wait for a hello packet from a neighbor before declaring the neighbor down.

	Command or Action	Purpose
	`RP/0/RSP0/CPU0:router(config-ospf-ar)# dead-interval 40`	
Step 7	**hello-interval** *seconds* **Example:** `RP/0/RSP0/CPU0:router(config-ospf-ar)# hello-interval 10`	(Optional) Specifies the interval between hello packets that OSPF sends on the interface. **Note** It is recommended to set the hello timer interval to the default of 10 seconds. OSPF sessions may flap during switchover if hello-interval timer configured is less then default value.
Step 8	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf-ar)# interface GigabitEthernet 0/2/0/0`	Enters interface configuration mode and associates one or more interfaces for the area configured in Step 4. • In this example, the interface inherits the nonbroadcast network type and the hello and dead intervals from the areas because the values are not set at the interface level.

Step 9	Do one of the following:
	• **neighbor** *ip-address* [**priority** *number*] [**poll-interval** *seconds*][**cost** *number*]
	• **neighbor** *ipv6-link-local-address* [**priority** *number*] [**poll-interval** *seconds*][**cost** *number*] [**database-filter** [**all**]]
	Example:
	`RP/0/RSP0/CPU0:router(config-ospf-ar-if)# neighbor 10.20.20.1 priority 3 poll-interval 15`
	or
	`RP/0/RSP0/CPU0:router(config-ospf-ar-if)# neighbor fe80::3203:a0ff:fe9d:f3fe`
		Configures the IPv4 address of OSPF neighbors interconnecting to nonbroadcast networks.
		or
		Configures the link-local IPv6 address of OSPFv3 neighbors.
		• The *ipv6-link-local-address* argument must be in the form documented in RFC 2373 in which the address is specified in hexadecimal using 16-bit values between colons.
		• The **priority** keyword notifies the router that this neighbor is eligible to become a DR or BDR. The priority value should match the actual priority setting on the neighbor router. The neighbor priority default value is zero. This keyword does not apply to point-to-multipoint interfaces.
		• The **poll-interval** keyword does not apply to point-to-multipoint interfaces. RFC 1247 recommends that this value be much larger than the hello interval. The default is 120 seconds (2 minutes).
		• Neighbors with no specific cost configured assumes the cost of the interface, based on the **cost** command. On point-to-multipoint interfaces, **cost** *number* is the only keyword and argument combination that works. The **cost** keyword does not apply to NBMA networks.

	Command or Action	Purpose
		• The **database-filter** keyword filters outgoing LSAs to an OSPF neighbor. If you specify the **all** keyword, incoming and outgoing LSAs are filtered. Use with extreme caution since filtering may cause the routing topology to be seen as entirely different between two neighbors, resulting in " black-holing" of data traffic or routing loops.
Step 10	Repeat Step 9 for all neighbors on the interface.	—
Step 11	exit **Example:** `RP/0/RSP0/CPU0:router(config-ospf-ar-if)# exit`	Enters area configuration mode.
Step 12	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Configuring Authentication at Different Hierarchical Levels for OSPF Version 2

This task explains how to configure MD5 (secure) authentication on the OSPF router process, configure one area with plain text authentication, and then apply one interface with clear text (null) authentication.

Note Authentication configured at the interface level overrides authentication configured at the area level and the router process level. If an interface does not have authentication specifically configured, the interface inherits the authentication parameter value from a higher hierarchical level.

Before you begin

If you choose to configure authentication, you must first decide whether to configure plain text or MD5 authentication, and whether the authentication applies to all interfaces in a process, an entire area, or specific interfaces. See Route Authentication Methods for OSPF, on page 9 for information about each type of authentication and when you should use a specific method for your network.

SUMMARY STEPS

1. **configure**
2. **router ospf** *process-name*
3. **router-id** { *router-id* }
4. **authentication** [**message-digest** | **null**]
5. **message-digest-key** *key-id* **md5** { *key* | **clear** *key* | **encrypted** *key* | **LINE**}
6. **area** *area-id*
7. **interface** *type interface-path-id*
8. Repeat Step 7 for each interface that must communicate, using the same authentication.
9. **exit**
10. **area** *area-id*
11. **authentication** [**message-digest** | **null**]
12. **interface** *type interface-path-id*
13. Repeat Step 12 for each interface that must communicate, using the same authentication.
14. **interface** *type interface-path-id*
15. **authentication** [**message-digest** | **null**]
16. Use the **commit** or **end** command.

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**router ospf** *process-name* **Example:** `RP/0/RSP0/CPU0:router(config)# router ospf 1`	Enables OSPF routing for the specified routing process and places the router in router configuration mode. **Note** The *process-name* argument is any alphanumeric string no longer than 40 characters.
Step 3	**router-id** { *router-id* } **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# router-id 192.168.4.3`	Configures a router ID for the OSPF process.
Step 4	**authentication** [**message-digest**	**null**] **Example:** `RP/0/RSP0/CPU0:router(config-ospf)#authentication message-digest`	Enables MD5 authentication for the OSPF process. • This authentication type applies to the entire router process unless overridden by a lower hierarchical level such as the area or interface.

	Command or Action	Purpose
Step 5	**message-digest-key** *key-id* **md5** { *key* | **clear** *key* | **encrypted** *key* | **LINE**} **Example:** `RP/0/RSP0/CPU0:router(config-ospf)#message-digest-key 4 md5 yourkey`	Specifies the MD5 authentication key for the OSPF process. • The neighbor routers must have the same key identifier.
Step 6	**area** *area-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# area 0`	Enters area configuration mode and configures a backbone area for the OSPF process.
Step 7	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf-ar)# interface GigabitEthernet 0/1/0/3`	Enters interface configuration mode and associates one or more interfaces to the backbone area. • All interfaces inherit the authentication parameter values specified for the OSPF process (Step 4, Step 5, and Step 6).
Step 8	Repeat Step 7 for each interface that must communicate, using the same authentication.	—
Step 9	**exit** **Example:** `RP/0/RSP0/CPU0:router(config-ospf-ar)# exit`	Enters area OSPF configuration mode.
Step 10	**area** *area-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# area 1`	Enters area configuration mode and configures a nonbackbone area 1 for the OSPF process. • The *area-id* argument can be entered in dotted-decimal or IPv4 address notation, such as area 1000 or area 0.0.3.232. However, you must choose one form or the other for an area. We recommend using the IPv4 address notation.
Step 11	**authentication** [**message-digest** | **null**] **Example:** `RP/0/RSP0/CPU0:router(config-ospf-ar)# authentication`	Enables Type 1 (plain text) authentication that provides no security. • The example specifies plain text authentication (by not specifying a keyword). Use the **authentication-key** command in interface configuration mode to specify the plain text password.
Step 12	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf-ar)# interface GigabitEthernet 0/1/0/0`	Enters interface configuration mode and associates one or more interfaces to the nonbackbone area 1 specified in Step 7. • All interfaces configured inherit the authentication parameter values configured for area 1.

	Command or Action	Purpose
Step 13	Repeat Step 12 for each interface that must communicate, using the same authentication.	—
Step 14	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf-ar)# interface GigabitEthernet 0/3/0/0`	Enters interface configuration mode and associates one or more interfaces to a different authentication type.
Step 15	**authentication** [**message-digest** | **null**] **Example:** `RP/0/RSP0/CPU0:router(config-ospf-ar-if)# authentication null`	Specifies no authentication on GigabitEthernet interface 0/3/0/0, overriding the plain text authentication specified for area 1. • By default, all of the interfaces configured in the same area inherit the same authentication parameter values of the area.
Step 16	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Controlling the Frequency That the Same LSA Is Originated or Accepted for OSPF

This task explains how to tune the convergence time of OSPF routes in the routing table when many LSAs need to be flooded in a very short time interval.

SUMMARY STEPS

1. **configure**
2. Do one of the following:
   - **router ospf** *process-name*
   - **router ospfv3** *process-name*
3. **router-id** { *router-id* }
4. Perform Step 5 or Step 6 or both to control the frequency that the same LSA is originated or accepted.
5. **timers lsa refresh** *seconds*
6. **timers lsa min-arrival** *seconds*
7. **timers lsa group-pacing** *seconds*

8. Use the **commit** or **end** command.

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.

Step 2	Do one of the following:
	• **router ospf** *process-name*
	• **router ospfv3** *process-name*
	Example:
	`RP/0/RSP0/CPU0:router:router(config)# router ospf 1`
	or
	`RP/0/RSP0/CPU0:router(config)# router ospfv3 1`
		Enables OSPF routing for the specified routing process and places the router in router configuration mode.
		or
		Enables OSPFv3 routing for the specified routing process and places the router in router ospfv3 configuration mode.
		Note
		The *process-name* argument is any alphanumeric string no longer than 40 characters.

Step 3	**router-id** { *router-id* } **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# router-id 192.168.4.3`	Configures a router ID for the OSPF process. **Note** We recommend using a stable IP address as the router ID.
Step 4	Perform Step 5 or Step 6 or both to control the frequency that the same LSA is originated or accepted.	—
Step 5	**timers lsa refresh** *seconds* **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# timers lsa refresh 1800`	Sets how often self-originated LSAs should be refreshed, in seconds. • The default is 1800 seconds for both OSPF and OSPFv3.
Step 6	**timers lsa min-arrival** *seconds* **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# timers lsa min-arrival 2`	Limits the frequency that new processes of any particular OSPF Version 2 LSA can be accepted during flooding. • The default is 1 second.
Step 7	**timers lsa group-pacing** *seconds* **Example:**	Changes the interval at which OSPF link-state LSAs are collected into a group for flooding. • The default is 240 seconds.

	Command or Action	Purpose
	`RP/0/RSP0 /CPU0:router(config-ospf)# timers lsa group-pacing 1000`	
Step 8	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Creating a Virtual Link with MD5 Authentication to Area 0 for OSPF

This task explains how to create a virtual link to your backbone (area 0) and apply MD5 authentication. You must perform the steps described on both ABRs, one at each end of the virtual link. To understand virtual links, see Virtual Link and Transit Area for OSPF, on page 15 .

Note After you explicitly configure area parameter values, they are inherited by all interfaces bound to that area—unless you override the values and configure them explicitly for the interface. An example is provided in Virtual Link Configured with MD5 Authentication for OSPF Version 2: Example, on page 123.

Before you begin

The following prerequisites must be met before creating a virtual link with MD5 authentication to area 0:

- You must have the router ID of the neighbor router at the opposite end of the link to configure the local router. You can execute the **show ospf** or **show ospfv3** command on the remote router to get its router ID.
- For a virtual link to be successful, you need a stable router ID at each end of the virtual link. You do not want them to be subject to change, which could happen if they are assigned by default. (See OSPF Process and Router ID, on page 8 for an explanation of how the router ID is determined.) Therefore, we recommend that you perform one of the following tasks before configuring a virtual link:
  - Use the **router-id** command to set the router ID. This strategy is preferable.
  - Configure a loopback interface so that the router has a stable router ID.
- Before configuring your virtual link for OSPF Version 2, you must decide whether to configure plain text authentication, MD5 authentication, or no authentication (which is the default). Your decision determines whether you need to perform additional tasks related to authentication.

Note If you decide to configure plain text authentication or no authentication, see the **authentication** command provided in *OSPF Commands on* Cisco ASR 9000 Series Router module in *Routing Command Reference for Cisco ASR 9000 Series Routers*.

SUMMARY STEPS

1. Do one of the following:
   - **show ospf** [*process-name*]
   - **show ospfv3** [*process-name*]
2. **configure**
3. Do one of the following:
   - **router ospf** *process-name*
   - **router ospfv3** *process-name*
4. **router-id** { *router-id* }
5. **area** *area-id*
6. **virtual-link** *router-id*
7. **authentication message-digest**
8. **message-digest-key** *key-id* **md5** { *key* | **clear** *key* | **encrypted** *key* }
9. Repeat all of the steps in this task on the ABR that is at the other end of the virtual link. Specify the same key ID and key that you specified for the virtual link on this router.
10. Use the **commit** or **end** command.
11. Do one of the following:
    - **show ospf** [*process-name*] [*area-id*] **virtual-links**
    - **show ospfv3** [*process-name*] **virtual-links**

DETAILED STEPS

Procedure

	Command or Action	Purpose

Step 1	Do one of the following:
	• **show ospf** [*process-name*]
	• **show ospfv3** [*process-name*]
	Example:
	`RP/0/RSP0/CPU0:router# show ospf`
	or
	`RP/0/RSP0/CPU0:router# show ospfv3`
		(Optional) Displays general information about OSPF routing processes.
		• The output displays the router ID of the local router. You need this router ID to configure the other end of the link.

	Command or Action	Purpose
Step 2	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.

Step 3	Do one of the following:
	• **router ospf** *process-name*
	• **router ospfv3** *process-name*
	Example:
	`RP/0/RSP0/CPU0:router(config)# router ospf 1`
	or
	`RP/0/RSP0/CPU0:router(config)# router ospfv3 1`
		Enables OSPF routing for the specified routing process and places the router in router configuration mode.
		or
		Enables OSPFv3 routing for the specified routing process and places the router in router ospfv3 configuration mode.
		Note
		The *process-name* argument is any alphanumeric string no longer than 40 characters.

Step 4	**router-id** { *router-id* } **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# router-id 192.168.4.3`	Configures a router ID for the OSPF process. **Note** We recommend using a stable IPv4 address as the router ID.
Step 5	**area** *area-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# area 1`	Enters area configuration mode and configures a nonbackbone area for the OSPF process. • The *area-id* argument can be entered in dotted-decimal or IPv4 address notation, such as area 1000 or area 0.0.3.232. However, you must choose one form or the other for an area. We recommend using the IPv4 address notation.
Step 6	**virtual-link** *router-id* **Example:** `RRP/0/RSP0/CPU0:router(config-ospf-ar)# virtual-link 10.3.4.5`	Defines an OSPF virtual link. • See .
Step 7	**authentication message-digest** **Example:** `RP/0/RSP0/CPU0:router(config-ospf-ar-vl)#authentication message-digest`	Selects MD5 authentication for this virtual link.
Step 8	**message-digest-key** *key-id* **md5** { *key* | **clear** *key* | **encrypted** *key* } **Example:** `RP/0/RSP0/CPU0:router(config-ospf-ar-vl)#message-digest-key 4 md5 yourkey`	Defines an OSPF virtual link. • See to understand a virtual link. • The *key-id* argument is a number in the range from 1 to 255. The *key* argument is an alphanumeric string of up to 16 characters. The routers at both ends of the

	Command or Action	Purpose
		virtual link must have the same key identifier and key to be able to route OSPF traffic. • The **authentication-key** *key* command is not supported for OSPFv3. • Once the key is encrypted it must remain encrypted.
Step 9	Repeat all of the steps in this task on the ABR that is at the other end of the virtual link. Specify the same key ID and key that you specified for the virtual link on this router.	—
Step 10	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Step 11	Do one of the following:
	• **show ospf** [*process-name*] [*area-id*] **virtual-links**
	• **show ospfv3** [*process-name*] **virtual-links**
	Example:
	`RP/0/RSP0/CPU0:router# show ospf 1 2 virtual-links`
	or
	`RP/0/RSP0/CPU0:router# show ospfv3 1 virtual-links`
		(Optional) Displays the parameters and the current state of OSPF virtual links.

Examples

OSPFv3 virtual link verification

In the following example, the **show ospfv3 virtual links** command executed in the EXEC configuration verifies that the OSPF_VL0 virtual link to the OSPFv3 neighbor is up, the ID of the virtual link interface is 2, and the IPv6 address of the virtual link endpoint is 2003:3000::1.

```
 show ospfv3 virtual-links

Virtual Links for OSPFv3 1

Virtual Link OSPF_VL0 to router 10.0.0.3 is up
  Interface ID 2, IPv6 address 2003:3000::1
  Run as demand circuit
  DoNotAge LSA allowed.
```

```
  Transit area 0.1.20.255, via interface GigabitEthernet 0/1/0/1, Cost of using 2
  Transmit Delay is 5 sec, State POINT_TO_POINT,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:02
    Adjacency State FULL (Hello suppressed)
    Index 0/2/3, retransmission queue length 0, number of retransmission 1
    First 0(0)/0(0)/0(0) Next 0(0)/0(0)/0(0)
    Last retransmission scan length is 1, maximum is 1
    Last retransmission scan time is 0 msec, maximum is 0 msec

Check for lines:
Virtual Link OSPF_VL0 to router 10.0.0.3 is up
    Adjacency State FULL (Hello suppressed)

State is up and Adjacency State is FULL
```

Summarizing Subnetwork LSAs on an OSPF ABR

If you configured two or more subnetworks when you assigned your IP addresses to your interfaces, you might want the software to summarize (aggregate) into a single LSA all of the subnetworks that the local area advertises to another area. Such summarization would reduce the number of LSAs and thereby conserve network resources. This summarization is known as interarea route summarization. It applies to routes from within the autonomous system. It does not apply to external routes injected into OSPF by way of redistribution.

This task configures OSPF to summarize subnetworks into one LSA, by specifying that all subnetworks that fall into a range are advertised together. This task is performed on an ABR only.

SUMMARY STEPS

1. **configure**
2. Do one of the following:
   - **router ospf** *process-name*
   - **router ospfv3** *process-name*
3. **router-id** { *router-id* }
4. **area** *area-id*
5. Do one of the following:
   - **range** *ip-address mask* [**advertise** | **not-advertise**]
   - **range** *ipv6-prefix / prefix-length* [**advertise** | **not-advertise**]
6. **interface** *type interface-path-id*
7. Use the **commit** or **end** command.

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:**	Enters global configuration mode.

	Command or Action	Purpose
	`RP/0/RSP0/CPU0:router# configure`	

Step 2	Do one of the following:
	• **router ospf** *process-name*
	• **router ospfv3** *process-name*
	Example:
	`RP/0/RSP0/CPU0:router(config)# router ospf 1`
	or
	`RP/0/RSP0/CPU0:router(config)# router ospfv3 1`
		Enables OSPF routing for the specified routing process and places the router in router configuration mode.
		or
		Enables OSPFv3 routing for the specified routing process and places the router in router ospfv3 configuration mode.
		Note
		The *process-name* argument is any alphanumeric string no longer than 40 characters.

Step 3	**router-id** { *router-id* } **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# router-id 192.168.4.3`	Configures a router ID for the OSPF process. **Note** We recommend using a stable IPv4 address as the router ID.
Step 4	**area** *area-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# area 10`	Enters area configuration mode and configures a nonbackbone area for the OSPF process. • The *area-id* argument can be entered in dotted-decimal or IPv4 address notation, such as area 1000 or area 0.0.3.232. However, you must choose one form or the other for an area. We recommend using the IPv4 address notation.

Step 5	Do one of the following:
	• **range** *ip-address mask* [**advertise** | **not-advertise**]
	• **range** *ipv6-prefix* / *prefix-length* [**advertise** | **not-advertise**]
	Example:
	`RP/0/RSP0/CPU0:router(config-ospf-ar)# range 192.168.0.0 255.255.0.0 advertise`
	or
	`RP/0/RSP0/CPU0:router(config-ospf-ar)# range 4004:f000::/32 advertise`
		Consolidates and summarizes OSPF routes at an area boundary.
		• The **advertise** keyword causes the software to advertise the address range of subnetworks in a Type 3 summary LSA.
		• The **not-advertise** keyword causes the software to suppress the Type 3 summary LSA, and the subnetworks in the range remain hidden from other areas.
		• In the first example, all subnetworks for network 192.168.0.0 are summarized and advertised by the ABR into areas outside the backbone.
		• In the second example, two or more IPv4 interfaces are covered by a 192.*x.x* network.

Step 6	**interface** *type interface-path-id* **Example:**	Enters interface configuration mode and associates one or more interfaces to the area.

	Command or Action	Purpose
	`RP/0/RSP0/CPU0:router(config-ospf-ar)# interface GigabitEthernet 0/2/0/3`	
Step 7	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Redistribute Routes into OSPF

This task redistributes routes from an IGP (could be a different OSPF process) into OSPF.

Before you begin

For information about configuring routing policy, see *Implementing Routing Policy on Cisco ASR 9000 Series Router* module in the *Routing Configuration Guide for Cisco ASR 9000 Series Routers*.

SUMMARY STEPS

1. **configure**
2. Do one of the following:
   - **router ospf** *process-name*
   - **router ospfv3** *process-name*
3. **router-id** { *router-id* }
4. **redistribute** *protocol* [*process-id*] { **level-1** | **level-1-2** | **level-2** } [**metric** *metric-value*] [**metric-type** *type-value*] [**match** { **external** [**1** | **2**]} [**tag** *tag-value*] [**route-policy** *policy-name*]
5. Do one of the following:
   - **summary-prefix** *address mask* [**not-advertise**] [**tag** *tag*]
   - **summary-prefix** *ipv6-prefix / prefix-length* [**not-advertise**] [**tag** *tag*]
6. Use the **commit** or **end** command.

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.

Step 2	Do one of the following:
	• **router ospf** *process-name*
	• **router ospfv3** *process-name*
	Example:
	`RP/0/RSP0/CPU0:router(config)# router ospf 1`
	or
	`RP/0/RSP0/CPU0:router(config)# router ospfv3 1`
		Enables OSPF routing for the specified routing process and places the router in router configuration mode.
		or
		Enables OSPFv3 routing for the specified routing process and places the router in router ospfv3 configuration mode.
		Note
		The *process-name* argument is any alphanumeric string no longer than 40 characters.

Step 3	**router-id** { *router-id* } **Example:** `RRP/0/RSP0/CPU0:router(config-ospf)# router-id 192.168.4.3`	Configures a router ID for the OSPF process. **Note** We recommend using a stable IPv4 address as the router ID.

Step 4	**redistribute** *protocol* [*process-id*] { **level-1** | **level-1-2** | **level-2** } [**metric** *metric-value*] [**metric-type** *type-value*] [**match** { **external** [**1** | **2**]} [**tag** *tag-value*] [**route-policy** *policy-name*]
	Example:
	`RP/0/RSP0/CPU0:router(config-ospf)# redistribute bgp 100`
	or
	`RP/0/RSP0/CPU0:router(config-router)#redistribute bgp 110`
		Redistributes OSPF routes from one routing domain to another routing domain.
		or
		Redistributes OSPFv3 routes from one routing domain to another routing domain.
		• This command causes the router to become an ASBR by definition.
		• OSPF tags all routes learned through redistribution as external.
		• The protocol and its process ID, if it has one, indicate the protocol being redistributed into OSPF.
		• The metric is the cost you assign to the external route. The default is 20 for all protocols except BGP, whose default metric is 1.
		• The OSPF example redistributes BGP autonomous system 1, Level 1 routes into OSPF as Type 2 external routes.

	Command or Action	Purpose
		• The OSPFv3 example redistributes BGP autonomous system 1, Level 1 and 2 routes into OSPF. The external link type associated with the default route advertised into the OSPFv3 routing domain is the Type 1 external route. **Note** RPL is not supported for OSPFv3.

Step 5	Do one of the following:
	• **summary-prefix** *address mask* [**not-advertise**] [**tag** *tag*]
	• **summary-prefix** *ipv6-prefix / prefix-length* [**not-advertise**] [**tag** *tag*]
	Example:
	`RP/0/RSP0/CPU0:router(config-ospf)# summary-prefix 10.1.0.0 255.255.0.0`
	or
	`RP/0/RSP0/CPU0:router(config-router)# summary-prefix 2010:11:22::/32`
		(Optional) Creates aggregate addresses for OSPF.
		or
		(Optional) Creates aggregate addresses for OSPFv3.
		• This command provides external route summarization of the non-OSPF routes.
		• External ranges that are being summarized should be contiguous. Summarization of overlapping ranges from two different routers could cause packets to be sent to the wrong destination.
		• This command is optional. If you do not specify it, each route is included in the link-state database and advertised in LSAs.
		• In the OSPFv2 example, the summary address 10.1.0.0 includes address 10.1.1.0, 10.1.2.0, 10.1.3.0, and so on. Only the address 10.1.0.0 is advertised in an external LSA.
		• In the OSPFv3 example, the summary address 2010:11:22::/32 has addresses such as 2010:11:22:0:1000::1, 2010:11:22:0:2000:679:1, and so on. Only the address 2010:11:22::/32 is advertised in the external LSA.

Step 6	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Configuring OSPF Shortest Path First Throttling

This task explains how to configure SPF scheduling in millisecond intervals and potentially delay SPF calculations during times of network instability. This task is optional.

SUMMARY STEPS

1. **configure**
2. Do one of the following:
   - **router ospf** *process-name*
   - **router ospfv3** *process-name*
3. **router-id** { *router-id* }
4. **timers throttle spf** *spf-start spf-hold spf-max-wait*
5. **area** *area-id*
6. **interface** *type interface-path-id*
7. Use the **commit** or **end** command.
8. Do one of the following:
   - **show ospf** [*process-name*]
   - **show ospfv3** [*process-name*]

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.

Step 2	Do one of the following:
	• **router ospf** *process-name*
	• **router ospfv3** *process-name*
	Example:
	`RP/0/RSP0/CPU0:router(config)# router ospf 1`
	or
	`RP/0/RSP0/CPU0:router(config)# router ospfv3 1`
		Enables OSPF routing for the specified routing process and places the router in router configuration mode.
		or
		Enables OSPFv3 routing for the specified routing process and places the router in router ospfv3 configuration mode.
		Note
		The *process-name* argument is any alphanumeric string no longer than 40 characters.

Step 3	**router-id** { *router-id* } **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# router-id 192.168.4.3`	Configures a router ID for the OSPF process. **Note** We recommend using a stable IPv4 address as the router ID.

	Command or Action	Purpose
Step 4	**timers throttle spf** *spf-start spf-hold spf-max-wait* **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# timers throttle spf 10 4800 90000`	Sets SPF throttling timers.
Step 5	**area** *area-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf)#  area 0`	Enters area configuration mode and configures a backbone area. • The *area-id* argument can be entered in dotted-decimal or IPv4 address notation, such as area 1000 or area 0.0.3.232. However, you must choose one form or the other for an area. We recommend using the IPv4 address notation.
Step 6	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf-ar)# interface GigabitEthernet 0/1/0/3`	Enters interface configuration mode and associates one or more interfaces to the area.
Step 7	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Step 8	Do one of the following:
	• **show ospf** [*process-name*]
	• **show ospfv3** [*process-name*]
	Example:
	`RP/0/RSP0/CPU0:router# show ospf 1`
	or
	`RP/0/RSP0/CPU0:router# RP/0/RP0/CPU0:router# show ospfv3 2`
		(Optional) Displays SPF throttling timers.

Examples

In the following example, the **show ospf** EXEC configuration command is used to verify that the initial SPF schedule delay time, minimum hold time, and maximum wait time are configured correctly. Additional details are displayed about the OSPF process, such as the router type and redistribution of routes.

```
show ospf 1

 Routing Process "ospf 1" with ID 192.168.4.3
  Supports only single TOS(TOS0) routes
  Supports opaque LSA
  It is an autonomous system boundary router
  Redistributing External Routes from,
     ospf 2
  Initial SPF schedule delay 5 msecs
  Minimum hold time between two consecutive SPFs 100 msecs
  Maximum wait time between two consecutive SPFs 1000 msecs
  Minimum LSA interval 5 secs. Minimum LSA arrival 1 secs
  Number of external LSA 0. Checksum Sum 00000000
  Number of opaque AS LSA 0. Checksum Sum 00000000
  Number of DCbitless external and opaque AS LSA 0
  Number of DoNotAge external and opaque AS LSA 0
  Number of areas in this router is 1. 1 normal 0 stub 0 nssa
  External flood list length 0
  Non-Stop Forwarding enabled
```

Note For a description of each output display field, see the **show ospf** command in the *OSPF Commands on Cisco ASR 9000 Series Router* module in *Routing Command Reference for Cisco ASR 9000 Series Routers*.

Configuring Nonstop Forwarding Specific to Cisco for OSPF Version 2

This task explains how to configure OSPF NSF specific to Cisco on your NSF-capable router. This task is optional.

Before you begin

OSPF NSF requires that all neighbor networking devices be NSF aware, which happens automatically after you install the Cisco IOS XR software image on the router. If an NSF-capable router discovers that it has non-NSF-aware neighbors on a particular network segment, it disables NSF capabilities for that segment. Other network segments composed entirely of NSF-capable or NSF-aware routers continue to provide NSF capabilities.

Note The following are restrictions when configuring nonstop forwarding:

- OSPF Cisco NSF for virtual links is not supported.
- Neighbors must be NSF aware.

SUMMARY STEPS

1. **configure**
2. **router ospf** *process-name*
3. **router-id** { *router-id* }
4. Do one of the following:
   - **nsf cisco**
   - **nsf cisco enforce global**
5. **nsf interval** *seconds*
6. **nsfflush-delay-time***seconds*
7. **nsflifetime***seconds*
8. **nsfietf**
9. Use the **commit** or **end** command.

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**router ospf** *process-name* **Example:** `RP/0/RSP0/CPU0:router(config)# router ospf 1`	Enables OSPF routing for the specified routing process and places the router in router configuration mode. **Note** The *process-name* argument is any alphanumeric string no longer than 40 characters.
Step 3	**router-id** { *router-id* } **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# router-id 192.168.4.3`	Configures a router ID for the OSPF process. **Note** We recommend using a stable IPv4 address as the router ID.
Step 4	Do one of the following: • **nsf cisco** • **nsf cisco enforce global** **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# nsf cisco enforce global`	Enables Cisco NSF operations for the OSPF process. • Use the **nsf cisco** command without the optional **enforce** and **global** keywords to abort the NSF restart mechanism on the interfaces of detected non-NSF neighbors and allow NSF neighbors to function properly. • Use the **nsf cisco** command with the optional **enforce** and **global** keywords if the router is expected to perform NSF during restart. However, if non-NSF

	Command or Action	Purpose
		neighbors are detected, NSF restart is canceled for the entire OSPF process.
Step 5	**nsf interval** *seconds* **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# nsf interval 120`	Sets the minimum time between NSF restart attempts. **Note** When you use this command, the OSPF process must be up for at least 90 seconds before OSPF attempts to perform an NSF restart.
Step 6	**nsfflush-delay-time***seconds* **Example:** `RP/0/RSP0/CPU0:router(config-ospf)#nsf flush-delay-time 1000`	Sets the maximum time allowed for external route learning in seconds.
Step 7	**nsflifetime***seconds* **Example:** `RP/0/RSP0/CPU0:router(config-ospf)#nsf lifetime 90`	Sets the maximum route lifetime of NSF following a restart in seconds.
Step 8	**nsfietf** **Example:** `RP/0/RSP0/CPU0:router(config-ospf)#nsf ietf`	Enables ietf graceful restart.
Step 9	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Configuring OSPF Version 2 for MPLS Traffic Engineering

This task explains how to configure OSPF for MPLS TE. This task is optional.

For a description of the MPLS TE tasks and commands that allow you to configure the router to support tunnels, configure an MPLS tunnel that OSPF can use, and troubleshoot MPLS TE, see *Implementing MPLS Traffic Engineering* on *Cisco ASR 9000 Series Router* module of the *MPLS Configuration Guide for Cisco ASR 9000 Series Routers*

Before you begin

Your network must support the following features before you enable MPLS TE for OSPF on your router:

- MPLS
- IP Cisco Express Forwarding (CEF)

Note You must enter the commands in the following task on every OSPF router in the traffic-engineered portion of your network.

SUMMARY STEPS

1. **configure**
2. **router ospf** *process-name*
3. **router-id** { *router-id* }
4. **mpls traffic-eng router-id** *interface-type interface-instance*
5. **area** *area-id*
6. **mpls traffic-eng**
7. **interface** *type interface-path-id*
8. Use the **commit** or **end** command.
9. **show ospf** [*process-name*] [*area-id*] **mpls traffic-eng** { **link** | **fragment** }

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**router ospf** *process-name* **Example:** `RP/0/RSP0/CPU0:router(config)# router ospf 1`	Enables OSPF routing for the specified routing process and places the router in router configuration mode. **Note** The *process-name* argument is any alphanumeric string no longer than 40 characters.
Step 3	**router-id** { *router-id* } **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# router-id 192.168.4.3`	Configures a router ID for the OSPF process. **Note** We recommend using a stable IPv4 address as the router ID.

	Command or Action	Purpose
Step 4	**mpls traffic-eng router-id** *interface-type interface-instance* **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# mpls traffic-eng router-id loopback 0`	(Optional) Specifies that the traffic engineering router identifier for the node is the IP address associated with a given interface. • This IP address is flooded to all nodes in TE LSAs. • For all traffic engineering tunnels originating at other nodes and ending at this node, you must set the tunnel destination to the traffic engineering router identifier of the destination node because that is the address that the traffic engineering topology database at the tunnel head uses for its path calculation. • We recommend that loopback interfaces be used for MPLS TE router ID because they are more stable than physical interfaces.
Step 5	**area** *area-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# area 0`	Enters area configuration mode and configures an area for the OSPF process. • The *area-id* argument can be entered in dotted-decimal or IPv4 address notation, such as area 1000 or area 0.0.3.232. However, you must choose one form or the other for an area.
Step 6	**mpls traffic-eng** **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# mpls traffic-eng`	Configures the MPLS TE under the OSPF area.
Step 7	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf-ar)# interface interface loopback0`	Enters interface configuration mode and associates one or more interfaces to the area.
Step 8	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

	Command or Action	Purpose
Step 9	**show ospf** [*process-name*] [*area-id*] **mpls traffic-eng** { **link** | **fragment** } **Example:** `RP/0/RSP0/CPU0:router# show ospf 1 0 mpls traffic-eng link`	(Optional) Displays information about the links and fragments available on the local router for MPLS TE.

Examples

This section provides the following output examples:

Sample Output for the show ospf Command Before Configuring MPLS TE

In the following example, the **show route ospf** EXEC configuration command verifies that GigabitEthernet interface 0/3/0/0 exists and MPLS TE is not configured:

```
show route ospf 1

O    11.0.0.0/24 [110/15] via 0.0.0.0, 3d19h, tunnel-te1
O    192.168.0.12/32 [110/11] via 11.1.0.2, 3d19h, GigabitEthernet0/3/0/0
O    192.168.0.13/32 [110/6] via 0.0.0.0, 3d19h, tunnel-te1
```

Sample Output for the show ospf mpls traffic-eng Command

In the following example, the **show ospf mpls traffic-eng** EXEC configuration command verifies that the MPLS TE fragments are configured correctly:

```
 show ospf 1 mpls traffic-eng fragment

OSPF Router with ID (192.168.4.3) (Process ID 1)

  Area 0 has 1  MPLS TE fragment. Area instance is 3.
  MPLS router address is 192.168.4.2
  Next fragment ID is 1

  Fragment 0 has 1 link. Fragment instance is 3.
  Fragment has 0 link the same as last update.
  Fragment advertise MPLS router address
    Link is associated with fragment 0. Link instance is 3
      Link connected to Point-to-Point network
      Link ID :55.55.55.55
      Interface Address :192.168.50.21
      Neighbor Address :192.168.4.1
      Admin Metric :0
      Maximum bandwidth :19440000
      Maximum global pool reservable bandwidth :25000000
      Maximum sub pool reservable bandwidth    :3125000
      Number of Priority :8
      Global pool unreserved BW
      Priority 0 :  25000000  Priority 1 :  25000000
      Priority 2 :  25000000  Priority 3 :  25000000
      Priority 4 :  25000000  Priority 5 :  25000000
      Priority 6 :  25000000  Priority 7 :  25000000
      Sub pool unreserved BW
```

```
    Priority 0 :   3125000  Priority 1 :   3125000
    Priority 2 :   3125000  Priority 3 :   3125000
    Priority 4 :   3125000  Priority 5 :   3125000
    Priority 6 :   3125000  Priority 7 :   3125000
    Affinity Bit :0
```

In the following example, the **show ospf mpls traffic-eng** EXEC configuration command verifies that the MPLS TE links on area instance 3 are configured correctly:

```
show ospf mpls traffic-eng link

            OSPF Router with ID (192.168.4.1) (Process ID 1)

  Area 0 has 1  MPLS TE links. Area instance is 3.

  Links in hash bucket 53.
    Link is associated with fragment 0. Link instance is 3
      Link connected to Point-to-Point network
      Link ID :192.168.50.20
      Interface Address :192.168.20.50
      Neighbor Address :192.168.4.1
      Admin Metric :0
      Maximum bandwidth :19440000
      Maximum global pool reservable bandwidth :25000000
      Maximum sub pool reservable bandwidth    :3125000
      Number of Priority :8
      Global pool unreserved BW
      Priority 0 :  25000000  Priority 1 :  25000000
      Priority 2 :  25000000  Priority 3 :  25000000
      Priority 4 :  25000000  Priority 5 :  25000000
      Priority 6 :  25000000  Priority 7 :  25000000
      Sub pool unreserved BW
      Priority 0 :   3125000  Priority 1 :   3125000
      Priority 2 :   3125000  Priority 3 :   3125000
      Priority 4 :   3125000  Priority 5 :   3125000
      Priority 6 :   3125000  Priority 7 :   3125000
      Affinity Bit :0
```

Sample Output for the show ospf Command After Configuring MPLS TE

In the following example, the **show route ospf** EXEC configuration command verifies that the MPLS TE tunnels replaced GigabitEthernet interface 0/3/0/0 and that configuration was performed correctly:

```
show route ospf 1

 O E2 192.168.10.0/24 [110/20] via 0.0.0.0, 00:00:15, tunnel2
 O E2 192.168.11.0/24 [110/20] via 0.0.0.0, 00:00:15, tunnel2
 O E2 192.168.1244.0/24 [110/20] via 0.0.0.0, 00:00:15, tunnel2
 O    192.168.12.0/24 [110/2] via 0.0.0.0, 00:00:15, tunnel2
```

Configuring OSPFv3 Graceful Restart

This task explains how to configure a graceful restart for an OSPFv3 process. This task is optional.

SUMMARY STEPS

1. **configure**
2. **router ospfv3** *process-name*
3. **graceful-restart**
4. **graceful-restart lifetime**
5. **graceful-restart interval** *seconds*
6. **graceful-restart helper disable**
7. Use the **commit** or **end** command.
8. **show ospfv3** [*process-name* [*area-id*]] **database grace**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**router ospfv3** *process-name* **Example:** `RP/0/RSP0/CPU0:router(config)# router ospfv3 test`	Enters router configuration mode for OSPFv3. The process name is a WORD that uniquely identifies an OSPF routing process. The process name is any alphanumeric string no longer than 40 characters without spaces.
Step 3	**graceful-restart** **Example:** `RP/0/RSP0/CPU0:router(config-ospfv3)#graceful-restart`	Enables graceful restart on the current router.
Step 4	**graceful-restart lifetime** **Example:** `RP/0/RSP0/CPU0:router(config-ospfv3)# graceful-restart lifetime 120`	Specifies a maximum duration for a graceful restart. • The default lifetime is 95 seconds. • The range is 90 to 3600 seconds.
Step 5	**graceful-restart interval** *seconds* **Example:** `RP/0/RSP0/CPU0:router(config-ospfv3)# graceful-restart interval 120`	Specifies the interval (minimal time) between graceful restarts on the current router. • The default value for the interval is 90 seconds. • The range is 90 to 3600 seconds.
Step 6	**graceful-restart helper disable** **Example:** `RP/0/RSP0/CPU0:router(config-ospfv3)# graceful-restart helper disable`	Disables the helper capability.

	Command or Action	Purpose
Step 7	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.
Step 8	**show ospfv3** [*process-name* [*area-id*]] **database grace** **Example:** `RP/0/RSP0/CPU0:router# show ospfv3 1 database grace`	Displays the state of the graceful restart link.

Displaying Information About Graceful Restart

This section describes the tasks you can use to display information about a graceful restart.

- To see if the feature is enabled and when the last graceful restart ran, use the **show ospf** command. To see details for an OSPFv3 instance, use the **show ospfv3** *process-name* [*area-id*] **database grace** command.

Displaying the State of the Graceful Restart Feature

The following screen output shows the state of the graceful restart capability on the local router:

```
RP/0/RSP0/CPU0:router# show ospfv3 1

 Routing Process "ospfv3 1" with ID 198.51.100.1
 Initial SPF schedule delay 5000 msecs
 Minimum hold time between two consecutive SPFs 10000 msecs
 Maximum wait time between two consecutive SPFs 10000 msecs
 Initial LSA throttle delay 0 msecs
 Minimum hold time for LSA throttle 5000 msecs
 Maximum wait time for LSA throttle 5000 msecs
 Minimum LSA arrival 1000 msecs
 LSA group pacing timer 240 secs
 Interface flood pacing timer 33 msecs
 Retransmission pacing timer 66 msecs
 Maximum number of configured interfaces 255
 Number of external LSA 0. Checksum Sum 00000000
 Number of areas in this router is 1. 1 normal 0 stub 0 nssa
 Graceful Restart enabled, last GR 11:12:26 ago (took 6 secs)
    Area BACKBONE(0)
        Number of interfaces in this area is 1
        SPF algorithm executed 1 times
        Number of LSA 6. Checksum Sum 0x0268a7
        Number of DCbitless LSA 0
        Number of indication LSA 0
```

```
        Number of DoNotAge LSA 0
        Flood list length 0
```

Displaying Graceful Restart Information for an OSPFv3 Instance

The following screen output shows the link state for an OSPFv3 instance:

```
RP/0/RSP0/CPU0:router# show ospfv3 1 database grace

            OSPFv3 Router with ID (192.0.2.1) (Process ID 1)

            Grace (Type-11) Link States (Area 0)

LS age: 2
LS Type: Grace Links
Link State ID: 34
Advertising Router: 192.0.2.1
LS Seq Number: 80000001
Checksum: 0x7a4a
Length: 36
    Grace Period : 90
    Graceful Restart Reason : Software reload/upgrade
```

Configuring an OSPFv2 Sham Link

This task explains how to configure a provider edge (PE) router to establish an OSPFv2 sham link connection across a VPN backbone. This task is optional.

Before you begin

Before configuring a sham link in a Multiprotocol Label Switching (MPLS) VPN between

provider edge (PE) routers, OSPF must be enabled as follows:

- Create an OSPF routing process.
- Configure a loopback interface that belongs to VRF and assign a IPv4 address with the host mask to it.
- Configure the sham link under the area submode.

See Enabling OSPF, on page 43 for information on these OSPF configuration prerequisites.

SUMMARY STEPS

1. **configure**
2. **interface** *type interface-path-id*
3. **vrf** *vrf-name*
4. **ipv4 address** *ip-address mask*
5. end
6. **router ospf** *instance-id*
7. **vrf** *vrf-name*
8. **router-id** { *router-id* }
9. **redistribute bgp** *process-id*

10. **area** *area-id*
11. **sham-link** *source-address destination-address*
12. **cost** *cost*
13. Use the **commit** or **end** command.

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config)# interface loopback 3`	Enters interface configuration mode.
Step 3	**vrf** *vrf-name* **Example:** `RP/0/RSP0/CPU0:router(config-if)# vrf vrf1`	Assigns an interface to the VPN routing and forwarding (VRF) instance.
Step 4	**ipv4 address** *ip-address mask* **Example:** `RP/0/RSP0/CPU0:router(config-if)# ipv4 address 172.18.189.38 255.255.255.225`	Assigns an IP address and subnet mask to the interface.
Step 5	end **Example:** `RP/0/RSP0/CPU0:router(config-if)# end`	Saves configuration changes. When you issue the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)?[cancel]:` • Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. • Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.

	Command or Action	Purpose
		• Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
Step 6	**router ospf** *instance-id* **Example:** `RP/0/RSP0/CPU0:router(config)# router ospf isp`	Enables OSPF routing for the specified routing process, and places the router in router configuration mode. In this example, the OSPF instance is called isp.
Step 7	**vrf** *vrf-name* **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# vrf vrf1`	Creates a VRF instance and enters VRF configuration mode.
Step 8	**router-id** { *router-id* } **Example:** `RP/0/RSP0/CPU0:router(config-ospf-vrf)# router-id 192.168.4.3`	Configures a router ID for the OSPF process. **Note** We recommend using a stable IPv4 address as the router ID.
Step 9	**redistribute bgp** *process-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf-vrf)# redistribute bgp 1`	Redistributes OSPF routes from the one routing domain to another routing domain. • This command causes the router to become an ASBR by definition. • OSPF tags all routes learned through redistribution as external. • The protocol and its process ID, if it has one, indicate the protocol being redistributed into OSPF. • The BGP MED value is copied to the LSA metric field when BGP VPN routes are redistributed to OSPF.
Step 10	**area** *area-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf-vrf)# area 0`	Enters area configuration mode and configures an area for the OSPF process. • The *area-id* argument can be entered in dotted-decimal or IPv4 address notation, such as area 1000 or area 0.0.3.232. However, you must choose one form or the other for an area.
Step 11	**sham-link** *source-address destination-address* **Example:** `RP/0/RSP0/CPU0:router(config-ospf-vrf-ar)# sham-link 10.0.0.1 10.0.0.3`	Configures a point-to-point unnumbered interface between two VPN sites.

	Command or Action	Purpose
Step 12	**cost** *cost* **Example:** `RP/0/RSP0/CPU0:router(config-ospf-vrf-ar-sl)# cost 76`	Explicitly specifies the cost of sending a packet on an OSPF interface. The specified cost overrides the auto-costing calculated default value for interfaces.
Step 13	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Configuring OSPF SPF Prefix Prioritization

Perform this task to configure OSPF SPF (shortest path first) prefix prioritization.

SUMMARY STEPS

1. **configure**
2. **prefix-set** *prefix-set name*
3. **route-policy** *route-policy name* **if destination in** *prefix-set name* **then set spf-priority** {**critical** | **high** | **medium**} **endif**
4. Use one of these commands:
   - **router ospf** *ospf-name*
   - **router ospfv3** *ospfv3-name*
5. **spf prefix-priority route-policy** *route-policy name*
6. Use the **commit** or **end** command.
7. **show rpl route-policy** *route-policy name* **detail**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.

	Command or Action	Purpose

Step 2	**prefix-set** *prefix-set name*
	Example:
	`RP/0/RSP0/CPU0:router(config)#prefix-set ospf-critical-prefixes`
	`RP/0/RSP0/CPU0:router(config-pfx)#66.0.0.0/16`
	`RP/0/RSP0/CPU0:router(config-pfx)#end-set`
		Configures the prefix set.

Step 3	**route-policy** *route-policy name* **if destination in** *prefix-set name* **then set spf-priority** {**critical** | **high** | **medium**} **endif**
	Example:
	`RP/0/RSP0/CPU0:router#route-policy ospf-spf-priority`
	`RP/0/RSP0/CPU0:router(config-rpl)#if destination in ospf-critical-prefixes then`
	`set spf-priority critical`
	`endif`
	`RP/0/RSP0/CPU0:router(config-rpl)#end-policy`
		Configures route policy and sets OSPF SPF priority.

Step 4	Use one of these commands:
	• **router ospf** *ospf-name*
	• **router ospfv3** *ospfv3-name*
	Example:
	`RP/0/RSP0/CPU0:router# router ospf 1`
	Or
	`RP/0/RSP0/CPU0:router# router ospfv3 1`
		Enters Router OSPF configuration mode.

Step 5	**spf prefix-priority route-policy** *route-policy name* **Example:** Or `RP/0/RSP0/CPU0:router(config-ospfv3)#spf prefix-priority route-policy ospf3-spf-priority`	Configures SPF prefix-priority for the defined route policy. **Note** Configure the **spf prefix-priority** command under router OSPF.
Step 6	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

	Command or Action	Purpose

Step 7	**show rpl route-policy** *route-policy name* **detail**
	Example:
	`RP/0/RSP0/CPU0:router#show rpl route-policy ospf-spf-priority detail`
	`  prefix-set ospf-critical-prefixes`
	`    66.0.0.0/16`
	`  end-set`
	`  !`
	`  route-policy ospf-spf-priority`
	`    if destination in ospf-critical-prefixes then`
	`      set spf-priority critical`
	`    endif`
	`  end-policy`
	`  !`
		Displays the set SPF prefix priority.

Enabling Multicast-intact for OSPFv2

This optional task describes how to enable multicast-intact for OSPFv2 routes that use IPv4 addresses.

SUMMARY STEPS

1. **configure**
2. **router ospf** *instance-id*
3. **mpls traffic-eng multicast-intact**
4. Use the **commit** or **end** command.

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**router ospf** *instance-id* **Example:** `RP/0/RSP0/CPU0:router(config)# router ospf isp`	Enables OSPF routing for the specified routing process, and places the router in router configuration mode. In this example, the OSPF instance is called isp.
Step 3	**mpls traffic-eng multicast-intact** **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# mpls traffic-eng multicast-intact`	Enables multicast-intact.

	Command or Action	Purpose
Step 4	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Associating Interfaces to a VRF

This task explains how to associate an interface with a VPN Routing and Forwarding (VRF) instance.

SUMMARY STEPS

1. **configure**
2. **router ospf** *process-name*
3. **vrf** *vrf-name*
4. **area** *area-id*
5. **interface** *type interface-path-id*
6. Use the **commit** or **end** command.

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**router ospf** *process-name* **Example:** `RP/0/RSP0/CPU0:router(config)# router ospf 1`	Enables OSPF routing for the specified routing process and places the router in router configuration mode. **Note** The *process-name* argument is any alphanumeric string no longer than 40 characters.
Step 3	**vrf** *vrf-name* **Example:**	Creates a VRF instance and enters VRF configuration mode.

	Command or Action	Purpose
	`RP/0/RSP0/CPU0:router(config-ospf)# vrf vrf1`	
Step 4	**area** *area-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf-vrf)# area 0`	Enters area configuration mode and configures an area for the OSPF process. • The *area-id* argument can be entered in dotted-decimal or IPv4 address notation, such as area 1000 or area 0.0.3.232. However, you must choose one form or the other for an area.
Step 5	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf-vrf-ar)# interface GigabitEthernet 0/0/0/0`	Enters interface configuration mode and associates one or more interfaces to the VRF.
Step 6	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Configuring OSPF as a Provider Edge to Customer Edge (PE-CE) Protocol

SUMMARY STEPS

1. **configure**
2. **router ospf** *process-name*
3. **vrf** *vrf-name*
4. **router-id** { *router-id* }
5. **redistribute** *protocol* [*process-id*] { **level-1** | **level-1-2** | **level-2** } [**metric** *metric-value*] [**metric-type** *type-value*] [**match** { **external** [**1** | **2**] }] [**tag** *tag-value*] **route-policy** *policy-name*]
6. **area** *area-id*
7. **interface** *type interface-path-id*
8. exit
9. **domain-id** *[* **secondary** *]* **type** *{* **0005** | **0105** | **0205** | **8005** *}* **value** *value*
10. **domain-tag** *tag*
11. disable-dn-bit-check
12. Use the **commit** or **end** command.

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**router ospf** *process-name* **Example:** `RP/0/RSP0/CPU0:router(config)# router ospf 1`	Enables OSPF routing for the specified routing process and places the router in router configuration mode. **Note** The *process-name* argument is any alphanumeric string no longer than 40 characters.
Step 3	**vrf** *vrf-name* **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# vrf vrf1`	Creates a VRF instance and enters VRF configuration mode.
Step 4	**router-id** { *router-id* } **Example:** `RP/0/RSP0/CPU0:router(config-ospf-vrf)# router-id 192.168.4.3`	Configures a router ID for the OSPF process. **Note** We recommend using a stable IPv4 address as the router ID.
Step 5	**redistribute** *protocol* [*process-id*] { **level-1** | **level-1-2** | **level-2** } [**metric** *metric-value*] [**metric-type** *type-value*] [**match** { **external** [**1** | **2**] }] [**tag** *tag-value*] **route-policy** *policy-name*] **Example:** `RP/0/RSP0/CPU0:router(config-ospf-vrf)# redistribute bgp 1 level-1`	Redistributes OSPF routes from one routing domain to another routing domain. • This command causes the router to become an ASBR by definition. • OSPF tags all routes learned through redistribution as external. • The protocol and its process ID, if it has one, indicate the protocol being redistributed into OSPF. • The metric is the cost you assign to the external route. The default is 20 for all protocols except BGP, whose default metric is 1. • The example shows the redistribution of BGP autonomous system 1, Level 1 routes into OSPF as Type 2 external routes.
Step 6	**area** *area-id* **Example:**	Enters area configuration mode and configures an area for the OSPF process.

	Command or Action	Purpose
	`RP/0/RSP0/CPU0:router(config-ospf-vrf)# area 0`	• The *area-id* argument can be entered in dotted-decimal or IPv4 address notation, such as area 1000 or area 0.0.3.232. However, you must choose one form or the other for an area.
Step 7	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf-vrf)# interface GigabitEthernet 0/0/0/0`	Enters interface configuration mode and associates one or more interfaces to the VRF.
Step 8	exit **Example:** `RP/0/RSP0/CPU0:router(config-if)# exit`	Exits interface configuration mode.
Step 9	**domain-id** *[* **secondary** *]* **type** *{* **0005** | **0105** | **0205** | **8005** *}* **value** *value* **Example:** `RP/0/RSP0/CPU0:router(config-ospf-vrf)# domain-id type 0105 value 1AF234`	Specifies the OSPF VRF domain ID. • The *value* argument is a six-octet hex number.
Step 10	**domain-tag** *tag* **Example:** `RP/0/RSP0/CPU0:router(config-0spf-vrf)# domain-tag 234`	Specifies the OSPF VRF domain tag. • The valid range for *tag* is 0 to 4294967295.
Step 11	disable-dn-bit-check **Example:** `RP/0/RSP0/CPU0:router(config-ospf-vrf)# disable-dn-bit-check`	Specifies that down bits should be ignored.
Step 12	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Creating Multiple OSPF Instances (OSPF Process and a VRF)

This task explains how to create multiple OSPF instances. In this case, the instances are a normal OSPF instance and a VRF instance.

SUMMARY STEPS

1. **configure**
2. **router ospf** *process-name*
3. **area** *area-id*
4. **interface** *type interface-path-id*
5. **exit**
6. **vrf** *vrf-name*
7. **area** *area-id*
8. **interface** *type interface-path-id*
9. Use the **commit** or **end** command.

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**router ospf** *process-name* **Example:** `RP/0/RSP0/CPU0:router(config)# router ospf 1`	Enables OSPF routing for the specified routing process and places the router in router configuration mode. **Note** The *process-name* argument is any alphanumeric string no longer than 40 characters.
Step 3	**area** *area-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf)#  area 0`	Enters area configuration mode and configures a backbone area. • The *area-id* argument can be entered in dotted-decimal or IPv4 address notation, such as area 1000 or area 0.0.3.232. However, you must choose one form or the other for an area. We recommend using the IPv4 address notation.
Step 4	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf-ar)# interface GigabitEthernet 0/1/0/3`	Enters interface configuration mode and associates one or more interfaces to the area.

	Command or Action	Purpose
Step 5	**exit** **Example:** `RP/0/RSP0/CPU0:router(config-ospf-ar)# exit`	Enters OSPF configuration mode.
Step 6	**vrf** *vrf-name* **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# vrf vrf1`	Creates a VRF instance and enters VRF configuration mode.
Step 7	**area** *area-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf-vrf)# area 0`	Enters area configuration mode and configures an area for a VRF instance under the OSPF process. • The *area-id* argument can be entered in dotted-decimal or IPv4 address notation, such as area 1000 or area 0.0.3.232. However, you must choose one form or the other for an area.
Step 8	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf-vrf)# interface GigabitEthernet 0/0/0/0`	Enters interface configuration mode and associates one or more interfaces to the VRF.
Step 9	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Configuring Multi-area Adjacency

This task explains how to create multiple areas on an OSPF primary interface.

Before you begin

Note You can configure multi-area adjacency on any interface where only two OSF speakers are attached. In the case of native broadcast networks, the interface must be configured as an OPSF point-to-point type using the **network point-to-point** command to enable the interface for a multi-area adjacency.

SUMMARY STEPS

1. **configure**
2. **router ospf** *process-name*
3. **area** *area-id*
4. **interface** *type interface-path-id*
5. **area** *area-id*
6. **multi-area-interface** *type interface-path-id*
7. Use the **commit** or **end** command.

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**router ospf** *process-name* **Example:** `RP/0/RSP0/CPU0:router(config)# router ospf 1`	Enables OSPF routing for the specified routing process and places the router in router configuration mode. **Note** The *process-name* argument is any alphanumeric string no longer than 40 characters.
Step 3	**area** *area-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf)#  area 0`	Enters area configuration mode and configures a backbone area. • The *area-id* argument can be entered in dotted-decimal or IPv4 address notation, such as area 1000 or area 0.0.3.232. However, you must choose one form or the other for an area. We recommend using the IPv4 address notation.
Step 4	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf-ar)# interface Serial 0/1/0/3`	Enters interface configuration mode and associates one or more interfaces to the area.
Step 5	**area** *area-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf)#  area 1`	Enters area configuration mode and configures an area used for multiple area adjacency. • The *area-id* argument can be entered in dotted-decimal or IPv4 address notation, such as area 1000 or area 0.0.3.232. However, you must choose one form or the other for an area. We recommend using the IPv4 address notation.

	Command or Action	Purpose
Step 6	**multi-area-interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# multi-area-interface Serial 0/1/0/3`	Enables multiple adjacencies for different OSPF areas and enters multi-area interface configuration mode
Step 7	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Configuring Label Distribution Protocol IGP Auto-configuration for OSPF

This task explains how to configure LDP auto-configuration for an OSPF instance.

Optionally, you can configure this feature for an area of an OSPF instance.

SUMMARY STEPS

1. **configure**
2. **router ospf** *process-name*
3. **mpls ldp auto-config**
4. Use the **commit** or **end** command.

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**router ospf** *process-name* **Example:** `RP/0/RSP0/CPU0:router(config)# router ospf 1`	Enables OSPF routing for the specified routing process and places the router in router configuration mode. **Note** The *process-name* argument is any alphanumeric string no longer than 40 characters.

	Command or Action	Purpose
Step 3	**mpls ldp auto-config** **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# mpls ldp auto-config`	Enables LDP IGP interface auto-configuration for an OSPF instance. • Optionally, this command can be configured for an area of an OSPF instance.
Step 4	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Configuring LDP IGP Synchronization: OSPF

Perform this task to configure LDP IGP Synchronization under OSPF.

Note By default, there is no synchronization between LDP and IGPs.

SUMMARY STEPS

1. **configure**
2. **router ospf** *process-name*
3. Use one of the following commands:
   - **mpls ldp sync**
   - **area** *area-id* **mpls ldp sync**
   - **area** *area-id* **interface** *name* **mpls ldp sync**
4. **commit**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure**	

	Command or Action	Purpose
Step 2	**router ospf** *process-name* **Example:** `RP/0/RSP0/CPU0:router(config)# router ospf 100`	Identifies the OSPF routing process and enters OSPF configuration mode.
Step 3	Use one of the following commands: • **mpls ldp sync** • **area** *area-id* **mpls ldp sync** • **area** *area-id* **interface** *name* **mpls ldp sync** **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# mpls ldp sync`	Enables LDP IGP synchronization on an interface.
Step 4	**commit**	

Configuring Authentication Message Digest Management for OSPF

This task explains how to manage authentication of a keychain on the OSPF interface.

Before you begin

A valid keychain must be configured before this task can be attempted.

To learn how to configure a keychain and its associated attributes, see the *Implementing Key Chain Management on Cisco ASR 9000 Series Router* module of the *System Security Configuration Guide for Cisco ASR 9000 Series Routers*.

SUMMARY STEPS

1. **configure**
2. **router ospf** *process-name*
3. **router-id** { *router-id* }
4. **area** *area-id*
5. **interface** *type interface-path-id*
6. **authentication** [**message-digest** *keychain* | **keychain** *keychain* | **null**]
7. Use the **commit** or **end** command.

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:**	Enters global configuration mode.

	Command or Action	Purpose
	`RP/0/RSP0/CPU0:router# configure`	
Step 2	**router ospf** *process-name* **Example:** `RP/0/RSP0/CPU0:router(config)# router ospf 1`	Enables OSPF routing for the specified routing process and places the router in router configuration mode. **Note** The *process-name* argument is any alphanumeric string no longer than 40 characters.
Step 3	**router-id** { *router-id* } **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# router id 192.168.4.3`	Configures a router ID for the OSPF process. **Note** We recommend using a stable IPv4 address as the router ID.
Step 4	**area** *area-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# area 1`	Enters area configuration mode. The *area-id* argument can be entered in dotted-decimal or IPv4 address notation, such as area 1000 or area 0.0.3.232. However, you must choose one form or the other for an area. We recommend using the IPv4 address notation.
Step 5	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf-ar)# interface GigabitEthernet0/4/0/1`	Enters interface configuration mode and associates one or more interfaces to the area.

Step 6	**authentication** [**message-digest** *keychain* | **keychain** *keychain* | **null**]
	Example:
	The following example shows the configuration for keychain authentication.
	`RP/0/RP0/CPU0:router(config-ospf)# authentication keychain test_chain -----` Router-level authentication
	`RP/0/RP0/CPU0:router(config-ospf)# router-id 1.1.1.1`
	`RP/0/RP0/CPU0:router(config-ospf)# address-family ipv4 unicast`
	`RP/0/RP0/CPU0:router(config-ospf)# area 1`
	`RP/0/RP0/CPU0:router(config-ospf-ar)# authentication keychain test_chain -----` Area-level authentication
	`RP/0/RP0/CPU0:router(config-ospf-ar)# interface TenGigE 0/0/0/1`
	`RP/0/RP0/CPU0:router(config-ospf-ar-if)# authentication keychain test_chain ---` Interface-level authentication
	`RP/0/RP0/CPU0:router(config-ospf-ar-if)# commit`
	Example:
		Configures an MD5 keychain. Keychains can be configured at the following three levels of authentication:
		• Router-level authentication
		• Area-level authentication
		• Interface-level authentication
		Note
		In the example, the *ospf_intl* keychain must be configured before you attempt this step.

	Command or Action	Purpose
	`RP/0/RSP0/CPU0:router(config-ospf-ar-if)# authentication message-digest keychain ospf_int1`	
Step 7	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Examples

The following example shows how to configure the keychain *ospf_intf_1* that contains five key IDs. Each key ID is configured with different **send-lifetime** values; however, all key IDs specify the same text string for the key.

```
key chain ospf_intf_1
key 1
send-lifetime 11:30:30 May 1 2007 duration 600
cryptographic-algorithm MD5T
key-string clear ospf_intf_1
key 2
send-lifetime 11:40:30 May 1 2007 duration 600
cryptographic-algorithm MD5
key-string clear ospf_intf_1
key 3
send-lifetime 11:50:30 May 1 2007 duration 600
cryptographic-algorithm MD5
key-string clear ospf_intf_1
key 4
send-lifetime 12:00:30 May 1 2007 duration 600
cryptographic-algorithm MD5
key-string clear ospf_intf_1
key 5
send-lifetime 12:10:30 May 1 2007 duration 600
cryptographic-algorithm MD5
key-string clear ospf_intf_1
```

The following example shows that keychain authentication is enabled on the Gigabit Ethernet 0/4/0/1 interface:

```
show ospf 1 interface GigabitEthernet0/4/0/1

GigabitEthernet0/4/0/1 is up, line protocol is up
  Internet Address 100.10.10.2/24, Area 0
  Process ID 1, Router ID 2.2.2.1, Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 2.2.2.1, Interface address 100.10.10.2
  Backup Designated router (ID) 1.1.1.1, Interface address 100.10.10.1
```

```
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:02
  Index 3/3, flood queue length 0
  Next 0(0)/0(0)
  Last flood scan length is 2, maximum is 16
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1, Adjacent neighbor count is 1
    Adjacent with neighbor 1.1.1.1  (Backup Designated Router)
  Suppress hello for 0 neighbor(s)
  Keychain-based authentication enabled
    Key id used is 3
  Multi-area interface Count is 0
```

The following example shows output for configured keys that are active:

```
show key chain ospf_intf_1

 Key-chain: ospf_intf_1/ -

 Key 1 -- text "0700325C4836100B0314345D"
   cryptographic-algorithm -- MD5
   Send lifetime:   11:30:30, 01 May 2007 - (Duration) 600
   Accept lifetime: Not configured
 Key 2 -- text "10411A0903281B051802157A"
   cryptographic-algorithm -- MD5
   Send lifetime:   11:40:30, 01 May 2007 - (Duration) 600
   Accept lifetime: Not configured
 Key 3 -- text "06091C314A71001711112D5A"
   cryptographic-algorithm -- MD5
   Send lifetime:   11:50:30, 01 May 2007 - (Duration) 600  [Valid now]
   Accept lifetime: Not configured
 Key 4 -- text "151D181C0215222A3C350A73"
   cryptographic-algorithm -- MD5
   Send lifetime:   12:00:30, 01 May 2007 - (Duration) 600
   Accept lifetime: Not configured
 Key 5 -- text "151D181C0215222A3C350A73"
   cryptographic-algorithm -- MD5
   Send lifetime:   12:10:30, 01 May 2007 - (Duration) 600
   Accept lifetime: Not configured
```

Configuring Generalized TTL Security Mechanism (GTSM) for OSPF

This task explains how to set the security time-to-live mechanism on an interface for GTSM.

SUMMARY STEPS

1. **configure**
2. **router ospf** *process-name*
3. **router-id** { *router-id* }
4. **log adjacency changes** [**detail** | **disable**]
5. **nsf** { **cisco** [**enforce global**] | **ietf** [**helper disable**]}
6. **timers throttle spf** *spf-start spf-hold spf-max-wait*
7. **area** *area-id*
8. **interface** *type interface-path-id*
9. **security ttl** [**disable** | **hops** *hop-count*]

10. Use the **commit** or **end** command.
11. **show ospf** [*process-name*] [**vrf** *vrf-name*] [*area-id*] **interface** [*type interface-path-id*]

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**router ospf** *process-name* **Example:** `RP/0/RSP0/CPU0:router(config)# router ospf 1`	Enables OSPF routing for the specified routing process and places the router in router configuration mode. **Note** The *process-name* argument is any alphanumeric string no longer than 40 characters.
Step 3	**router-id** { *router-id* } **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# router id 10.10.10.100`	Configures a router ID for the OSPF process. **Note** We recommend using a stable IPv4 address as the router ID.
Step 4	**log adjacency changes** [**detail** | **disable**] **Example:** `RP/0/RSP0/CPU0:router(config-ospf-ar-if)# log adjacency changes detail`	(Optional) Requests notification of neighbor changes. • By default, this feature is enabled. • The messages generated by neighbor changes are considered notifications, which are categorized as severity Level 5 in the **logging console** command. The **logging console** command controls which severity level of messages are sent to the console. By default, all severity level messages are sent.
Step 5	**nsf** { **cisco** [**enforce global**] | **ietf** [**helper disable**]} **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# nsf ietf`	(Optional) Configures NSF OSPF protocol. The example enables graceful restart.
Step 6	**timers throttle spf** *spf-start spf-hold spf-max-wait* **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# timers throttle spf 500 500 10000`	(Optional) Sets SPF throttling timers.
Step 7	**area** *area-id* **Example:**	Enters area configuration mode.

	Command or Action	Purpose
	`RP/0/RSP0/CPU0:router(config-ospf)# area 1`	The *area-id* argument can be entered in dotted-decimal or IPv4 address notation, such as area 1000 or area 0.0.3.232. However, you must choose one form or the other for an area. We recommend using the IPv4 address notation.
Step 8	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf-ar)# interface GigabitEternet0/5/0/0`	Enters interface configuration mode and associates one or more interfaces to the area.
Step 9	**security ttl** [**disable** | **hops** *hop-count*] **Example:** `RP/0/RSP0/CPU0:router(config-ospf-ar-if)# security ttl hopes 2`	Sets the security TTL value in the IP header for OSPF packets.
Step 10	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.
Step 11	**show ospf** [*process-name*] [**vrf** *vrf-name*] [*area-id*] **interface** [*type interface-path-id*] **Example:** `RP/0/RSP0/CPU0:router# show ospf 1 interface GigabitEthernet0/5/0/0`	Displays OSPF interface information.

Examples

The following is sample output that displays the GTSM security TTL value configured on an OSPF interface:

```
show ospf 1 interface GigabitEthernet0/5/0/0

 GigabitEthernet0/5/0/0 is up, line protocol is up
   Internet Address 120.10.10.1/24, Area 0
   Process ID 1, Router ID 100.100.100.100, Network Type BROADCAST, Cost: 1
   Transmit Delay is 1 sec, State BDR, Priority 1
   TTL security enabled, hop count 2
   Designated Router (ID) 102.102.102.102, Interface address 120.10.10.3
   Backup Designated router (ID) 100.100.100.100, Interface address 120.10.10.1
```

```
Flush timer for old DR LSA due in 00:02:36
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
  Hello due in 00:00:05
Index 1/1, flood queue length 0
Next 0(0)/0(0)
Last flood scan length is 1, maximum is 4
Last flood scan time is 0 msec, maximum is 0 msec
Neighbor Count is 1, Adjacent neighbor count is 1
  Adjacent with neighbor 102.102.102.102  (Designated Router)
Suppress hello for 0 neighbor(s)
Multi-area interface Count is 0
```

Verifying OSPF Configuration and Operation

This task explains how to verify the configuration and operation of OSPF.

SUMMARY STEPS

1. **show** { **ospf** | **ospfv3** } [*process-name*]
2. **show** { **ospf** | **ospfv3** } [*process-name*] **border-routers** [*router-id*]
3. **show** { **ospf** | **ospfv3** } [*process-name*] **database**
4. **show** { **ospf** | **ospfv3** } [*process-name*] [*area-id*] **flood-list interface** *type interface-path-id*
5. **show** { **ospf** | **ospfv3** } [*process-name*] [**vrf** *vrf-name*] [*area-id*] **interface** [*type interface-path-id*]
6. **show** { **ospf** | **ospfv3** }[*process-name*] [*area-id*] **neighbor** [*t ype interface- path-id*] [*neighbor-id*] [**detail**]
7. **clear** { **ospf** | **ospfv3** }[*process-name*] **process**
8. **clear**{**ospf**|**ospfv3**[*process-name*] **redistribution**
9. **clear**{**ospf**|**ospfv3**[*process-name*] **routes**
10. **clear**{**ospf**|**ospfv3**[*process-name*] **vrf** [*vrf-name*|**all**] {**process** |**redistribution**|**routes**|**statistics** [**interface** *type interface-path-id*|**message-queue**|**neighbor**]}
11. **clear** { **ospf** | **ospfv3** }[*process-name*] **statistics** [**neighbor** [*type interface-path-id*] [*ip-address*]]

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**show** { **ospf** | **ospfv3** } [*process-name*] **Example:** `RP/0/RSP0/CPU0:router# show ospf group1`	(Optional) Displays general information about OSPF routing processes.
Step 2	**show** { **ospf** | **ospfv3** } [*process-name*] **border-routers** [*router-id*] **Example:**	(Optional) Displays the internal OSPF routing table entries to an ABR and ASBR.

	Command or Action	Purpose
	`RP/0/RSP0/CPU0:router# show ospf group1 border-routers`	
Step 3	**show** { **ospf** | **ospfv3** } [*process-name*] **database** **Example:** `RP/0/RSP0/CPU0:router# show ospf group2 database`	(Optional) Displays the lists of information related to the OSPF database for a specific router. • The various forms of this command deliver information about different OSPF LSAs.
Step 4	**show** { **ospf** | **ospfv3** } [*process-name*] [*area-id*] **flood-list interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router# show ospf 100 flood-list interface GigabitEthernet 0/3/0/0`	(Optional) Displays a list of OSPF LSAs waiting to be flooded over an interface.
Step 5	**show** { **ospf** | **ospfv3** } [*process-name*] [**vrf** *vrf-name*] [*area-id*] **interface** [*type interface-path-id*] **Example:** `RP/0/RSP0/CPU0:router# show ospf 100 interface GigabitEthernet 0/3/0/0`	(Optional) Displays OSPF interface information.
Step 6	**show** { **ospf** | **ospfv3** }[*process-name*] [*area-id*] **neighbor** [*t ype interface- path-id*] [*neighbor-id*] [**detail**] **Example:** `RP/0/RSP0/CPU0:router# show ospf 100 neighbor`	(Optional) Displays OSPF neighbor information on an individual interface basis.
Step 7	**clear** { **ospf** | **ospfv3** }[*process-name*] **process** **Example:** `RP/0/RSP0 /CPU0:router# clear ospf 100 process`	(Optional) Resets an OSPF router process without stopping and restarting it.
Step 8	**clear**{**ospf**|**ospfv3**[*process-name*] **redistribution** **Example:** `RP/0/RSP0/CPU0:router#clear ospf 100 redistribution`	Clears OSPF route redistribution.
Step 9	**clear**{**ospf**|**ospfv3**[*process-name*] **routes** **Example:** `RP/0/RSP0/CPU0:router#clear ospf 100 routes`	Clears OSPF route table.
Step 10	**clear**{**ospf**|**ospfv3**[*process-name*] **vrf** [*vrf-name*|**all**] {**process** |**redistribution**|**routes**|**statistics** [**interface** *type interface-path-id*|**message-queue**|**neighbor**]}	Clears OSPF route table.

	Command or Action	Purpose
	Example: `RP/0/RSP0/CPU0:router#clear ospf 100 vrf vrf_1 process`	
Step 11	**clear** { **ospf** | **ospfv3** }[*process-name*] **statistics** [**neighbor** [*type interface-path-id*] [*ip-address*]] **Example:** `RP/0/RSP0/CPU0:router# clear ospf 100 statistics`	(Optional) Clears the OSPF statistics of neighbor state transitions.

OSPF Link-State Database Overload Protection

The OSPF Link-State Database Overload Protection feature allows you to protect the OSPF routing process from the large number of received link-state advertisements (LSAs) that can result from a misconfiguration on another router in the OSPF domain (for example, the redistribution of a large number of IP prefixes to OSPF). In this feature, the router monitors the count of all nonself-generated LSAs it receives. When the total number of LSAs reaches the value set as a threshold in the configuration, the router logs a warning message. When the total LSAs exceed the max number in configuration, the router stops accepting new LSAs. Therefore, the OSPF Link-State Database Overload Protection feature allows you to limit the number of nonself-generated LSAs for a given OSPF process. Excessive LSAs generated by other routers in the OSPF domain can substantially drain the CPU and memory resources of the router.

If the count of received LSAs is higher than the configured max number after one minute, the OSPF process disables all adjacencies in the given context and clears the OSPF database. This state is called the ignore state. In this state, the router ignores all OSPF packets received on all interfaces belonging to the OSPF instance and stops OSPF packet generation on its interfaces. The OSPF process remains in ignore state for the duration of the configured ignore time. When the ignore time expires, the OSPF process returns to a normal operation state and starts building adjacencies on all its interfaces.

To prevent the OSPF instance from endlessly oscillating between the normal state and ignore state, as a result of the LSA counts immediately exceeding the max number again after it returns from the ignore state, the OSPF instance keeps a count of how many times it has been in ignore state. This counter is called the ignore count. If the ignore count exceeds its configured value, the OSPF instance remains in ignore state permanently.

To return the OSPF instance to its normal state, use the **clear IP OSPF process** command. The ignore count is reset to zero if the LSA count doesn't exceed the max number again during the time configured by the reset-time keyword.

Note The are no default values for the **max-lsa** command. The router considers the max-lsa limits only if it's available in the configuration. After configuring the OSPF Link-State Database Overload Protection feature, the default values for other OSPF parameters are as follows:

- Default threshold percentage to log warning: 75%.
- Default ignore count value: 5
- Default ignore time in minutes: 5 minutes
- Default time to reset ignore count: 10 minutes

In the event of LSA count reaches or exceeds the configured threshold value, router displays the following logs:

```
Router:Oct 25 11:42:49.756 IST: ospf[1046]: %ROUTING-OSPF-4-MAX_LSA_THR : Threshold for
maximum number of non self-generated LSAs has been reached "default" - 9000 LSAs
Router:Oct 25 11:42:49.756 IST: ospf[1046]: %ROUTING-OSPF-4-MAX_LSA : Maximum number of non
 self-generated LSAs has been exceeded "default" - 12001 LSAs

Router:Oct 25 11:42:49.756 IST: ospf[1046]: %ROUTING-OSPF-4-MAX_LSA_THR : Threshold for
maximum number of non self-generated LSAs has been reached "V1" - 750 LSAs
Router:Oct 25 11:42:49.756 IST: ospf[1046]: %ROUTING-OSPF-4-MAX_LSA : Maximum number of non
 self-generated LSAs has been exceeded "V1" - 1001 LSA
```

Configuration Example

The following example shows how to configure the OSPF instance to accept 12000 nonself-generated LSAs in the global routing table and 1000 nonself-generated LSAs in VRF V1:

```
Router# configure
Router(config)# router ospf 0
Router(config-ospf)# max-lsa 12000
Router(config-ospf)# vrf V1
Router(config-ospf)# max-lsa 1000
```

Running Configuration

The following example shows how to display the current status of the OSPF instance:

```
Router# show ospf 0
  Routing Process "ospf 0" with ID 10.0.0.2
  NSR (Non-stop routing) is Disabled
  Supports only single TOS(TOS0) routes
  Supports opaque LSA
  It is an area border router
  Maximum number of non self-generated LSA allowed 12000
    Current number of non self-generated LSA 1
    Threshold for warning message 75%
    Ignore-time 5 minutes, reset-time 10 minutes
    Ignore-count allowed 5, current ignore-count 0

Router# show ospf vrf V1
 VRF V1 active in Routing Process "ospf 0" with ID 10.0.0.2
 Role: Primary Active
 NSR (Non-stop routing) is Enabled
 Supports only single TOS(TOS0) routes
 Supports opaque LSA
 It is an area border router
 Maximum number of non self-generated LSA allowed 1000
    Current number of non self-generated LSA 1
    Threshold for warning message 75%
    Ignore-time 5 minutes, reset-time 10 minutes
    Ignore-count allowed 5, current ignore-count 0
 Router is not originating router-LSAs with maximum metric
```

IGP link state

IGP Link-State Database Distribution

A given BGP node may have connections to multiple, independent routing domains. IGP link-state database distribution into BGP-LS is supported for both OSPF and IS-IS protocols in order to distribute this information on to controllers or applications that desire to build paths spanning or including these multiple domains.

To distribute OSPFv2 link-state data using BGP-LS, use the **distribute link-state** command in router configuration mode.

```
Router# configure
Router(config)# router ospf 100
Router(config-ospf)# distribute link-state instance-id 32
```

OSPF Link State

With OSPF link state configured (as given above), the entire link-state data is advertised by BGPLS to the controllers. But the controllers might not be interested in the bulk of LS information and unwanted information might be dropped by them. A selective filtering in this case would reduce their burden. You can now filter the unwanted summary LSAs by the LSLIB and selectively allow only some of the PE's prefixes to LSLIB consumers. This selective filtering helps in reducing the burden of the controllers.

There are several ways in which you can filter:

- Filtering based on a route policy at OSPF instance level.
  - Set of prefixes as destination attribute.
  - Route-type attribute
- Option to exclude all external LSAs at OSPF instance level.
- Option to disable link-state information from a selected OSPF area.
- Option to exclude all summary LSAs at OSPF area level.
- Option to exclude all NSSA LSAs at OSPF area level.

Configuration Example

You can use the **distribute link state** command to selectively filter the LSAs.

```
Router(config)#router ospf 1
Router(config-ospf)#distribute link-state ?
  allow-prefix   Selectively allow prefixes from route policy
  excl-external  Filter advertisement of external prefixes
  instance-id    Set distribution process instance identifier
  throttle       Throttle time between successive LSA updates
```

You can also filter based on a route policy at OSPF instance level.

```
Router(config-ospf)#distribute link-state allow-prefix ?
  route-policy  Specify the route-policy to allow a set of prefixes

Router(config-ospf)#distribute link-state allow-prefix route-policy ?
```

```
  ospf-bgpls-rpl1     Name of the policy
  ospf-bgpls-rpl2     Name of the policy
  WORD  Name of the policy

Router#distribute link-state allow-prefix route-policy ospf-bgpls-rpl1  ?
  (              Specify parameter values for the policy
  excl-external  Filter advertisement of external prefixes
  instance-id    Set distribution process instance identifier
  throttle       Throttle time between successive LSA updates
```

Filter option to exclude all external LSAs at OSPF instance level.

```
RP/0/0/CPU0:ios(config-ospf)#distribute link-state excl-external ?
  allow-prefix  Selectively allow prefixes from route policy
  instance-id   Set distribution process instance identifier
  throttle      Throttle time between successive LSA updates
  <cr>
RP/0/0/CPU0:ios(config-ospf)#
```

The following example shows how to filter syntax at OSPF area level:

```
Router(config-ospf)#area 1
Router(config-ospf-ar)#distribute link-state ?
  disable       Disable link-state advertisement of this area
  excl-nssa     Filter advertisement of NSSA prefixes
  excl-summary  Filter advertisement of summary prefixes
```

The following example shows the option to disable link-state information from a selected OSPF area.

```
Router(config-ospf-ar)#distribute link-state disable ?
  excl-nssa     Filter advertisement of NSSA prefixes
  excl-summary  Filter advertisement of summary prefixes
```

The following example shows option to exclude all summary LSAs at OSPF area level.

```
Router(config-ospf-ar)#distribute link-state excl-nssa ?
  disable       Disable link-state advertisement of this area
  excl-summary  Filter advertisement of summary prefixes
```

The following example shows option to exclude all NSSA LSAs at OSPF area level.

```
Router(config-ospf-ar)#distribute link-state excl-summary ?
  disable    Disable link-state advertisement of this area
  excl-nssa  Filter advertisement of NSSA prefixes
```

Verification

The following example shows sample RPLs and prefix-set.

```
Router#do show running-config prefix-set pe_list

prefix-set pe_list
  100.0.0.0/24 ge 24,
  101.0.0.0/24 ge 24
end-set
!

Router#do show running-config route-policy ospf-bgpls-rpl1
route-policy ospf-bgpls-rpl1
  if destination in pe_list then
    pass
  endif
end-policy
!
```

```
Router(config)#do show running-config route-policy ospf-bgpls-rpl2
route-policy ospf-bgpls-rpl2
  if route-type is ospf-external-type-2 then
    drop
  else
    pass
  endif
end-policy
!
```

Configuring IP Fast Reroute Loop-free Alternate

This task describes how to enable the IP fast reroute (IPFRR) per-link loop-free alternate (LFA) computation to converge traffic flows around link failures.

To enable protection on broadcast links, IPFRR and bidirectional forwarding detection (BFD) must be enabled on the interface under OSPF.

Enabling IPFRR LFA

SUMMARY STEPS

1. **configure**
2. **router ospf** *process-name*
3. **area** *area-id*
4. **interface** *type interface-path-id*
5. **fast-reroute per-link** { **enable** | **disable** }
6. Use the **commit** or **end** command.

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**router ospf** *process-name* **Example:** `RP/0/RSP0/CPU0:router(config)# router ospf`	Enables OSPF routing for the specified routing process and places the router in router configuration mode.
Step 3	**area** *area-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf)#area 1`	Enters area configuration mode.

	Command or Action	Purpose
Step 4	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf-ar)# interface GigabitEternet0/5/0/0`	Enters interface configuration mode and associates one or more interfaces to the area. .
Step 5	**fast-reroute per-link** { **enable** | **disable** } **Example:** `RP/0/RSP0/CPU0:router(config-ospf-ar)#fast-reroute per-link enable`	Enables or disables per-link LFA computation for the interface.
Step 6	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Excluding an Interface From IP Fast Reroute Per-link Computation

SUMMARY STEPS

1. **configure**
2. **router ospf** *process-name*
3. **area** *area-id*
4. **interface** *type interface-path-id*
5. **fast-reroute per-link exclude interface** *type interface-path-id*
6. Use the **commit** or **end** command.

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.

	Command or Action	Purpose
Step 2	**router ospf** *process-name* **Example:** `RP/0/RSP0/CPU0:router(config)# router ospf`	Enables the OSPF routing for the specified routing process and places the router in router configuration mode.
Step 3	**area** *area-id* **Example:** `RP/0/RSP0/CPU0:router(config)#area area-id`	Enters area configuration mode.
Step 4	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf)#interface type interface-path-id`	Enters interface configuration mode and associates one or more interfaces to the area.
Step 5	**fast-reroute per-link exclude interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config-ospf-ar)# fast-reroute per-link exclude interface GigabitEternet0/5/0/1`	Excludes an interface from IP fast reroute per-link computation.
Step 6	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Enabling OSPF Interaction with SRMS Server

To enable OSPF interaction with SRMS server:

SUMMARY STEPS

1. **configure**
2. **router ospf** *instance-id*
3. **segment-routing mpls**
4. **segment-routing forwarding mpls**
5. **segment-routing prefix-sid-mapadvertise-local**
6. **segment-routing sr-preferprefix-list***[acl-name]*

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**router ospf** *instance-id* **Example:** `RP/0/RSP0/CPU0:router(config)# router ospf isp`	Enables OSPF routing for the specified routing instance, and places the router in router configuration mode.
Step 3	**segment-routing mpls** **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# segment-routing mpls`	
Step 4	**segment-routing forwarding mpls** **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# segment-routing forwarding mpls`	Enables SR forwarding on all interfaces where this instance OSPF is enabled.
Step 5	**segment-routing prefix-sid-mapadvertise-local** **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# segment-routing prefix-sid-map advertise local`	Enables server functionality and allows OSPF to advertise the local mapping entries using area-scope flooding. The flooding is limited to areas where segment-routing is enabled. Disabled by default.
Step 6	**segment-routing sr-preferprefix-list***[acl-name]* **Example:** `RP/0/RSP0/CPU0:router(config-ospf)# segment-routing sr-prefer prefix-list foo`	Enables OSPF to communicate to the routing information base (RIB) that SR labels are preferred to LDP labels. If ACL is used, OSPF signals the preference of SR labels over LDP labels for prefixes that match ACL. If ACL is not used, OSPF signals the preference of SR labels for all prefixes.

Example

The following example shows how OSPF advertises local mapping entries using area-flooding scope.

```
ipv4 prefix-list foo
permit 2.2.2.2/32
!
router ospf 1
router-id 1.1.1.1
segment-routing mpls
segment-routing forwarding mpls
segment-routing prefix-sid-map receive
```

```
segment-routing prefix-sid-map advertise-local
segment-routing sr-prefer prefix-list foo
area 0
interface Loopback0
prefix-sid index 1
!
interface GigabitEthernet0/0/0/0
!
interface GigabitEthernet0/2/0/0
!
interface GigabitEthernet0/2/0/3
!
!
area 1
interface GigabitEthernet0/2/0/7
!
```

OSPF Penalty for Link Delay Anomaly

Note For information on configuring the link delay anomaly threshold values, refer to Link Anomaly Detection with IGP Penalty in the Segment Routing Configuration Guide.

When you configure link delay anomaly detection in SR-PM, PM sends an anomaly bit (A-bit) when the upper bound of the anomaly threshold is exceeded. When an anomaly is received for an interface, OSPF can increase the IGP metric or TE metric to make the link less attractive for traffic.

You can specify how to increase the metric in the following ways:

- As a factor by which the base metric is multiplied.
- As an increment that is added to the base metric.
- As a fixed high value (up to 0xFFFFFFFF).

Note Due to protocol limitations, there is a maximum value applied for the metric for all three options:

- IGP metric maximum value: 0xFFFF
- TE metric maximum value: 0xFFFFFFFF

The configuration can be applied at the OSPF interface, area, and instance levels, and is applicable only to non-loopback interfaces. When the configuration is applied at the OSPF interface level, it is applicable to that interface only.

Examples

In the following examples, the base IGP metric and TE metric values are 10.

Example 1

This example shows how to increase the IGP and TE metrics for an interface. The IGP metric will be increased by 10; the TE metric will be multiplied by 10. When an anomalous bit notification comes for interface GigabitEthernet0/2/0/0, the values advertised in the TLVs will be IGP metric 20 and TE metric 100.

```
RP/0/RSP0/CPU0:ios(config)# router ospf 1
RP/0/RSP0/CPU0:ios(config-ospf)# area 0
RP/0/RSP0/CPU0:ios(config-ospf-ar)# interface GigabitEthernet 0/2/0/0
RP/0/RSP0/CPU0:ios(config-ospf-ar-if)# cost-fallback anomaly delay igp-metric increment 25
```

Example 2

This example shows how to increase the IGP and TE metrics for non-loopback interfaces in an OSPF area. Interfaces GigabitEthernet0/2/0/0 and GigabitEthernet0/2/0/1 inherit the configuration.

```
Router(config)# router ospf 1
Router(config-ospf)# area 0
Router(config-ospf-ar)# cost-fallback anomaly delay igp-metric increment 10
Router(config-ospf-ar)# cost-fallback anomaly delay te-metric multiplier 10
Router(config-ospf-ar)# interface Loopback 0
Router(config-ospf-ar-if)# exit
Router(config-ospf-ar)# interface GigabitEthernet 0/2/0/0
Router(config-ospf-ar-if)# exit
Router(config-ospf-ar)# interface GigabitEthernet 0/2/0/1
```

Example 3

This example shows how to increase the IGP and TE metrics for non-loopback interfaces in an OSPF instance. Interfaces GigabitEthernet0/2/0/1 and GigabitEthernet0/2/0/2 inherit the configuration. The metric penalty is disabled on a specific interface (GigabitEthernet0/2/0/0).

```
Router(config)# router ospf 1
Router(config-ospf)# cost-fallback anomaly delay igp-metric increment 10
Router(config-ospf)# cost-fallback anomaly delay te-metric multiplier 10
Router(config-ospf)# area 0
Router(config-ospf-ar)# interface Loopback 0
Router(config-ospf-ar-if)# exit
Router(config-ospf-ar)# interface GigabitEthernet 0/2/0/0
Router(config-ospf-ar-if)# cost-fallback anomaly delay igp-metric disable
Router(config-ospf-ar-if)# cost-fallback anomaly delay te-metric disable
Router(config-ospf-ar-if)# exit
Router(config-ospf-ar)# interface GigabitEthernet 0/2/0/1
Router(config-ospf-ar-if)# exit
Router(config-ospf-ar)# interface GigabitEthernet 0/2/0/2
```

Limiting LSA Numbers in a OSPF Link-State Database

Table 1: Feature History Table

Feature Name	Release	Description
Limiting LSA numbers in a OSPF Link-State Database	Release 7.9.1	The nonself-generated link-state advertisements (LSAs) for a given Open Shortest Path First (OSPF) process is limited to 500000. This protection mechanism prevents routers from receiving many LSAs, preventing CPU failure and memory shortages, and is enabled by default from this release onwards. If you have over 500000 LSAs in your network, configure the **max-lsa** command with the expected LSA scale before upgrading to this release or later. This feature modifies the following commands: • **show ospf** to display the maximum number of redistributed prefixes. • **show ospf database database-summary detail** to display the number of LSA counts per router. • **show ospf database database-summary adv-router** *router ID* to display the router information and the LSAs received from a particular router.

The OSPF Link-State Database Overload Protection feature allows you to protect the OSPF routing process by limiting the number of nonself-generated link-state advertisements (LSAs) for a given Open Shortest Path First (OSPF) process. When other routers in the network have been misconfigured, they may generate a high volume of LSAs. This mechanism prevents routers from receiving a large number of LSAs, thereby preventing CPU failure and memory shortages. With this feature, the router keeps a count of the number of nonself-generated LSAs it has received.

Note The max-lsa limit was not enabled by default before Release 7.9.1. Starting from Release 7.9.1, this command is enabled by default and the default limit of the nonself-generated LSA is set at 500000. If you have more than 500000 LSAs in a network, you must configure the **max-lsa** command with the expected LSA scale before upgrading to Release 7.9.1 or above.

Restriction

This feature is supported only on OSPFv2 and not on OSPFv3.

System output messages

The range of nonself-generated LSA allowed is 1-4294967294. The threshold percentage to log warning is 75%. The system log message is generated every 5% above the default or configured threshold value until 100% is reached.

When the number of LSAs reaches or exceeds the threshold limit, the router displays the following logs:

When number of LSAs exceed threshold value

```
%ROUTING-OSPF-4-MAX_LSA_THR : Reached threshold (60% [configured: 60%])
for maximum number of non self-generated LSAs in vrf "default" - LSA (max:
1000 cur: 600)
```

When number of LSAs exceed maximum limit

```
%ROUTING-OSPF-1-MAX_LSA : Maximum number of non self-generated LSAs
exceeded in vrf "default" - LSA (max: 1000, cur: 1001)
```

When OSPF instance ignores all adjacencies for ignore-time period if the number of LSAs exceed the limit

```
%ROUTING-OSPF-2-MAX_LSA_IGNORE_ENTER : Max LSA exceeded in vrf "default".
Adjacencies will be kept down for 5 minutes
```

When OSPF instance tries to recover the adjacencies after ignore-time period

```
%ROUTING-OSPF-6-MAX_LSA_IGNORE_EXIT : Max-lsa ignore timed out in vrf
"default". Adjacencies will be brought up by accepting and sending hellos
```

When the ignore count is exceeded on the OSPF instance

```
%ROUTING-OSPF-1-MAX_LSA_PERM_IGNORE : Max-lsa ignore count exceeded in
vrf "default" - Staying in ignore state. Restart or Clear OSPF process
to recover
```

When number of LSAs exceed threshold or limit the top contributing routers information will be displayed

```
%ROUTING-OSPF-2-MAX_LSA_RTR_INFO : Top 1 LSA contributor in vrf "default".
RTR:192.168.0.4   Total:498   Type3:0   Type5:492   Type7:0   Type10:0
Type11:6   Others:0
```

The following commands displays the LSA counts:

- **show ospf database database-summary detail** command displays the number of LSA counts per router sorted by total LSA count.

```
Router#show ospf database database-summary detail

            OSPF Router with ID (192.168.0.1) (Process ID 1)

Router 192.168.0.4 LSA summary
  LSA Type      Count    Delete   Maxage
  Router        0        0        0
  Network       0        0        0
  Summary Net   0        0        0
  Summary ASBR  0        0        0
  Type-5 Ext    697      0        0
  Type-7 Ext    0        0        0
  Opaque Link   0        0        0
  Opaque Area   0        0        0
  Opaque AS     6        0        0
  Total         703      0        0

Router 192.168.0.1 LSA summary
  LSA Type      Count    Delete   Maxage
  Router        1        0        0
  Network       0        0        0
  Summary Net   0        0        0
  Summary ASBR  0        0        0
  Type-5 Ext    0        0        0
  Type-7 Ext    0        0        0
  Opaque Link   0        0        0
  Opaque Area   64       0        0
  Opaque AS     0        0        0
  Total         65       0        0

Router 192.168.0.2 LSA summary
  LSA Type      Count    Delete   Maxage
  Router        1        0        0
  Network       0        0        0
  Summary Net   21       0        0
  Summary ASBR  2        0        0
  Type-5 Ext    0        0        0
  Type-7 Ext    0        0        0
  Opaque Link   0        0        0
  Opaque Area   21       0        0
  Opaque AS     0        0        0
  Total         45       0        0

Router 192.168.0.6 LSA summary
  LSA Type      Count    Delete   Maxage
  Router        1        0        0
  Network       0        0        0
  Summary Net   21       0        0
  Summary ASBR  2        0        0
  Type-5 Ext    0        0        0
  Type-7 Ext    0        0        0
  Opaque Link   0        0        0
  Opaque Area   19       0        0
  Opaque AS     0        0        0
  Total         43       0        0

Router 192.168.0.3 LSA summary
  LSA Type      Count    Delete   Maxage
  Router        0        0        0
  Network       0        0        0
  Summary Net   0        0        0
  Summary ASBR  0        0        0
```

```
  Type-5 Ext    7         0         0
  Type-7 Ext    0         0         0
  Opaque Link   0         0         0
  Opaque Area   0         0         0
  Opaque AS     6         0         0
  Total         13        0         0
```

- **show ospf database database-summary adv-router *router ID*** command displays the router information and the LSAs received from the particular router.

```
Router#show ospf database database-summary adv-router 192.168.0.4


            OSPF Router with ID (192.168.0.1) (Process ID 1)

Router 192.168.0.4 LSA summary
  LSA Type      Count    Delete   Maxage
  Router        0        0        0
  Network       0        0        0
  Summary Net   0        0        0
  Summary ASBR  0        0        0
  Type-5 Ext    697      0        0
  Type-7 Ext    0        0        0
  Opaque Link   0        0        0
  Opaque Area   0        0        0
  Opaque AS     6        0        0
  Total         703      0        0
```

Limiting the Maximum Redistributed Type-3 LSA Prefixes in OSPF

Table 2: Feature History Table

Feature Name	Release	Description
Limiting the Maximum Redistributed Type-3 LSA Prefixes in OSPF	Release 7.9.1	By default, the maximum redistributed Type-3 LSA prefixes for a given OSPF process is now limited to 100000. This mechanism prevents OSPF from redistributing a large number of prefixes as Type-3 LSAs and therefore preventing high CPU utilization and memory shortages. Once the number of redistributed prefixes is reached or exceeds the threshold value, the system log message is generated, and no more prefixes are redistributed. Support was added to count only the number of redistributed prefixes instead of the number of LSAs. Individual prefixes are counted when multiple prefixes are aggregated in an LSA using the **summary-prefix** command.

Redistribution allows different routing protocols to exchange routing information. This is used to allow connectivity to span multiple routing protocols. Open Shortest Path First (OSPF) supports a user-defined maximum number of prefixes (routes) that are allowed to be redistributed into OSPF from other protocols or other OSPF instances.

Prior to Release 7.9.1, the maximum redistributed-prefixes limit was applied only to those prefixes that are redistributed as Type-5 and Type-7 LSAs. Starting from Release 7.9.1, the maximum redistributed-prefixes limit is also applied to the prefixes that are redistributed as Type-3 LSAs. The maximum redistributed Type-3 LSA prefixes for a given OSPF process is limited to 100000.

If the router redistributes more than 10000 prefixes as Type 3, 5, or 7 LSAs, then you must configure a higher limit using the **maximum redistributed-prefixes** command.

Starting from Release 7.9.1, if the **redistribute protocol lsa-type summary** command is configured to redistribute the routes from particular protocol as Type-3 LSAs, then those Type-3 LSAs are accounted for maximum redistributed prefixes.

System output messages

The range of prefixes that are redistributed as Type-3 LSAs is 1-4294967295. The threshold percentage to log warning is 75%. The system log message is generated every 5% above the default or configured threshold value until 100% is reached.

When the number of LSAs reaches or exceeds the threshold limit, the router displays the following logs:

The redistributed prefixes count reached the maximum limit

```
%ROUTING-OSPF-4-REDIST_THR_PFX : Reached Redistribution prefix threshold
in vrf "default", current (70%) 700 prefixes, limit  1000
```

The redistributed prefixes count exceeds the threshold percentage

```
%ROUTING-OSPF-1-REDIST_MAX_PFX : Redistribution prefix limit has been
reached in vrf "default" - current 1000 prefixes, limit 1000
```

The redistributed prefixes count falls below the threshold percentage

```
%ROUTING-OSPF-5-REDIST_MAX_PFX_RECOVER : Recovered from Redistribution
limit-hit scenario in vrf "default", prefix count less than threshold -
current (69%) 699 prefixes, limit 1000
```

The **show ospf** command displays the maximum number of redistributed prefixes, which is configured at 1000.

```
Router #show ospf
Thu Dec  8 18:16:48.332 IST

 Routing Process "ospf 1" with ID 192.168.0.1
 Role: Primary Active
 NSR (Non-stop routing) is Enabled
 Supports only single TOS(TOS0) routes
 Supports opaque LSA
 It is an autonomous system boundary router
 Maximum number of non self-generated LSA allowed 1000
    Current number of non self-generated LSA 804
    Threshold for warning message 60%
    Ignore-time 1 minutes, reset-time 2 minutes
    Ignore-count allowed 2, current ignore-count 0
 Redistributing External Routes from,
    static
 Maximum number of redistributed prefixes 1000
    Threshold for warning message 70%
    Current number of redistributed prefixes 100
```

Autonomous System Boundary Router Isolation and Adjacency Control for LSA Overflows

Table 3: Feature History Table

Feature Name	Release Name	Description
Autonomous System Boundary Router Isolation and Adjacency Control for LSA Overflows	Release 7.10.1	In a network employing an Autonomous System Boundary Router (ASBR) and other routers, you are now assured of uninterrupted traffic flow even if the ASBR generates LSAs that exceed the limit you configured. This is made possible as you can now isolate ASBRs and also control the duration of adjacency in the EXCHANGE or LOADING phase. By isolating the ASBR from its immediate neighbors, the remaining network topology can continue to function without disruption, effectively preventing any adverse impact on traffic flow. This approach also simplifies the recovery process, as manual intervention is only necessary for the immediate neighbors of the ASBR routers. This feature introduces these changes: **CLI:** • **max-external-lsa** • **exchange-timer** **YANG Data Model:** • `Cisco-IOS-XR-ipv4-ospf-cfg.yang` • `Cisco-IOS-XR-ipv4-ospf-oper.yang` • `Cisco-IOS-XR-um-router-ospf-cfg.yang` (see GitHub, YANG Data Models Navigator)

Overview

The Autonomous System Boundary Routers (ASBR) Isolation and Adjacency Control for LSA Overflows feature prevents LSAs generated by a misbehaving ASBR from flooding the autonomous system. This, in turn, averts disruptions in the OSPF network. The feature accomplishes this by restricting external LSAs from immediate neighbors and by limiting the duration of adjacency in the EXCHANGE or LOADING phase.

The default BGP routing table is distributed in OSPF when there is a need to propagate the default route to OSPF routers. This occurs when OSPF routers are configured to advertise default routes to their OSPF neighbors or when the OSPF routers receive a default route from their BGP peers. The need for using ACL or RPL in OSPF arises when specific filtering, modification, or manipulation is required.

The misconfiguration of ASBR can occur in several scenarios. These include instances where a filter mechanism, such as an Access Control List (ACL) or Routing Policy Language (RPL) policy, is missing. Additionally, misconfiguration can arise when the configured filter mechanism fails due to reasons like human errors during rule creation or modification. Unintended overlaps or similar issues can also lead to ASBR misconfiguration.

The misconfiguration in the ASBR leads to the unintended redistribution of the default BGP routing table in OSPF. As a result, the ASBR generates millions of LSAs, of either Type 5 or Type 7, within the OSPF domain causing an unexpected flood of external LSAs. These LSAs flood throughout the entire autonomous system triggering route calculations on all routers causing the depletion of the available resources, such as high memory and CPU usage. This causes a strain on the system. The sustained strain ultimately results in the failure of the router. As a result, the entire OSPF domain may experience a shutdown, causing disruptions.

This feature facilitates the isolation of a misbehaving ASBR if the number of LSAs exceed a predetermined threshold. The immediate neighbors of the misbehaving ASBR isolate it from themselves. Hence, the rest of the network continues uninterrupted operation. The feature mitigates the potential loss of network traffic and ensure stability of the network. If another ASBR exists, which correctly leaks only relevant routes into the OSPF domain, it ensures uninterrupted connectivity. This feature simplifies the recovery process as manual interruption is limited to the immediate neighbors of the ASBR routers.

The neighboring routers constantly monitor the influx of type 5 and type 7 LSAs originating from the peer ASBR. Once the predetermined threshold is exceeded, the neighboring router proceeds to terminate the adjacency with the misbehaving ASBR. This action effectively halts the communication link between the neighboring router and the misbehaving ASBR, ensuring compliance with the imposed limit.

The neighbor maintains the adjacency in a deactivated state for a specified interval. After the interval elapses, the neighbor initiates the process of forming the adjacency again.

When the ASBR rectifies the issue with the origination of the external LSA, the neighbor establishes the adjacency successfully. Alternatively, if the neighbor disrupts the adjacency, user intervention is required to enable ASBR to rectify the redistribution issue. If the ASBR successfully rectifies the redistribution issue, the adjacency recovers automatically. If the ASBR fails to rectify the redistribution issue, it results in the repetition of the cycle. However, it’s not recommended for the system to attempt retries indefinitely. Therefore, this feature incorporates a counter to monitor the number of times the adjacency towards the ASBR is unsuccessful due to reaching the configured maximum limit for external LSAs. Once the count reaches a specified number of attempts, the neighbor ceases further efforts to establish the adjacency, resulting in a permanent adjacency downtime.

After reaching the permanent adjacency downtime, manual intervention is necessary to restore the adjacency. This involves shutting down the interface and after bringing it back up by issuing the **no shutdown** command.

Restrictions for ASBR Isolation and Adjacency Control for LSA Overflows

- All neighbors of the ASBR must support this feature for the protection mechanism to function effectively. If any neighbor fails to support this feature, that neighbor leaks external LSAs to the rest of the OSPF domain.
- To add a second level of protection, enable the **max-lsa** command on the routers within the OSPF domain. For more information on enabling a second level of protection, see "Limiting LSA numbers in a OSPF Link-State Database".

Configure ASBR Isolation and Adjacency Control for LSA Overflows

Configuration Example

- Configure the timers value for the maximum limit for external LSAs.
- Configure the threshold percentage for maximum limit for external LSA using the **exchange-timer** command.
- Configure the redistribution of BGP into OSPF domain using the **redistribute bgp** command.

```
Router(config)# router ospf 1
Router(config-ospf)# log adjacency changes detail
Router(config-ospf)# router-id 203.0.113.1
Router(config-ospf)# maximum redistributed-prefixes 150 90
Router(config-ospf)# exchange-timer 3 hold-time 2 recovery-count 5
Router(config-ospf)# max-external-lsa 100 75
Router(config-ospf)# redistribute bgp 100
```

Running Configuration

```
router ospf 1
  log adjacency changes detail
  router-id 203.0.113.1
  maximum redistributed-prefixes 150 90
  exchange-timer 3 hold-time 2 recovery-count 5
  max-external-lsa 100 75
  redistribute bgp 100
```

Verification

Verify the configuration of the maximum number of external LSAs and the exchange timer. The output displays the list of ASBRs that went down because the number of LSAs exceeded the configured maximum number.

```
Router# show ospf

 Routing Process "ospf 1" with ID 203.0.113.1
 Role: Primary Active
 NSR (Non-stop routing) is Enabled
 Supports only single TOS(TOS0) routes
 Supports opaque LSA
 It is an area border and autonomous system boundary router
 Redistributing External Routes from,
```

```
    bgp 100
 Maximum number of redistributed prefixes 150
    Threshold for warning message 90%
    Current number of redistributed prefixes 0
Maximum of external prefixes per router 100 (suppress-neighbor)
 Warning threshold 75%
 2 ASBR(s) have hit the limit now and links made down:
      192.168.0.5
      192.168.0.6
Maximum Exchange time 3 Hold time 2 Max Recovery count 5
Time remaining for suppressed-asbr stale-checker to expire: 00:03:48
```

Verify the state of the OSPF interface. The show output displays the status of adjacency hold timer and exchange timer. The output indicates that the exchange timer is recovering from being down due to exceeding the configured limit of maximum external LSAs.

```
Router# show ospf interface

TenGigE0/0/0/3.1 is up, line protocol is up
  Internet Address 203.0.113.1/24, Area 0, SID 0, Strict-SPF SID 0

Adjacency hold timer expired last : Mar 28 10:44:28.510
  Exchange timer expired last : Mar 28 10:47:38.077
  Exchange timer status: Recovering after max external LSA
    Exchange timer is running, time remaining: 00:08:29
    Recovery count: 1
```

The show command output shows the ASBRs that went down because they exceeded the configured limit of maximum external LSAs.

```
Router# show ospf suppressed-asbrs

Suppressed ASBR(s) for ospf 1 with ID 203.0.113.1

ASBR : 209.165.200.254
  ASBR down since : Apr  9 18:32:07.257
  Interface(s):
    Area 0                TenGigE0/0/0/3.3
      Adjacency hold timer expired last : Never
      Exchange timer expired last : Never
      Exchange timer status: Down due to max external LSA
      Hold timer is running, time remaining: 00:01:52
      Recovery count 0
    Area 1                TenGigE0/0/0/3.1
      Adjacency hold timer expired last : Never
      Exchange timer expired last : Never
      Exchange timer status: Down due to max external LSA
      Hold timer is running, time remaining: 00:01:52
      Recovery count 0
```

Configuration Examples for Implementing OSPF

This section provides the following configuration examples:

Cisco IOS XR Software for OSPF Version 2 Configuration: Example

The following example shows how an OSPF interface is configured for an area in Cisco IOS XR Software.

area 0 must be explicitly configured with the **area** command and all interfaces that are in the range from 10.1.2.0 to 10.1.2.255 are bound to area 0. Interfaces are configured with the **interface** command (while the router is in area configuration mode) and the **area** keyword is not included in the interface statement.

Cisco IOS XR Software Configuration

```
interface GigabitEthernet 0/3/0/0
 ip address 10.1.2.1 255.255.255.255
 negotiation auto
!
router ospf 1
router-id 10.2.3.4
 area 0
  interface GigabitEthernet 0/3/0/0
!
!
```

The following example shows how OSPF interface parameters are configured for an area in Cisco IOS XR software.

In Cisco IOS XR software, OSPF interface-specific parameters are configured in interface configuration mode and explicitly defined for area 0. In addition, the **ip ospf** keywords are no longer required.

Cisco IOS XR Software Configuration

```
interface GigabitEthernet 0/3/0/0
 ip address 10.1.2.1 255.255.255.0
 negotiation auto
!
router ospf 1
 router-id 10.2.3.4
area 0
 interface GigabitEthernet 0/3/0/0
  cost 77
  mtu-ignore
  authentication message-digest
  message-digest-key 1 md5 0 test
!
!
```

The following example shows the hierarchical CLI structure of Cisco IOS XR software:

In Cisco IOS XR software, OSPF areas must be explicitly configured, and interfaces configured under the area configuration mode are explicitly bound to that area. In this example, interface 10.1.2.0/24 is bound to area 0 and interface 10.1.3.0/24 is bound to area 1.

Cisco IOS XR Software Configuration

```
interface GigabitEthernet 0/3/0/0
 ip address 10.1.2.1 255.255.255.0
 negotiation auto
!
interface GigabitEthernet 0/3/0/1
 ip address 10.1.3.1 255.255.255.0
```

```
 negotiation auto
!
router ospf 1
 router-id 10.2.3.4
area 0
 interface GigabitEthernet 0/3/0/0
!
area 1
 interface GigabitEthernet 0/3/0/1
!
!
```

CLI Inheritance and Precedence for OSPF Version 2: Example

The following example configures the cost parameter at different hierarchical levels of the OSPF topology, and illustrates how the parameter is inherited and how only one setting takes precedence. According to the precedence rule, the most explicit configuration is used.

The cost parameter is set to 5 in router configuration mode for the OSPF process. Area 1 sets the cost to 15 and area 6 sets the cost to 30. All interfaces in area 0 inherit a cost of 5 from the OSPF process because the cost was not set in area 0 or its interfaces.

In area 1, every interface has a cost of 15 because the cost is set in area 1 and 15 overrides the value 5 that was set in router configuration mode.

Area 4 does not set the cost, but GigabitEthernet interface 01/0/2 sets the cost to 20. The remaining interfaces in area 4 have a cost of 5 that is inherited from the OSPF process.

Area 6 sets the cost to 30, which is inherited by GigabitEthernet interfaces 0/1/0/3 and 0/2/0/3. GigabitEthernet interface 0/3/0/3 uses the cost of 1, which is set in interface configuration mode.

```
router ospf 1
 router-id 10.5.4.3
 cost 5
 area 0
  interface GigabitEthernet 0/1/0/0
  !
  interface GigabitEthernet 0/2/0/0
  !
  interface GigabitEthernet 0/3/0/0
  !
 !
 area 1
  cost 15
  interface GigabitEthernet 0/1/0/1
  !
  interface GigabitEthernet 0/2/0/1
  !
  interface GigabitEthernet 0/3/0/1
  !
 !
 area 4
  interface GigabitEthernet 0/1/0/2
   cost 20
  !
  interface GigabitEthernet 0/2/0/2
  !
  interface GigabitEthernet 0/3/0/2
  !
 !
 area 6
```

```
   cost 30
   interface GigabitEthernet 0/1/0/3
   !
   interface GigabitEthernet 0/2/0/3
   !
   interface GigabitEthernet 0/3/0/3
    cost 1
   !
  !
```

MPLS TE for OSPF Version 2: Example

The following example shows how to configure the OSPF portion of MPLS TE. However, you still need to build an MPLS TE topology and create an MPLS TE tunnel. See the *MPLS Configuration Guide for Cisco ASR 9000 Series Routers*for information.

In this example, loopback interface 0 is associated with area 0 and MPLS TE is configured within area 0.

```
interface Loopback 0
 address 10.10.10.10 255.255.255.0
!
interface GigabitEthernet 0/2/0/0
 address 10.1.2.2 255.255.255.0
!
router ospf 1
 router-id 10.10.10.10
 nsf
 auto-cost reference-bandwidth 10000
 mpls traffic-eng router-id Loopback 0
 area 0
  mpls traffic-eng
  interface GigabitEthernet 0/2/0/0
  interface Loopback 0
```

ABR with Summarization for OSPFv3: Example

The following example shows the prefix range 2300::/16 summarized from area 1 into the backbone:

```
router ospfv3 1
 router-id 192.168.0.217
 area 0
  interface GigabitEthernet 0/2/0/1
 area 1
  range 2300::/16
  interface GigabitEthernet 0/2/0/0
```

ABR Stub Area for OSPFv3: Example

The following example shows that area 1 is configured as a stub area:

```
  router ospfv3 1
   router-id 10.0.0.217
   area 0
    interface GigabitEthernet 0/2/0/1
   area 1
    stub
```

```
    interface GigabitEthernet 0/2/0/0
```

ABR Totally Stub Area for OSPFv3: Example

The following example shows that area 1 is configured as a totally stub area:

```
router ospfv3 1
 router-id 10.0.0.217
 area 0
  interface GigabitEthernet 0/2/0/1
 area 1
  stub no-summary
  interface GigabitEthernet 0/2/0/0
```

Configuring OSPF SPF Prefix Prioritization: Example

This example shows how to configure /32 prefixes as medium-priority, in general, in addition to placing some /32 and /24 prefixes in critical-priority and high-priority queues:

```
prefix-set ospf-critical-prefixes
  192.41.5.41/32,
  11.1.3.0/24,
  192.168.0.44/32
  end-set
  !
  prefix-set ospf-high-prefixes
  44.4.10.0/24,
  192.41.4.41/32,
  41.4.41.41/32
  end-set
  !
  prefix-set ospf-medium-prefixes
  0.0.0.0/0 ge 32
  end-set
  !

  route-policy ospf-priority
    if destination in ospf-high-prefixes then
      set spf-priority high
    else
      if destination in ospf-critical-prefixes then
        set spf-priority critical
      else
        if destination in ospf-medium-prefixes then
          set spf-priority medium
        endif
      endif
    endif
  end-policy
```

OSPFv2

```
router ospf 1
   spf prefix-priority route-policy ospf-priority
   area 0
    interface GigabitEthernet0/3/0/0
    !
```

```
   !
   area 3
    interface GigabitEthernet0/2/0/0
    !
   !
   area 8
    interface GigabitEthernet0/2/0/0.590
```

OSPFv3

```
router ospfv3 1
   spf prefix-priority route-policy ospf-priority
   area 0
    interface GigabitEthernet0/3/0/0
    !
   !
   area 3
    interface GigabitEthernet0/2/0/0
    !
   !
   area 8
    interface GigabitEthernet0/2/0/0.590
```

Route Redistribution for OSPFv3: Example

The following example uses prefix lists to limit the routes redistributed from other protocols.

Only routes with 9898:1000 in the upper 32 bits and with prefix lengths from 32 to 64 are redistributed from BGP 42. Only routes *not* matching this pattern are redistributed from BGP 1956.

```
ipv6 prefix-list list1
 seq 10 permit 9898:1000::/32 ge 32 le 64
ipv6 prefix-list list2
 seq 10 deny 9898:1000::/32 ge 32 le 64
 seq 20 permit ::/0 le 128
router ospfv3 1
 router-id 10.0.0.217
 redistribute bgp 42
 redistribute bgp 1956
 distribute-list prefix-list list1 out bgp 42
 distribute-list prefix-list list2 out bgp 1956
 area 1
  interface GigabitEthernet 0/2/0/0
```

Virtual Link Configured Through Area 1 for OSPFv3: Example

This example shows how to set up a virtual link to connect the backbone through area 1 for the OSPFv3 topology that consists of areas 0 and 1 and virtual links 10.0.0.217 and 10.0.0.212:

ABR 1 Configuration

```
router ospfv3 1
 router-id 10.0.0.217
 area 0
  interface GigabitEthernet 0/2/0/1
 area 1
```

```
  virtual-link 10.0.0.212
  interface GigabitEthernet 0/2/0/0
```

ABR 2 Configuration

```
router ospfv3 1
 router-id 10.0.0.212
 area 0
  interface GigabitEthernet 0/3/0/1
 area 1
  virtual-link 10.0.0.217
  interface GigabitEthernet 0/2/0/0
```

Check the virtual links:

```
show ospfv3 virtual-links
Mon Dec 17 11:18:29.249 EST

Virtual Link OSPF_VL0 to router 192.168.0.4 is up
Interface ID 1000000, IPv6 address 13:13:13::4
Run as demand circuit
DoNotAge LSA allowed.
Transit area 1, via interface GigabitEthernet0/0/0/0, Cost of using 2
Transmit Delay is 1 sec, State POINT_TO_POINT,
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
Hello due in 00:00:06
Adjacency State INIT (Hello suppressed)
Index 0/0/0, retransmission queue length 0, number of retransmission 0
First 0(0)/0(0)/0(0) Next 0(0)/0(0)/0(0)
Last retransmission scan length is 0, maximum is 0
Last retransmission scan time is 0 msec, maximum is 0 msec
```

Virtual Link Configured with MD5 Authentication for OSPF Version 2: Example

The following examples show how to configure a virtual link to your backbone and apply MD5 authentication. You must perform the steps described on both ABRs at each end of the virtual link.

After you explicitly configure the ABRs, the configuration is inherited by all interfaces bound to that area—unless you override the values and configure them explicitly for the interface.

To understand virtual links, see Virtual Link and Transit Area for OSPF, on page 15.

In this example, all interfaces on router ABR1 use MD5 authentication:

```
router ospf ABR1
 router-id 10.10.10.10
 authentication message-digest
 message-digest-key 100 md5 0 cisco
 area 0
  interface GigabitEthernet 0/2/0/1
  interface GigabitEthernet 0/3/0/0
 area 1
  interface GigabitEthernet 0/3/0/1
  virtual-link 10.10.5.5
!
!
```

In this example, only area 1 interfaces on router ABR3 use MD5 authentication:

```
router ospf ABR2
```

```
 router-id 10.10.5.5
 area 0
 area 1
  authentication message-digest
  message-digest-key 100 md5 0 cisco
  interface GigabitEthernet 0/9/0/1
  virtual-link 10.10.10.10
 area 3
  interface Loopback 0
  interface GigabitEthernet 0/9/0/0
!
```

VPN Backbone and Sham Link Configured for OSPF Version 2: Example

The following examples show how to configure a provider edge (PE) router to establish a VPN backbone and sham link connection:

```
logging console debugging
 vrf vrf_1
  address-family ipv4 unicast
  import route-target
   100:1
   !
  export route-target
   100:1
   !
 !
!
  interface Loopback0
   ipv4 address 2.2.2.1 255.255.255.255
   !
  interface Loopback1
   vrf vrf_1
   ipv4 address 10.0.1.3 255.255.255.255
   !
  interface GigabitEthernet0/2/0/2
   vrf vrf_1
   ipv4 address 100.10.10.2 255.255.255.0
   !
  interface GigabitEthernet0/2/0/3
   ipv4 address 100.20.10.2 255.255.255.0
   !
  !
route-policy pass-all
 pass
 end-policy
 !
router ospf 1
 log adjacency changes
 router-id 2.2.2.2
 vrf vrf_1
  router-id 22.22.22.2
  domain-id type 0005 value 111122223333
  domain-tag 140
  nsf ietf
  redistribute bgp 10
  area 0
   sham-link 10.0.1.3 10.0.0.101
    !
   interface GigabitEthernet0/2/0/2
    !
  !
```

```
 !
!
router ospf 2
 router-id 2.22.2.22
 area 0
  interface Loopback0
   !
  interface GigabitEthernet0/2/0/3
   !
   !
 !
router bgp 10
 bgp router-id 2.2.2.1
 bgp graceful-restart restart-time 300
 bgp graceful-restart
 address-family ipv4 unicast
  redistribute connected
  !
 address-family vpnv4 unicast
  !
 neighbor 2.2.2.2
 remote-as 10
 update-source Loopback0
 address-family ipv4 unicast
  !
 address-family vpnv4 unicast
  !
 !
 vrf vrf_1
  rd 100:1
   address-family ipv4 unicast
    redistribute connected route-policy pass-all
    redistribute ospf 1 match internal external
    !
   !
  !
 mpls ldp
  router-id 2.2.2.1
  interface GigabitEthernet0/2/0/3
  !
 !
```

The show command for the configuration is as follows:

```
show ospf vrf all-inclusive sham-links
Mon Dec 17 10:27:41.815 EST


Sham Links for OSPF 1, VRF vrf1

Sham Link OSPF_SL0 to address 3.3.3.3 is up
Area 1, source address 1.1.1.1
IfIndex = 3
Run as demand circuit
DoNotAge LSA allowed., Cost of using 2
Transmit Delay is 1 sec, State POINT_TO_POINT,
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
Hello due in 00:00:08:911
Adjacency State FULL (Hello suppressed)
Number of DBD retrans during last exchange 0
Index 2/2, retransmission queue length 0, number of retransmission 1
First 0(0)/0(0) Next 0(0)/0(0)
Last retransmission scan length is 1, maximum is 1
Last retransmission scan time is 0 msec, maximum is 0 msec
Keychain-based authentication enabled
```

```
Keychain name key1
Key id used is 1
Cryptographic algorithm MD5_16
```

OSPF v3 Sham Links

The following example shows a configuration for ospfv3 sham links:

```
router ospfv3 1
vrf vrf1
auto-cost reference-bandwidth 1000
router-id 1.1.1.1
redistribute bgp 100 route-policy vrf1_rpl
area 1
sham-link 1111::1111 3333::3333
cost 2
!
```

The show command for the configuration is as follows:

```
show ospfv3 vrf all-inclusive sham-links
Mon Dec 17 11:06:05.192 EST

Sham Links for OSPFv3 1, VRF vrf1

Sham Link OSPF_SL0 to address 3333::3333 is up
Area 1, source address 1111::1111
IfIndex = 3
Run as demand circuit
DoNotAge LSA allowed., Cost of using 2
Transmit Delay is 1 sec, State POINT_TO_POINT,
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
Hello due in 00:00:08
Adjacency State FULL (Hello suppressed)
Number of DBD retrans during last exchange 0
Index 2/2, retransmission queue length 0, number of retransmission 1
First 0(0)/0(0) Next 0(0)/0(0)
Last retransmission scan length is 1, maximum is 1
Last retransmission scan time is 0 msec, maximum is 0 msec
```

Where to Go Next

To configure route maps through the RPL for OSPF Version 2, see *Implementing Routing Policy on Cisco ASR 9000 Series Router* module.

To build an MPLS TE topology, create tunnels, and configure forwarding over the tunnel for OSPF Version 2; see *MPLS Configuration Guide for Cisco ASR 9000 Series Routers*.

Additional References

The following sections provide references related to implementing OSPF.

Related Documents

Related Topic	Document Title
OSPF Commands and OSPFv3 Commands: complete command syntax, command modes, command history, defaults, usage guidelines, and examples	*Routing Command Reference for Cisco ASR 9000 Series Routers*
MPLS TE feature information	*Implementing MPLS Traffic Engineering on* Cisco ASR 9000 Series Router module in *MPLS Configuration Guide for Cisco ASR 9000 Series Routers*
MIB Reference	*Cisco ASR 9000 Series Aggregation Services Router MIB Specification Guide*

Standards

Standards	Title
draft-ietf-ospf-multi-area-adj-07.txt	OSPF Multi-Area Adjacency
draft-ietf-pce-disco-proto-ospf-08.txt	OSPF Protocol Extensions for Path Computation Element (PCE)
draft-ietf-mpls-igp-sync-00.txt	LDP IGP Synchronization
draft-ietf-ospf-ospfv3-graceful-restart-07.txt	OSPFv3 Graceful Restart

MIBs

MIBs	MIBs Link
—	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

RFCs

RFCs	Title
RFC 1587	The OSPF NSSA Option
RFC 1793	Extending OSPF to Support Demand Circuits
RFC 2328	OSPF Version 2
RFC 2370	The OSPF Opaque LSA Option

RFCs	Title
RFC 2740	OSPF for IPv6
RFC 3101	The OSPF Not-So-Stubby Area (NSSA) Option
RFC 3137	OSPF Stub Router Advertisement
RFC 3509	Alternative Implementations of OSPF Area Border Routers
RFC 3623	Graceful OSPF Restart
RFC 3630	Traffic Engineering (TE) Extensions to OSPF Version 2
RFC 3682	The Generalized TTL Security Mechanism (GTSM)
RFC 3906	Calculating Interior Gateway Protocol (IGP) Routes Over Traffic Engineering Tunnels
RFC 4136	OSPF Refresh and Flooding Reduction in Stable Topologies
RFC 4206	Label Switched Paths (LSP) Hierarchy with Generalized Multi-Protocol Label Switching (GMPLS) Traffic Engineering (TE)
RFC 4124	Protocol Extensions for Support of Diffserv-aware MPLS Traffic Engineering
RFC 4576	Using a Link State Advertisement (LSA) Options Bit to Prevent Looping in BGP/MPLS IP Virtual Private Networks (VPNs) ownbit Extension for L3VPN
RFC 4577	OSPF as the Provider/Customer Edge Protocol for BGP/MPLS IP Virtual Private Networks (VPNs)
RFC 4750	OSPF Version 2 Management Information Base
RFC 4811	OSPF Out-of-Band Link State Database (LSDB) Resynchronization
RFC 4812	OSPF Restart Signaling
RFC 4813	OSPF Link-Local Signaling
RFC 4970	Extensions to OSPF for Advertising Optional Router Capabilities

RFCs	Title
RFC 5643	Management Information Base (MIB) for OSPFv3

Technical Assistance

Description	Link
The Cisco Technical Support website contains thousands of pages of searchable technical content, including links to products, technologies, solutions, technical tips, and tools. Registered Cisco.com users can log in from this page to access even more content.	http://www.cisco.com/techsupport