



IP Routing: OSPF Configuration Guide Cisco IOS XE 3SE (Catalyst 3850 Switches)

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CHAPTER

1

Configuring OSPF

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

Cisco supports RFC 1253, *OSPF Version 2 Management Information Base*, August 1991. The OSPF MIB defines an IP routing protocol that provides management information related to OSPF and is supported by Cisco routers.

For protocol-independent features that work with OSPF, see the "Configuring IP Routing Protocol-Independent Features" module.

- [Finding Feature Information](#), page 1
- [Information About OSPF](#), page 2
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- [Additional References for OSPF Not-So-Stubby Areas \(NSSA\)](#), page 52
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Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see [Bug Search Tool](#) and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table.

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

Information About OSPF

Cisco OSPF Implementation

The Cisco implementation conforms to the OSPF Version 2 specifications detailed in the Internet RFC 2328. The following list outlines key features supported in the Cisco OSPF implementation:

- Stub areas—The definition of stub areas is supported.
- Route redistribution—Routes learned via any IP routing protocol can be redistributed into any other IP routing protocol. At the intradomain level, OSPF can import routes learned via Interior Gateway Routing Protocol (IGRP), Routing Information Protocol (RIP), and Intermediate System-to-Intermediate System (IS-IS). OSPF routes can also be exported into IGRP, RIP, and IS-IS. At the interdomain level, OSPF can import routes learned via Exterior Gateway Protocol (EGP) and Border Gateway Protocol (BGP). OSPF routes can be exported into EGP and BGP.
- Authentication—Plain text and message-digest algorithm 5 (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 3101, which replaces and is backward compatible with RFC 1587.
- OSPF over demand circuit—RFC 1793.

Router Coordination for OSPF

OSPF typically requires coordination among many internal routers: Area Border Routers (ABRs), which are routers connected to multiple areas, and Autonomous System Boundary Routers (ASBRs). 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.

Route Distribution for OSPF

You can specify route redistribution; see the task “Redistribute Routing Information” in the *Network Protocols Configuration Guide, Part 1*, for information on how to configure route redistribution.

The Cisco OSPF implementation allows you to alter certain interface-specific OSPF parameters, as needed. You are not required to alter any of these parameters, but some interface parameters must be consistent across all routers in an attached network. Those parameters are controlled by the **ip ospf hello-interval**, **ip ospf dead-interval**, and **ip ospf authentication-key** interface configuration commands. Therefore, if you do configure any of these parameters, ensure that the configurations for all routers on your network have compatible values.

By default, OSPF classifies different media into the following three types of networks:

- Broadcast networks (Ethernet, Token Ring, and FDDI)
- Nonbroadcast multiaccess (NBMA) networks (Switched Multimegabit Data Service [SMDS], Frame Relay, and X.25)
- Point-to-point networks (High-Level Data Link Control [HDLC] and PPP)

You can configure your network as either a broadcast or an NBMA network.

X.25 and Frame Relay provide an optional broadcast capability that can be configured in the map to allow OSPF to run as a broadcast network. See the **x25 map** and **frame-relay map** command pages in the *Cisco IOS Wide-Area Networking Command Reference* publication for more detail.

OSPF Network Type

You have the choice of configuring your OSPF network type as either broadcast or NBMA, regardless of the default media type. 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. You also can configure NBMA networks (such as X.25, Frame Relay, and SMDS) as broadcast networks. This feature saves you from needing to configure neighbors, as described in the “Configuring OSPF for Nonbroadcast Networks” section later in this module.

Configuring NBMA networks as either broadcast or nonbroadcast assumes that there are virtual circuits (VCs) from every router to every router, that is, a fully meshed network. This is not true in some cases, for example, because of cost constraints or when you have only a partially meshed network. In these cases, you can configure the OSPF network type as a point-to-multipoint network. Routing between two routers that are not directly connected will go through the router that has VCs to both routers. Note that you need not configure neighbors when using this feature.

An OSPF point-to-multipoint interface is defined as a numbered point-to-point interface having one or more neighbors. It creates multiple host routes. An OSPF point-to-multipoint network has the following benefits compared to NBMA and point-to-point networks:

- Point-to-multipoint is easier to configure because it requires no configuration of neighbor commands, it consumes only one IP subnet, and it requires no designated router election.
- It costs less because it does not require a fully meshed topology.
- It is more reliable because it maintains connectivity in the event of VC failure.

On point-to-multipoint broadcast networks, there is no need to specify neighbors. However, you can specify neighbors with the **neighbor** router configuration command, in which case you should specify a cost to that neighbor.

Before the **point-to-multipoint** keyword was added to the **ip ospf network** interface configuration command, some OSPF point-to-multipoint protocol traffic was treated as multicast traffic. Therefore, the **neighbor** router configuration command was not needed for point-to-multipoint interfaces because multicast took care of the traffic. Hello, update, and acknowledgment messages were sent using multicast. In particular, multicast hello messages discovered all neighbors dynamically.

On any point-to-multipoint interface (broadcast or not), the Cisco IOS software assumed that the cost to each neighbor was equal. The cost was configured with the **ip ospf cost** interface configuration command. In reality, the bandwidth to each neighbor is different, so the cost should differ. With this feature, you can configure a separate cost to each neighbor. This feature applies to point-to-multipoint interfaces only.

Because many routers might be attached to an OSPF network, a *designated router* is selected for the network. Special configuration parameters are needed in the designated router selection if broadcast capability is not configured.

These parameters need only be configured in those devices that are themselves eligible to become the designated router or backup designated router (in other words, routers with a nonzero router priority value).

You can specify the following neighbor parameters, as required:

- Priority for a neighboring router
- Nonbroadcast poll interval

On point-to-multipoint, nonbroadcast networks, use the **neighbor** router configuration command to identify neighbors. Assigning a cost to a neighbor is optional.

Prior to Cisco IOS Release 12.0, some customers were using point-to-multipoint on nonbroadcast media (such as classic IP over ATM), so their routers could not dynamically discover their neighbors. This feature allows the **neighbor** router configuration command to be used on point-to-multipoint interfaces.

Area Parameters

Use OSPF Not-So-Stubby Areas (NSSA) feature to simplify administration if you are an Internet service provider (ISP) or a network administrator that must connect a central site that is using OSPF to a remote site that is using a different routing protocol.

Prior to NSSA, the connection between the corporate site border router and the remote router could not be run as an OSPF stub area because routes for the remote site could not be redistributed into the stub area, and two routing protocols needed to be maintained. A simple protocol such as 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 the remote router as an NSSA.

As with OSPF stub areas, NSSA areas cannot be injected with distributed routes via Type 5 LSAs. Route redistribution into an NSSA area is possible only with a special type of LSA that is known as Type 7 that can exist only in an NSSA area. An NSSA ASBR generates the Type 7 LSA so that the routes can be redistributed, and an NSSA ABR translates the Type 7 LSA into a Type 5 LSA, which can be flooded throughout the whole OSPF routing domain. Summarization and filtering are supported during the translation.

RFC 3101 allows you to configure an NSSA ABR router as a forced NSSA LSA translator. This means that the NSSA ABR router will unconditionally assume the role of LSA translator, preempting the default behavior, which would only include it among the candidates to be elected as translator.



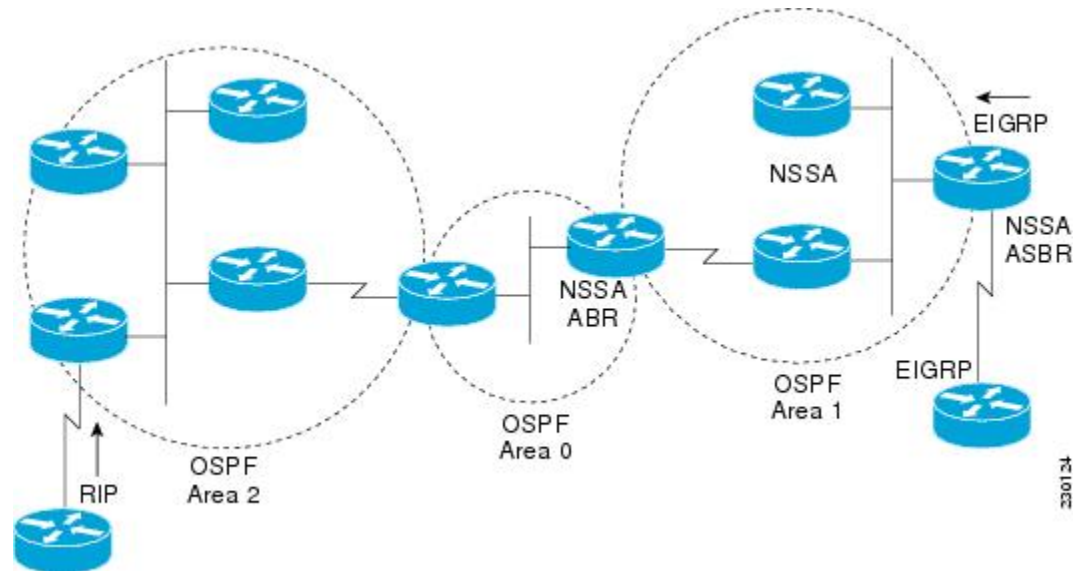
Note

Even a forced translator might not translate all LSAs; translation depends on the contents of each LSA.

The figure below shows a network diagram in which OSPF Area 1 is defined as the stub area. The Enhanced Interior Gateway Routing Protocol (EIGRP) routes cannot be propagated into the OSPF domain because

routing redistribution is not allowed in the stub area. However, once OSPF Area 1 is defined as an NSSA, an NSSA ASBR can inject the EIGRP routes into the OSPF NSSA by creating Type 7 LSAs.

Figure 1: OSPF NSSA



The redistributed routes from the RIP router will not be allowed into OSPF Area 1 because NSSA is an extension to the stub area. The stub area characteristics will still exist, including the exclusion of Type 5 LSAs.

Route summarization is the consolidation of advertised addresses. This feature causes a single summary route to be advertised to other areas by an ABR. In OSPF, an ABR will advertise networks in one area into another area. If the network numbers in an area are assigned in a way such that they are contiguous, you can configure the ABR to advertise a summary route that covers all the individual networks within the area that fall into the specified range.

When routes from other protocols are redistributed into OSPF (as described in the module "Configuring IP Routing Protocol-Independent Features"), each route is advertised individually in an external LSA. However, you can configure the Cisco IOS software to advertise a single route for all the redistributed routes that are covered by a specified network address and mask. Doing so helps decrease the size of the OSPF link-state database.

In OSPF, all areas must be connected to a backbone area. If there is a break in backbone continuity, or the backbone is purposefully partitioned, you can establish a virtual link. The two endpoints of a virtual link are ABRs. The virtual link must be configured in both routers. The configuration information in each router consists of the other virtual endpoint (the other ABR) and the nonbackbone area that the two routers have in common (called the transit area). Note that virtual links cannot be configured through stub areas.

You can force an ASBR to generate a default route into an OSPF routing domain. Whenever you specifically configure redistribution of routes into an OSPF routing domain, the router automatically becomes an ASBR. However, an ASBR does not, by default, generate a default route into the OSPF routing domain.

You can configure OSPF to look up Domain Naming System (DNS) names for use in all OSPF show EXEC command displays. You can use this feature to more easily identify a router, because the router is displayed by name rather than by its router ID or neighbor ID.

OSPF uses the largest IP address configured on the interfaces as its router ID. If the interface associated with this IP address is ever brought down, or if the address is removed, the OSPF process must recalculate a new router ID and resend all its routing information out its interfaces.

If a loopback interface is configured with an IP address, the Cisco IOS software will use this IP address as its router ID, even if other interfaces have larger IP addresses. Because loopback interfaces never go down, greater stability in the routing table is achieved.

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

In Cisco IOS Release 10.3 and later releases, by default OSPF calculates the OSPF metric for an interface according to the bandwidth of the interface. For example, a 64-kbps link gets a metric of 1562, and a T1 link gets a metric of 64.

The OSPF metric is calculated as the ref-bw value divided by the bandwidth value, with the ref-bw value equal to 108 by default, and the bandwidth value determined by the bandwidth interface configuration command. The calculation gives FDDI a metric of 1. If you have multiple links with high bandwidth, you might want to specify a larger number to differentiate the cost on those links.

An administrative distance is a rating of the trustworthiness of a routing information source, such as an individual router or a group of routers. Numerically, an administrative distance is an integer from 0 to 255. In general, the higher the value, the lower the trust rating. An administrative distance of 255 means the routing information source cannot be trusted at all and should be ignored.

OSPF uses three different administrative distances: intra-area, interarea, and external. Routes within an area are intra-area; routes to another area are interarea; and routes from another routing domain learned via redistribution are external. The default distance for each type of route is 110.

Because simplex interfaces between two devices on an Ethernet represent only one network segment, for OSPF you must configure the sending interface to be a passive interface. This configuration prevents OSPF from sending hello packets for the sending interface. Both devices are able to see each other via the hello packet generated for the receiving interface.

You can configure the delay time between when OSPF receives a topology change and when it starts a shortest path first (SPF) calculation. You can also configure the hold time between two consecutive SPF calculations.

The OSPF on-demand circuit is an enhancement to the OSPF protocol that allows efficient operation over on-demand circuits such as ISDN, X.25 switched virtual circuits (SVCs), and dialup lines. This feature supports RFC 1793, Extending OSPF to Support Demand Circuits.

Prior to this feature, OSPF periodic hello and LSA updates would be exchanged between routers that connected the on-demand link, even when no changes occurred in the hello or LSA information.

With this feature, periodic hellos are suppressed and the periodic refreshes of LSAs are not flooded over the demand circuit. These packets bring up the link only when they are exchanged for the first time, or when a change occurs in the information they contain. This operation allows the underlying data link layer to be closed when the network topology is stable.

This feature is useful when you want to connect telecommuters or branch offices to an OSPF backbone at a central site. In this case, OSPF for on-demand circuits allows the benefits of OSPF over the entire domain, without excess connection costs. Periodic refreshes of hello updates, LSA updates, and other protocol overhead are prevented from enabling the on-demand circuit when there is no "real" data to send.

Overhead protocols such as hellos and LSAs are transferred over the on-demand circuit only upon initial setup and when they reflect a change in the topology. This means that critical changes to the topology that require new SPF calculations are sent in order to maintain network topology integrity. Periodic refreshes that do not include changes, however, are not sent across the link.

The OSPF LSA group pacing feature allows the router to group OSPF LSAs and pace the refreshing, checksumming, and aging functions. The group pacing results in more efficient use of the router.

The router groups OSPF LSAs and paces the refreshing, checksumming, and aging functions so that sudden increases in CPU usage and network resources are avoided. This feature is most beneficial to large OSPF networks.

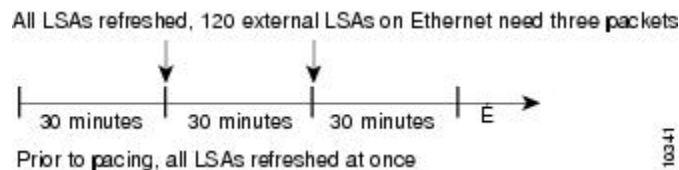
OSPF LSA group pacing is enabled by default. For typical customers, the default group pacing interval for refreshing, checksumming, and aging is appropriate and you need not configure this feature.

Original LSA Behavior

Each OSPF LSA has an age, which indicates whether the LSA is still valid. Once the LSA reaches the maximum age (1 hour), it is discarded. During the aging process, the originating router sends a refresh packet every 30 minutes to refresh the LSA. Refresh packets are sent to keep the LSA from expiring, whether there has been a change in the network topology or not. Checksumming is performed on all LSAs every 10 minutes. The router keeps track of LSAs that it generates and LSAs that it receives from other routers. The router refreshes LSAs that it generated; it ages the LSAs that it received from other routers.

Prior to the LSA group pacing feature, the Cisco software would perform refreshing on a single timer and checksumming and aging on another timer. In the case of refreshing, for example, the software would scan the whole database every 30 minutes, refreshing every LSA that the router generated, no matter how old it was. The figure below illustrates all the LSAs being refreshed at once. This process wasted CPU resources because only a small portion of the database needed to be refreshed. A large OSPF database (several thousand LSAs) could have thousands of LSAs with different ages. Refreshing on a single timer resulted in the age of all LSAs becoming synchronized, which resulted in much CPU processing at once. Furthermore, a large number of LSAs could cause a sudden increase of network traffic, consuming a large amount of network resources in a short time.

Figure 2: OSPF LSAs on a Single Timer Without Group Pacing



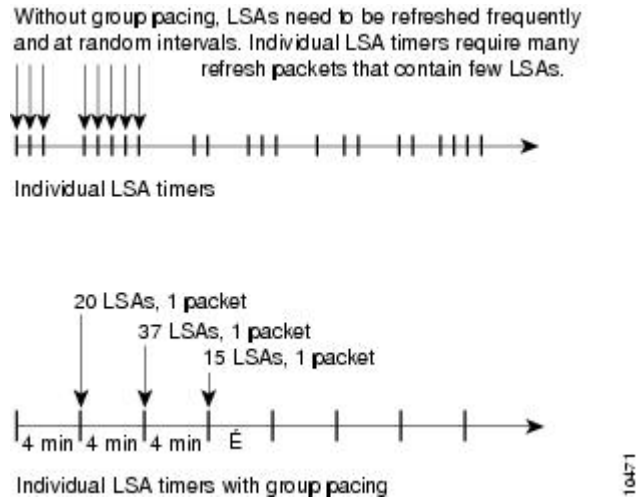
LSA Group Pacing with Multiple Timers

Configuring each LSA to have its own timer avoids excessive CPU processing and sudden network-traffic increase. To again use the example of refreshing, each LSA gets refreshed when it is 30 minutes old, independent of other LSAs. So the CPU is used only when necessary. However, LSAs being refreshed at frequent, random intervals would require many packets for the few refreshed LSAs that the router must send, which would be inefficient use of bandwidth.

Therefore, the router delays the LSA refresh function for an interval of time instead of performing it when the individual timers are reached. The accumulated LSAs constitute a group, which is then refreshed and sent out in one packet or more. Thus, the refresh packets are paced, as are the checksumming and aging. The pacing interval is configurable; it defaults to 4 minutes, which is randomized to further avoid synchronization.

The figure below illustrates the case of refresh packets. The first timeline illustrates individual LSA timers; the second timeline illustrates individual LSA timers with group pacing.

Figure 3: OSPF LSAs on Individual Timers with Group Pacing



The group pacing interval is inversely proportional to the number of LSAs that the router is refreshing, checksumming, and aging. For example, if you have approximately 10,000 LSAs, decreasing the pacing interval would benefit you. If you have a very small database (40 to 100 LSAs), increasing the pacing interval to 10 to 20 minutes might benefit you slightly.

The default value of pacing between LSA groups is 240 seconds (4 minutes). The range is from 10 seconds to 1800 seconds (30 minutes).

By default, OSPF floods new LSAs over all interfaces in the same area, except the interface on which the LSA arrives. Some redundancy is desirable, because it ensures robust flooding. However, too much redundancy can waste bandwidth and might destabilize the network due to excessive link and CPU usage in certain topologies. An example would be a fully meshed topology.

You can block OSPF flooding of LSAs in two ways, depending on the type of networks:

- On broadcast, nonbroadcast, and point-to-point networks, you can block flooding over specified OSPF interfaces.
- On point-to-multipoint networks, you can block flooding to a specified neighbor.

The growth of the Internet has increased the importance of scalability in IGPs such as OSPF. By design, OSPF requires LSAs to be refreshed as they expire after 3600 seconds. Some implementations have tried to improve the flooding by reducing the frequency to refresh from 30 minutes to about 50 minutes. This solution reduces the amount of refresh traffic but requires at least one refresh before the LSA expires. The OSPF flooding reduction solution works by reducing unnecessary refreshing and flooding of already known and unchanged information. To achieve this reduction, the LSAs are now flooded with the higher bit set. The LSAs are now set as “do not age.”

Cisco routers do not support LSA Type 6 Multicast OSPF (MOSPF), and they generate syslog messages if they receive such packets. If the router is receiving many MOSPF packets, you might want to configure the router to ignore the packets and thus prevent a large number of syslog messages.

The former OSPF implementation for sending update packets needed to be more efficient. Some update packets were getting lost in cases where the link was slow, a neighbor could not receive the updates quickly enough, or the router was out of buffer space. For example, packets might be dropped if either of the following topologies existed:

- A fast router was connected to a slower router over a point-to-point link.
- During flooding, several neighbors sent updates to a single router at the same time.

OSPF update packets are now automatically paced so they are not sent less than 33 milliseconds apart. Pacing is also added between resends to increase efficiency and minimize lost retransmissions. Also, you can display the LSAs waiting to be sent out an interface. The benefit of pacing is that OSPF update and retransmission packets are sent more efficiently. There are no configuration tasks for this feature; it occurs automatically.

You can display specific statistics such as the contents of IP routing tables, caches, and databases. Information provided can be used to determine resource utilization and solve network problems. You can also display information about node reachability and discover the routing path that your device packets are taking through the network.

How to Configure OSPF

To configure OSPF, perform the tasks described in the following sections. The tasks in the “Enabling OSPF” section are required; the tasks in the remaining sections are optional, but might be required for your application. For information about the maximum number of interfaces, see the “Restrictions for OSPF” section.

Enabling OSPF

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **router ospf** *process-id*
4. **network** *ip-address wildcard-mask area area-id*
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> • Enter your password if prompted.

	Command or Action	Purpose
Step 2	configure terminal Example: Device# configure terminal	Enters global configuration mode.
Step 3	router ospf <i>process-id</i> Example: Device(config)# router ospf 109	Enables OSPF routing and enters router configuration mode.
Step 4	network <i>ip-address wildcard-mask area area-id</i> Example: Device(config-router)# network 192.168.129.16 0.0.0.3 area 20	Defines an interface on which OSPF runs and defines the area ID for that interface.
Step 5	end Example: Device(config-router)# end	Exits router configuration mode and returns to privileged EXEC mode.

Configuring OSPF Interface Parameters

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface *type number***
4. **ip ospf cost *cost***
5. **ip ospf retransmit-interval *seconds***
6. **ip ospf transmit-delay *seconds***
7. **ip ospf priority *number-value***
8. **ip ospf hello-interval *seconds***
9. **ip ospf dead-interval *seconds***
10. **ip ospf authentication-key *key***
11. **ip ospf message-digest-key *key-id md5 key***
12. **ip ospf authentication [*message-digest* | null]**
13. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Device> enable	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	configure terminal Example: Device# configure terminal	Enters global configuration mode.
Step 3	interface <i>type number</i> Example: Device(config)# interface GigabitEthernet 0/0	Configures an interface type and enters interface configuration mode.
Step 4	ip ospf cost <i>cost</i> Example: Device(config-if)# ip ospf cost 65	Explicitly specifies the cost of sending a packet on an OSPF interface.
Step 5	ip ospf retransmit-interval <i>seconds</i> Example: Device(config-if)# ip ospf retransmit-interval 1	Specifies the number of seconds between link-state advertisement (LSA) retransmissions for adjacencies belonging to an OSPF interface.
Step 6	ip ospf transmit-delay <i>seconds</i> Example: Device(config-if)# ip ospf transmit-delay	Sets the estimated number of seconds required to send a link-state update packet on an OSPF interface.
Step 7	ip ospf priority <i>number-value</i> Example: Device(config-if)# ip ospf priority 1	Sets priority to help determine the OSPF designated router for a network.
Step 8	ip ospf hello-interval <i>seconds</i> Example: Device(config-if)# ip ospf hello-interval 1	Specifies the length of time between the hello packets that the Cisco IOS software sends on an OSPF interface.

	Command or Action	Purpose
Step 9	ip ospf dead-interval <i>seconds</i> Example: Device(config-if)# ip ospf dead-interval 1	Sets the number of seconds that a device must wait before it declares a neighbor OSPF router down because it has not received a hello packet.
Step 10	ip ospf authentication-key <i>key</i> Example: Device(config-if)# ip ospf authentication-key 1	Assigns a password to be used by neighboring OSPF routers on a network segment that is using the OSPF simple password authentication.
Step 11	ip ospf message-digest-key <i>key-id md5 key</i> Example: Device(config-if)# ip ospf message-digest-key 1 md5 23456789	Enables OSPF MD5 authentication. The values for the <i>key-id</i> and <i>key</i> arguments must match values specified for other neighbors on a network segment.
Step 12	ip ospf authentication [message-digest null] Example: Device(config-if)# ip ospf authentication message-digest	Specifies the authentication type for an interface.
Step 13	end Example: Device(config-if)# end	Exits interface configuration mode and returns to privileged EXEC mode.

Configuring OSPF over Different Physical Networks

Configuring OSPF for Point-to-Multipoint Broadcast Networks

SUMMARY STEPS

1. **configure terminal**
2. **interface** *type number*
3. **ip ospf network point-to-multipoint**
4. **exit**
5. **router ospf** *process-id*
6. **neighbor** *ip-address* [**cost** *number*]

DETAILED STEPS

	Command or Action	Purpose
Step 1	configure terminal Example: Device# configure terminal	Enters global configuration mode.
Step 2	interface type number Example: Device(config)# interface gigabitethernet 0/0/0	Specifies an interface type and number, and enters interface configuration mode.
Step 3	ip ospf network point-to-multipoint Example: Device#(config-if) ip ospf network point-to-multipoint	Configures an interface as point-to-multipoint for broadcast media.
Step 4	exit Example: Device#(config-if) exit	Enters global configuration mode.
Step 5	router ospf process-id Example: Device#(config) router ospf 109	Configures an OSPF routing process and enters router configuration mode.
Step 6	neighbor ip-address [cost number] Example: Device#(config-router) neighbor 192.168.3.4 cost 180	Specifies a neighbor and assigns a cost to the neighbor. Note Repeat this step for each neighbor if you want to specify a cost. Otherwise, neighbors will assume the cost of the interface, based on the ip ospf cost interface configuration command.

Configuring OSPF for Nonbroadcast Networks

SUMMARY STEPS

1. **configure terminal**
2. **interface** *type number*
3. **ip ospf network point-to-multipoint non-broadcast**
4. **exit**
5. **router ospf** *process-id*
6. **neighbor** *ip-address* [*cost number*]

DETAILED STEPS

	Command or Action	Purpose
Step 1	configure terminal Example: Device# configure terminal	Enters global configuration mode.
Step 2	interface <i>type number</i> Example: Device(config)# interface gigabitethernet 0/0/0	Specifies an interface type and number, and enters interface configuration mode.
Step 3	ip ospf network point-to-multipoint non-broadcast Example: Device#(config-if) ip ospf network point-to-multipoint non-broadcast	Configures an interface as point-to-multipoint for nonbroadcast media.
Step 4	exit Example: Device#(config-if) exit	Enters global configuration mode.
Step 5	router ospf <i>process-id</i> Example: Device#(config) router ospf 109	Configures an OSPF routing process and enters router configuration mode.
Step 6	neighbor <i>ip-address</i> [<i>cost number</i>]	Specifies a neighbor and assigns a cost to the neighbor.

	Command or Action	Purpose
	Example: <pre>Device#(config-router) neighbor 192.168.3.4 cost 180</pre>	Note Repeat this step for each neighbor if you want to specify a cost. Otherwise, neighbors will assume the cost of the interface, based on the ip ospf cost interface configuration command.

Configuring OSPF Area Parameters

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **router ospf *process-id***
4. **area *area-id* authentication**
5. **area *area-id* stub [no summary]**
6. **area *area-id* default-cost *cost***
7. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: <pre>Device> enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> • Enter your password if prompted.
Step 2	configure terminal Example: <pre>Device# configure terminal</pre>	Enters global configuration mode.
Step 3	router ospf <i>process-id</i> Example: <pre>Device(config)# router ospf 10</pre>	Enables OSPF routing and enters router configuration mode.

	Command or Action	Purpose
Step 4	area <i>area-id</i> authentication Example: Device(config-router)# area 10.0.0.0 authentication	Enables authentication for an OSPF area.
Step 5	area <i>area-id</i> stub [no summary] Example: Device(config-router)# area 10.0.0.0 stub no-summary	Defines an area to be a stub area.
Step 6	area <i>area-id</i> default-cost <i>cost</i> Example: Device(config-router)# area 10.0.0.0 default-cost 1	Specifies a cost for the default summary route that is sent into a stub area or not-so-stubby area (NSSA)
Step 7	end Example: Device(config-router)# end	Exits router configuration mode and returns to privileged EXEC mode.

Configuring OSPFv2 NSSA

Configuring an OSPFv2 NSSA Area and Its Parameters

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **router ospf** *process-id*
4. **redistribute** *protocol* [*process-id*] {**level-1** | **level-1-2** | **level-2**} [*autonomous-system-number*] [**metric** {**metric-value** | **transparent**}] [**metric-type** *type-value*] [**match** {**internal** | **external 1** | **external 2**}] [**tag** *tag-value*] [**route-map** *map-tag*] [**subnets**] [**nssa-only**]
5. **network** *ip-address wildcard-mask area area-id*
6. **area** *area-id* **nssa** [**no-redistribution**] [**default-information-originate** [**metric**] [**metric-type**]] [**no-summary**] [**nssa-only**]
7. **summary-address** *prefix mask* [**not-advertise**] [**tag** *tag*] [**nssa-only**]
8. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> • Enter your password if prompted.
Step 2	configure terminal Example: Device# configure terminal	Enters global configuration mode.
Step 3	router ospf <i>process-id</i> Example: Device(config)# router ospf 10	Enables OSPF routing and enters router configuration mode. <ul style="list-style-type: none"> • The <i>process-id</i> argument identifies the OSPF process. The range is from 1 to 65535.
Step 4	redistribute <i>protocol</i> [<i>process-id</i>] { level-1 level-1-2 level-2 } [<i>autonomous-system-number</i>] [metric { metric-value transparent }] [metric-type <i>type-value</i>] [match { internal external 1 external 2 }] [tag <i>tag-value</i>] [route-map <i>map-tag</i>] [subnets] [nssa-only] Example: Device(config-router)# redistribute rip subnets	Redistributes routes from one routing domain to another routing domain. <ul style="list-style-type: none"> • In the example, Routing Information Protocol (RIP) subnets are redistributed into the OSPF domain.
Step 5	network <i>ip-address wildcard-mask area area-id</i> Example: Device(config-router)# network 192.168.129.11 0.0.0.255 area 1	Defines the interfaces on which OSPF runs and the area ID for those interfaces.
Step 6	area <i>area-id nssa</i> [no-redistribution] [default-information-originate [metric] [metric-type]] [no-summary] [nssa-only] Example: Device(config-router)# area 1 nssa	Configures a Not-So-Stubby Area (NSSA) area.
Step 7	summary-address <i>prefix mask</i> [not-advertise] [tag <i>tag</i>] [nssa-only] Example: Device(config-router)# summary-address 10.1.0.0	Controls the route summarization and filtering during the translation and limits the summary to NSSA areas.

	Command or Action	Purpose
	255.255.0.0 not-advertise	
Step 8	end Example: Device(config-router)# end	Exits router configuration mode and returns to privileged EXEC mode.

Configuring an NSSA ABR as a Forced NSSA LSA Translator

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **router ospf** *process-id*
4. **area** *area-id* **nssa translate type7 always**
5. **area** *area-id* **nssa translate type7 suppress-fa**
6. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> • Enter your password if prompted.
Step 2	configure terminal Example: Device# configure terminal	Enters global configuration mode.
Step 3	router ospf <i>process-id</i> Example: Device(config)# router ospf 1	Enables OSPF routing and enters router configuration mode. <ul style="list-style-type: none"> • The <i>process-id</i> argument identifies the OSPF process. The range is from 1 to 65535.

	Command or Action	Purpose
Step 4	area <i>area-id</i> nssa translate type7 always Example: <pre>Device(config-router)# area 10 nssa translate type7 always</pre>	Configures a Not-So-Stubby Area Area Border Router (NSSA ABR) device as a forced NSSA Link State Advertisement (LSA) translator. Note You can use the always keyword in the area nssa translate command to configure an NSSA ABR device as a forced NSSA LSA translator. This command can be used if RFC 3101 is disabled and RFC 1587 is used.
Step 5	area <i>area-id</i> nssa translate type7 suppress-fa Example: <pre>Device(config-router)# area 10 nssa translate type7 suppress-fa</pre>	Allows ABR to suppress the forwarding address in translated Type-5 LSA.
Step 6	end Example: <pre>Device(config-router)# end</pre>	Exits router configuration mode and returns to privileged EXEC mode.

Disabling RFC 3101 Compatibility and Enabling RFC 1587 Compatibility

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **router ospf** *process-id*
4. **compatible rfc1587**
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: <pre>Device> enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> • Enter your password if prompted.

	Command or Action	Purpose
Step 2	configure terminal Example: Device# configure terminal	Enters global configuration mode.
Step 3	router ospf <i>process-id</i> Example: Device(config)# router ospf 1	Enables OSPF routing and enters router configuration mode. <ul style="list-style-type: none"> • The <i>process-id</i> argument identifies the OSPF process. • Use router ospf <i>process-id</i> command to enable OSPFv2 routing.
Step 4	compatible rfc1587 Example: Device(config-router)# compatible rfc1587	Enables the device to be RFC 1587 compliant.
Step 5	end Example: Device(config-router)# end	Exits router configuration mode and returns to privileged EXEC mode.

Configuring OSPF NSSA Parameters

Prerequisites

Evaluate the following considerations before you implement this feature:

- You can set a Type 7 default route that can be used to reach external destinations. When configured, the device generates a Type 7 default into the Not-So-Stubby Area (NSSA or the NSSA Area Border Router (ABR).
- Every device within the same area must agree that the area is NSSA; otherwise, the devices cannot communicate.

Configuring Route Summarization Between OSPF Areas

Configuring Route Summarization When Redistributing Routes into OSPF

SUMMARY STEPS

1. `summary-address {ip-address mask | prefix mask} [not-advertise][tag tag [nssa-only]`

DETAILED STEPS

	Command or Action	Purpose
Step 1	<code>summary-address {ip-address mask prefix mask}</code> <code>[not-advertise][tag tag [nssa-only]</code> Example: Device#(config-router) summary-address 10.1.0.0 255.255.0.0	Specifies an address and mask that covers redistributed routes, so that only one summary route is advertised. <ul style="list-style-type: none"> • You can use the optional not-advertise keyword to filter out a set of routes.

Establishing Virtual Links

SUMMARY STEPS

1. `area area-id virtual-link router-id [authentication [message-digest | null]] [hello-interval seconds]`
`[retransmit-interval seconds] [transmit-delay seconds] [dead-interval seconds] [authentication-key`
`key | message-digest-key key-id md5 key]`

DETAILED STEPS

	Command or Action	Purpose
Step 1	<code>area area-id virtual-link router-id [authentication [message-digest null]]</code> <code>[hello-interval seconds] [retransmit-interval seconds] [transmit-delay seconds]</code> <code>[dead-interval seconds] [authentication-key key message-digest-key key-id md5 key]</code> Example: Device(config-router-af)# area 1 virtual-link 10.1.1.1 router1	Establishes a virtual link.

Generating a Default Route

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **router ospf** *process-id*
4. **default-information originate** [**always**] [**metric** *metric-value*] [**metric-type** *type-value*] [**route-map** *map-name*]
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> • Enter your password if prompted.
Step 2	configure terminal Example: Device# configure terminal	Enters global configuration mode.
Step 3	router ospf <i>process-id</i> Example: Device(config)# router ospf 109	Enables OSPF routing and enters router configuration mode.
Step 4	default-information originate [always] [metric <i>metric-value</i>] [metric-type <i>type-value</i>] [route-map <i>map-name</i>] Example: Device(config-router)# default-information originate always	Forces the ASBR to generate a default route into the OSPF routing domain. Note The always keyword includes the following exception when a route map is used. When a route map is used, the origination of the default route by OSPF is not bound to the existence of a default route in the routing table.
Step 5	end Example: Device(config-router)# end	Exits router configuration mode and returns to privileged EXEC mode.

Configuring Lookup of DNS Names

SUMMARY STEPS

1. `enable`
2. `configure terminal`
3. `ip ospf name-lookup`
4. `end`

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> • Enter your password if prompted.
Step 2	configure terminal Example: Device# configure terminal	Enters global configuration mode.
Step 3	ip ospf name-lookup Example: Device# ip ospf name-lookup	Enables OSPF routing and enters router configuration mode.
Step 4	end Example: Device(config)# end	Exits global configuration mode and returns to privileged EXEC mode.

Forcing the Router ID Choice with a Loopback Interface

SUMMARY STEPS

1. `configure terminal`
2. `interface type number`
3. `ip address ip-address mask`

DETAILED STEPS

	Command or Action	Purpose
Step 1	configure terminal Example: Device# configure terminal	Enters global configuration mode.
Step 2	interface type number Example: Device(config)# interface loopback 0	Creates a loopback interface and enters interface configuration mode.
Step 3	ip address ip-address mask Example: Device#(config-if) ip address 192.108.1.27 255.255.255.0	Assigns an IP address to this interface.

Controlling Default Metrics

SUMMARY STEPS

1. enable
2. configure terminal
3. router ospf *process-id*
4. auto-cost reference-bandwidth *ref-bw*
5. end

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Device> enable	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	configure terminal Example: Device# configure terminal	Enters global configuration mode.
Step 3	router ospf <i>process-id</i> Example: Device# router ospf 109	Enables OSPF routing and enters router configuration mode.
Step 4	auto-cost reference-bandwidth <i>ref-bw</i> Example: Device(config-router)# auto-cost reference-bandwidth 101	Differentiates high -bandwidth links.
Step 5	end Example: Device(config-router)# end	Exits router configuration mode and returns to privileged EXEC mode.

Changing the OSPF Administrative Distances

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **router ospf *process-id***
4. **distance ospf {intra-area | inter-area | external} *dist***
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Device> enable	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	configure terminal Example: Device# configure terminal	Enters global configuration mode.
Step 3	router ospf process-id Example: Device(config)# router ospf 109	Enables OSPF routing and enters router configuration mode.
Step 4	distance ospf {intra-area inter-area external} dist Example: Device(config-router)# distance ospf external 200	Changes the OSPF distance values.
Step 5	end Example: Device(config-router)# end	Exits router configuration mode and returns to privileged EXEC mode.

Configuring OSPF on Simplex Ethernet Interfaces

Command	Purpose
passive-interface interface-type interface-number	Suppresses the sending of hello packets through the specified interface.

Configuring Route Calculation Timers

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **router ospf process-id**
4. **timers throttle spf spf-start spf-hold spf-max-wait**
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> • Enter your password if prompted.
Step 2	configure terminal Example: Device# configure terminal	Enters global configuration mode.
Step 3	router ospf <i>process-id</i> Example: Device(config)# router ospf 109	Enables OSPF routing and enters router configuration mode.
Step 4	timers throttle spf <i>spf-start spf-hold spf-max-wait</i> Example: Device(config-router)# timers throttle spf 5 1000 9000	Configures route calculation timers.
Step 5	end Example: Device(config-router)# end	Exits router configuration mode and returns to privileged EXEC mode.

Configuring OSPF over On-Demand Circuits

SUMMARY STEPS

1. **router ospf *process-id***
2. **interface *type number***
3. **ip ospf demand-circuit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	<code>router ospf process-id</code>	Enables OSPF operation.
Step 2	<code>interface type number</code>	Enters interface configuration mode.
Step 3	<code>ip ospf demand-circuit</code>	Configures OSPF over an on-demand circuit.

What to Do Next



Note

You can prevent an interface from accepting demand-circuit requests from other routers to by specifying the **ignore** keyword in the **ip ospf demand-circuit** command.

Prerequisites

Evaluate the following considerations before implementing the On-Demand Circuits feature:

- Because LSAs that include topology changes are flooded over an on-demand circuit, we recommend that you put demand circuits within OSPF stub areas or within NSSAs to isolate the demand circuits from as many topology changes as possible.
- Every router within a stub area or NSSA must have this feature loaded in order to take advantage of the on-demand circuit functionality. If this feature is deployed within a regular area, all other regular areas must also support this feature before the demand circuit functionality can take effect because Type 5 external LSAs are flooded throughout all areas.
- Hub-and-spoke network topologies that have a point-to-multipoint (P2MP) OSPF interface type on a hub might not revert to nondemand circuit mode when needed. You must simultaneously reconfigure OSPF on all interfaces on the P2MP segment when reverting them from demand circuit mode to nondemand circuit mode.
- Do not implement this feature on a broadcast-based network topology because the overhead protocols (such as hello and LSA packets) cannot be successfully suppressed, which means the link will remain up.
- Configuring the router for an OSPF on-demand circuit with an asynchronous interface is not a supported configuration. The supported configuration is to use dialer interfaces on both ends of the circuit. For more information, refer to [Why OSPF Demand Circuit Keeps Bringing Up the Link](#) .

Logging Neighbors Going Up or Down

SUMMARY STEPS

1. `enable`
2. `configure terminal`
3. `router ospf process-id`
4. `log-adjacency-changes [detail]`
5. `end`

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> • Enter your password if prompted.
Step 2	configure terminal Example: Device# configure terminal	Enters global configuration mode.
Step 3	router ospf process-id Example: Device(config)# router ospf 109	Enables OSPF routing and enters router configuration mode.
Step 4	log-adjacency-changes [detail] Example: Device(config-router)# log-adjacency-changes detail	Changes the group pacing of LSAs. Note Configure the log-adjacency-changes command if you want to know about OSPF neighbors going up or down without turning on the debug ip ospf adjacency EXEC command because the log-adjacency-changes command provides a higher-level view of the peer relationship with less output. Configure the log-adjacency-changes detail command if you want to see messages for each state change.
Step 5	end Example: Device(config-router)# end	Exits router configuration mode and returns to privileged EXEC mode.

Changing the LSA Group Pacing Interval

SUMMARY STEPS

1. `enable`
2. `configure terminal`
3. `router ospf process-id`
4. `timers pacing lsa-group seconds`
5. `end`

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> • Enter your password if prompted.
Step 2	configure terminal Example: Device# configure terminal	Enters global configuration mode.
Step 3	router ospf <i>process-id</i> Example: Device(config)# router ospf 109	Enables OSPF routing and enters router configuration mode.
Step 4	timers pacing lsa-group <i>seconds</i> Example: Device(config-router)# timers pacing lsa-group 60	Changes the group pacing of LSAs.
Step 5	end Example: Device(config-router)# end	Exits router configuration mode and returns to privileged EXEC mode.

Blocking OSPF LSA Flooding

Command	Purpose
<code>ip ospf database-filter all out</code>	Blocks the flooding of OSPF LSA packets to the interface.

On point-to-multipoint networks, to block flooding of OSPF LSAs, use the following command in router configuration mode:

Command	Purpose
<code>neighbor <i>ip-address</i> database-filter all out</code>	Blocks the flooding of OSPF LSA packets to the specified neighbor.

Reducing LSA Flooding

Command	Purpose
<code>ip ospf flood-reduction</code>	Suppresses the unnecessary flooding of LSAs in stable topologies.

Ignoring MOSPF LSA Packets

Command	Purpose
<code>ignore lsa mospf</code>	Prevents the router from generating syslog messages when it receives MOSPF LSA packets.

Monitoring and Maintaining OSPF

Command	Purpose
<code>show ip ospf [process-id]</code>	Displays general information about OSPF routing processes.
<code>show ip ospf border-routers</code>	Displays the internal OSPF routing table entries to the ABR and ASBR.
	Displays lists of information related to the OSPF database.

Command	Purpose
<pre> show ip ospf [<i>process-id</i> [<i>area-id</i>]] database show ip ospf [<i>process-id</i> [<i>area-id</i>]] database [database-summary] show ip ospf [<i>process-id</i> [<i>area-id</i>]] database [router] [self-originate] show ip ospf [<i>process-id</i> [<i>area-id</i>]] database [router] [adv-router [<i>ip-address</i>]] show ip ospf [<i>process-id</i> [<i>area-id</i>]] database [router] [<i>link-state-id</i>] show ip ospf [<i>process-id</i> [<i>area-id</i>]] database [network] [<i>link-state-id</i>] show ip ospf [<i>process-id</i> [<i>area-id</i>]] database [summary] [<i>link-state-id</i>] show ip ospf [<i>process-id</i> [<i>area-id</i>]] database [asbr-summary] [<i>link-state-id</i>] show ip ospf [<i>process-id</i> [Router# <i>area-id</i>]] database [external] [<i>link-state-id</i>] show ip ospf [<i>process-id</i> [<i>area-id</i>]] database [nssa-external] [<i>link-state-id</i>] show ip ospf [<i>process-id</i> [<i>area-id</i>]] database [opaque-link] [<i>link-state-id</i>] show ip ospf [<i>process-id</i> [<i>area-id</i>]] database [opaque-area] [<i>link-state-id</i>] show ip ospf [<i>process-id</i> [<i>area-id</i>]] database [opaque-as] [<i>link-state-id</i>] </pre>	
<pre> show ip ospf flood-list interface <i>type</i> </pre>	Displays a list of LSAs waiting to be flooded over an interface (to observe OSPF packet pacing).
<pre> show ip ospf interface [<i>type number</i>] </pre>	Displays OSPF-related interface information.

Command	Purpose
show ip ospf neighbor [<i>interface-name</i>] [<i>neighbor-id</i>] detail	Displays OSPF neighbor information on a per-interface basis.
show ip ospf request-list [<i>neighbor</i>] [<i>interface</i>] [<i>interface-neighbor</i>]	Displays a list of all LSAs requested by a router.
show ip ospf retransmission-list [<i>neighbor</i>] [<i>interface</i>] [<i>interface-neighbor</i>]	Displays a list of all LSAs waiting to be re-sent.
show ip ospf [<i>process-id</i>] summary-address	Displays a list of all summary address redistribution information configured under an OSPF process.
show ip ospf virtual-links	Displays OSPF-related virtual links information.

To restart an OSPF process, use the following command in EXEC mode:

Command	Purpose
clear ip ospf [<i>pid</i>] { process redistribution counters [<i>neighbor</i> <i>neighbor - interface</i>] [<i>neighbor-id</i>] }	Clears redistribution based on the OSPF routing process ID. If the <i>pid</i> option is not specified, all OSPF processes are cleared.

Displaying OSPF Update Packet Pacing

SUMMARY STEPS

1. **show ip ospf flood-list** *interface-type interface-number*

DETAILED STEPS

	Command or Action	Purpose
Step 1	show ip ospf flood-list <i>interface-type interface-number</i> Example: Device> show ip ospf flood-list ethernet 1	Displays a list of OSPF LSAs waiting to be flooded over an interface.

Restrictions for OSPF

On systems with a large number of interfaces, it may be possible to configure OSPF such that the number of links advertised in the router LSA causes the link-state update packet to exceed the size of a “huge” Cisco buffer. To resolve this problem, reduce the number of OSPF links or increase the huge buffer size by entering the **buffers huge size size** command.

A link-state update packet containing a router LSA typically has a fixed overhead of 196 bytes, and an additional 12 bytes are required for each link description. With a huge buffer size of 18024 bytes, there can be a maximum of 1485 link descriptions.

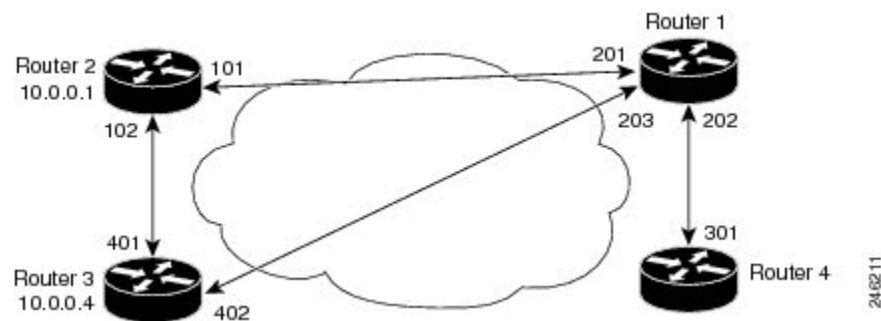
Because the maximum size of an IP packet is 65,535 bytes, there is still an upper bound on the number of links possible on a router.

Configuration Examples for OSPF

Example: OSPF Point-to-Multipoint

In the figure below, Router 1 uses data-link connection identifier (DLCI) 201 to communicate with Router 2, DLCI 202 to communicate with Router 4, and DLCI 203 to communicate with Router 3. Router 2 uses DLCI 101 to communicate with Router 1 and DLCI 102 to communicate with Router 3. Router 3 communicates with Router 2 (DLCI 401) and Router 1 (DLCI 402). Router 4 communicates with Router 1 (DLCI 301). Configuration examples follow the figure.

Figure 4: OSPF Point-to-Multipoint Example



Router 1 Configuration

```
hostname Router 1
!
interface serial 1
 ip address 10.0.0.2 255.0.0.0
 ip ospf network point-to-multipoint
 encapsulation frame-relay
 frame-relay map ip 10.0.0.1 201 broadcast
 frame-relay map ip 10.0.0.3 202 broadcast
 frame-relay map ip 10.0.0.4 203 broadcast
!
router ospf 1
 network 10.0.0.0 0.0.0.255 area 0
```

Router 2 Configuration

```

hostname Router 2
!
interface serial 0
 ip address 10.0.0.1 255.0.0.0
 ip ospf network point-to-multipoint
 encapsulation frame-relay
 frame-relay map ip 10.0.0.2 101 broadcast
 frame-relay map ip 10.0.0.4 102 broadcast
!
router ospf 1
 network 10.0.0.0 0.0.0.255 area 0

```

Router 3 Configuration

```

hostname Router 3
!
interface serial 3
 ip address 10.0.0.4 255.0.0.0
 ip ospf network point-to-multipoint
 encapsulation frame-relay
 clock rate 1000000
 frame-relay map ip 10.0.0.1 401 broadcast
 frame-relay map ip 10.0.0.2 402 broadcast
!
router ospf 1
 network 10.0.0.0 0.0.0.255 area 0

```

Router 4 Configuration

```

hostname Router 4
!
interface serial 2
 ip address 10.0.0.3 255.0.0.0
 ip ospf network point-to-multipoint
 encapsulation frame-relay
 clock rate 2000000
 frame-relay map ip 10.0.0.2 301 broadcast
!
router ospf 1
 network 10.0.0.0 0.0.0.255 area 0

```

Example: OSPF Point-to-Multipoint with Broadcast

The following example illustrates a point-to-multipoint network with broadcast:

```

interface Serial0
 ip address 10.0.1.1 255.255.255.0
 encapsulation frame-relay
 ip ospf cost 100
 ip ospf network point-to-multipoint
 frame-relay map ip 10.0.1.3 202 broadcast
 frame-relay map ip 10.0.1.4 203 broadcast
 frame-relay map ip 10.0.1.5 204 broadcast
 frame-relay local-dlci 200
!
router ospf 1
 network 10.0.1.0 0.0.0.255 area 0
 neighbor 10.0.1.5 cost 5
 neighbor 10.0.1.4 cost 10

```

The following example shows the configuration of the neighbor at 10.0.1.3:

```
interface serial 0
 ip address 10.0.1.3 255.255.255.0
 ip ospf network point-to-multipoint
 encapsulation frame-relay
 frame-relay local-dlci 301
 frame-relay map ip 10.0.1.1 300 broadcast
 no shutdown
!
router ospf 1
 network 10.0.1.0 0.0.0.255 area 0
```

The output shown for neighbors in the first configuration is as follows:

```
Device# show ip ospf neighbor
Neighbor ID      Pri   State           Dead Time   Address      Interface
172.16.1.1       1    FULL/ -         00:01:50    10.0.1.5     Serial0
172.16.1.4       1    FULL/ -         00:01:47    10.0.1.4     Serial0
172.16.1.8       1    FULL/ -         00:01:45    10.0.1.3     Serial0
```

The route information in the first configuration is as follows:

```
Device# show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, * - candidate default
       U - per-user static route, o - ODR
Gateway of last resort is not set
C    1.0.0.0/8 is directly connected, Loopback0
     10.0.0.0/8 is variably subnetted, 4 subnets, 2 masks
O    10.0.1.3/32 [110/100] via 10.0.1.3, 00:39:08, Serial0
C    10.0.1.0/24 is directly connected, Serial0
O    10.0.1.5/32 [110/5] via 10.0.1.5, 00:39:08, Serial0
O    10.0.1.4/32 [110/10] via 10.0.1.4, 00:39:08, Serial0
```

Example: OSPF Point-to-Multipoint with Nonbroadcast

The following example illustrates a point-to-multipoint network with nonbroadcast:

```
interface Serial0
 ip address 10.0.1.1 255.255.255.0
 ip ospf network point-to-multipoint non-broadcast
 encapsulation frame-relay
 no keepalive
 frame-relay local-dlci 200
 frame-relay map ip 10.0.1.3 202
 frame-relay map ip 10.0.1.4 203
 frame-relay map ip 10.0.1.5 204
 no shutdown
!
router ospf 1
 network 10.0.1.0 0.0.0.255 area 0
 neighbor 10.0.1.3 cost 5
 neighbor 10.0.1.4 cost 10
 neighbor 10.0.1.5 cost 15
```

The following example is the configuration for the router on the other side:

```
interface Serial9/2
 ip address 10.0.1.3 255.255.255.0
 encapsulation frame-relay
 ip ospf network point-to-multipoint non-broadcast
 no ip mroute-cache
 no keepalive
 no fair-queue
```

```

frame-relay local-dlci 301
frame-relay map ip 10.0.1.1 300
no shutdown
!
router ospf 1
 network 10.0.1.0 0.0.0.255 area 0

```

The output shown for neighbors in the first configuration is as follows:

```
Device# show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
172.16.1.1	1	FULL/ -	00:01:52	10.0.1.5	Serial0
172.16.1.4	1	FULL/ -	00:01:52	10.0.1.4	Serial0
172.16.1.8	1	FULL/ -	00:01:52	10.0.1.3	Serial0

Example: Variable-Length Subnet Masks

OSPF, static routes, and IS-IS support variable-length subnet masks (VLSMs). With VLSMs, you can use different masks for the same network number on different interfaces, which allows you to conserve IP addresses and more efficiently use available address space.

In the following example, a 30-bit subnet mask is used, leaving two bits of address space reserved for serial-line host addresses. There is sufficient host address space for two host endpoints on a point-to-point serial link.

```

interface ethernet 0
 ip address 172.16.10.1 255.255.255.0
! 8 bits of host address space reserved for ethernet
interface serial 0
 ip address 172.16.20.1 255.255.255.252
! 2 bits of address space reserved for serial lines
! Router is configured for OSPF and assigned AS 107
router ospf 107
! Specifies network directly connected to the router
 network 172.16.0.0 0.0.255.255 area 0.0.0.0

```

Example: Configuring OSPF NSSA

In the following example, an Open Shortest Path First (OSPF) stub network is configured to include OSPF Area 0 and OSPF Area 1, using five devices. Device 3 is configured as the NSSA Autonomous System Border Router (ASBR). Device 2 configured to be the NSSA Area Border Router (ABR). OSPF Area 1 is defined as a Not-So-Stubby Area (NSSA).

Device 1

```

hostname Device1
!
interface Loopback1
 ip address 10.1.0.1 255.255.255.255
!
interface Ethernet0/0
 ip address 192.168.0.1 255.255.255.0
 ip ospf 1 area 0
 no cdp enable
!
interface Serial10/0
 description Device2 interface s11/0
 ip address 192.168.10.1 255.255.255.0
 ip ospf 1 area 1
 serial restart-delay 0
 no cdp enable

```

```
!  
router ospf 1  
  area 1 nssa  
!  
end
```

Device 2

```
hostname Device2  
!  
!  
interface Loopback1  
  ip address 10.1.0.2 255.255.255.255  
!  
interface Serial10/0  
  description Device1 interface s11/0  
  no ip address  
  shutdown  
  serial restart-delay 0  
  no cdp enable  
!  
interface Serial11/0  
  description Device1 interface s10/0  
  ip address 192.168.10.2 255.255.255.0  
  ip ospf 1 area 1  
  serial restart-delay 0  
  no cdp enable  
!  
interface Serial14/0  
  description Device3 interface s13/0  
  ip address 192.168.14.2 255.255.255.0  
  ip ospf 1 area 1  
  serial restart-delay 0  
  no cdp enable  
!  
router ospf 1  
  area 1 nssa  
!  
end
```

Device 3

```
hostname Device3  
!  
interface Loopback1  
  ip address 10.1.0.3 255.255.255.255  
!  
interface Ethernet3/0  
  ip address 192.168.3.3 255.255.255.0  
  no cdp enable  
!  
interface Serial13/0  
  description Device2 interface s14/0  
  ip address 192.168.14.3 255.255.255.0  
  ip ospf 1 area 1  
  serial restart-delay 0  
  no cdp enable  
!  
router ospf 1  
  log-adjacency-changes  
  area 1 nssa  
  redistribute rip subnets  
!  
router rip  
  version 2  
  redistribute ospf 1 metric 15  
  network 192.168.3.0  
end
```

Device 4

```

hostname Device4
!
interface Loopback1
 ip address 10.1.0.4 255.255.255.255
!
interface Ethernet3/0
 ip address 192.168.3.4 255.255.255.0
 no cdp enable
!
interface Ethernet4/1
 ip address 192.168.41.4 255.255.255.0
!
router rip
 version 2
 network 192.168.3.0
 network 192.168.41.0
!
end

```

Device 5

```

hostname Device5
!
interface Loopback1
 ip address 10.1.0.5 255.255.255.255
!
interface Ethernet0/0
 ip address 192.168.0.10 255.255.255.0
 ip ospf 1 area 0
 no cdp enable
!
interface Ethernet1/1
 ip address 192.168.11.10 255.255.255.0
 ip ospf 1 area 0
!
router ospf 1
!
end

```

Example: OSPF NSSA Area with RFC 3101 Disabled and RFC 1587 Active

In the following example, the output for the **show ip ospf** and **show ip ospf database nssa** commands shows an Open Shortest Path First Not-So-Stubby Area (OSPF NSSA) area where RFC 3101 is disabled, RFC 1587 is active, and an NSSA Area Border Router (ABR) device is configured as a forced NSSA LSA translator. If RFC 3101 is disabled, the forced NSSA LSA translator remains inactive.

```
Device# show ip ospf
```

```

Routing Process "ospf 1" with ID 10.0.2.1
Start time: 00:00:25.512, Time elapsed: 00:01:02.200
Supports only single TOS(TOS0) routes
Supports opaque LSA
Supports Link-local Signaling (LLS)
Supports area transit capability
Supports NSSA (compatible with RFC 1587)
Event-log enabled, Maximum number of events: 1000, Mode: cyclic
Router is not originating router-LSAs with maximum metric
Initial SPF schedule delay 5000 msec
Minimum hold time between two consecutive SPF's 10000 msec
Maximum wait time between two consecutive SPF's 10000 msec
Incremental-SPF disabled
Minimum LSA interval 5 secs
Minimum LSA arrival 1000 msec

```

```

LSA group pacing timer 240 secs
Interface flood pacing timer 33 msec
Retransmission pacing timer 66 msec
Number of external LSA 0. Checksum Sum 0x000000
Number of opaque AS LSA 0. Checksum Sum 0x000000
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. 0 normal 0 stub 1 nssa
Number of areas transit capable is 0
External flood list length 0
IETF NSF helper support enabled
Cisco NSF helper support enabled
Reference bandwidth unit is 100 mbps
Area 1
Number of interfaces in this area is 1
It is a NSSA area
Configured to translate Type-7 LSAs, inactive (RFC3101 support
disabled)
Area has no authentication
SPF algorithm last executed 00:00:07.160 ago
SPF algorithm executed 3 times
Area ranges are
Number of LSA 3. Checksum Sum 0x0245F0
Number of opaque link LSA 0. Checksum Sum 0x000000
Number of DCbitless LSA 0
Number of indication LSA 0
Number of DoNotAge LSA 0
Flood list length 0
    
```

The table below describes the **show ip ospf** display fields and their descriptions.

Table 1: show ip ospf Field Descriptions

Field	Description
Supports NSSA (compatible with RFC 1587)	Specifies that RFC 1587 is active or that the OSPF NSSA area is RFC 1587 compatible.
Configured to translate Type-7 LSAs, inactive (RFC3101 support disabled)	Specifies that OSPF NSSA area has an ABR device configured to act as a forced translator of Type 7 LSAs. However, it is inactive because RFC 3101 is disabled

Device2# **show ip ospf database nssa**

```

Router Link States (Area 1)
LS age: 28
Options: (No TOS-capability, DC)
LS Type: Router Links
Link State ID: 10.0.2.1
Advertising Router: 10.0.2.1
LS Seq Number: 80000004
Checksum: 0x5CA2
Length: 36
Area Border Router
AS Boundary Router
Unconditional NSSA translator
Number of Links: 1
Link connected to: a Stub Network
(Link ID) Network/subnet number: 192.0.2.5
(Link Data) Network Mask: 255.255.255.0
Number of MTID metrics: 0
TOS 0 Metrics: 10
    
```

The table below describes the **show ip ospf database nssa** display fields and their descriptions.

Table 2: show ip ospf database nssa Field Descriptions

Field	Description
Unconditional NSSA translator	Specifies that NSSA ASBR device is a forced NSSA LSA translator

Example: OSPF Routing and Route Redistribution

OSPF typically requires coordination among many internal routers, ABRs, and ASBRs. At a minimum, OSPF-based routers can be configured with all default parameter values, with no authentication, and with interfaces assigned to areas.

Three types of examples follow:

- The first is a simple configuration illustrating basic OSPF commands.
- The second example illustrates a configuration for an internal router, ABR, and ASBRs within a single, arbitrarily assigned, OSPF autonomous system.
- The third example illustrates a more complex configuration and the application of various tools available for controlling OSPF-based routing environments.

Example: Basic OSPF Configuration

The following example illustrates a simple OSPF configuration that enables OSPF routing process 9000, attaches Ethernet interface 0 to area 0.0.0.0, and redistributes RIP into OSPF and OSPF into RIP:

```
interface ethernet 0
 ip address 10.93.1.1 255.255.255.0
 ip ospf cost 1
!
interface ethernet 1
 ip address 10.94.1.1 255.255.255.0
!
router ospf 9000
 network 10.93.0.0 0.0.0.255 area 0.0.0.0
 redistribute rip metric 1 subnets
!
router rip
 network 10.94.0.0
 redistribute ospf 9000
 default-metric 1
```

Example: Basic OSPF Configuration for Internal Router ABR and ASBRs

The following example illustrates the assignment of four area IDs to four IP address ranges. In the example, OSPF routing process 109 is initialized, and four OSPF areas are defined: 10.9.50.0, 2, 3, and 0. Areas 10.9.50.0, 2, and 3 mask specific address ranges, and area 0 enables OSPF for *all other* networks.

```
router ospf 109
 network 192.168.10.0 0.0.0.255 area 10.9.50.0
 network 192.168.20.0 0.0.255.255 area 2
 network 192.168.30.0 0.0.0.255 area 3
 network 192.168.40.0 255.255.255.255 area 0
```



```
!  
! Interface Ethernet0 is in area 10.9.50.0:  
interface ethernet 0  
  ip address 192.168.10.5 255.255.255.0  
!  
! Interface Ethernet1 is in area 2:  
interface ethernet 1  
  ip address 192.168.20.5 255.255.255.0  
!  
! Interface Ethernet2 is in area 2:  
interface ethernet 2  
  ip address 192.168.20.7 255.255.255.0  
!  
! Interface Ethernet3 is in area 3:  
interface ethernet 3  
  ip address 192.169.30.5 255.255.255.0  
!  
! Interface Ethernet4 is in area 0:  
interface ethernet 4  
  ip address 192.168.40.1 255.255.255.0  
!  
! Interface Ethernet5 is in area 0:  
interface ethernet 5  
  ip address 192.168.40.12 255.255.0.0
```

Each **network area** router configuration command is evaluated sequentially, so the order of these commands in the configuration is important. The Cisco software sequentially evaluates the address/wildcard-mask pair for each interface. See the **network area** command page in the *Cisco IOS IP Routing: OSPF Command Reference* for more information.

Consider the first **network area** command. Area ID 10.9.50.0 is configured for the interface on which subnet 192.168.10.0 is located. Assume that a match is determined for Ethernet interface 0. Ethernet interface 0 is attached to area 10.9.50.0 only.

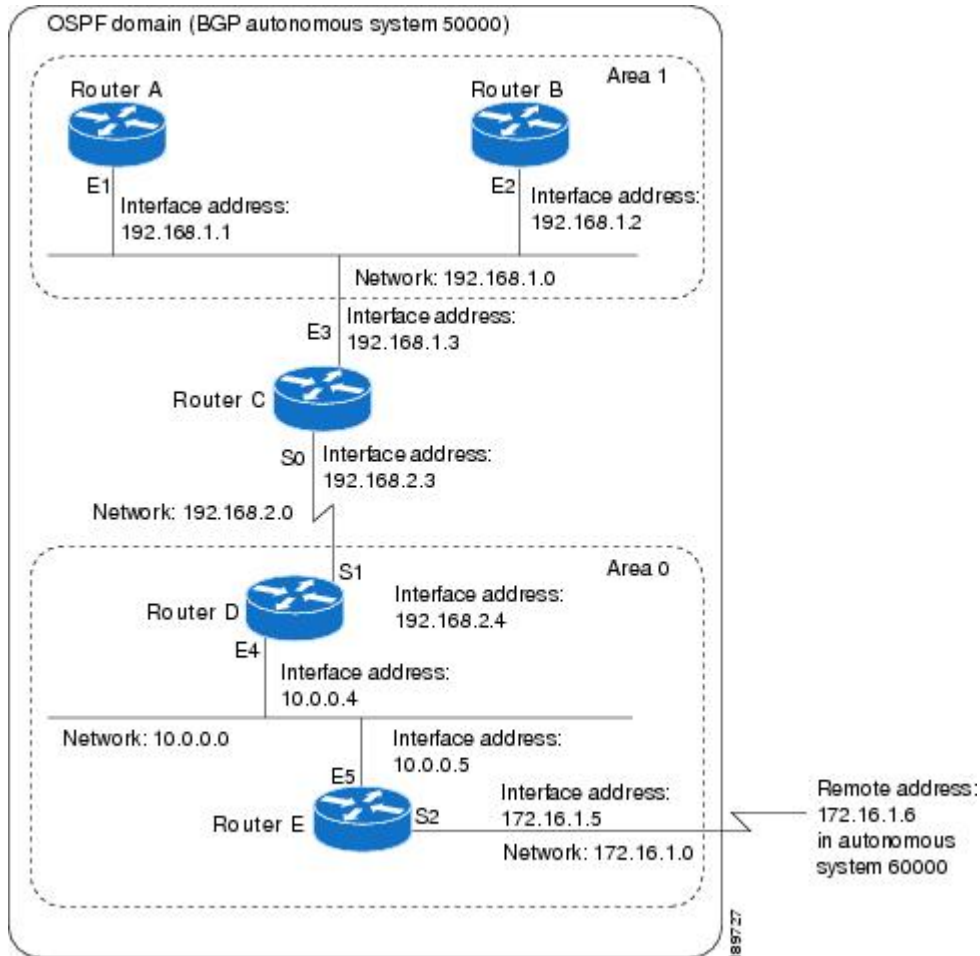
The second **network area** command is evaluated next. For area 2, the same process is then applied to all interfaces (except Ethernet interface 0). Assume that a match is determined for Ethernet interface 1. OSPF is then enabled for that interface, and Ethernet interface 1 is attached to area 2.

This process of attaching interfaces to OSPF areas continues for all **network area** commands. Note that the last **network area** command in this example is a special case. With this command, all available interfaces (not explicitly attached to another area) are attached to area 0.

Example: Complex Internal Router with ABR and ASBR

The following example outlines a configuration for several routers within a single OSPF autonomous system. The figure below provides a general network map that illustrates this sample configuration.

Figure 5: Sample OSPF Autonomous System Network Map



In this configuration, five routers are configured with OSPF:

- Router A and Router B are both internal routers within area 1.
- Router C is an OSPF ABR. Note that for Router C, Area 1 is assigned to E3 and area 0 is assigned to S0.
- Router D is an internal router in area 0 (backbone area). In this case, both **network** router configuration commands specify the same area (area 0, or the backbone area).
- Router E is an OSPF ASBR. Note that BGP routes are redistributed into OSPF and that these routes are advertised by OSPF.

**Note**

You do not need to include definitions of all areas in an OSPF autonomous system in the configuration of all routers in the autonomous system. Only the *directly* connected areas must be defined. In the example that follows, routes in area 0 are learned by the routers in area 1 (Router A and Router B) when the ABR (Router C) injects summary LSAs into area 1.

The OSPF domain in BGP autonomous system 109 is connected to the outside world via the BGP link to the external peer at IP address 10.0.0.6. Sample configurations follow.

Following is the sample configuration for the general network map shown in the figure above.

Router A Configuration—Internal Router

```
interface ethernet 1
 ip address 192.168.1.1 255.255.255.0
 router ospf 1
 network 192.168.0.0 0.0.255.255 area 1
```

Router B Configuration—Internal Router

```
interface ethernet 2
 ip address 192.168.1.2 255.255.255.0
 router ospf 202
 network 192.168.0.0 0.0.255.255 area 1
```

Router C Configuration—ABR

```
interface ethernet 3
 ip address 192.168.1.3 255.255.255.0
 interface serial 0
 ip address 192.168.2.3 255.255.255.0
 router ospf 999
 network 192.168.1.0 0.0.0.255 area 1
 network 192.168.2.0 0.0.0.255 area 0
```

Router D Configuration—Internal Router

```
interface ethernet 4
 ip address 10.0.0.4 255.0.0.0
 interface serial 1
 ip address 192.168.2.4 255.255.255.0
 router ospf 50
 network 192.168.2.0 0.0.0.255 area 0
 network 10.0.0.0 0.255.255.255 area 0
```

Router E Configuration—ASBR

```
interface ethernet 5
 ip address 10.0.0.5 255.0.0.0
 interface serial 2
 ip address 172.16.1.5 255.255.255.0
 router ospf 65001
 network 10.0.0.0 0.255.255.255 area 0
 redistribute bgp 109 metric 1 metric-type 1
 router bgp 109
 network 192.168.0.0
 network 10.0.0.0
 neighbor 172.16.1.6 remote-as 110
```

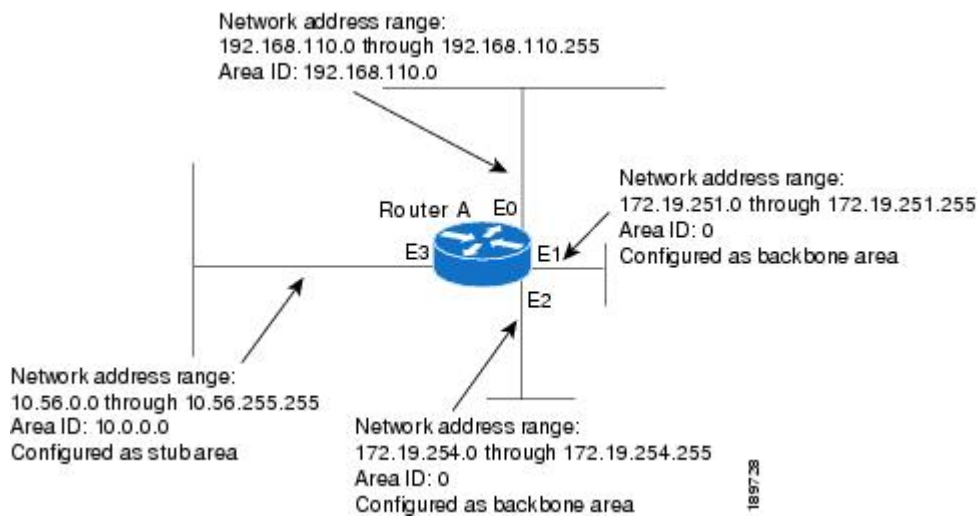
Example: Complex OSPF Configuration for ABR

The following sample configuration accomplishes several tasks in setting up an ABR. These tasks can be split into two general categories:

- Basic OSPF configuration
- Route redistribution

The specific tasks outlined in this configuration are detailed briefly in the following descriptions. The figure below illustrates the network address ranges and area assignments for the interfaces.

Figure 6: Interface and Area Specifications for OSPF Sample Configuration



The basic configuration tasks in this example are as follows:

- Configure address ranges for Ethernet interface 0 through Ethernet interface 3.
- Enable OSPF on each interface.
- Set up an OSPF authentication password for each area and network.
- Assign link-state metrics and other OSPF interface configuration options.
- Create a *stub area* with area ID 36.0.0.0. (Note that the **authentication** and **stub** options of the **area** router configuration command are specified with separate **area** command entries, but can be merged into a single **area** command.)
- Specify the backbone area (area 0).

Configuration tasks associated with redistribution are as follows:

- Redistribute IGRP and RIP into OSPF with various options set (including including **metric-type**, **metric**, **tag**, and **subnet**).
- Redistribute IGRP and OSPF into RIP.

The following is a sample OSPF configuration:

```
interface ethernet 0
 ip address 192.0.2.201 255.255.255.0
 ip ospf authentication-key abcdefgh
 ip ospf cost 10
!
interface ethernet 1
 ip address 172.19.251.202 255.255.255.0
 ip ospf authentication-key ijklmnop
 ip ospf cost 20
 ip ospf retransmit-interval 10
 ip ospf transmit-delay 2
 ip ospf priority 4
!
interface ethernet 2
 ip address 172.19.254.2 255.255.255.0
 ip ospf authentication-key abcdefgh
 ip ospf cost 10
!
interface ethernet 3
 ip address 10.56.0.0 255.255.0.0
 ip ospf authentication-key ijklmnop
 ip ospf cost 20
 ip ospf dead-interval 80
```

In the following configuration, OSPF is on network 172.16.0.0:

```
router ospf 201
 network 10.10.0.0 0.255.255.255 area 10.10.0.0
 network 192.42.110.0 0.0.0.255 area 192.42.110.0
 network 172.16.0.0 0.0.255.255 area 0
 area 0 authentication
 area 10.10.0.0 stub
 area 10.10.0.0 authentication
 area 10.10.0.0 default-cost 20
 area 192.42.110.0 authentication
 area 10.10.0.0 range 10.10.0.0 255.0.0.0
 area 192.42.110.0 range 192.42.110.0 255.255.255.0
 area 0 range 172.16.251.0 255.255.255.0
 area 0 range 172.16.254.0 255.255.255.0
 redistribute igrp 200 metric-type 2 metric 1 tag 200 subnets
 redistribute rip metric-type 2 metric 1 tag 200
```

In the following configuration, IGRP autonomous system 200 is on 192.0.2.1:

```
router igrp 200
 network 172.31.0.0
!
! RIP for 192.168.110
!
router rip
 network 192.168.110.0
 redistribute igrp 200 metric 1
 redistribute ospf 201 metric 1
```

Examples: Route Map

The examples in this section illustrate the use of redistribution, with and without route maps. Examples from the IP and Connectionless Network Service (CLNS) routing protocols are given.

The following example redistributes all OSPF routes into IGRP:

```
router igrp 109
 redistribute ospf 110
```

The following example redistributes RIP routes with a hop count equal to 1 into OSPF. These routes will be redistributed into OSPF as external LSAs with a metric of 5, a metric type of Type 1, and a tag equal to 1.

```
router ospf 109
 redistribute rip route-map rip-to-ospf
!
route-map rip-to-ospf permit
 match metric 1
 set metric 5
 set metric-type type1
 set tag 1
```

The following example redistributes OSPF learned routes with tag 7 as a RIP metric of 15:

```
router rip
 redistribute ospf 109 route-map 5
!
route-map 5 permit
 match tag 7
 set metric 15
```

The following example redistributes OSPF intra-area and interarea routes with next-hop routers on serial interface 0 into BGP with an INTER_AS metric of 5:

```
router bgp 109
 redistribute ospf 109 route-map 10
!
route-map 10 permit
 match route-type internal
 match interface serial 0
 set metric 5
```

The following example redistributes two types of routes into the integrated IS-IS routing table (supporting both IP and CLNS). The first type is OSPF external IP routes with tag 5; these routes are inserted into Level 2 IS-IS link state packets (LSPs) with a metric of 5. The second type is ISO-IGRP derived CLNS prefix routes that match CLNS access list 2000; these routes will be redistributed into IS-IS as Level 2 LSPs with a metric of 30.

```
router isis
 redistribute ospf 109 route-map 2
 redistribute iso-igrp nsfnet route-map 3
!
route-map 2 permit
 match route-type external
 match tag 5
 set metric 5
 set level level-2
!
route-map 3 permit
 match address 2000
 set metric 30
```

With the following configuration, OSPF external routes with tags 1, 2, 3, and 5 are redistributed into RIP with metrics of 1, 1, 5, and 5, respectively. The OSPF routes with a tag of 4 are not redistributed.

```
router rip
 redistribute ospf 109 route-map 1
!
route-map 1 permit
 match tag 1 2
 set metric 1
!
route-map 1 permit
 match tag 3
 set metric 5
!
route-map 1 deny
 match tag 4
!
```

```
route map 1 permit
  match tag 5
  set metric 5
```

In the following configuration, a RIP-learned route for network 192.168.0.0 and an ISO-IGRP-learned route with prefix 49.0001.0002 are redistributed into an IS-IS Level 2 LSP with a metric of 5:

```
router isis
  redistribute rip route-map 1
  redistribute iso-igrp remote route-map 1
  !
route-map 1 permit
  match ip address 1
  match clns address 2
  set metric 5
  set level level-2
  !
access-list 1 permit 192.168.0.0 0.0.255.255
clns filter-set 2 permit 49.0001.0002...
```

The following configuration example illustrates how a route map is referenced by the **default-information** router configuration command. This type of reference is called *conditional default origination*. OSPF will originate the default route (network 0.0.0.0) with a Type 2 metric of 5 if 172.16.0.0 is in the routing table.



Note

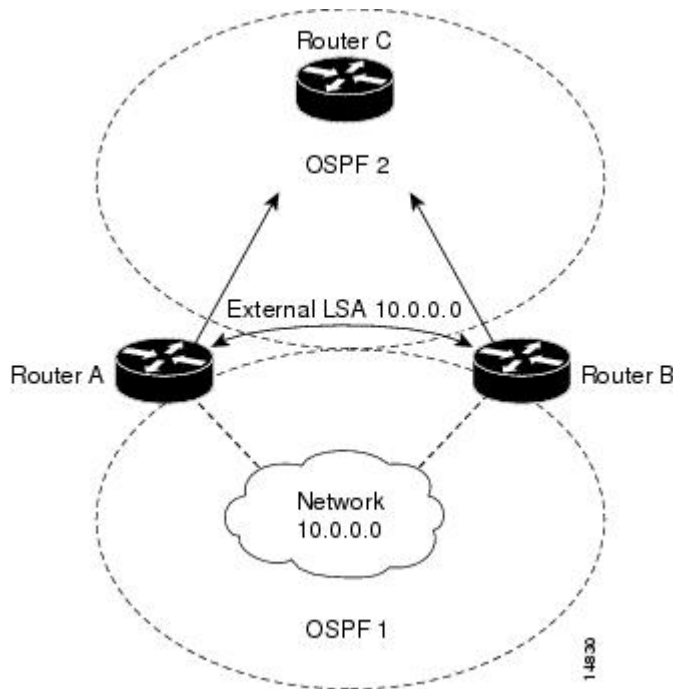
Only routes external to the OSPF process can be used for tracking, such as non-OSPF routes or OSPF routes from a separate OSPF process.

```
route-map ospf-default permit
  match ip address 1
  set metric 5
  set metric-type type-2
  !
access-list 1 permit 172.16.0.0 0.0.255.255
  !
router ospf 109
  default-information originate route-map ospf-default
```

Example: Changing the OSPF Administrative Distances

The following configuration changes the external distance to 200, making it less trustworthy. The figure below illustrates the example.

Figure 7: OSPF Administrative Distance



Router A Configuration

```
router ospf 1
 redistribute ospf 2 subnet
 distance ospf external 200
!
router ospf 2
 redistribute ospf 1 subnet
 distance ospf external 200
```

Router B Configuration

```
router ospf 1
 redistribute ospf 2 subnet
 distance ospf external 200
!
router ospf 2
 redistribute ospf 1 subnet
 distance ospf external 200
```


Example: OSPF over On-Demand Routing

The following configuration allows OSPF over an on-demand circuit, as shown in the figure below. Note that the on-demand circuit is defined on one side only (BRI 0 on Router A); it is not required to be configured on both sides.

Figure 8: OSPF over On-Demand Circuit



Router A Configuration

```
username RouterB password 7 060C1A2F47
isdn switch-type basic-5ess
ip routing
!
interface TokenRing0
 ip address 192.168.50.5 255.255.255.0
 no shutdown
!
interface BRI0
 no cdp enable
 description connected PBX 1485
 ip address 192.168.45.30 255.255.255.0
 encapsulation ppp
 ip ospf demand-circuit
 dialer map ip 192.0.2.6 name RouterB broadcast 61484
 dialer-group 1
 ppp authentication chap
 no shutdown
!
router ospf 100
 network 192.168.45.0 0.0.0.255 area 0
 network 192.168.45.50 0.0.0.255 area 0
!
dialer-list 1 protocol ip permit
```

Router B Configuration

```
username RouterA password 7 04511E0804
isdn switch-type basic-5ess
ip routing
!
interface Ethernet0
 ip address 192.168.50.16 255.255.255.0
 no shutdown
!
interface BRI0
 no cdp enable
 description connected PBX 1484
 ip address 192.168.45.17 255.255.255.0
 encapsulation ppp
 dialer map ip 192.168.45.19 name RouterA broadcast 61485
 dialer-group 1
 ppp authentication chap
 no shutdown
!
router ospf 100
 network 192.168.45.0 0.0.0.255 area 0
```

```

network 192.168.45.50 0.0.0.255 area 0
!
dialer-list 1 protocol ip permit

```

Example: LSA Group Pacing

The following example changes the OSPF pacing between LSA groups to 60 seconds:

```

router ospf
 timers pacing lsa-group 60

```

Example: Blocking OSPF LSA Flooding

The following example prevents flooding of OSPF LSAs to broadcast, nonbroadcast, or point-to-point networks reachable through Ethernet interface 0:

```

interface ethernet 0
 ip ospf database-filter all out

```

The following example prevents flooding of OSPF LSAs to point-to-multipoint networks to the neighbor at IP address 10.10.10.45:

```

router ospf 109
 neighbor 10.10.10.45 database-filter all out

```

Example: Ignoring MOSPF LSA Packets

The following example configures the router to suppress the sending of syslog messages when it receives MOSPF packets:

```

router ospf 109
 ignore lsa mospf

```

Additional References for OSPF Not-So-Stubby Areas (NSSA)

Related Documents

Related Topic	Document Title
Cisco IOS commands	Cisco IOS Master Command List, All Releases
OSPF commands	Cisco IOS IP Routing: OSPF Command Reference
Protocol-independent features that work with OSPF	“Configuring IP Routing Protocol-Independent Features” module in <i>IP Routing: Protocol-Independent Configuration Guide</i>

RFCs

RFC	Title
RFC 1587	The OSPF NSSA Option , March 1994
RFC 3101	The OSPF NSSA Option January 2003

Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	http://www.cisco.com/cisco/web/support/index.html

Feature Information for Configuring OSPF

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to [http://www.cisco.com/go/featurenavigator](#). An account on Cisco.com is not required.

Table 3: Feature Information for OSPF

Feature Name	Releases	Feature Information
OSPF	Cisco IOS XE Release 3.2SE Cisco IOS XE Release 3.3SE Cisco IOS XE Release 3.6E	<p>OSPF is an IGP developed by the OSPF working group of the 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.</p> <p>In Cisco IOS XE Release 3.3SE, this feature is supported on Cisco Catalyst 3850 Series Switches.</p> <p>In Cisco IOS XE Release 3.6E, this feature is supported on Cisco Catalyst 3850 Series Switches.</p>



OSPFv3 Fast Convergence: LSA and SPF Throttling

The Open Shortest Path First version 3 (OSPFv3) link-state advertisement (LSAs) and shortest-path first (SPF) throttling feature provides a dynamic mechanism to slow down link-state advertisement updates in OSPFv3 during times of network instability. It also allows faster OSPFv3 convergence by providing LSA rate limiting in milliseconds.

- [Finding Feature Information, page 55](#)
- [Information About OSPFv3 Fast Convergence: LSA and SPF Throttling, page 56](#)
- [How to Configure OSPFv3 Fast Convergence: LSA and SPF Throttling, page 56](#)
- [Configuration Examples for OSPFv3 Fast Convergence: LSA and SPF Throttling, page 59](#)
- [Additional References, page 59](#)
- [Feature Information for OSPFv3 Fast Convergence: LSA and SPF Throttling, page 60](#)

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see [Bug Search Tool](#) and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table.

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

Information About OSPFv3 Fast Convergence: LSA and SPF Throttling

Fast Convergence: LSA and SPF Throttling

The OSPFv3 LSA and SPF throttling feature provides a dynamic mechanism to slow down link-state advertisement updates in OSPFv3 during times of network instability. It also allows faster OSPFv3 convergence by providing LSA rate limiting in milliseconds.

OSPFv3 can use static timers for rate-limiting SPF calculation and LSA generation. Although these timers are configurable, the values used are specified in seconds, which poses a limitation on OSPFv3 convergence. LSA and SPF throttling achieves subsecond convergence by providing a more sophisticated SPF and LSA rate-limiting mechanism that is able to react quickly to changes and also provide stability and protection during prolonged periods of instability.

How to Configure OSPFv3 Fast Convergence: LSA and SPF Throttling

Tuning LSA and SPF Timers for OSPFv3 Fast Convergence

This task can be performed in Cisco IOS Release 15.1(3)S and 15.2(1)T and later releases.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **router ospfv3** *[process-id]*
4. **timers lsa arrival** *milliseconds*
5. **timers pacing flood** *milliseconds*
6. **timers pacing lsa-group** *seconds*
7. **timers pacing retransmission** *milliseconds*

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> • Enter your password if prompted.

	Command or Action	Purpose
Step 2	configure terminal Example: Device# configure terminal	Enters global configuration mode.
Step 3	router ospfv3 [<i>process-id</i>] Example: Device(config)# router ospfv3 1	Enables OSPFv3 router configuration mode for the IPv4 or IPv6 address family.
Step 4	timers lsa arrival <i>milliseconds</i> Example: Device(config-rtr)# timers lsa arrival 300	Sets the minimum interval at which the software accepts the same LSA from OSPFv3 neighbors.
Step 5	timers pacing flood <i>milliseconds</i> Example: Device(config-rtr)# timers pacing flood 30	Configures LSA flood packet pacing.
Step 6	timers pacing lsa-group <i>seconds</i> Example: Device(config-router)# timers pacing lsa-group 300	Changes the interval at which OSPFv3 LSAs are collected into a group and refreshed, checksummed, or aged.
Step 7	timers pacing retransmission <i>milliseconds</i> Example: Device(config-router)# timers pacing retransmission 100	Configures LSA retransmission packet pacing in IPv4 OSPFv3.

Configuring LSA and SPF Throttling for OSPFv3 Fast Convergence

This task can be performed in releases prior to Cisco IOS Release 15.1(3)S and 15.2(1)T.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ipv6 router ospf** *process-id*
4. **timers throttle spf** *spf-start spf-hold spf-max-wait*
5. **timers throttle lsa** *start-interval hold-interval max-interval*
6. **timers lsa arrival** *milliseconds*
7. **timers pacing flood** *milliseconds*

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Device> enable	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	configure terminal Example: Device# configure terminal	Enters global configuration mode.
Step 3	ipv6 router ospf <i>process-id</i> Example: Device(config)# ipv6 router ospf 1	Enables OSPFv3 router configuration mode.
Step 4	timers throttle spf <i>spf-start spf-hold spf-max-wait</i> Example: Device(config-rtr)# timers throttle spf 200 200 200	Turns on SPF throttling.
Step 5	timers throttle lsa <i>start-interval hold-interval max-interval</i> Example: Device(config-rtr)# timers throttle lsa 300 300 300	Sets rate-limiting values for OSPFv3 LSA generation.
Step 6	timers lsa arrival <i>milliseconds</i> Example: Device(config-rtr)# timers lsa arrival 300	Sets the minimum interval at which the software accepts the same LSA from OSPFv3 neighbors.

	Command or Action	Purpose
Step 7	timers pacing flood <i>milliseconds</i> Example: Device(config-rtr)# timers pacing flood 30	Configures LSA flood packet pacing.

Configuration Examples for OSPFv3 Fast Convergence: LSA and SPF Throttling

Example: Configuring LSA and SPF Throttling for OSPFv3 Fast Convergence

The following example show how to display the configuration values for SPF and LSA throttling timers:

```
Device# show ipv6 ospf
Routing Process "ospfv3 1" with ID 10.9.4.1
Event-log enabled, Maximum number of events: 1000, Mode: cyclic
It is an autonomous system boundary router
Redistributing External Routes from,
  ospf 2
Initial SPF schedule delay 5000 msec
Minimum hold time between two consecutive SPF's 10000 msec
Maximum wait time between two consecutive SPF's 10000 msec
Minimum LSA interval 5 secs
Minimum LSA arrival 1000 msec
```

Additional References

Related Documents

Related Topic	Document Title
IPv6 addressing and connectivity	IPv6 Configuration Guide
Cisco IOS commands	Cisco IOS Master Commands List, All Releases
IPv6 commands	Cisco IOS IPv6 Command Reference
Cisco IOS IPv6 features	Cisco IOS IPv6 Feature Mapping

Related Topic	Document Title
OSPFv3 Fast Convergence: LSA and SPF Throttling	" <i>OSPF Link-State Advertisement Throttling</i> " module

Standards and RFCs

Standard/RFC	Title
RFCs for IPv6	IPv6 RFCs

MIBs

MIB	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

Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	http://www.cisco.com/cisco/web/support/index.html

Feature Information for OSPFv3 Fast Convergence: LSA and SPF Throttling

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to [http://www.cisco.com/go/featurenavigator](#). An account on Cisco.com is not required.

Table 4: Feature Information for OSPFv3 Fast Convergence: LSA and SPF Throttling

Feature Name	Releases	Feature Information
OSPFv3 Fast Convergence: LSA and SPF Throttling	Cisco IOS XE Release 3.2SE Cisco IOS XE Release 3.3SE Cisco IOS XE Release 3.6E	<p>The OSPFv3 LSA and SPF throttling feature provides a dynamic mechanism to slow down link-state advertisement updates in OSPFv3 during times of network instability.</p> <p>In Cisco IOS XE Release 3.2SE, support was added for the Cisco Catalyst 3850 Series Switches.</p> <p>In Cisco IOS XE Release 3.3SE, support was added for the Cisco Catalyst 3650 Series Switches.</p> <p>In Cisco IOS XE Release 3.6E, this feature is supported on Cisco Catalyst 3850 Series Switches.</p>



OSPF Forwarding Address Suppression in Translated Type-5 LSAs

The OSPF Forwarding Address Suppression in Translated Type-5 LSAs feature causes a not-so-stubby area (NSSA) area border router (ABR) to translate Type-7 link state advertisements (LSAs) to Type-5 LSAs, but use the address 0.0.0.0 for the forwarding address instead of that specified in the Type-7 LSA. This feature causes routers that are configured not to advertise forwarding addresses into the backbone to direct forwarded traffic to the translating NSSA ABRs.

- [Finding Feature Information, page 63](#)
- [Prerequisites for OSPF Forwarding Address Suppression in Translated Type-5 LSAs, page 64](#)
- [Information About OSPF Forwarding Address Suppression in Translated Type-5 LSAs, page 64](#)
- [How to Suppress OSPF Forwarding Address in Translated Type-5 LSAs, page 66](#)
- [Configuration Examples for OSPF Forwarding Address Suppression in Translated Type-5 LSAs, page 67](#)
- [Additional References, page 67](#)
- [Feature Information for OSPF Forwarding Address Suppression in Translated Type-5 LSAs, page 68](#)

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see [Bug Search Tool](#) and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table.

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

Prerequisites for OSPF Forwarding Address Suppression in Translated Type-5 LSAs

This document presumes you have OSPF configured on the networking device; it does not document other steps to configure OSPF.

Information About OSPF Forwarding Address Suppression in Translated Type-5 LSAs

Benefits of OSPF Forwarding Address Suppression in Translated Type-5 LSAs

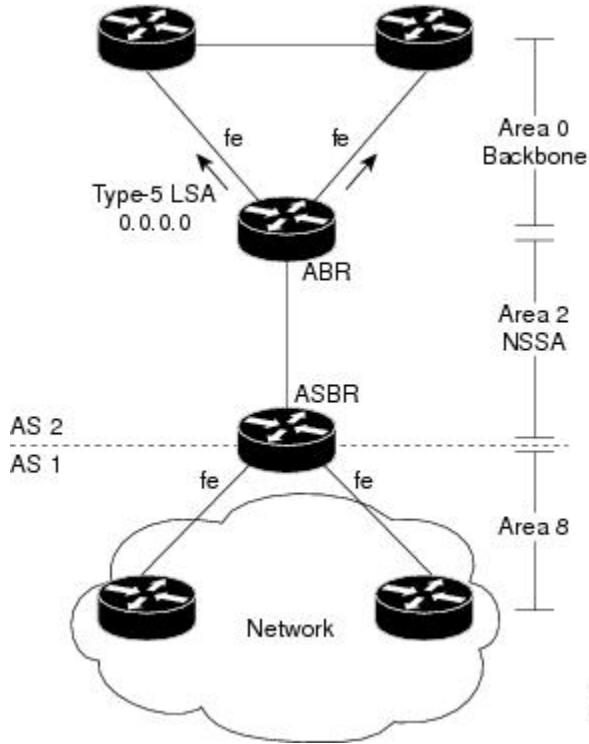
The OSPF Forwarding Address Suppression in Translated Type-5 LSAs feature causes an NSSA ABR to translate Type-7 LSAs to Type-5 LSAs, but use the 0.0.0.0 as the forwarding address instead of that specified in the Type-7 LSA. This feature causes routers that are configured not to advertise forwarding addresses into the backbone to direct forwarded traffic to the translating NSSA ASBRs.

When to Suppress OSPF Forwarding Address in Translated Type-5 LSAs

In the figure below, it would be advantageous to filter Area 2 addresses from Area 0 to minimize the number of routes introduced into the backbone (Area 0). However, using the **area range** command to consolidate and summarize routes at the area boundary--filtering the Area 2 addresses--will not work because the Area 2 addresses include forwarding addresses for Type-7 LSAs that are generated by the ASBR. If these Type-7

LSA forwarding addresses have been filtered out of Area 0, the backbone routers cannot reach the prefixes advertised in the translated Type-5 LSAs (autonomous system external LSAs).

Figure 9: OSPF Forwarding Address Suppression in Translated Type-5 LSAs



This problem is solved by suppressing the forwarding address on the ABR so that the forwarding address is set to 0.0.0.0 in the Type-5 LSAs that were translated from Type-7 LSAs. A forwarding address set to 0.0.0.0 indicates that packets for the external destination should be forwarded to the advertising OSPF router, in this case, the translating NSSA ABR.

Before configuring this feature, consider the following caution.



Caution

Configuring this feature causes the router to be noncompliant with RFC 1587. Also, suboptimal routing might result because there might be better paths to reach the destination's forwarding address. This feature should not be configured without careful consideration and not until the network topology is understood.

How to Suppress OSPF Forwarding Address in Translated Type-5 LSAs

Suppressing OSPF Forwarding Address in Translated Type-5 LSAs



Caution

Configuring this feature causes the router to be noncompliant with RFC 1587. Also, suboptimal routing might result because there might be better paths to reach the destination's forwarding address. This feature should not be configured without careful consideration and not until the network topology is understood.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **router ospf *process-id***
4. **area *area-id* nssa translate type7 suppress-fa**
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Device> enable	Enables higher privilege levels, such as privileged EXEC mode. <ul style="list-style-type: none"> • Enter your password if prompted.
Step 2	configure terminal Example: Device# configure terminal	Enters global configuration mode.
Step 3	router ospf <i>process-id</i> Example: Device(config)# router ospf 1	Enables OSPF routing and enters device configuration mode. <ul style="list-style-type: none"> • The <i>process-id</i> argument identifies the OSPF process.
Step 4	area <i>area-id</i> nssa translate type7 suppress-fa Example: Device(config-router)# area 10 nssa translate type7 suppress-fa	Configures an area as a not-so-stubby-area (NSSA) and suppresses the forwarding address in translated Type-7 LSAs.

	Command or Action	Purpose
Step 5	end Example: Device(config-router)# end	Exits configuration mode and returns to privileged EXEC mode.

Configuration Examples for OSPF Forwarding Address Suppression in Translated Type-5 LSAs

Example Suppressing OSPF Forwarding Address in Translated Type-5 LSAs

This example suppresses the forwarding address in translated Type-5 LSAs:

```
interface ethernet 0
 ip address 10.93.1.1 255.255.255.0
 ip ospf cost 1
 !
interface ethernet 1
 ip address 10.94.1.1 255.255.255.0
 !
router ospf 1
 network 10.93.0.0 0.0.255.255 area 0.0.0.0
 network 10.94.0.0 0.0.255.255 area 10
 area 10 nssa translate type7 suppress-fa
```

Additional References

Related Documents

Related Topic	Document Title
OSPF commands	<i>Cisco IOS IP Routing: OSPF Command Reference</i>
OSPFv3 Address Families	“OSPFv3 Address Families” module

Standards

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

MIBs

MIBs	MIBs Link
No new or modified MIBs are supported by this feature, and support for existing MIBs has not been modified by this feature.	To locate and download MIBs for selected platforms, Cisco software releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

RFCs

RFCs	Title
Configuring the OSPF Forwarding Address Suppression in Translated Type-5 LSAs feature causes the router to be noncompliant with RFC 1587.	<i>The OSPF NSSA Option</i>

Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	http://www.cisco.com/cisco/web/support/index.html

Feature Information for OSPF Forwarding Address Suppression in Translated Type-5 LSAs

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to [http://www.cisco.com/go/featurenavigator](#). An account on Cisco.com is not required.

Table 5: Feature Information for OSPF Forwarding Address Suppression in Translated Type-5 LSAs

Feature Name	Releases	Feature Information
OSPF Forwarding Address Suppression in Translated Type-5 LSAs	Cisco IOS XE Release 3.1.0 SG Cisco IOS XE Release 3.6E Cisco IOS XE Release 3.3SE	<p>The OSPF Forwarding Address Suppression in Translated Type-5 LSAs feature causes a not-so-stubby area (NSSA) area border router (ABR) to translate Type-7 link state advertisements (LSAs) to Type-5 LSAs, but to use the address 0.0.0.0 for the forwarding address instead of that specified in the Type-7 LSA. This feature causes routers that are configured not to advertise forwarding addresses into the backbone to direct forwarded traffic to the translating NSSA ABRs.</p> <p>In Cisco IOS XE Release 3.1.0SG, support was added for the Cisco Catalyst 4000 Series Switches.</p> <p>The following commands are introduced or modified:</p> <ul style="list-style-type: none"> • area nssa translate • show ip ospf <p>In Cisco IOS XE Release 3.6E, this feature is supported on Cisco Catalyst 3850 Series Switches.</p> <p>In Cisco IOS XE Release 3.3SE, this feature is supported on Cisco Catalyst 3850 Series Switches.</p>

