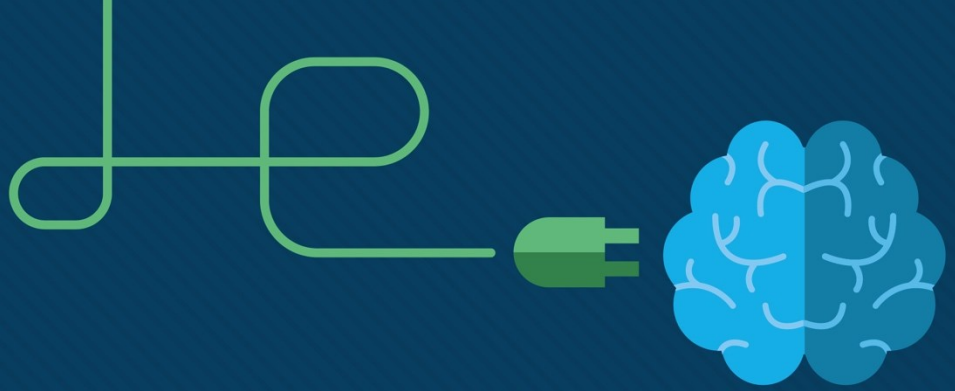

Chapter 10: OSPFv3

Instructor Materials

CCNP Enterprise: Core Networking

Chapter 10 Content

This chapter covers the following content:

OSPFv3 Fundamentals: This section provides an overview of the OSPFv3 routing protocol and the similarities to OSPFv2.

OSPFv3 Configurations: This section demonstrates the configuration and verification of an OSPFv3 environment.

IPv4 Support in OSPFv3: This section explains and demonstrates how OSPFv3 can be used for exchanging IPv4 routes.

OSPFv3 Fundamentals

- OSPFv3 supports IPv4 and IPv6 address families.
- New LSA types have been created to carry IPv6 prefixes.
- The IP prefix information is carried as LSA payload information, making the protocol essentially address family independent.
- Includes a new link-state type field that is used to determine the flooding scope of LSA, as well as the handling of unknown LSA types.
- OSPFv3 runs directly over IPv6, and the number of fields in the packet header has been reduced.

Features

- **Router ID -** The router ID is used to identify neighbors, regardless of the network type in OSPFv3. The router ID must always be manually assigned in the routing process.
- **Authentication -** Neighbor authentication has been removed from the OSPF protocol and is now performed through IPsec extension headers in the IPv6 packet.
- **Neighbor adjacencies -** OSPFv3 inter-router communication is handled by IPv6 link-local addressing.
- **Multiple subnets on an interface -** Allows for neighbor adjacency to form even if the two routers do not share a common subnet.
- **Multiple instances -** OSPFv3 packets include an instance ID field that may be used to manipulate which routers on a network segment are allowed to form adjacencies.

OSPFv3 Link-State Advertisement

- OSPFv3 packets use protocol ID 89.
- Routers communicate with each other using the link-local address.
- OSPFv3 modifies the structure of the router LSA (type 1).
- It renames the network summary LSA to the interarea prefix LSA.
- It renames the ASBR summary LSA to the interarea router LSA.
- Router LSA is responsible for announcing interface parameters such as the interface type and metric.
- IP address information is advertised independently by two new LSA types:
  - Intra-area prefix LSA
  - Link-local LSA
- Link-state database(LSDB) creates a shortest path topology tree based on links instead of networks. Since IP address information is advertised using new LSA types there is no longer a need to run SPF calculations every time a new address prefix is added or changed on an interface.

OSPFv3 Link-State Advertisement

LS Type	Name	Description
0x2001	Router	Every router generates router LSAs that describe the state and cost of the router's interfaces to the area.
0x2002	Network	A designated router generates network LSAs to announce all of the routers attached to the link, including itself.
0x2003	Interarea Prefix	Area border routers generate interarea prefix LSAs to describe routes to IPv6 address prefixes that belong to other areas.
0x2004	Interarea router	Area border routers generate interarea router LSAs to announce the addresses of autonomous system boundary routers in other areas.
0x4005	AS external	Autonomous system boundary routers advertise AS external LSAs to announce default routes or routes learned through redistribution from other protocols.
0x2007	NSSA	Autonomous system boundary routers that are located in a not-so-stubby area advertise NSSA LSAs for routes redistributed into the area.
0x0008	Link	The link LSA maps all of the global unicast address prefixes associated with an interface to the link-local interface IP address of the router. The link LSA is shared only between neighbors on the same link.
0x2009	Intra-area prefix	The intra-area prefix LSA is used to advertise one or more IPv6 prefixes that are associated with a router, stub, or transit network segment.

Table 10-2 OSPFv3 LSA Types

OSPFv3 Communication

Destination address is either a unicast link-local address or a multicast link-local scoped address:

FF02::05: OSPFv3 AllSPFRouters

Every router uses AllSPFRouters multicast address to send OSPF hello messages to routers on the same link.

Hello messages are used for neighbor discovery and detecting whether a neighbor relationship is down.

DR and BDR routers also use this address to send link-state update and flooding acknowledgment messages to all routers.

FF02::06: OSPFv3 AllDRouters designated router (DR)

Non-DR/BDR routers send an update or link-state acknowledgment message to the DR and BDR by using the AllDRouters.

OSPFv3 uses the same five packet types and logic as OSPFv2.

OSPFv3 Packet Types

Table 10-3 OSPFv3 Packet Types

Type	Packet Name	Source	Destination	Purpose
1	Hello	Link-local address	FF02::5 (all routers)	Discover and maintain neighbors
		Link-local address	Link-local address	Initial adjacency forming, immediate hello
2	Database description	Link-local address	Link-local address	Summarize database contents
3	Link-state request	Link-local address	Link-local address	Database information request
4	Link-state update	Link-local address	Link-local address	Initial adjacency forming, in response to a link-state request
		Link-local address (from DR)	FF02::5 (all routers)	Database update
		Link-local address (from non-DR)	FF02::6 (DR/ BDR)	Database update
5	Link-state acknowledgment	Link-local address	Link-local address	Initial adjacency forming, in response to a link-state update
		Link-local address (from DR)	FF02::5 (all routers)	Flooding acknowledgment
		Link-local address (from non-DR)	FF02::6 (DR/BDR)	Flooding acknowledgment

OSPFv3 Configurations

Configuration Steps:

- Step 1. Initialize the routing process with the command 'ipv6 unicast-routing'.
- Step 2. Define the 32-bit router ID within the OSPFv3 router process.
- Step 3. (Optional) Initialize the address family - enabled automatically when OSPFv3 is enabled on an interface.
- Step 4. Enable OSPFv3 on an interface using a process-id and area-id.

OSPFv3 Topology

Figure 10-1 displays a simple four-router topology to demonstrate OSPFv3 configuration.

Area 0 consists of R1, R2, and R3, and Area 34 contains R3 and R4. R3 is the ABR.

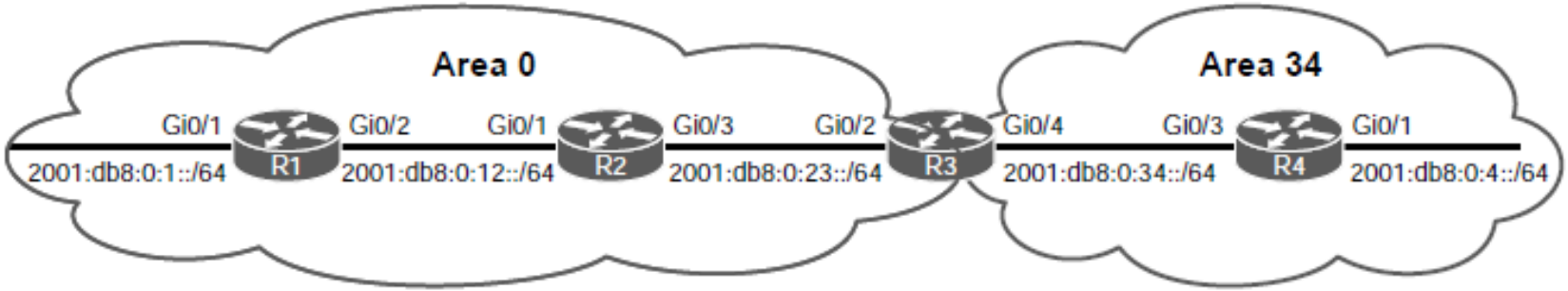

Figure 10-1 *OSPFv3 Topology*

Example OSPFv3 Configuration

Earlier versions of IOS used the commands **ipv6 router ospf** for initialization of the OSPF process and **ipv6 ospf *process-id* area *area-id*** for identification of the interface. These commands are considered legacy and should be migrated to the current practice such as **ospfv3 *process-id* ipv6 area *area-id*** in the R1 & R2 configurations, as highlighted below.

Example 10-1 *IPv6 Addressing and OSPFv3 Configuration*

```
R1
interface Loopback0
 ipv6 address 2001:DB8::1/128
 ospfv3 1 ipv6 area 0
!
interface GigabitEthernet0/1
 ipv6 address FE80::1 link-local
 ipv6 address 2001:DB8:0:1::1/64
 ospfv3 1 ipv6 area 0
!
interface GigabitEthernet0/2
 ipv6 address FE80::1 link-local
 ipv6 address 2001:DB8:0:12::1/64
 ospfv3 1 ipv6 area 0
!
router ospfv3 1
 router-id 192.168.1.1
```

```
R2
interface Loopback0
 ipv6 address 2001:DB8::2/128
 ospfv3 1 ipv6 area 0
!
interface GigabitEthernet0/1
 ipv6 address FE80::2 link-local
 ipv6 address 2001:DB8:0:12::2/64
 ospfv3 1 ipv6 area 0
!
interface GigabitEthernet0/3
 ipv6 address FE80::2 link-local
 ospfv3 1 ipv6 area 0
!
router ospfv3 1
 router-id 192.168.2.2
```

Example OSPFv3 Configuration (Cont.)

R3 & R4 configurations steps are highlighted below.

R3

```
interface Loopback0
 ipv6 address 2001:DB8::3/128
 ospfv3 1 ipv6 area 0
!
interface GigabitEthernet0/2
 ipv6 address FE80::3 link-local
 ipv6 address 2001:DB8:0:23::3/64
 ospfv3 1 ipv6 area 0
!
interface GigabitEthernet0/4
 ipv6 address FE80::3 link-local
 ipv6 address 2001:DB8:0:34::3/64
 ospfv3 1 ipv6 area 34
!
router ospfv3 1
 router-id 192.168.3.3
```

R4

```
interface Loopback0
ipv6 address 2001:DB8::4/128
 ospfv3 1 ipv6 area 34
!
interface GigabitEthernet0/1
 ipv6 address FE80::4 link-local
 ipv6 address 2001:DB8:0:4::4/64
 ospfv3 1 ipv6 area 34
!
interface GigabitEthernet0/3
 ipv6 address FE80::4 link-local
 ipv6 address 2001:DB8:0:34::4/64
 ospfv3 1 ipv6 area 34
!
router ospfv3 1
 router-id 192.168.4.4
```

OSPFv3 Verification – Neighbor Adjacency

To view the R3 OSPFv3 Neighbor Adjacency the **show opsfv3 ipv6 neighbor** command is used.

Neighbors router-id is displayed, OSPFv3 priority, state of the connection, and the interface the neighbor is learned on.

Example 10-2 *Identifying R3's OSPFv3 Neighbors*

```
R3# show ospfv3 ipv6 neighbor

          OSPFv3 1 address-family ipv6 (router-id 192.168.3.3)

Neighbor ID  Pri   State       Dead Time   Interface ID    Interface
192.168.2.2   1   FULL/DR      00:00:32    5               GigabitEthernet0/2
192.168.4.4   1   FULL/BDR     00:00:33    5               GigabitEthernet0/4
```

OSPFv3 Verification

Verifying the OSPFv3 interface information provides the following:

- Interface ID
- Router ID
- DR and Backup DR
- Neighbor Adjacency

```
R1# show ospfv3 interface GigabitEthernet0/2
GigabitEthernet0/2 is up, line protocol is up
  Link Local Address FE80::1, Interface ID 3
  Area 0, Process ID 1, Instance ID 0, Router ID 192.168.1.1
  Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 192.168.1.1, local address FE80::1
  Backup Designated router (ID) 192.168.2.2, local address FE80::2
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:01
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1, Adjacent neighbor count is 1
    Adjacent with neighbor 192.168.2.2  (Backup Designated Router)
  Suppress hello for 0 neighbor(s)
```

OSPFv3 Interface Verification

To show a brief listing of the interfaces participating in OSPFv3 Routing on R3 use the **show ospfv3 interface brief** command.

Important information includes the Interface, the area the interface belongs to, and the role of the router on the link (State)

Example 10-4 *Viewing a Brief Version of OSPFv3 Interfaces*

```
R3# show ospfv3 interface brief
Interface    PID   Area            AF          Cost  State Nbrs F/C
Lo0          1     0               ipv6        1     LOOP  0/0
Gi0/2        1     0               ipv6        1     BDR   1/1
Gi0/4        1     34              ipv6        1     DR    1/1
```

OSPFv3 Routing Verification

Output from the OSPFv3 routing table showing both Intra-Area routes (O) and Inter-Area routes (OI) using the command **show ipv6 route ospf.**

Example 10-5 *Viewing the OSPFv3 Routes in the IPv6 Routing Table*

```
R1# show ipv6 route ospf
! Output omitted for brevity
IPv6 Routing Table - default - 11 entries
       RL - RPL, O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1
       OE2 - OSPF ext 2, ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
..
O   2001:DB8::2/128 [110/1]
     via FE80::2, GigabitEthernet0/2
O   2001:DB8::3/128 [110/2]
     via FE80::2, GigabitEthernet0/2
OI  2001:DB8::4/128 [110/3]
     via FE80::2, GigabitEthernet0/2
OI  2001:DB8:0:4::/64 [110/4]
     via FE80::2, GigabitEthernet0/2
O   2001:DB8:0:23::/64 [110/2]
     via FE80::2, GigabitEthernet0/2
OI  2001:DB8:0:34::/64 [110/3]
     via FE80::2, GigabitEthernet0/2
```

OSPFv3 Passive Interface

OSPFv3 supports marking an interface as passive. The command is placed under the OSPFv3 process or under the specific address family. Placing the command under the global process cascades the setting to both address families.

- The passive interface can be set explicitly to an interface (R1 configuration).
- The passive interface can be set as default (R4 configuration).

Example 10-6 *Configuring OSPFv3 Passive Interfaces*

```
R1(config)# router ospfv3 1
R1(config-router)# passive-interface GigabitEthernet0/1
```

```
R4(config)# router ospfv3 1
R4(config-router)# passive-interface default
22:10:46.838: %OSPFv3-5-ADJCHG: Process 1, IPv6, Nbr 192.168.3.3 on GigabitEthernet0/3
from FULL to DOWN, Neighbor Down: Interface down or detached
R4(config-router)# no passive-interface GigabitEthernet 0/3
```

OSPFv3 Route Summarization

Example 10-9 shows the summarization commands applied to R3.

Route summarization reduces the number of route entries on the neighboring router as shown in examples 10-8 and 10-10.

Example 10-9 *IPv6 Summarization*

```
R3# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
R3(config)# router ospfv3 1
R3(config-router)# address-family ipv6 unicast
R3(config-router-af)# area 0 range 2001:db8:0:0::/65
```

Example 10-8 *R4's IPv6 Routing Table Before Summarization*

```
R4# show ipv6 route ospf | begin Application
       lA - LISP away, a - Application
OI   2001:DB8::1/128 [110/3]
     via FE80::3, GigabitEthernet0/3
OI   2001:DB8::2/128 [110/2]
     via FE80::3, GigabitEthernet0/3
OI   2001:DB8::3/128 [110/1]
     via FE80::3, GigabitEthernet0/3
```

Example 10-10 *R4's IPv6 Routing Table After Summarization*

```
R4# show ipv6 route ospf | begin Application
       lA - LISP away, a - Application
OI   2001:DB8::/65 [110/4]
     via FE80::3, GigabitEthernet0/3
OI   2001:DB8:0:1::/64 [110/4]
     via FE80::3, GigabitEthernet0/3
```

OSPFv3 Verify Network Type

Configuration changes may be necessary for a dynamically learned network type. As shown in Example 10-11 the R2 G0/3 interface is shown as a BROADCAST network type.

Based on the topology it should be a point-to-point.

Example 10-11 *Viewing the Dynamic Configured OSPFv3 Network Type*

```
R2# show ospfv3 interface GigabitEthernet 0/3 | include Network
  Network Type BROADCAST, Cost: 1
```

```
R2# show ospfv3 interface brief
Interface    PID   Area            AF          Cost  State Nbrs F/C
Lo0          1     0               ipv6        1     LOOP  0/0
Gi0/3        1     0               ipv6        1     DR    1/1
Gi0/1        1     0               ipv6        1     BDR   1/1
```

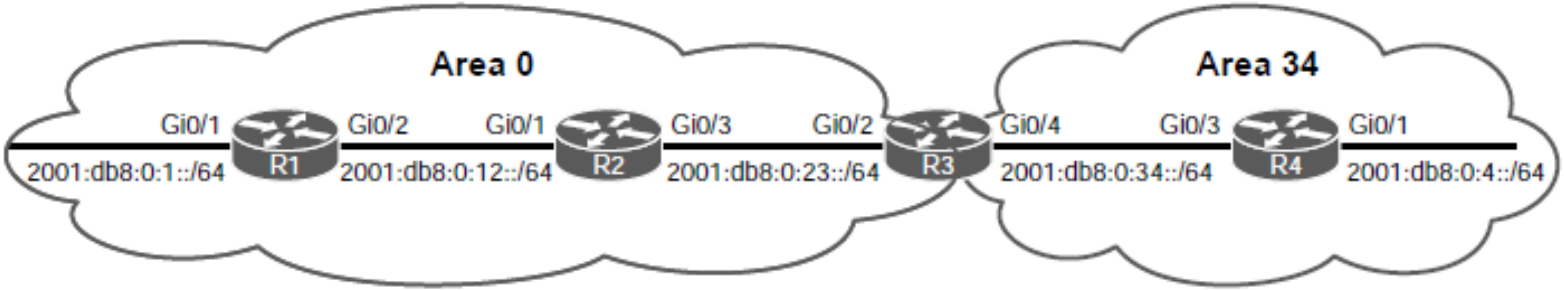

Figure 10-1 *OSPFv3 Topology*

OSPFv3 Change Network Type

When changes are made to the network type it is necessary to change both ends of the link to match. The change is made directly on the interface.

Example 10-12 *Changing the OSPFv3 Network Type*

```
R2# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)# interface GigabitEthernet 0/3
R2(config-if)# ospfv3 network point-to-point
```

```
R3(config)# interface GigabitEthernet 0/2
R3(config-if)# ospfv3 network point-to-point
```

Example 10-13 *Viewing the Statically Configured OSPFv3 Network Type*

```
R2# show ospfv3 interface GigabitEthernet 0/3 | include Network
  Network Type POINT_TO_POINT, Cost: 1
```

```
R2# show ospfv3 interface brief
Interface    PID   Area            AF          Cost  State Nbrs F/C
Lo0          1     0               ipv6        1     LOOP  0/0
Gi0/3        1     0               ipv6        1     P2P   1/1
Gi0/1        1     0               ipv6        1     BDR   1/1
```

IPv4 Support in OSPFv3

Enabling IPv4 Support

- Step 1. Ensure that the IPv4 interface has an IPv6 address (global or link local) configured.
- Step 2. Enable the OSPFv3 process for IPv4 on the interface with the command **ospfv3** *process-id* **ipv4 area** *area-id*.

Adding IPv4 support to existing interfaces

Using the command **ospfv3 *process-id* ipv4 area *area-id*** on an interface configured for IPv6 adds IPv4 support. The interface must have an IPv6 global or link-local address.

Example 10-14 *Configuration Changes for IPv4 Support*

```
R1(config)# interface Loopback 0
R1(config-if)# ospfv3 1 ipv4 area 0
R1(config-if)# interface GigabitEthernet0/1
R1(config-if)# ospfv3 1 ipv4 area 0
R1(config-if)# interface GigabitEthernet0/2
R1(config-if)# ospfv3 1 ipv4 area 0
```

```
R3(config)# interface Loopback 0
R3(config-if)# ospfv3 1 ipv4 area 0
R3(config-if)# interface GigabitEthernet0/2
R3(config-if)# ospfv3 1 ipv4 area 0
R3(config-if)# interface GigabitEthernet0/4
R3(config-if)# ospfv3 1 ipv4 area 34
```

```
R2(config)# interface Loopback 0
R2(config-if)# ospfv3 1 ipv4 area 0
R2(config-if)# interface GigabitEthernet0/1
R2(config-if)# ospfv3 1 ipv4 area 0
R2(config-if)# interface GigabitEthernet0/3
R2(config-if)# ospfv3 1 ipv4 area 0
```

```
R4(config)# interface Loopback 0
R4(config-if)# ospfv3 1 ipv4 area 34
R4(config-if)# interface GigabitEthernet0/1
R4(config-if)# ospfv3 1 ipv4 area 34
R4(config-if)# interface GigabitEthernet0/3
R4(config-if)# ospfv3 1 ipv4 area 34
```

Verifying IPv4 Routes

Verifying OSPFv3 routes for IPv4 is accomplished using the command **show ip route ospfv3.**

Example 10-15 *Verifying IPv4 Route Exchange with OSPFv3*

```
R4# show ip route ospfv3 | begin Gateway
Gateway of last resort is not set

      10.0.0.0/8 is variably subnetted, 5 subnets, 2 masks
O IA     10.1.1.0/24 [110/4] via 10.34.1.3, 00:00:39, GigabitEthernet0/3
O IA     10.12.1.0/24 [110/3] via 10.34.1.3, 00:00:39, GigabitEthernet0/3
O IA     10.23.1.0/24 [110/2] via 10.34.1.3, 00:00:39, GigabitEthernet0/3
      192.168.1.0/32 is subnetted, 1 subnets
O IA     192.168.1.1 [110/3] via 10.34.1.3, 00:00:39, GigabitEthernet0/3
      192.168.2.0/32 is subnetted, 1 subnets
```

Displaying OSPFv3 Interfaces

To display the interfaces configured for OSPFv3 and the respective address family use the command **show ospfv3 interface brief.**

Example 10-16 *Listing of OSPFv3 Interfaces and Their Address Families*

```
R4# show ospfv3 interface brief
Interface    PID   Area            AF          Cost  State Nbrs F/C
Lo0          1     34              ipv4        1     LOOP  0/0
Gi0/1        1     34              ipv4        1     DR    1/1
Gi0/3        1     34              ipv4        1     DR    1/1
Lo0          1     34              ipv6        1     LOOP  0/0
Gi0/1        1     34              ipv6        1     DR    0/0
Gi0/3        1     34              ipv6        1     BDR   1/1
```

Verifying OSPFv3 Neighbors

To verify the OSPFv3 neighbors for both IPv4 and IPv6 use the command **show ospfv3 neighbor.**

Example 10-17 *Verifying OSPFv3 IPv4 Neighbors*

```
R4# show ospfv3 neighbor

          OSPFv3 1 address-family ipv4 (router-id 192.168.4.4)

Neighbor ID     Pri   State           Dead Time   Interface ID    Interface
192.168.3.3       1   FULL/BDR        00:00:30    6               GigabitEthernet0/3

          OSPFv3 1 address-family ipv6 (router-id 192.168.4.4)

Neighbor ID     Pri   State           Dead Time   Interface ID    Interface
192.168.3.3       1   FULL/DR         00:00:31    6               GigabitEthernet0/3
```

Prepare for the Exam

Prepare for the Exam

Key Topics for Chapter 10

Description
OSPFv3 fundamentals
OSPFv3 Packet Types
OSPFv3 verification
OSPFv3 summarization
IPv4 support on OSPFv3

Command Reference for Chapter 10

Task	Command Syntax
Configure OSPFv3 on a router and enable it on an interface	**router ospfv3 [***process-id***]** **interface** *interface-id* **ospfv3** *process-id* **{ipv4 | ipv6} area** *area-id*
Configure a specific OSPFv3 interface as passive	**passive-interface** *interface-id*
Configure all OSPFv3 interfaces as passive	**passive-interface default**
Summarize an IPv6 network range on an ABR	**area** *area-id* **range** *prefix/prefix-length*
Configure an OSPFv3 interface as point-to-point or broadcast network type	**ospfv3 network {point-to-point | broadcast}**

Command Reference for Chapter 10 (Cont.)

Task	Command Syntax
Display OSPFv3 interface settings	**show ospfv3 interface [*interface-id*]**
Display OSPFv3 IPv6 neighbors	**show ospfv3 ipv6 neighbor**
Display OSPFv3 router LSAs	**show ospfv3 database router**
Display OSPFv3 network LSAs	**show ospfv3 database network**
Display OSPFv3 link LSAs	**show ospfv3 database link**


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