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OmniSwitch 6800 Series Advanced Routing Configuration Guide

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This user guide documents release 5.3.1 of the OmniSwitch 6800 Series.
The functionality described in this guide is subject to change without notice.

This OmniSwitch product contains components which may be covered by one or more of the following U.S. Patents:

- U.S. Patent No. 6,339,830
- U.S. Patent No. 6,070,243
- U.S. Patent No. 6,061,368
- U.S. Patent No. 5,394,402
- U.S. Patent No. 6,047,024
- U.S. Patent No. 6,314,106
- U.S. Patent No. 6,542,507

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Contents

About This Guide

This *OmniSwitch 6800 Series Advanced Routing Configuration Guide* describes how to set up and monitor advanced routing protocols for operation in a live network environment. The routing protocols described in this manual are purchased as an add-on package to the base switch software.

Supported Platforms

This information in this guide applies to the following products:

- OmniSwitch 6800-24
- OmniSwitch 6800-48

The OmniSwitch 6800-24 switch has 20 unshared auto-sensing and auto-MDIX copper RJ-45 10/100/1000 Mbps ports (ports 1–20) and four combo ports (ports 21–24) that are shared between four copper RJ-45 10/100/1000 Mbps ports and four SFP 1000 Mbps (1Gbps) ports. The OmniSwitch 6800-48 switch has 44 unshared auto-sensing and auto-MDIX copper RJ-45 10/100/1000 Mbps ports (ports 1–44) and four combo ports (ports 45–48) that are shared between four copper RJ-45 10/100/1000 Mbps ports and four SFP 1000 Mbps (1Gbps) ports.

In addition, OmniSwitch 6800 Series switches offer fixed stacking ports. The stacking ports on OmniSwitch 6800 Series switches allow two to eight switches to be assembled and managed as one virtual chassis known as a *stack*.

Unsupported Platforms

The information in this guide does not apply to the following products:

- OmniSwitch (original version with no numeric model name)
- OmniSwitch 6624
- OmniSwitch 6648
- OmniSwitch 6600-U24
- OmniSwitch 6600-P24
- OmniSwitch 6602-24
- OmniSwitch 6602-48
- OmniSwitch 7700
- OmniSwitch 7800
- OmniSwitch 8800
- Omni Switch/Router
- OmniStack
- OmniAccess

Who Should Read this Manual?

The audience for this user guide is network administrators and IT support personnel who need to configure, maintain, and monitor switches and routers in a live network. However, anyone wishing to gain knowledge on how advanced routing software features are implemented in the OmniSwitch 6800 Series will benefit from the material in this configuration guide.

When Should I Read this Manual?

Read this guide as soon as you are ready to integrate your OmniSwitch into your network and you are ready to set up advanced routing protocols. You should already be familiar with the basics of managing a single OmniSwitch as described in the *OmniSwitch 6800 Series Switch Management Guide*.

The topics and procedures in this manual assume an understanding of the OmniSwitch directory structure and basic switch administration commands and procedures. This manual will help you set up your switches to route on the network using routing protocols, such as OSPF.

What is in this Manual?

This configuration guide includes information about configuring the following features:

- Open Shortest Path First (OSPF) protocol
- Multicast routing boundaries
- Distance Vector Multicast Routing Protocol (DVMRP)
- Protocol-Independent Multicast, Sparse Mode (PIM-SM) protocol

What is Not in this Manual?

The configuration procedures in this manual use Command Line Interface (CLI) commands in all examples. CLI commands are text-based commands used to manage the switch through serial (console port) connections or via Telnet sessions. Procedures for other switch management methods, such as web-based (WebView or OmniVista) or SNMP, are outside the scope of this guide.

For information on WebView and SNMP switch management methods consult the *OmniSwitch 6800 Series Switch Management Guide.* Information on using WebView and OmniVista can be found in the context-sensitive on-line help available with those network management applications.

This guide provides overview material on software features, how-to procedures, and application examples that will enable you to begin configuring your OmniSwitch. It is not intended as a comprehensive reference to all CLI commands available in the OmniSwitch. For such a reference to all OmniSwitch CLI commands, consult the *OmniSwitch CLI Reference Guide*.

How is the Information Organized?

Chapters in this guide are broken down by software feature. The titles of each chapter include protocol or feature names (e.g., OSPF, PIM-SM) with which most network professionals will be familiar.

Each software feature chapter includes sections that will satisfy the information requirements of casual readers, rushed readers, serious detail-oriented readers, advanced users, and beginning users.

Quick Information. Most chapters include a *specifications table* that lists RFCs and IEEE specifications supported by the software feature. In addition, this table includes other pertinent information such as minimum and maximum values and sub-feature support. Most chapters also include a *defaults table* that lists the default values for important parameters along with the CLI command used to configure the parameter. Many chapters include a *Quick Steps* section, which is a procedure covering the basic steps required to get a software feature up and running.

In-Depth Information. All chapters include *overview sections* on the software feature as well as on selected topics of that software feature. *Topical sections* may often lead into *procedure sections* that describe how to configure the feature just described. Serious readers and advanced users will also find the many *application examples*, located near the end of chapters, helpful. Application examples include diagrams of real networks and then provide solutions using the CLI to configure a particular feature, or more than one feature, within the illustrated network.

Documentation Roadmap

The OmniSwitch user documentation suite was designed to supply you with information at several critical junctures of the configuration process. The following section outlines a roadmap of the manuals that will help you at each stage of the configuration process. Under each stage, we point you to the manual or manuals that will be most helpful to you.

Stage 1: Using the Switch for the First Time

Pertinent Documentation: *OmniSwitch 6800 Series Getting Started Guide*
Release Notes

The *OmniSwitch 6800 Series Getting Started Guide* provides all the information you need to get your switch up and running the first time. This guide provides information on unpacking the switch, rack mounting the switch, installing stacking cables, installing backup power supplies, unlocking access control, setting the switch's IP address, setting up a password, and setting up stacks. It also includes succinct overview information on fundamental aspects of the switch, such as hardware LEDs, the software directory structure, stacking, CLI conventions, and web-based management.

At this time you should also familiarize yourself with the Release Notes that accompanied your switch. This document includes important information on feature limitations that are not included in other user guides.

Stage 2: Gaining Familiarity with Basic Switch Functions

Pertinent Documentation: *OmniSwitch 6800 Series Hardware Users Guide*
OmniSwitch 7700/7800 Switch Management Guide

Once you have your switch up and running, you will want to begin investigating basic aspects of its hard ware and software. Information about switch hardware is provided in the *OmniSwitch 6800 Series Hardware Users Guide*. This guide provide specifications, illustrations, and descriptions of all hardware components—e.g., chassis, stacking ports and stacking cables, backup power supplies, etc. It also includes steps for common procedures, such as removing and installing switch modules.

The *OmniSwitch 6800 Series Switch Management Guide* is the primary user guide for the basic software features on a single switch. This guide contains information on the switch directory structure, basic file and directory utilities, switch access security, SNMP, and web-based management. It is recommended that you read this guide before connecting your switch to the network.

Stage 3: Integrating the Switch Into a Network

Pertinent Documentation: *OmniSwitch 6800 Series Network Configuration Guide*
OmniSwitch 6800 Series Advanced Routing Configuration Guide

When you are ready to connect your switch to the network, you will need to learn how the OmniSwitch implements fundamental software features, such as 802.1Q, VLANs, Spanning Tree, and network routing protocols. The *OmniSwitch 6800 Series Network Configuration Guide* contains overview information, procedures, and examples on how standard networking technologies are configured in the OmniSwitch 6800 Series.

The *OmniSwitch 6800 Series Advanced Routing Configuration Guide* includes configuration information for networks using advanced routing technologies (OSPF) and multicast routing protocols (DVMRP and PIM-SM).

Anytime

The *OmniSwitch CLI Reference Guide* contains comprehensive information on all CLI commands supported by the switch. This guide includes syntax, default, usage, example, related CLI command, and CLI-to-MIB variable mapping information for all CLI commands supported by the switch. This guide can be consulted anytime during the configuration process to find detailed and specific information on each CLI command.

Related Documentation

The following are the titles and descriptions of all the OmniSwitch 6800 Series user manuals:

- *OmniSwitch 6800 Series Getting Started Guide*

  Describes the hardware and software procedures for getting an OmniSwitch 6800 Series switch up and running. Also provides information on fundamental aspects of OmniSwitch software and stacking architecture.

- *OmniSwitch 6800 Series Hardware Users Guide*

  Detailed technical specifications and procedures for the OmniSwitch 6800 Series chassis and components. This manual also includes comprehensive information on assembling and managing stacked configurations.

- *OmniSwitch CLI Reference Guide*

  Complete reference to all CLI commands supported on the OmniSwitch 6600, 6800, 7700, 7800, and 8800. Includes syntax definitions, default values, examples, usage guidelines and CLI-to-MIB variable mappings.

- *OmniSwitch 6800 Series Switch Management Guide*

  Includes procedures for readying an individual switch for integration into a network. Topics include the software directory architecture, image rollback protections, authenticated switch access, managing switch files, system configuration, using SNMP, and using web management software (WebView).

- *OmniSwitch 6800 Series Network Configuration Guide*

  Includes network configuration procedures and descriptive information on all the major software features and protocols included in the base software package. Chapters cover Layer 2 information (Ethernet and VLAN configuration), Layer 3 information (routing protocols, such as RIP), security options (authenticated VLANs), Quality of Service (QoS), and link aggregation.

- *OmniSwitch 6800 Series Advanced Routing Configuration Guide*

  Includes network configuration procedures and descriptive information on all the software features and protocols included in the advanced routing software package. Chapters cover multicast routing (DVMRP and PIM-SM), and OSPF.

- Technical Tips, Field Notices

  Includes information published by Alcatel’s Customer Support group.

- *Release Notes*

  Includes critical Open Problem Reports, feature exceptions, and other important information on the features supported in the current release and any limitations to their support.

User Manual CD

All user guides for the OmniSwitch 6800 Series are included on the User Manual CD that accompanied your switch. This CD also includes user guides for other Alcatel data enterprise products. In addition, it contains a stand-alone version of the on-line help system that is embedded in the OmniVista network management application.

Besides the OmniVista documentation, all documentation on the User Manual CD is in PDF format and requires the Adobe Acrobat Reader program for viewing. Acrobat Reader freeware is available at www.adobe.com.

Note. In order to take advantage of the documentation CD's global search feature, it is recommended that you select the option for *searching PDF files* before downloading Acrobat Reader freeware.

To verify that you are using Acrobat Reader with the global search option, look for the following button in the toolbar:

Note. When printing pages from the documentation PDFs, de-select Fit to Page if it is selected in your print dialog. Otherwise pages may print with slightly smaller margins.

Technical Support

An Alcatel service agreement brings your company the assurance of 7x24 no-excuses technical support. You'll also receive regular software updates to maintain and maximize your Alcatel product's features and functionality and on-site hardware replacement through our global network of highly qualified service delivery partners. Additionally, with 24-hour-a-day access to Alcatel's Service and Support web page, you'll be able to view and update any case (open or closed) that you have reported to Alcatel's technical support, open a new case or access helpful release notes, technical bulletins, and manuals. For more information on Alcatel's Service Programs, see our web page at eservice.ind.alcatel.com, call us at 1-800-995-2696, or email us at support@ind.alcatel.com.

1 Configuring OSPF

Open Shortest Path First routing (OSPF) is a shortest path first (SPF), or *link state*, protocol. OSPF is an interior gateway protocol (IGP) that distributes routing information between routers in a single Autonomous System (AS). OSPF chooses the least-cost path as the best path. OSPF is suitable for complex networks with large numbers of routers since it provides faster convergence where multiple flows to a single destination can be forwarded on one or more interfaces simultaneously.

In This Chapter

This chapter describes the basic components of OSPF and how to configure them through the Command Line Interface (CLI). CLI commands are used in the configuration examples; for more details about the syntax of commands, see the *OmniSwitch CLI Reference Guide*.

Configuration procedures described in this chapter include:

- Loading and enabling OSPF. See "Activating OSPF" on page 1-16.
- Creating OSPF areas. See "Creating an Area" on page 1-17.
- Creating OSPF interfaces. See "Creating OSPF Interfaces" on page 1-20.
- Creating virtual links. See "Creating Virtual Links" on page 1-23
- Using redistribution policies and filters. See "Enabling Redistribution" on page 1-24

For information on creating and managing VLANs, see "Configuring VLANs" in the *OmniSwitch 6800 Series Network Configuration Guide*.

OSPF Specifications

RFCs Supported	1370—Applicability Statement for OSPF 1850—OSPF Version 2 Management Information Base 2328—OSPF Version 2 2370—The OSPF Opaque LSA Option 3101—The OSPF Not-So-Stubby Area (NSSA) Option 3623—Graceful OSPF Restart
Maximum number of Areas (per router)	10
Maximum number of Interfaces (per router)	70
Maximum number of Link State Database entries (per router)	50000
Maximum number of adjacencies (per router)	70
Maximum number of ECMP gateways (per destination)	4
Maximum number of neighbors (per router)	64
Maximum number of routes (per router)	Up to 40000 (Depending on the number of interfaces/neighbors, this value may vary.)

OSPF Defaults Table

The following table shows the default settings of the configurable OSPF parameters.

Parameter Description	Command	Default Value/Comments
Enables OSPF.	**ip ospf status**	disabled
Enables an area.	**ip ospf area status**	disabled
Enables an interface.	**ip ospf interface status**	disabled
Enables OSPF redistribution.	**ip ospf redist status**	disabled
Sets the overflow interval value.	**ip ospf exit-overflow-interval**	0
Assigns a limit to the number of External Link-State Database (LSDB) entries.	**ip ospf extlsdb-limit**	-1
Configures timers for Shortest Path First (SPF) calculation.	**ip ospf spf-timer**	delay: 5 hold: 10
Creates or deletes an area default metric.	**ip ospf area default-metric**	ToS: 0 Type: OSPF Cost: 1
Configures OSPF interface dead interval.	**ip ospf interface dead-interval**	40 seconds (broadcast and point-to-point) 120 seconds (NBMA and point-to-multipoint)
Configures OSPF interface hello interval.	**ip ospf interface hello-interval**	10 seconds (broadcast and point-to-point) 30 seconds (NBMA and point-to-multipoint)
Configures the OSPF interface cost.	**ip ospf interface cost**	1
Configures the OSPF poll interval.	**ip ospf interface poll-interval**	120 seconds
Configures the OSPF interface priority.	**ip ospf interface priority**	1
Configures OSPF interface retransmit interval.	**ip ospf interface retrans-interval**	5 seconds
Configures the OSPF interface transit delay.	**ip ospf interface transit-delay**	1 second
Configures the OSPF interface type.	**ip ospf interface type**	broadcast
Configures graceful restart on switches in a stack	**ip ospf restart-support**	Disabled

OSPF Quick Steps

The followings steps are designed to show the user the necessary set of commands for setting up a router to use OSPF:

1 Create a VLAN using the **vlan** command. For example:

```
-> vlan 5

-> vlan 5 enable
```

2 Assign a router IP address and subnet mask to the VLAN using the **vlan router ip** command. For example:

```
-> vlan 5 router ip 120.1.4.1 255.0.0.0
```

3 Assign a port to the created VLANs using the **vlan** command. For example:

```
-> vlan 5 port default 2/1
```

Note. The port will be statically assigned to the VLAN, as a VLAN must have a physical port assigned to it in order for the router port to function. However, the router could be set up in such a way that mobile ports are dynamically assigned to VLANs using VLAN rules. See the chapter titled "Defining VLAN Rules" in the *OmniSwitch 6800 Series Network Configuration Guide*.

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4 Assign a router ID to the router using the **ip router router-id** command. For example:

```
-> ip router router-id 1.1.1.1
```

5 Load and enable OSPF using the **ip load ospf** and the **ip ospf status** commands. For example:

```
-> ip load ospf

-> ip ospf status enable
```

6 Create a backbone to connect this router to others, and an area for the router's traffic, using the **ip ospf area** command. (Backbones are always labeled area 0.0.0.0.) For example:

```
-> ip ospf area 0.0.0.0

-> ip ospf area 0.0.0.1
```

7 Enable the backbone and area using the **ip ospf area status** command. For example:

```
-> ip ospf area 0.0.0.0 status enable

-> ip ospf area 0.0.0.1 status enable
```

8 Create an OSPF interface for each VLAN created in Step 1, using the **ip ospf interface** command. The OSPF interface should use the same IP address used for the VLAN router IP created in Step 2. For example:

```
-> ip ospf interface 120.1.4.1
```

9 Assign the OSPF interface to the area and the backbone using the **ip ospf interface area** command. For example:

```
-> ip ospf interface 120.1.4.1 area 0.0.0.0
```

10 Enable the OSPF interfaces using the **ip ospf interface status** command. For example:

```
-> ip ospf interface 120.1.4.1 status enable
```

11 You can now display the router OSPF settings by using the **show ip ospf** command. The output generated is similar to the following:

```
-> show ip ospf

Router Id                          = 1.1.1.1,     ———— Router ID
                                                       As set in Step 5
OSPF Version Number                = 2,
Admin Status                       = Enabled,
Area Border Router?               = Yes,
AS Border Router Status            = Disabled,
Route Redistribution Status        = Disabled,
Route Tag                          = 0,
SPF Hold  Time (in seconds)        = 10,
SPF Delay  Time (in seconds)       = 5,
MTU Checking                       = Disabled,
# of Routes                        = 0,
# of AS-External LSAs              = 0,
# of self-originated LSAs          = 0,
# of LSAs received                 = 0,
External LSDB Limit                = -1,
Exit Overflow Interval             = 0,
# of SPF calculations done         = 1,
# of Incr SPF calculations done    = 0,
# of Init State Nbrs               = 0,
# of 2-Way State Nbrs              = 0,
# of Exchange State Nbrs           = 0,
# of Full State Nbrs               = 0,
# of attached areas                = 2,
# of Active areas                  = 2,
# of Transit areas                 = 0,
# of attached NSSAs                = 0
```

12 You can display OSPF area settings using the **show ip ospf area** command. For example:

```
-> show ip ospf area 0.0.0.0

Area Identifier                               = 0.0.0.0,   ———— Area ID
                                                                As set in Step 7
Admin Status                                  = Enabled,   ———— Area Status
                                                                As set in Step 8
Operational Status                            = Up,
Area Type                                     = normal,
Area Summary                                  = Enabled,
Time since last SPF Run                       = 00h:08m:37s,
# of Area Border Routers known                = 1,
# of AS Border Routers known                  = 0,
# of LSAs in area                             = 1,
# of SPF Calculations done                    = 1,
# of Incremental SPF Calculations done        = 0,
# of Neighbors in Init State                  = 0,
# of Neighbors in 2-Way State                 = 0,
# of Neighbors in Exchange State              = 0,
# of Neighbors in Full State                  = 0
# of Interfaces attached                      = 1
```

13 You can display OSPF interface settings using the **show ip ospf interface** command. For example:

```
-> show ip ospf interface 120.1.4.1

VLAN Id                                 = 5,
Interface IP Address                    = 120.1.4.1,
Interface IP Mask                       = 255.0.0.0,
Admin Status                            = Enabled,
Operational Status                      = Down,
OSPF Interface State                    = Down,
Interface Type                          = Broadcast,
Area Id                                 = 0.0.0.0,
Designated Router IP Address            = 0.0.0.0,
Designated Router RouterId              = 0.0.0.0,
Backup Designated Router IP Address     = 0.0.0.0,
Backup Designated Router RouterId       = 0.0.0.0,
MTU  (bytes)                            = 1500,
Metric Cost                             = 1,
Priority                                = 1,
Hello Interval (seconds)                = 10,
Transit Delay (seconds)                 = 1,
Retrans Interval (seconds)              = 5,
Dead Interval (seconds)                 = 40,
Poll Interval (seconds)                 = 120,
Link Type                               = Broadcast,
Authentication Type                     = none,
# of Events                             = 0,
# of Init State Neighbors               = 0,
# of 2-Way State Neighbors              = 0,
# of Exchange State Neighbors           = 0,
# of Full State Neighbors               = 0
```

VLAN ID
As set in Step 1

Interface ID
As set in Step 9

Interface Status
As set in Step 11

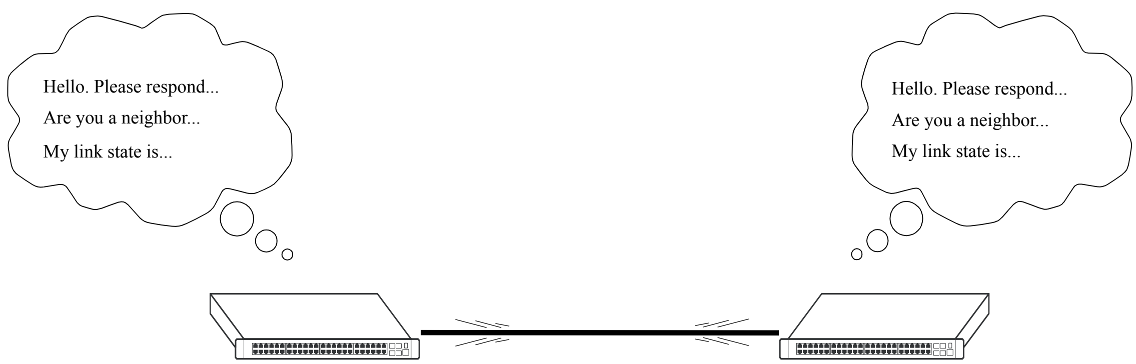
Area ID
As set in Step 7

OSPF Overview

Open Shortest Path First routing (OSPF) is a shortest path first (SPF), or link-state, protocol. OSPF is an interior gateway protocol (IGP) that distributes routing information between routers in a Single Autonomous System (AS). OSPF chooses the least-cost path as the best path.

Each participating router distributes its local state (i.e., the router's usable interfaces, local networks, and reachable neighbors) throughout the AS by flooding. In a link-state protocol, each router maintains a database describing the entire topology. This database is built from the collected link state advertisements of all routers. Each multi-access network that has at least two attached routers has a designated router and a backup designated router. The designated router floods a link state advertisement for the multi-access network.

When a router starts, it uses the OSPF Hello Protocol to discover neighbors. The router sends Hello packets to its neighbors, and in turn receives their Hello packets. On broadcast and point-to-point networks, the router dynamically detects its neighboring routers by sending Hello packets to a multicast address. On nonbroadcast and point-to-multipoint networks, some configuration information is necessary in order to configure neighbors. On all networks (broadcast or nonbroadcast), the Hello Protocol also elects a designated router for the network.



OSPF Hello Protocol

The router will attempt to form full adjacencies with all of its newly acquired neighbors. Only some pairs, however, will be successful in forming full adjacencies. Topological databases are synchronized between pairs of fully adjacent routers.

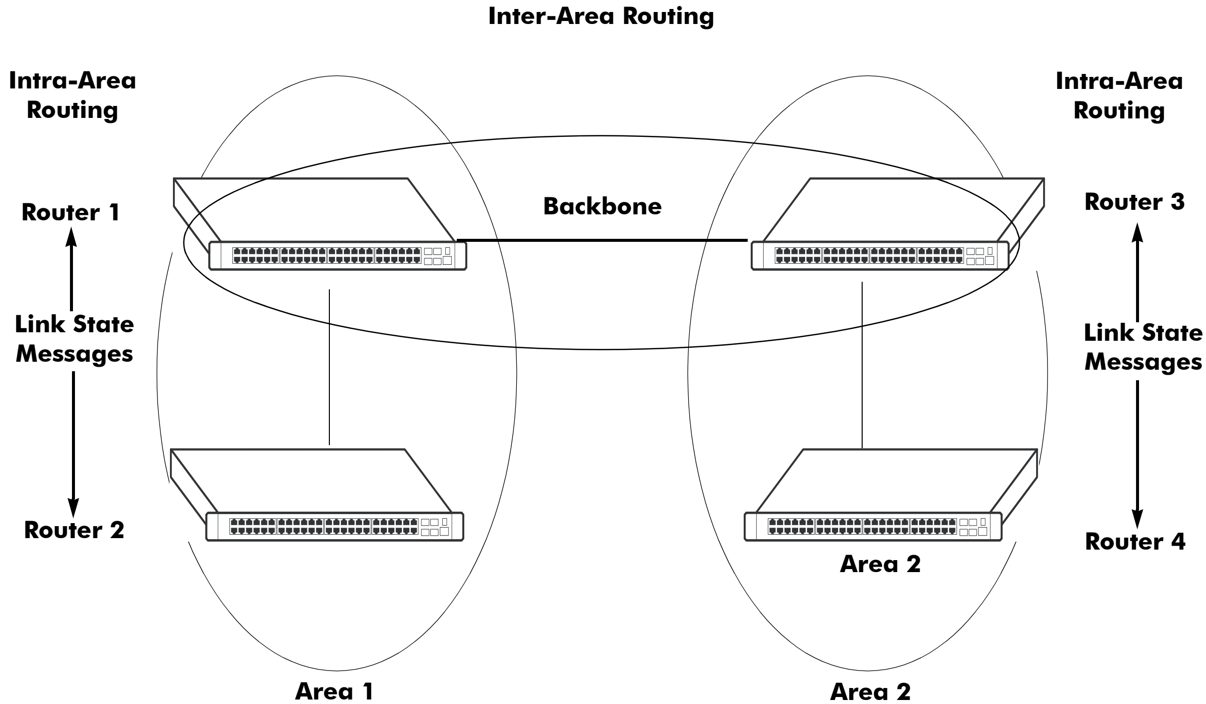
Adjacencies control the distribution of routing protocol packets. Routing protocol packets are sent and received only on adjacencies. In particular, distribution of topological database updates proceeds along adjacencies.

Link state is also advertised when a router's state changes. A router's adjacencies are reflected in the contents of its link state advertisements. This relationship between adjacencies and link state allows the protocol to detect downed routers in a timely fashion.

Link state advertisements are flooded throughout the AS. The flooding algorithm ensures that all routers have exactly the same topological database. This database consists of the collection of link state advertisements received from each router belonging to the area. From this database each router calculates a shortest-path tree, with itself as root. This shortest-path tree in turn yields a routing table for the protocol.

OSPF Areas

OSPF allows collections of contiguous networks and hosts to be grouped together as an *area*. Each area runs a separate copy of the basic link-state routing algorithm (usually called SPF). This means that each area has its own topological database, as explained in the previous section.



OSPF Intra-Area and Inter-Area Routing

An area's topology is visible only to the members of the area. Conversely, routers internal to a given area know nothing of the detailed topology external to the area. This isolation of knowledge enables the protocol to reduce routing traffic by concentrating on small areas of an AS, as compared to treating the entire AS as a single link-state domain.

Areas cause routers to maintain a separate topological database for each area to which they are connected. (Routers connected to multiple areas are called *area border routers*). Two routers belonging to the same area have identical area topological databases.

Different areas communicate with each other through a *backbone*. The backbone consists of routers with contacts between multiple areas. A backbone must be contiguous (i.e., it must be linked to all areas).

The backbone is responsible for distributing routing information between areas. The backbone itself has all of the properties of an area. The topology of the backbone is invisible to each of the areas, while the backbone itself knows nothing of the topology of the areas.

All routers in an area must agree on that area's parameters. Since a separate copy of the link-state algorithm is run in each area, most configuration parameters are defined on a per-router basis. All routers belonging to an area must agree on that area's configuration. Misconfiguration will keep neighbors from forming adjacencies between themselves, and OSPF will not function.

Classification of Routers

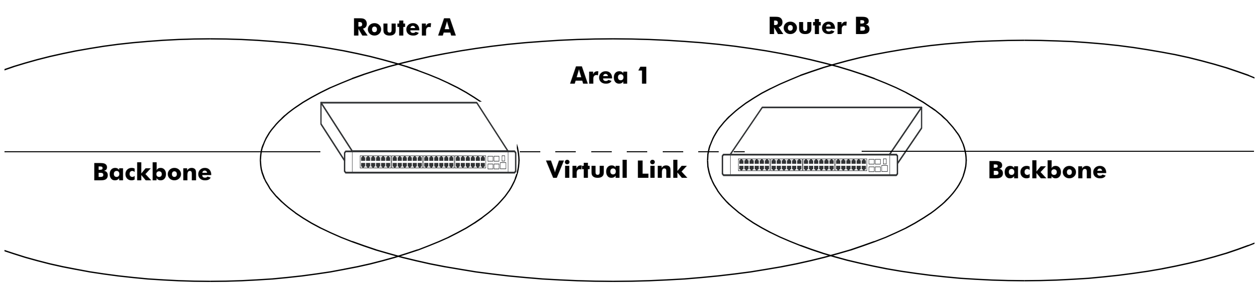
When an AS is split into OSPF areas, the routers are further divided according to function into the following four overlapping categories:

- **Internal routers**. A router with all directly connected networks belonging to the same area. These routers run a single copy of the SPF algorithm.
- **Area border routers**. A router that attaches to multiple areas. Area border routers run multiple copies of the SPF algorithm, one copy for each attached area. Area border routers condense the topological information of their attached areas for flooding to other areas.
- **Backbone routers**. A router that has an interface to the backbone. This includes all routers that interface to more than one area (i.e., area border routers). However, backbone routers do not have to be area border routers. Routers with all interfaces connected to the backbone are considered to be internal routers.
- **AS boundary routers**. A router that exchanges routing information with routers belonging to other Autonomous Systems. Such a router has AS external routes that are advertised throughout the Autonomous System. The path to each AS boundary router is known by every router in the AS. This classification is completely independent of the previous classifications (i.e., internal, area border, and backbone routers). AS boundary routers may be internal or area border routers, and may or may not participate in the backbone.

Virtual Links

It is possible to define areas in such a way that the backbone is no longer contiguous. (This is not an ideal OSPF configuration, and maximum effort should be made to avoid this situation.) In this case the system administrator must restore backbone connectivity by configuring *virtual links*.

Virtual links can be configured between any two backbone routers that have a connection to a common non-backbone area. The protocol treats two routers joined by a virtual link as if they were connected by an unnumbered point-to-point network. The routing protocol traffic that flows along the virtual link uses intra-area routing only, and the physical connection between the two routers is not managed by the network administrator (i.e., there is no dedicated connection between the routers as there is with the OSPF backbone).



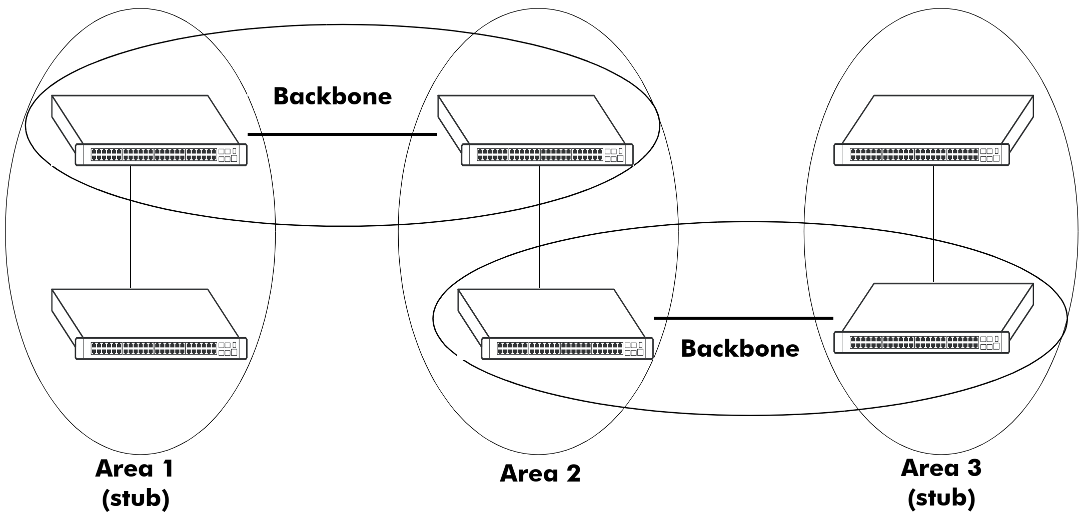
OSPF Routers Connected with a Virtual Link

In the above diagram, Router A and Router B are connected via a virtual link in Area 1, which is known as a transit area. See "Creating Virtual Links" on page 1-23 for more information.

Stub Areas

OSPF allows certain areas to be configured as *stub areas*. A stub area is an area with routers that have no AS external Link State Advertisements (LSAs).

In order to take advantage of the OSPF stub area support, default routing must be used in the stub area. This is accomplished by configuring only one of the stub area's border routers to advertise a default route into the stub area. The default routes will match any destination that is not explicitly reachable by an intra-area or inter-area path (i.e., AS external destinations).



OSPF Stub Area

Area 1 and Area 3 could be configured as stub areas. Stub areas are configured using the OSPF **ip ospf area** command, described in "Creating an Area" on page 1-17. For more overview information on areas, see "OSPF Areas" on page 1-8.

The OSPF protocol ensures that all routers belonging to an area agree on whether the area has been configured as a stub. This guarantees that no confusion will arise in the flooding of AS external advertisements.

Two restrictions on the use of stub areas are:

- Virtual links cannot be configured through stub areas.
- AS boundary routers cannot be placed internal to stub areas.

Not-So-Stubby-Areas

NSSA, or not-so-stubby area, is an extension to the base OSPF specification and is defined in RFC 1587. An NSSA is similar to a stub area in many ways: AS-external LSAs are not flooded into an NSSA and virtual links are not allowed in an NSSA. The primary difference is that selected external routing information can be imported into an NSSA and then redistributed into the rest of the OSPF routing domain. These routes are imported into the NSSA using a new LSA type: Type-7 LSA. Type-7 LSAs are flooded within the NSSA and are translated at the NSSA boundary into AS-external LSAs so as to convey the external routing information to other areas.

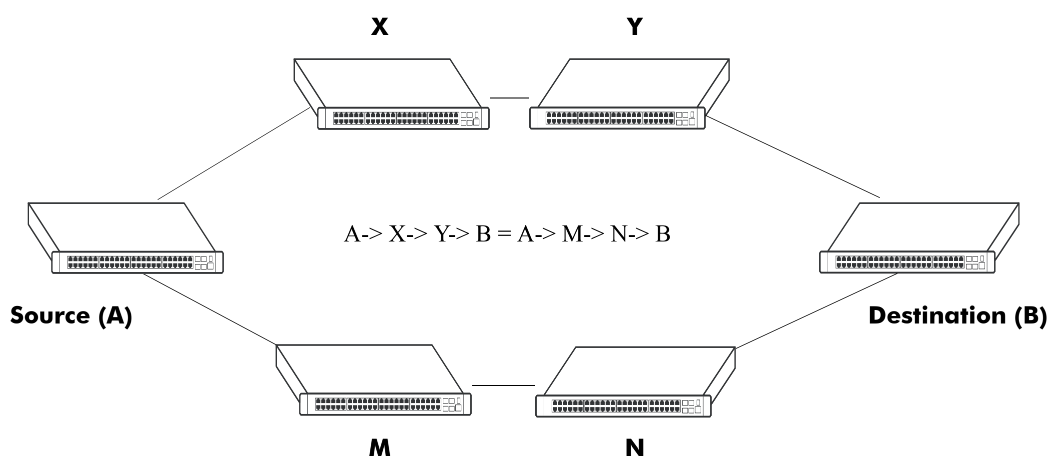
NSSAs enable routers with limited resources to participate in OSPF routing while also allowing the import of a selected number of external routes into the area. For example, an area which connects to a small external routing domain running RIP may be configured as an NSSA. This will allow the import of RIP routes into this area and the rest of the OSPF routing domain and at the same time, prevent the flooding of other external routing information (learned, for example, through RIP) into this area.

All routers in an NSSA must have their OSPF area defined as an NSSA. To configure otherwise will ensure that the router will be unsuccessful in establishing an adjacent in the OSPF domain.

Equal Cost Multi-Path (ECMP) Routing

Using information from its continuously updated databases, OSPF calculates the shortest path to a given destination. Shortest path is determined from metric values at each hop along a path. At times, two or more paths to the same destination will have the same metric cost.

In the network illustration below, there are two paths from Source router A to Destination router B. One path traverses two hops at routers X and Y and the second path traverses two hops at M and N. If the total cost through X and Y to B is the same as the cost via M and N to B, then these two paths have equal cost. In this version of OSPF both paths will be stored and used to transmit data.



Multiple Equal Cost Paths

Delivery of packets along equal paths is based on flows rather than a round-robin scheme. Equal cost is determined based on standard routing metrics. However, other variables, such as line speed, are not considered. So it is possible for OSPF to decide two paths have an equal cost even though one may contain faster links than another.

Non Broadcast OSPF Routing

OSPF can operate in two modes on non-broadcast networks: NBMA and point-to-multipoint. The interface type for the corresponding network segment should be set to non broadcast or point-to-multipoint, respectively.

For non-broadcast networks neighbors should be statically configured. For NBMA neighbors the eligibility option must be enabled for the neighboring router to participate in Designated Router (DR) election.

For the correct working of an OSPF NBMA network, a fully meshed network is mandatory. Also, the neighbor eligibility configuration for a router on every other router should match the routers interface priority configuration.

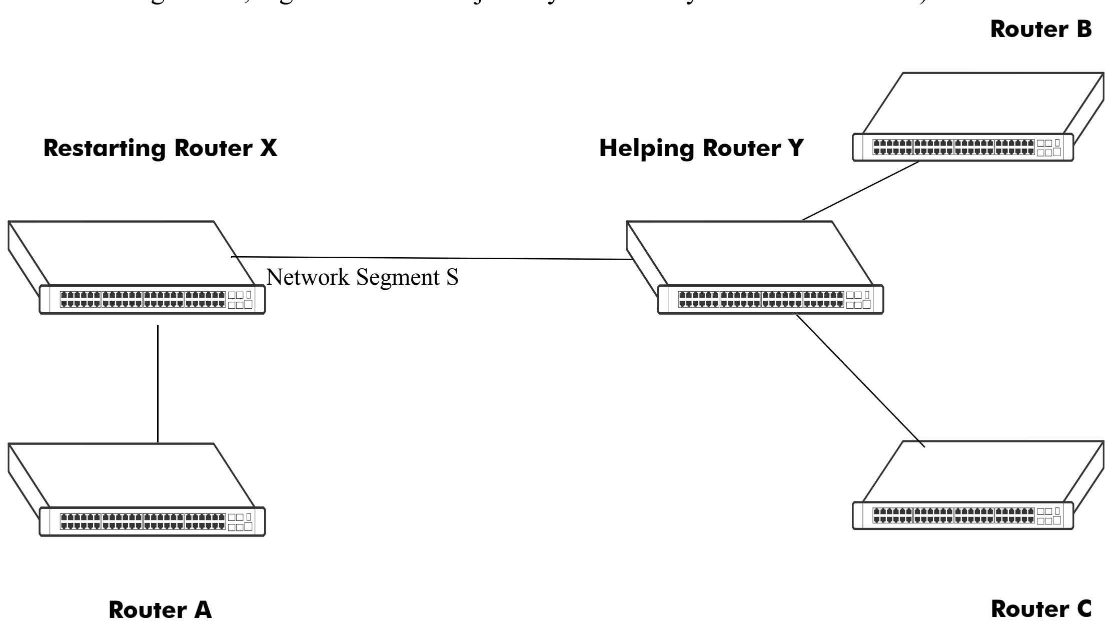
See "Configuring Static Neighbors" on page 1-28 for more information and setting up static neighbors.

Graceful Restart on Stacks with Redundant Switches

OmniSwitch 6800 Series stacks with two or more switches can support redundancy where if the primary switch fails or goes offline for any reason, the secondary switch is instantly notified. The secondary switch automatically assumes the primary role. This switch between the primary and secondary switches is known as *takeover*.

When a takeover occurs, which can be planned (e.g., the users performs the takeover) or unplanned (e.g., the primary switch unexpectedly fails), an OSPF router must reestablish full adjacencies with all its previously fully adjacent neighbors. This time period between the restart and the reestablishment of adjacencies is termed *graceful restart*.

In the network illustration below, a helper router, Router Y, monitors the network for topology changes. As long as there are none, it continues to advertise its LSAs as if the restarting router, Router X, had remained in continuous OSPF operation (i.e., Router Y's LSAs continue to list an adjacency to Router X over network segment S, regardless of the adjacency's current synchronization state.)



OSPF Graceful Restart Helping and Restarting Router Example

If the restarting router, Router X, was the Designated Router (DR) on network segment S when the helping relationship began, the helper neighbor, Router Y, maintains Router X as the DR until the helping relationship is terminated. If there are multiple adjacencies with the restarting Router X, Router Y will act as a helper on all other adjacencies.

Note. See "Configuring Redundant Switches in a Stack for Graceful Restart" on page 1-29 for more information on configuring graceful restart.

Configuring OSPF

Configuring OSPF on a router requires several steps. Depending on your requirements, you may not need to perform all of the steps listed below.

By default, OSPF is disabled on the router. Configuring OSPF consists of these tasks:

- Set up the basics of the OSPF network by configuring the required VLANs, assigning ports to the VLANs, and assigning router identification numbers to the routers involved. This is described in "Preparing the Network for OSPF" on page 1-15.
- Enable OSPF. When the image file for advanced routing is installed, you must load the code and enable OSPF. The commands for enabling OSPF are described in "Activating OSPF" on page 1-16.
- Create an OSPF area and the backbone. The commands to create areas and backbones are described in "Creating an OSPF Area" on page 1-17.
- Set area parameters (optional). OSPF will run with the default area parameters, but different networks may benefit from modifying the parameters. Modifying area parameters is described in "Configuring Stub Area Default Metrics" on page 1-19.
- Create OSPF interfaces. OSPF interfaces are created and assigned to areas. Creating interfaces is described in "Creating an Interface" on page 1-20, and assigning interfaces is described in "Assigning an Interface to an Area" on page 1-20.
- Set interface parameters (optional). OSPF will run with the default interface parameters, but different networks may benefit from modifying the parameters. Also, it is possible to set authentication on an interface. Setting interface authentication is described in "Interface Authentication" on page 1-21, and modifying interface parameters is described in "Modifying Interface Parameters" on page 1-22.
- Configure virtual links (optional). A virtual link is used to establish backbone connectivity when two backbone routers are not physically contiguous. To create a virtual link, see "Creating Virtual Links" on page 1-23.
- Create a redistribution policy (optional). A redistribution policy allows for the control of how routes are advertised into OSPF from outside the Autonomous System. Once a policy is created, redistribution must be enabled. Creating a redistribution policy is described in "Creating A Redistribution Policy" on page 1-25, and enabling redistribution is described in "Enabling Redistribution" on page 1-24.
- Create redistribution filters (optional). A redistribution filter controls whether routes are advertised in the OSPF network. Creating a redistribution filter is described in "Creating a Redistribution Filter" on page 1-25.
- Configuring router capabilities (optional). There are several commands that influence router operation. These are covered briefly in a table in "Configuring Router Capabilities" on page 1-27.
- Creating static neighbors (optional). These commands allow you to statically configure neighbors. See "Configuring Static Neighbors" on page 1-28.
- Configuring redundant switches for graceful OSPF restart (optional). Configuring switches with redundant switches for graceful restart is described in "Configuring Redundant Switches in a Stack for Graceful Restart" on page 1-29.

At the end of the chapter is a simple OSPF network diagram with instructions on how it was created on a router-by-router basis. See "OSPF Application Example" on page 1-30 for more information.

Preparing the Network for OSPF

OSPF operates on top of normal switch functions, using existing ports, virtual ports, VLANs, etc. The following network components should already be configured:

- **Configure VLANs that are to be used in the OSPF network**. VLANS should be created for both the backbone interfaces and all other connected devices that will participate in the OSPF network. A VLAN should exist for each instance in which the backbone connects two routers. VLAN configuration is described in "Configuring VLANs," in the *OmniSwitch 6800 Series Network Configuration Guide*.
- **Assign IP interfaces to the VLANs.** IP interfaces, or router ports, must be assigned to the VLAN. Assigning IP interfaces is described in "Configuring VLANs," in the *OmniSwitch 6800 Series Network Configuration Guide*.
- **Assign ports to the VLANs**. The physical ports participating in the OSPF network must be assigned to the created VLANs. Assigning ports to a VLAN is described in "Assigning Ports to VLANs," in the *OmniSwitch 6800 Series Network Configuration Guide*.
- **Set the router identification number**. (optional) The routers participating in the OSPF network must be assigned a router identification number. This number can be any number, as long as it is in standard dotted decimal format (e.g., 1.1.1.1). Router identification number assignment is discussed in "Configuring IP," in the *OmniSwitch 6800 Series Network Configuration Guide*. If this is not done, the router identification number is automatically the primary interface address.

Activating OSPF

For OSPF to run on the router, the advanced routing image must be installed. (For information on how to install image files, see the *OmniSwitch 6800 Series Switch Management Guide*.)

After the image file has been installed onto the router, you will need to load the OSPF software into memory and enable it, as described below.

Loading the Software

To load the OSPF software into the router's running configuration, enter the **ip load ospf** command at the system prompt:

```
-> ip load ospf
```

The OPSF software is now loaded into memory, and can be enabled.

Enabling OSPF

Once the OSPF software has been loaded into the router's running configuration (either through the CLI or on startup), it must be enabled. To enable OSPF on a router, enter the **ip ospf status** command at the CLI prompt, as shown:

```
-> ip ospf status enable
```

Once OSPF is enabled, you can begin to set up OSPF parameters. To disable OSPF, enter the following:

```
-> ip ospf status disable
```

Removing OSPF from Memory

To remove OSPF from the router memory, it is necessary to manually edit the **boot.cfg** file. The **boot.cfg** file is an ASCII text-based file that controls many of the switch parameters. Open the file and delete all references to OSPF.

For the operation to take effect the switch needs to be rebooted.

Creating an OSPF Area

OSPF allows a set of network devices in an AS system to be grouped together in *areas*.

There can be more than one router in an area. Likewise, there can be more than one area on a single router (in effect, making the router the Area Border Router (ABR) for the areas involved), but standard networking design does not recommended that more than three areas be handled on a single router.

Areas are named using 32-bit dotted decimal format (e.g., 1.1.1.1). Area 0.0.0.0 is reserved for the backbone.

Creating an Area

To create an area and associate it with a router, enter the **ip ospf area** command with the area identification number at the CLI prompt, as shown:

```
-> ip ospf area 1.1.1.1
```

Area 1.1.1.1 will now be created on the router with the default parameters.

The backbone is always area 0.0.0.0. To create this area on a router, you would use the above command, but specify the backbone, as shown:

```
-> ip ospf area 0.0.0.0
```

The backbone would now be attached to the router, making it an Area Border Router (ABR).

Enabling an Area

Once an area is created, it must be enabled using the **ip ospf area status** command, as shown:

```
-> ip ospf area 0.0.0.0 status enable
```

Specifying an Area Type

When creating areas, an area type can be specified (normal, stub, or NSSA). Area types are described above in "OSPF Areas" on page 1-8. To specify an area type, use the **ip ospf area** command as shown:

```
-> ip ospf area 1.1.1.1 type stub
```

Note. By default, an area is a **normal** area. The **type** keyword would be used to change a stub or NSSA area into a normal area.

Enabling and Disabling Summarization

Summarization can also be enabled or disabled when creating an area. Enabling summarization allows for ranges to be used by Area Border Routers (ABRs) for advertising routes as a single route rather than multiple routes, while disabling summarization prevents set ranges from functioning in stub and NSSA areas. (Configuring ranges is described in "Setting Area Ranges" on page 1-19.)

For example, to enable summarization for Area 1.1.1.1, enter the following:

```
-> ip ospf area 1.1.1.1 summary enable
```

To disable summarization for the same area, enter the following:

```
-> ip ospf area 1.1.1.1 summary disable
```

Note. By default, an area has summarization enabled. Disabling summarization for an area is useful when ranges need to be deactivated, but not deleted.

Displaying Area Status

You can check the status of the newly created area by using the **show** command, as demonstrated:

```
-> show ip ospf area 1.1.1.1
```

or

```
-> show ip ospf area
```

The first example gives specifics about area 1.1.1.1, and the second example shows all areas configured on the router.

To display a stub area's parameters, use the **show ip ospf area stub** command as follows:

```
-> show ip ospf area 1.1.1.1 stub
```

Deleting an Area

To delete an area, enter the **ip ospf area** command as shown:

```
-> no ip ospf area 1.1.1.1
```

Configuring Stub Area Default Metrics

The default metric configures the type of cost metric that a default area border router (ABR) will advertise in the default summary Link State Advertisement (LSA). Use the **ip ospf area default-metric** command to create or delete a default metric for stub or Not So Stubby Area (NSSA) area. Specify the stub area and select a cost value or a route type, as shown:

```
-> ip ospf area 1.1.1.1 default-metric 0 cost 50
```

or

```
-> ip ospf area 1.1.1.1 default-metric 0 type type1
```

A route has a preset metric associated to it depending on its type. The first example, the stub area is given a default metric of 0 (this is Type of Service 0) and a cost of 50 added to routes from the area. The second example specifies that the cost associated with Type 1 routes should be applied to routes from the area.

Note. At this time, only the default metric of ToS 0 is supported.

To remove the area default-metric setting, enter the **ip ospf area default-metric** command using the **no** command, as shown:

```
-> no ip ospf area 1.1.1.1 default-metric 0
```

Setting Area Ranges

Area ranges are used to summarize many area routes into a single advertisement at an area boundary. Ranges are advertised as summaries or NSSAs. Ranges also act as filters that either allow the summary to be advertised or not. Ranges are created using the **ip ospf area range** command. An area and the summary IP address and IP mask must be specified. For example, to create a summary range with IP address 192.5.40.1 and an IP mask of 255.255.255.0 for area 1.1.1.1, the following commands would be entered at the CLI prompt:

```
-> ip ospf area 1.1.1.1 range summary 192.5.40.1 255.255.255.0

-> ip ospf area 1.1.1.1 range summary 192.5.40.1 255.255.255.0 effect noMatching
```

To view the configured ranges for an area, use the **show ip ospf area range** command as demonstrated:

```
-> show ip ospf area 1.1.1.1 range
```

Creating OSPF Interfaces

Once areas have been established, interfaces need to be created and assigned to the areas.

Creating an Interface

To create an interface, enter the **ip ospf interface** command with an IP address, as shown:

```
-> ip ospf interface 120.5.80.1
```

The interface can be deleted the by using the **no** keyword, as shown:

```
-> no ip ospf interface 120.5.80.1
```

Assigning an Interface to an Area

Once an interface is created, it must be assigned to an area. (Creating areas is described in "Creating an Area" on page 1-17 above.)

To assign an interface to an area, enter the **ip ospf interface area** command with the interface IP address and area identification number at the CLI prompt. For example to add interface 120.5.80.1 to area 1.1.1.1, enter the following:

```
-> ip ospf interface 120.5.80.1 area 1.1.1.1
```

An interface can be removed from an area by reassigning it to a new area.

Once an interface has been created and enabled, you can check its status and configuration by using the **show** command, as demonstrated:

```
-> show ip ospf interface 120.5.80.1
```

Instructions for configuring authentication are given in "Interface Authentication" on page 1-21, and interface parameter options are described in "Modifying Interface Parameters" on page 1-22.

Activating an Interface

Once the interface is created and assigned to an area, it must be activated using the **ip ospf interface status** command, as shown:

```
-> ip ospf interface 120.5.80.1 status enable
```

The interface can be disabled using the **disable** keyword in place of the **enable** keyword.

Interface Authentication

OSPF allows for the use of authentication on configured interfaces. When authentication is enabled, only neighbors using the same type of authentication and the matching passwords or keys can communicate.

There are two types of authentication: simple and MD5. Simple authentication requires only a text string as a password, while MD5 is a form of encrypted authentication that requires a key and a password. Both types of authentication require the use of more than one command.

Simple Authentication

To enable simple authentication on an interface, enter the **ip ospf interface auth-type** command with the specified interface, as shown:

```
-> ip ospf interface 120.5.80.1 auth-type simple
```

Once simple authentication is enabled, the password must be set with the **ip ospf interface auth-key** command, as shown:

```
-> ip ospf interface 120.5.80.1 auth-key test
```

In the above instance, only other interfaces with simple authentication and a password of "test" will be able to use the configured interface.

MD5 Encryption

To configure the same interface for MD5 encryption, enter the **ip ospf interface auth-type** as shown:

```
-> ip ospf interface 120.5.80.1 auth-type md5
```

Once MD5 authentication is set, a key identification and key string must be set with the **ip ospf interface md5 key** command. For example to set interface 120.5.80.1 to use MD5 authentication with a key identification of 7 and key string of "test", enter:

```
-> ip ospf interface 120.5.80.1 md5 7
```

and

```
-> ip ospf interface 120.5.80.1 md5 7 key "test"
```

Note that setting the key ID and key string must be done in two separate commands. Once the key ID and key string have been set, MD5 authentication is enabled. To disable it, use the **ip ospf interface md5** command, as shown:

```
-> ip ospf interface 120.5.80.1 md5 7 disable
```

To remove all authentication, enter the **ip ospf interface auth-type** as follows:

```
-> ip ospf interface 120.5.80.1 auth-type none
```

Modifying Interface Parameters

There are several interface parameters that can be modified on a specified interface. Most of these deal with timer settings.

The cost parameter and the priority parameter help to determine the cost of the route using this interface, and the chance that this interface's router will become the designated router, respectively.

The following table shows the various interface parameters that can be set:

ip ospf interface dead-interval	Configures OSPF interface dead interval. If no hello packets are received in this interval from a neighboring router the neighbor is considered dead.
ip ospf interface hello-interval	Configures the OSPF interface interval for NBMA segments.
ip ospf interface cost	Configures the OSPF interface cost. A cost metric refers to the network path preference assigned to certain types of traffic.
ip ospf interface poll-interval	Configures the OSPF poll interval.
ip ospf interface priority	Configures the OSPF interface priority. The priority number helps determine if this router will become the designated router.
ip ospf interface retrans-interval	Configures OSPF interface retransmit interval. The number of seconds between link state advertisement retransmissions for adjacencies belonging to this interface.
ip ospf interface transit-delay	Configures the OSPF interface transit delay. The estimated number of seconds required to transmit a link state update over this interface.

These parameters can be added any time. (See "Creating OSPF Interfaces" on page 1-20 for more information.) For example, to set an the dead interval to 50 and the cost to 100 on interface 120.5.80.1, enter the following:

```
-> ip ospf interface 120.5.80.1 dead-interval 50 cost 100
```

To set an the poll interval to 25, the priority to 100, and the retransmit interval to 10 on interface 120.5.80.1, enter the following:

```
-> ip ospf interface 120.5.80.1 poll-interval 25 priority 100 retrans-interval
10
```

To set the hello interval to 5000 on interface 120.5.80.1, enter the following:

```
-> ip ospf interface 120.5.80.1 hello-interval 5000
```

To reset any parameter to its default value, enter the keyword with no parameter value, as shown:

```
-> ip ospf interface 120.5.80.1 dead-interval
```

Note. Although you can configure several parameters at once, you can only reset them to the default one at a time.

Creating Virtual Links

A virtual link is a link between two backbones through a transit area. Use the **ip ospf virtual-link** command to create or delete a virtual link.

Accepted network design theory states that virtual links are the option of last resort. For more information on virtual links, see "Virtual Links" on page 1-9 and refer to the figure on page 1-9.

Creating a Virtual Link

To create a virtual link, commands must be submitted to the routers at both ends of the link. The router being configured should point to the other end of the link, and both routers must have a common area.

When entering the **ip ospf virtual-link** command, it is necessary to enter the Router ID of the far end of the link, and the area ID that both ends of the link share.

For example, a virtual link needs to be created between Router A (router ID 1.1.1.1) and Router B (router ID 2.2.2.2). We must:

1 Establish a transit area between the two routers using the commands discussed in "Creating an OSPF Area" on page 1-17 (in this example, we will use Area 0.0.0.1).

2 Then use the **ip ospf virtual-link** command on Router A as shown:

```
ip ospf virtual-link 0.0.0.1 2.2.2.2
```

3 Next, enter the following command on Router B:

```
ip ospf virtual-link 0.0.0.1 1.1.1.1
```

Now there is a virtual link across Area 0.0.0.1 linking Router A and Router B.

4 To display virtual links configured on a router, enter the following **show** command:

```
show ip ospf virtual-link
```

5 To delete a virtual link, enter the **ip ospf virtual-link** command with the area and far end router information, as shown:

```
no ip ospf virtual-link 0.0.0.1 2.2.2.2
```

Modifying Virtual Link Parameters

There are several parameters for a virtual link (such as authentication type and cost) that can be modified at the time of the link creation. They are described in the **ip ospf virtual-link** command description.These parameters are identical in function to their counterparts in the section "Modifying Interface Parameters" on page 1-22.

Creating Redistribution Policies and Filters

Redistribution in OSPF controls the way routes are learned and distributed in the OSPF network. Non OSPF routers can be advertised into the OSPF network as AS-external or NSSA-external routes. NSSA-external routes are advertised only in OSPF-NSSA areas. Redistribution policies are set on Autonomous System Boundary Routers (ASBRs) and control how routes from outside the Autonomous System (AS) are learned and distributed. Redistribution Filters are set on any OSPF router and control how routes on the router are distributed to other routers in the OSPF network.

To set up redistribution on a router:

1 Specify the router as an ASBR, as described in "Specifying an Autonomous System Boundary Router" on page 1-24. (For redistribution policies only.)

2 Enable redistribution, as described in "Enabling Redistribution" on page 1-24.

3 Create a redistribution policy or filter, as described in "Creating A Redistribution Policy" on page 1-25 and "Creating a Redistribution Filter" on page 1-25.

Specifying an Autonomous System Boundary Router

Redistribution policies can only be created on ASBRs. ASBRs are routers that are directly connected to a network outside of the AS (e.g., the internet). To configure a router to be an ASBR, enter the **ip ospf asbr** command at the CLI prompt, as shown:

```
-> ip ospf asbr
```

You can check to see if a router is an ASBR router by using the **show ip ospf** command.

Enabling Redistribution

Before using any type of redistribution policy or filter, you must enable redistribution on the router, using the **ip ospf redist status** command. To enable redistribution, enter the command at the CLI prompt as shown:

```
-> ip ospf redist status enable
```

To disable redistribution, enter the command as shown:

```
-> ip ospf redist status disable
```

Creating A Redistribution Policy

Once a router is set as an ASBR and redistribution is enabled, a redistribution policy can be created. This is done using the **ip ospf redist** command. When setting up a redistribution policy, choose the type of route or protocol that will be redistributed as an OSPF route in the OSPF network. For example, to redistribute RIP routes, enter the following:

```
-> ip ospf redist rip
```

To redistribute static routes, enter the following:

```
-> ip ospf redist static
```

A cost metric can be added to the redistributed route, either as a set number or by specifying a route type (route types have preassigned metrics and other rule that control how they are redistributed). For example, to add a cost metric of 50 to RIP routes, enter the following:

```
-> ip ospf redist rip metric 50
```

To set RIP route redistribution as type 1 routes, enter the following:

```
-> ip ospf redist rip metric-type type1
```

For more information on route types, see the **ip ospf redist** command in the *OmniSwitch CLI Reference Guide*.

To display the redistribution policies on a router, enter the **show ip ospf redist** command at the CLI prompt.

To delete a redistribution policy, enter the **ip ospf redist** command with the route or protocol type, and the **no** keyword, as shown:

```
-> no ip ospf redist rip
```

Creating a Redistribution Filter

Redistribution filters are used by routers to control which routes are advertised to the rest of the network. Filters can be created on any OSPF router that has redistribution enabled.

Filters are created using the **ip ospf redist-filter** command.When using a filter, a route or protocol type must be specified, along with the IP address and mask. Only routes matching the specified criteria will be advertised. For example, to create a filter for RIP routes 1.1.0.0 with a mask of 255.255.0.0, enter the following:

```
-> ip ospf redist-filter rip 1.1.0.0 255.255.0.0
```

Filters can also be used to prevent routes from being advertised by using the **effect** keyword. Using the above example, to prevent RIP routes learned from 1.1.0.0 being advertised, enter the following:

```
-> ip ospf redist-filter rip 1.1.0.0 255.255.0.0 effect deny
```

This filter would stop the advertisement of RIP routes learned within the range 1.1.0.0 with a mask of 255.255.0.0. All other routes would be advertised normally.

Note. By default, filters are set to **permit**. If **permit** is the filter action desired, it is not necessary to use the **effect** keyword.

In certain cases, redistribution can either be an adjacent route or a subnet. In these cases, the redistributed route can correspond to several routes. It is possible to advertise these routes separately or not with the **redist-control** keyword.

If it is desired to advertise only an aggregated route instead of all the routes to comprise the aggregate, use the **ip ospf redist-filter** command with the **redist-control aggregate** keyword, as shown (you will also need to enter the route information as above):

```
-> ip ospf redist-filter rip 1.1.0.0 255.255.0.0 redist-control aggregate
```

If it is desired that the subnet routes that fall within the aggregate range should not be advertised, use the **ip ospf redist-filter** command with the **redist-control** keyword as shown (you will also need to enter the route information as above):

```
-> ip ospf redist-filter rip 1.1.0.0 255.255.0.0 redist-control no-subnets
```

Note. By default, filters are set to allow subnet routes to be advertised. If this is the filter action desired, it is not necessary to use the **redist-control** keyword.

A cost metric and route tag can be assigned to the routes that are allowed to pass through the filter, by using the **metric** and **route-tag** keywords, as shown (these options are described in the **ip ospf redist-filter** command):

```
-> ip ospf redist-filter rip 1.1.0.0 255.255.0.0 metric 100 route-tag 5
```

To display all of the configured filters on a router, enter the **show ip ospf redist-filter** command as shown:

```
-> show ip ospf redist-filter
```

To display the configured filters for a specific route or protocol type, enter the **show** command and the route or protocol type:

```
-> show ip ospf redist-filter rip
```

To display a specific filter, enter the **show** command with the route or protocol type and the ip address and mask, as demonstrated:

```
-> show ip ospf redist-filter rip 1.1.0.0 255.255.0.0
```

To delete a redistribution filter, enter the **ip ospf redist-filter** command with the route or protocol type and its associated IP address and mask, as shown:

```
-> no ip ospf redist-filter rip 1.1.0.0 255.255.0.0
```

Configuring Router Capabilities

The following list shows various commands that can be useful in tailoring a router's performance capabilities. All of the listed parameters have defaults that are acceptable for running an OSPF network.

ip ospf exit-overflow-interval	Sets the overflow interval value. The overflow interval is the time whereby the router will wait before attempting to leave the database overflow state.
ip ospf extlsdb-limit	Sets a limit to the number of external Link State Databases entries learned by the router. An external LSDB entry is created when the router learns a link address that exists outside of its Autonomous System (AS).
ip ospf host	Creates and deletes an OSPF entry for directly attached hosts.
ip ospf mtu-checking	Enables or disables the use of Maximum Transfer Unit (MTU) checking on received OSPF database description packets.
ip ospf route-tag	Configures a tag value for Autonomous System External (ASE) routes created.
ip ospf spf-timer	Configures timers for Shortest Path First (SPF) calculation.

To configure a router parameter, enter the parameter at the CLI prompt with the new value or required variables. For example to set the exit overflow interval to 40, enter:

```
-> ip ospf exit-overflow-interval 40
```

To enable MTU checking, enter:

```
-> ip ospf mtu-checking
```

To set the route tag to 5, enter:

```
-> ip ospf route-tag 5
```

To set the SPF timer delay to 3 and the hold time to 6, enter:

```
-> ip ospf spf-timer delay 3 hold 6
```

To return a parameter to its default setting, enter the command with no parameter value, as shown:

```
-> ip ospf spf-timer
```

Configuring Static Neighbors

It is possible to configure neighbors statically on Non Broadcast Multi Access (NBMA), point-to-point, and point-to-multipoint networks.

NBMA requires all routers attached to the network to communicate directly (unicast), and every attached router in this network becomes aware of all of its neighbors through configuration. It also requires a Designated Router (DR) "eligibility" flag to be set for every neighbor.

To set up a router to use NBMA routing, follow the following steps:

1 Create an OSPF interface using the CLI command **ip ospf interface** and perform all the normal configuration for the interface as with broadcast networks (attaching it to an area, enabling the status, etc.).

2 The OSPF interface type for this interface should be set to non-broadcast using the CLI **ip ospf interface type** command. For example, to set interface 1.1.1.1 to be an NBMA interface, enter the following:

```
-> ip ospf interface 1.1.1.1 type non-broadcast
```

3 Configure static neighbors for every OSPF router in the network using the **ip ospf neighbor** command. For example, to create an OSPF neighbor with an IP address of 1.1.1.8 to be a static neighbor, enter the following:

```
-> ip ospf neighbor 1.1.1.8 eligible
```

The neighbor attaches itself to the right interface by matching the network address of the neighbor and the interface. If the interface has not yet been created, the neighbor gets attached to the interface as and when the interface comes up.

If this neighbor is not required to participate in DR election, configure it as non-eligible. The eligibility can be changed at any time as long as the interface it is attached to is in the disabled state.

Configuring Redundant Switches in a Stack for Graceful Restart

By default, OSPF graceful restart is disabled. To configure OSPF graceful restart support use the **ip ospf restart-support** command by entering ip **ospf restart-support** followed by either **planned-unplanned** (the default) or **planned-only**.

For example, to modify OSPF graceful restart so that it only supports planned restarts enter:

```
-> ip ospf restart-support planned-only
```

To disable support for graceful restart use the **no** form of the **ip ospf restart-support** command by entering:

```
-> no ip ospf restart-support
```

Continuous forwarding during a graceful restart depends on several factors. If the secondary module has a different router MAC than the primary module, or if one or more ports of a VLAN belonged to the primary module, spanning tree re-convergence might disrupt forwarding state, even though OSPF performs a graceful restart.

Note. Graceful restart is only supported on active ports (i.e., interfaces), which are on the secondary or idle switches in a stack during a takeover. It is not supported on ports on a primary switch in a stack.

Optionally, you can configure graceful restart parameters with the following CLI commands:

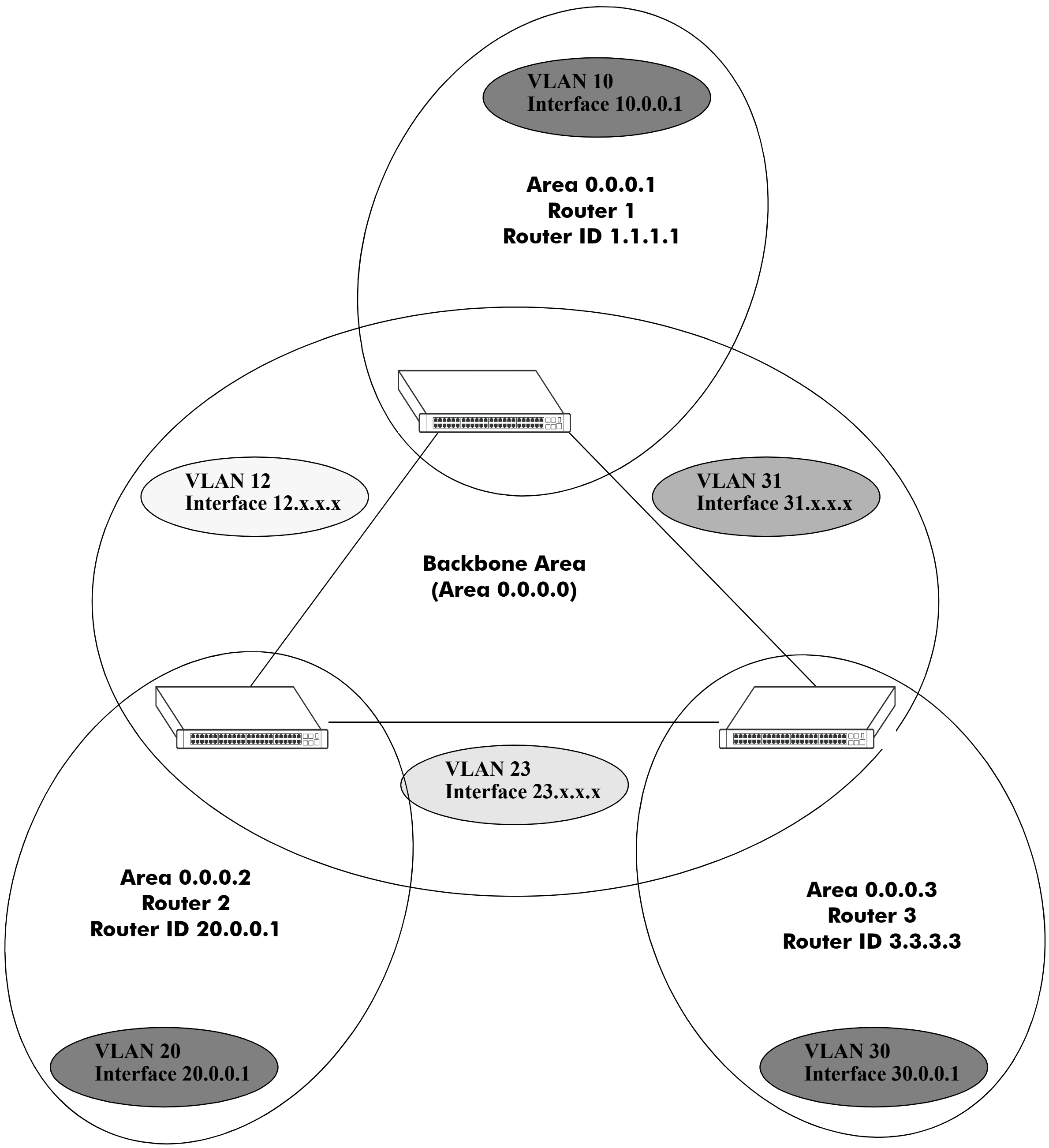
ip ospf restart-interval	Configures the grace period for achieving a graceful OSPF restart.
ip ospf restart-helper status	Administratively enables and disables the capability of an OSPF router to operate in helper mode in response to a router performing a graceful restart.
ip ospf restart-helper strict-lsa-checking-status	Administratively enables and disables whether or not a changed Link State Advertisement (LSA) will result in termination of graceful restart by a helping router.
ip ospf restart initiate	Initiates a planned graceful restart.

For more information about graceful restart commands, see the “OSPF Commands” chapter in the *OmniSwitch CLI Reference Guide*.

OSPF Application Example

This section will demonstrate how to set up a simple OSPF network. It uses three routers, each with an area. Each router uses three VLANs. A backbone connects all the routers. This section will demonstrate how to set it up by explaining the necessary commands for each router.

The following diagram is a simple OSPF network. It will be created by the steps listed on the following pages.



Three Area OSPF Network

Step 1: Prepare the Routers

The first step is to create the VLANs on each router, add an IP interface to the VLAN, assign a port to the VLAN, and assign a router identification number to the routers. For the backbone, the network design in this case uses slot 2, port 1 as the egress port and slot 2, port 2 as ingress port on each router. Router 1 connects to Router 2, Router 2 connects to Router 3, and Router 3 connects to Router 1 using 10/100 Ethernet cables.

Note. The ports will be statically assigned to the router, as a VLAN must have a physical port assigned to it in order for the router port to function. However, the router could be set up in such a way that mobile ports are dynamically assigned to VLANs using VLAN rules. See the chapter titled "Defining VLAN Rules" in the *OmniSwitch 6800 Series Network Configuration Guide.*

The commands setting up VLANs are shown below:

Router 1 (using ports 2/1 and 2/2 for the backbone, and ports 2/3-5 for end devices):

```
-> vlan 31
-> vlan 31 router ip 31.0.0.1 255.0.0.0
-> vlan 31 port default 2/1

-> vlan 12
-> vlan 12 router ip 12.0.0.1 255.0.0.0
-> vlan 12 port default 2/2

-> vlan 10
-> vlan 10 router ip 10.0.0.1 255.0.0.0
-> vlan 10 port default 2/3-5

-> ip router router-id 1.1.1.1
```

These commands created VLANs 31, 12, and 10.

- VLAN 31 handles the backbone connection from Router 1 to Router 3, using the IP router port 31.0.0.1 and physical port 2/1.
- VLAN 12 handles the backbone connection from Router 1 to Router 2, using the IP router port 12.0.0.1 and physical port 2/2.
- VLAN 10 handles the device connections to Router 1, using the IP router port 10.0.0.1 and physical ports 2/3-5. More ports could be added at a later time if necessary.

The router was assigned the Router ID of 1.1.1.1.

Router 2 (using ports 2/1 and 2/2 for the backbone, and ports 2/3-5 for end devices):

```
-> vlan 12
-> vlan 12 router ip 12.0.0.2 255.0.0.0
-> vlan 12 port default 2/1

-> vlan 23
-> vlan 23 router ip 23.0.0.2 255.0.0.0
-> vlan 23 port default 2/2

-> vlan 20
-> vlan 20 router ip 20.0.0.2 255.0.0.0
-> vlan 20 port default 2/3-5
```

```
-> ip router router-id 2.2.2.2
```

These commands created VLANs 12, 23, and 20.

- VLAN 12 handles the backbone connection from Router 1 to Router 2, using the IP router port 12.0.0.2 and physical port 2/1.
- VLAN 23 handles the backbone connection from Router 2 to Router 3, using the IP router port 23.0.0.2 and physical port 2/2.
- VLAN 20 handles the device connections to Router 2, using the IP router port 20.0.0.2 and physical ports 2/3-5. More ports could be added at a later time if necessary.

The router was assigned the Router ID of 2.2.2.2.

Router 3 (using ports 2/1 and 2/2 for the backbone, and ports 2/3-5 for end devices)

```
-> vlan 23
-> vlan 23 router ip 23.0.0.3 255.0.0.0
-> vlan 23 port default 2/1

-> vlan 31
-> vlan 31 router ip 31.0.0.3 255.0.0.0
-> vlan 31 port default 2/2

-> vlan 30
-> vlan 30 router ip 30.0.0.3 255.0.0.0
-> vlan 30 port default 2/3-5

-> ip router router-id 3.3.3.3
```

These commands created VLANs 23, 31, and 30.

- VLAN 23 handles the backbone connection from Router 2 to Router 3, using the IP router port 23.0.0.3 and physical port 2/1.
- VLAN 31 handles the backbone connection from Router 3 to Router 1, using the IP router port 31.0.0.3 and physical port 2/2.
- VLAN 30 handles the device connections to Router 3, using the IP router port 30.0.0.3 and physical ports 2/3-5. More ports could be added at a later time if necessary.

The router was assigned the Router ID of 3.3.3.3.

Step 2: Enable OSPF

The next step is to load and enable OSPF on each router. The commands for this step are below (the commands are the same on each router):

```
-> ip load ospf
-> ip ospf status enable
```

Step 3: Create and Enable the Areas and Backbone

Now the areas should be created and enabled. In this case, we will create an area for each router, and a backbone (area 0.0.0.0) that connects the areas.

The commands for this step are below:

Router 1

```
-> ip ospf area 0.0.0.0
-> ip ospf area 0.0.0.0 status enable

-> ip ospf area 0.0.0.1
-> ip ospf area 0.0.0.1 status enable
```

These commands created area 0.0.0.0 (the backbone) and area 0.0.0.1 (the area for Router 1). Both of these areas are also enabled.

Router 2

```
-> ip ospf area 0.0.0.0
-> ip ospf area 0.0.0.0 status enable

-> ip ospf area 0.0.0.2
-> ip ospf area 0.0.0.2 status enable
```

These commands created Area 0.0.0.0 (the backbone) and Area 0.0.0.2 (the area for Router 2). Both of these areas are also enabled.

Router 3

```
-> ip ospf area 0.0.0.0
-> ip ospf area 0.0.0.0 status enable

-> ip ospf area 0.0.0.3
-> ip ospf area 0.0.0.3 status enable
```

These commands created Area 0.0.0.0 (the backbone) and Area 0.0.0.3 (the area for Router 3). Both of these areas are also enabled.

Step 4: Create, Enable, and Assign Interfaces

Next, OSPF interfaces must be created, enabled, and assigned to the areas. The OSPF interfaces should have the same IP address as the IP router ports created above in "Step 1: Prepare the Routers" on page 1-31.

Router 1

```
-> ip ospf interface 31.0.0.1
-> ip ospf interface 31.0.0.1 area 0.0.0.0
-> ip ospf interface 31.0.0.1 status enable

-> ip ospf interface 12.0.0.1
-> ip ospf interface 12.0.0.1 area 0.0.0.0
-> ip ospf interface 12.0.0.1 status enable

-> ip ospf interface 10.0.0.1
-> ip ospf interface 10.0.0.1 area 0.0.0.1
-> ip ospf interface 10.0.0.1 status enable
```

IP router port 31.0.0.1 was associated to OSPF interface 31.0.0.1, enabled, and assigned to the backbone. IP router port 12.0.0.1 was associated to OSPF interface 12.0.0.1, enabled, and assigned to the backbone. IP router port 10.0.0.1 which connects to end stations and attached network devices, was associated to OSPF interface 10.0.0.1, enabled, and assigned to Area 0.0.0.1.

Router 2

```
-> ip ospf interface 12.0.0.2
-> ip ospf interface 12.0.0.2 area 0.0.0.0
-> ip ospf interface 12.0.0.2 status enable

-> ip ospf interface 23.0.0.2
-> ip ospf interface 23.0.0.2 area 0.0.0.0
-> ip ospf interface 23.0.0.2 status enable

-> ip ospf interface 20.0.0.2
-> ip ospf interface 20.0.0.2 area 0.0.0.2
-> ip ospf interface 20.0.0.2 status enable
```

IP router port 12.0.0.2 was associated to OSPF interface 12.0.0.2, enabled, and assigned to the backbone. IP router port 23.0.0.2 was associated to OSPF interface 23.0.0.2, enabled, and assigned to the backbone. IP router port 20.0.0.2, which connects to end stations and attached network devices, was associated to OSPF interface 20.0.0.2, enabled, and assigned to Area 0.0.0.2.

Router 3

```
-> ip ospf interface 23.0.0.3
-> ip ospf interface 23.0.0.3 area 0.0.0.0
-> ip ospf interface 23.0.0.3 status enable

-> ip ospf interface 31.0.0.3
-> ip ospf interface 31.0.0.3 area 0.0.0.0
-> ip ospf interface 31.0.0.3 status enable

-> ip ospf interface 30.0.0.3
-> ip ospf interface 30.0.0.3 area 0.0.0.3
-> ip ospf interface 30.0.0.3 status enable
```

IP router port 23.0.0.3 was associated to OSPF interface 23.0.0.3, enabled, and assigned to the backbone. IP router port 31.0.0.3 was associated to OSPF interface 31.0.0.3, enabled, and assigned to the backbone. IP router port 30.0.0.3, which connects to end stations and attached network devices, was associated to OSPF interface 30.0.0.3, enabled, and assigned to Area 0.0.0.3.

Step 5: Examine the Network

After the network has been created, you can check various aspects of it using show commands:

- For OSPF in general, use the **show ip ospf** command.
- For areas, use the **show ip ospf area** command.
- For interfaces, use the **show ip ospf interface** command.
- To check for adjacencies formed with neighbors, use the **show ip ospf neighbor** command.
- For routes, use the **show ip ospf routes** command.

Verifying OSPF Configuration

To display information about areas, interfaces, virtual links, redistribution, or OPSF in general, use the **show** commands listed in the following table:

show ip ospf	Displays OSPF status and general configuration parameters.
show ip ospf border-routers	Displays information regarding all or specified border routers.
show ip ospf ext-lsdb	Displays external Link State Advertisements from the areas to which the router is attached.
show ip ospf host	Displays information on directly attached hosts.
show ip ospf lsdb	Displays LSAs in the Link State Database associated with each area.
show ip ospf neighbor	Displays information on OSPF non-virtual neighbor routers
show ip ospf redist-filter	Displays OSPF redistribution filter attributes.
show ip ospf redist	Displays the specified redistribution instance that allows routes to be redistributed into OSPF.
show ip ospf routes	Displays OSPF routes known to the router.
show ip ospf virtual-link	Displays virtual link information.
show ip ospf virtual-neighbor	Displays OSPF virtual neighbors.
show ip ospf area	Displays either all OSPF areas, or a specified OSPF area.
show ip ospf area range	Displays all or specified configured area address range summaries for the given area.
show ip ospf area stub	Displays stub area status.
show ip ospf interface	Displays OSPF interface information.
show ip ospf restart	Displays the OSPF graceful restart related configuration and status.

For more information about the resulting displays form these commands, see the “OSPF Commands” chapter in the *OmniSwitch CLI Reference Guide*.

Examples of the **show ip ospf**, **show ip ospf area**, and **show ip ospf interface** command outputs are given in the section “OSPF Quick Steps” on page 1-4.

2 Configuring Multicast Address Boundaries

Multicast boundaries confine scoped multicast addresses to a particular domain. Confining scoped addresses helps to ensure that multicast traffic passed within a multicast domain does not conflict with multicast users outside the domain.

In This Chapter

This chapter describes the basic components of scoped multicast boundaries and how to configure them through the Command Line Interface (CLI). CLI commands are used in the configuration examples; for more details about the syntax of commands, see the *OmniSwitch CLI Reference Guide*.

Configuration procedures described in this chapter include:

- Configuring multicast address boundaries—see page 2-7.
- Verifying the multicast address boundary configuration—see page 2-7.

For information about additional multicast routing commands, see the “Multicast Routing Commands” chapter in the *OmniSwitch CLI Reference Guide*.

Multicast Boundary Specifications

RFCs Supported	2365—Administratively Scoped IP Multicast 2932—IPv4 Multicast Routing MIB
Maximum Multicast Flows per Network Interface (NI) Module	400 (with hardware routing; see note below)
Valid Scoped Address Range	239.0.0.0 to 239.255.255.255

Note. If software routing is used, the number of total flows supported is variable, depending on the number of flows and the number of routes per flow.

To enable or disable IP multicast hardware routing, use the **ip multicast hardware-routing** command. For more information on this command, see the “Configuring IP Multicast Switching” chapter in the *OmniSwitch 6800 Network Configuration Guide* or the “IP Multicast Switching Commands” chapter in the *OmniSwitch CLI Reference Guide*.

Quick Steps for Configuring Multicast Address Boundaries

Using Existing Router Ports

1 Before attempting to configure a multicast address boundary, be sure that you have manually loaded the multicast protocol software for your network (e.g., PIM-SM or DVMRP). Otherwise, you will receive an error stating that “the specified application is not loaded.” To manually load multicast protocol software, use the **ip load** command. For example:

```
-> ip load pimsm
```

2 Configure a multicast address boundary for a VLAN interface using the **ip mroute-boundary** command. Information must include the interface IP address, followed by the multicast boundary address and the corresponding subnet mask. For example:

```
-> ip mroute-boundary 178.14.1.43 239.120.0.0 255.255.0.0
```

On New Router Ports

1 Be sure that you have loaded one of the dynamic routing features (e.g., PIM-SM). Otherwise, you will receive an error stating that “the specified application is not loaded.” To load a dynamic routing feature, use the **ip load** command. For example:

```
-> ip load pimsm
```

2 Create a new router port on an existing VLAN by specifying a valid IP address. For example:

```
-> vlan 2 router ip 178.14.1.43
```

The VLAN must already be created on the switch. For information about creating VLANs, see the “Configuring VLANs” chapter in the *OmniSwitch 6800 Network Configuration Guide*.

3 Configure a multicast address boundary on the router port. Information must include the IP address assigned at step 2, as well as a scoped multicast address and the corresponding subnet mask.
For example:

```
-> ip mroute-boundary 178.14.1.43 239.120.0.0 255.255.0.0
```

Note. *Optional.* To verify the multicast boundary configuration, enter the **show ip mroute-boundary** command. The display is similar to the one shown here:

```
-> show ip mroute-boundary
ifIndex  Vlan     Boundary Address
--------+--------+-------------------
13600022 22       239.120.0.0/16
```

For more information about this display, see the "Multicast Routing Commands" chapter in the *OmniSwitch CLI Reference Guide*.

Multicast Address Boundaries Overview

Multicast Addresses and the IANA

The Internet Assigned Numbers Authority (IANA) regulates unique parameters for different types of network protocols. For example, the IANA regulates addresses for IP, DVMRP, PIM-SM, PIM-SSM, etc., and also provides a range of administratively scoped multicast addresses. For more information, refer to the section below.

Administratively Scoped Multicast Addresses

Multicast addresses 239.0.0.0 through 239.255.255.255 have been reserved by the IANA as administratively scoped addresses for use in private multicast domains. These addresses cannot be used for any other protocol or network function. Because they are regulated by the IANA, these addresses can theoretically be used by network administrators without conflicting with networks outside of their multicast domains. However, to ensure that the addresses used in a private multicast domain do not conflict with other domains (e.g., within the company network or out on the Internet), multicast address boundaries must be configured.

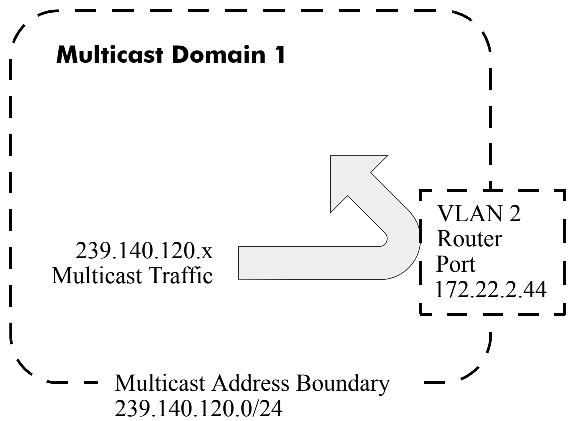
Source-Specific Multicast Addresses

Multicast addresses 232.0.0.0 through 232.255.255.255 have been reserved by the Internet Assigned Numbers Authority (IANA) as source-specific multicast (SSM) destination addresses. Addresses within this range are reserved for use by source-specific applications and protocols (e.g., PIM-SSM) and cannot be used for any other functions or protocols.

Multicast Address Boundaries

Without multicast address boundaries, multicast traffic conflicts can occur between domains. For example, a multicast packet addressed to 239.140.120.10 from a device in one domain could “leak” into another domain. If the other domain contains a device attempting to send a separate multicast packet with the same address, a conflict may occur. A boundary is used to eliminate these conflicts by confining multicast traffic on an interface (i.e., a VLAN router port). When a boundary is set, multicast packets with a destination address within the specified boundary *will not* be forwarded on the interface.

The figure below provides an example of a multicast address boundary configured on an interface.



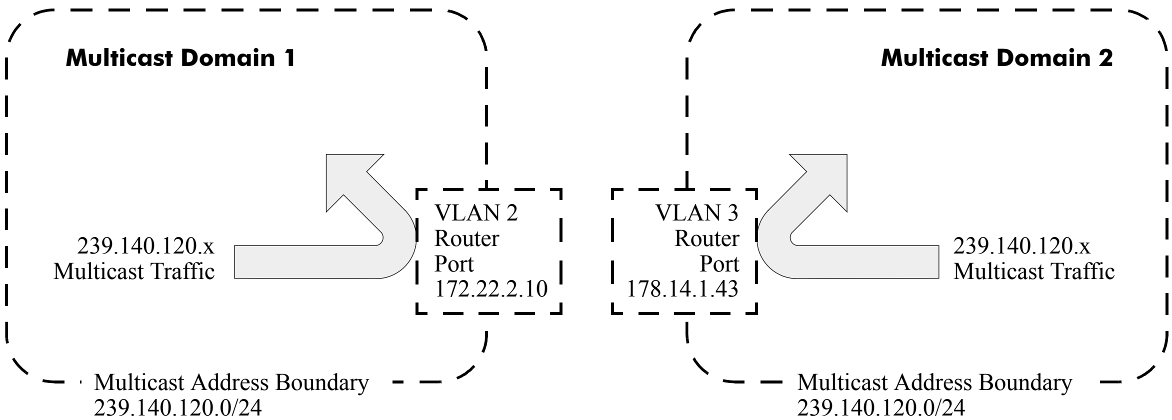
Simple Multicast Address Boundary Example

A router port is configured on VLAN 2, with the IP address 172.22.2.44. The router port is also referred to as the router *interface*; the IP address serves as the identifier for the interface.

In this example, the multicast address boundary has been defined as 239.140.120.0. The mask value of 255.255.255.0 is shown in Classless Inter-Domain Routing (CIDR) prefix format as **/24**. This specifies that no multicast traffic addressed to multicast addresses 239.140.120.0 through 239.140.120.255 will be forwarded on interface 172.22.2.44.

Concurrent Multicast Addresses

Because multicast boundaries confine scoped multicast addresses to a particular domain, multicast addresses can be used concurrently in more than one region in the network. In other words, scoped multicast addresses can be reused throughout the network. This allows network administrators to conserve limited multicast address space. The figure below shows multicast addresses 239.140.120.0 through 239.140.120.255 being used by both Multicast Domain 1 and Multicast Domain 2.



Concurrent Multicast Addresses Example

Although the same block of multicast addresses—239.140.120.0 through 239.140.120.255—is being used in two different domains at once, multicast traffic from one domain cannot conflict with multicast traffic in the other domain because they are effectively confined by boundaries on their corresponding interfaces. In this case, the boundary 239.140.120.0/24 has been configured on interfaces 172.22.2.120 and 178.14.1.43.

Configuring Multicast Address Boundaries

Because multicast address boundaries are part of the Advanced Routing software, the **Kadvrout.img** file must be present on the switch before you can begin configuring the feature. In addition, the multicast routing protocol (e.g., PIM-SM or DVMRP) for your network must first be loaded to memory via the **ip load** command.

Basic Multicast Address Boundary Configuration

Configuring a multicast address boundary prevents multicast traffic that is addressed to a particular address or range of addresses from being forwarded on an interface (i.e., a VLAN router port). Boundaries may be configured in more than one region in the network.

The basic command for creating a multicast address boundary is:

ip mroute-boundary

The next section describes how to use this command.

Creating a Multicast Address Boundary

To create a multicast address boundary on an interface, enter the **ip mroute-boundary** command, with the interface IP address, the boundary address, and the corresponding mask. For example:

```
-> ip mroute-boundary 178.14.1.43 239.120.0.0 255.255.0.0
```

The interface IP address must be a valid router port IP address that has been assigned to an existing VLAN. For information about creating VLANs and assigning router port IP addresses, see the "Configuring VLANs" chapter in the *OmniSwitch 6800 Network Configuration Guide*.

The boundary address must be an administratively-scoped multicast address from 239.0.0.0 to 239.255.255.255.

Deleting a Multicast Address Boundary

To delete a multicast address boundary from an interface, enter the **no ip mroute-boundary** command, with the interface IP address, the boundary address, and the corresponding mask. For example:

```
-> no ip mroute-boundary 178.14.1.43 239.120.0.0 255.255.0.0
```

Verifying the Multicast Address Boundary Configuration

A summary of the show commands used for verifying the multicast address boundary configuration is given here:

show ip mroute-boundary	Displays scoped multicast address boundaries for the switch's router interfaces.

For more information about the displays that result from these commands, see the *OmniSwitch CLI Reference Guide*.

Application Example for Configuring Multicast Address Boundaries

This section illustrates multicast address boundary configuration for a simple multicast network. The network consists of a core switch with a backbone connection to the Internet. The core switch is given a boundary of 239.0.0.0/8. This is the broadest boundary, keeping all multicast traffic addressed to 239.0.0.0 through 239.255.255.255 from leaving the company network.

The core switch is connected to two wiring closet switches. The wiring closet switches serve the Human Resources and Training network domains. A boundary of 239.188.0.0/16 is created for both the Human Resources and Training domains. No multicast traffic within the range of 239.188.0.0 through 239.188.255.255 is permitted to leave either domain. This allows multicast addresses within the range to be used simultaneously in both domains without conflict.

Note. For a diagram showing this sample network with the multicast address boundaries described above, refer to page 2-10.

---

1 Verify that either PIM-SM or DVMRP is loaded on the switch. Refer to the "Configuring PIM-SM" or "Configuring DVMRP" chapters in the *OmniSwitch 6800 Advanced Routing Configuration Guide* for more information.

2 Create a VLAN on the core switch. For example:

```
-> vlan 2
```

3 Next, create a router port on the VLAN. The router port IP address serves as the interface identifier on which the boundary will be created. To create a router port, use the **vlan router ip** command.
For example:

```
-> vlan 2 router ip 178.10.1.1
```

4 You are now ready to create a boundary on the core switch's router interface. For this example, the broadest possible boundary, 239.0.0.0, will be configured on the interface. This boundary will keep all traffic addressed to multicast addresses 239.0.0.0 through 239.255.255.255 from being forwarded on the interface. To assign the boundary, use the **ip mroute-boundary** command. For example:

```
-> ip mroute-boundary 178.10.1.1 239.0.0.0 255.0.0.0
```

Note that the command includes the interface IP address (178.10.1.1), along with the multicast address boundary (239.0.0.0) and the corresponding subnet mask (255.0.0.0).

5 Verify your changes using the **show ip mroute-boundary** command:

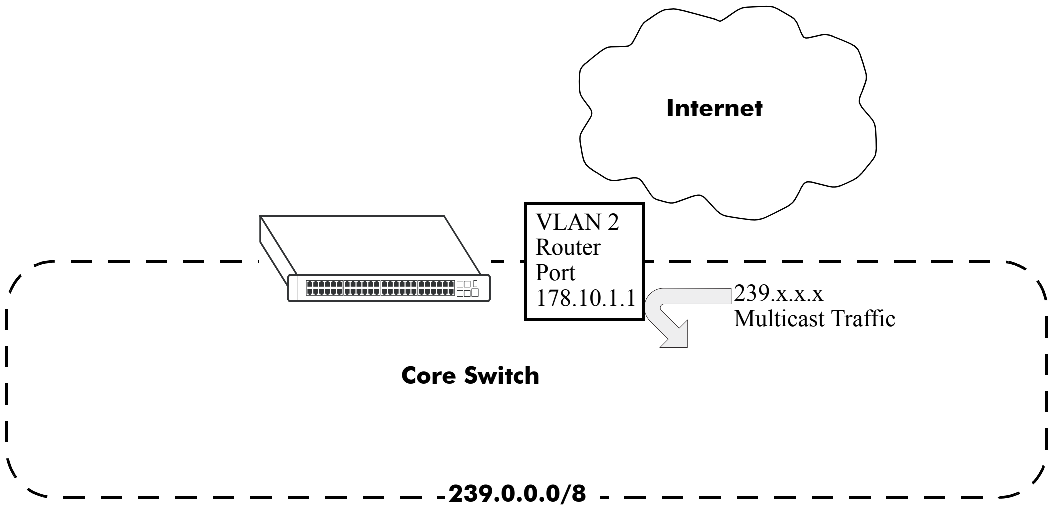
```
-> show ip mroute-boundary

ifIndex  Vlan     Boundary Address
--------+--------+-------------------
13600002 2        239.0.0.0/8
```

The correct multicast address boundary of 239.0.0.0 is shown on VLAN 2. (VLAN 2 is displayed in the table because it contains the router port on which the boundary was configured. In this case, that router port is 178.10.1.1.) In addition, the subnet mask has been translated into the CIDR prefix length of **/8**.

Note. The ifIndex heading refers to SNMP MIB information. For a detailed description of table output, refer to the *OmniSwitch CLI Reference Guide*.

The figure below illustrates the multicast address boundary as currently configured.



Network with a Single Multicast Address Boundary

All multicast traffic ranging from 239.0.0.0 through 239.255.255.255 is blocked and cannot be forwarded from switch's 178.10.1.1 router interface. As shown by the arrow, multicast traffic addressed to 239.x.x.x cannot leave the domain.

6 Next, create a VLAN on the wiring closet switch used for Human Resources. For example:

```
-> vlan 3
```

VLAN 3 is now used to define the Human Resources network domain.

7 Create a router interface on VLAN 3. For example:

```
-> vlan 3 router ip 178.20.1.1
```

8 Assign a boundary on the switch's router interface. For this example, the interface is given the boundary 239.188.0.0/16. This boundary will keep all traffic addressed to multicast addresses 239.188.0.0 through 239.188.255.255 from being forwarded on the interface:

```
-> ip mroute-boundary 178.20.1.1 239.188.0.0 255.255.0.0
```

The command syntax includes the interface IP address (178.20.1.1), along with the multicast address boundary (239.188.0.0) and the corresponding subnet mask (255.255.0.0).

9 Create a VLAN on the separate wiring closet switch used for Training. For example:

```
-> vlan 4
```

VLAN 4 is now used to define the Training network domain.

10 Create a router interface on VLAN 4. For example:

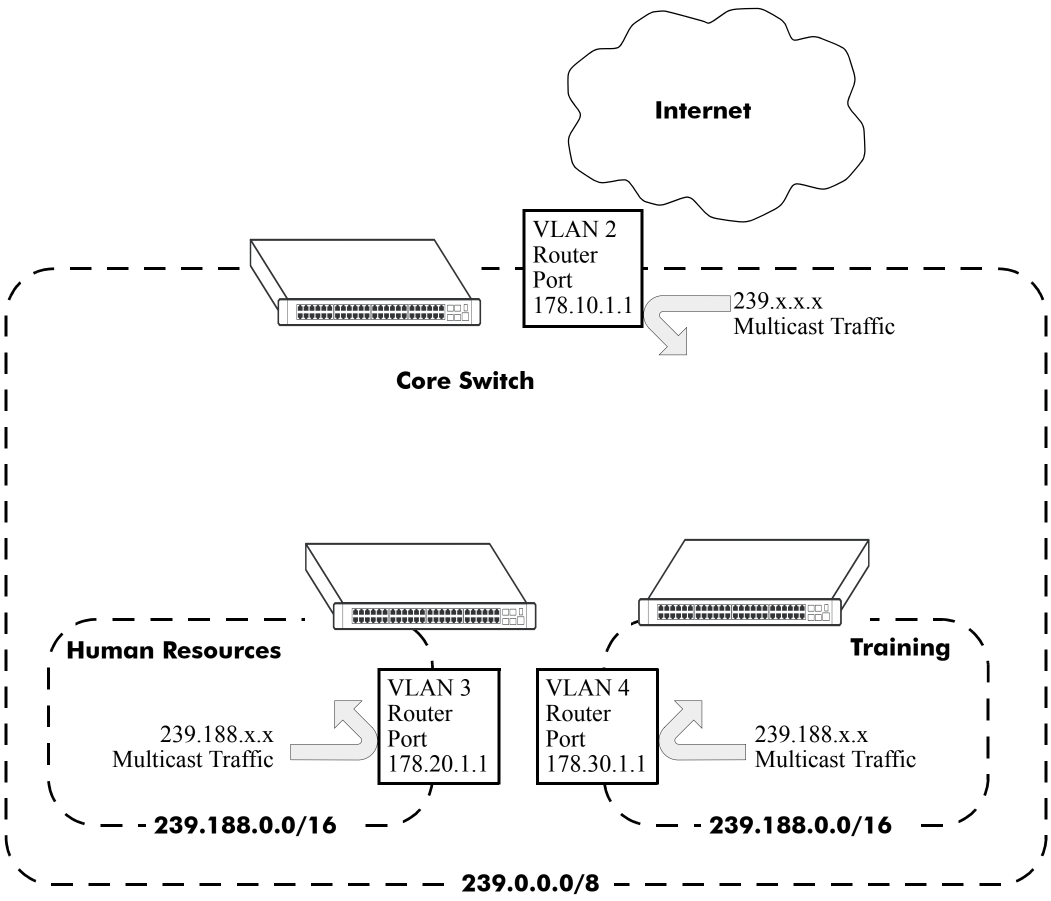
```
-> vlan 4 router ip 178.30.1.1
```

11 Assign a boundary on the Training router interface. The interface is given the same boundary as Human Resources (i.e., 239.188.0.0/16).

```
-> ip mroute-boundary 178.30.1.1 239.188.0.0 255.255.0.0
```

Because there is a boundary configured at each domain, multicast users in Human Resources can forward 239.188.x.x multicast traffic without conflicting with users in Training who are forwarding traffic with the same addresses. By allowing addresses to be used concurrently in more than one department, network administrators can conserve limited scoped multicast address space.

The figure below illustrates all configured multicast address boundaries for this network.



Network with Multiple Multicast Addresses Boundaries

3 Configuring DVMRP

This chapter includes descriptions for Distance Vector Multicast Routing Protocol (DVMRP). DVMRP is a dense-mode multicast routing protocol. DVMRP—which is essentially a “broadcast and prune” routing protocol—is designed to assist routers in propagating IP multicast traffic through a network.

In This Chapter

This chapter describes the basic components of DVMRP and how to configure them through the Command Line Interface (CLI). CLI commands are used in the configuration examples; for more details about the syntax of commands, see the *OmniSwitch CLI Reference Guide*.

Configuration procedures described in this chapter include:

- Loading DVMRP into memory—see page 3-10.
- Enabling DVMRP—see page 3-12.
- Neighbor communications—see page 3-13.
- Routes—see page 3-14.
- Pruning—see page 3-15.
- Grafting—see page 3-17.
- Tunnels—see page 3-17.
- Verifying the DVMRP configuration—see page 3-18.

DVMRP Specifications

RFCs Supported	2667—IP Tunnel MIB
IETF Internet-Drafts Supported	Distance-Vector Multicast Routing Protocol MIB draft-ietf-idmr-dvmrp-v3-11.txt
DVMRP Version Supported	DVMRPv3.255
DVMRP Attributes Supported	Reverse Path Multicasting, Neighbor Discovery, Multicast Source Location, Route Report Messages, Distance metrics, Dependent Downstream Routers, Poison Reverse, Pruning, Grafting, DVMRP Tunnels
DVMRP Timers Supported	Flash update interval, Graft retransmissions, Neighbor probe interval, Neighbor timeout, Prune lifetime, Prune retransmission, Route report interval, Route holddown, Route expiration timeout
Range for Interface Distance Metrics	1 to 31
Range for Tunnel TTL Value	0 to 255
Multicast Protocols per Interface	1 (e.g., you cannot enable both PIM-SM and DVMRP on the same IP interface)

DVMRP Defaults

The following table lists the defaults for DVMRP configuration:

Parameter Description	Command	Default Value/Comments
DVMRP load status	**ip load dvmrp**	Unloaded
DVMRP status	**ip dvmrp status**	Disabled
DVMRP interface status	**ip dvmrp interface**	Disabled
Flash update interval	**ip dvmrp flash-interval**	5 seconds
Graft retransmission timeout	**ip dvmrp graft-timeout**	5 seconds
Neighbor probe interval time	**ip dvmrp neighbor-interval**	10 seconds
Neighbor timeout	**ip dvmrp neighbor-timeout**	35 seconds
Prune lifetime	**ip dvmrp prune-lifetime**	7200 seconds
Prune retransmission timeout	**ip dvmrp prune-timeout**	30 seconds
Route report interval	**ip dvmrp report-interval**	60 seconds
Route holddown time	**ip dvmrp route-holddown**	120 seconds
Route expiration timeout	**ip dvmrp route-timeout**	140 seconds
Interface distance metric	**ip dvmrp interface metric**	1
DVMRP tunnel status	**ip dvmrp tunnel**	Disabled
DVMRP tunnel TTL value	**ip dvmrp tunnel ttl**	255
Subordinate neighbor status	**ip dvmrp subord-default**	true

Quick Steps for Configuring DVMRP

Note. DVMRP requires that IP Multicast Switching (IPMS) is enabled. IPMS is automatically enabled when a multicast routing protocol (either PIM-SM or DVMRP) is enabled globally and on an interface *and* when the operational status of the interface is *up*. However, if you wish to manually enable IPMS on the switch, use the **ip multicast switching** command.

1 Manually load DVMRP into memory by entering the following command:

```
-> ip load dvmrp
```

2 Create a router port (i.e., *interface*) on an existing VLAN by specifying a valid IP address. To do this, use the **vlan router ip** command. For example:

```
-> vlan 2 router ip 178.14.1.43
```

3 Enable the DVMRP protocol on the interface via the **ip dvmrp interface** command. For example:

```
-> ip dvmrp interface 178.14.1.43
```

4 Globally enable the DVMRP protocol by entering the following command:

```
-> ip dvmrp status enable
```

5 Save your changes to the Working directory's **boot.cfg** file by entering the following command:

```
-> write memory
```

Once loaded and enabled, DVMRP is typically ready to use because its default values are appropriate for the majority of installations.

Note. *Optional*. To verify DVMRP interface status, enter the **show ip dvmrp interface** command. The display is similar to the one shown here:

```
 Address           Vlan   Metric  Admin-Status  Oper-Status
-----------------+------+--------+-------------+-------------
178.14.1.43        44       1       Enabled      Enabled
```

To verify the global DVMRP status, enter the **show ip dvmrp** command:

```
DVMRP Admin Status = enabled,
Flash Interval     = 5,
Graft Timeout      = 5,
Neighbor Interval  = 10,
Neighbor Timeout   = 35,
Prune Lifetime     = 7200,
Prune Timeout      = 30,
Report Interval    = 60,
Route Holddown     = 120,
Route Timeout      = 140,
Subord Default     = true,

Number of Routes           = 20,
Number of Reachable Routes = 18
```

For more information about these displays, see the “DVMRP Commands” chapter in the *OmniSwitch CLI Reference Guide*.

DVMRP Overview

Distance Vector Multicast Routing Protocol (DVMRP) Version 3 is a multicast routing protocol that enables routers to efficiently propagate IP multicast traffic through a network. Multicast traffic consists of a data stream that originates from a single source and is sent to hosts that have subscribed to that stream. Live video broadcasts, video conferencing, corporate communications, distance learning, and distribution of software, stock quotes, and news services are examples of multicast traffic. Multicast traffic is distinguished from unicast traffic and broadcast traffic as follows:

- Unicast traffic is addressed to a single host.
- Broadcast traffic is transmitted to all hosts.
- Multicast traffic is transmitted to a subset of hosts (the hosts that have subscribed to the multicast data stream).

DVMRP is a distributed multicast routing protocol that dynamically generates per-source delivery trees based upon routing exchanges, using a technique called *Reverse Path Multicasting*. When a multicast source begins to transmit, the multicast data is flooded down the delivery tree to all points in the network. DVMRP then *prunes* (i.e., removes branches from) the delivery tree where the traffic is unwanted.

Pruning continues to occur as group membership changes or routers determine that no group members are present. This restricts the delivery trees to the minimum branches necessary to reach all group members, thus optimizing router performance. New branches can also be added to the delivery trees dynamically as new members join the multicast group. The addition of new branches is referred to as *grafting*.

Reverse Path Multicasting

DVMRP uses Internet Group Management Protocol (IGMP) messages to exchange the routing information needed to build per-source multicast delivery trees. Once built, packets follow a multicast delivery tree from the source to all members of the multicast group. Packets are replicated only at necessary branches in the delivery tree. The trees are calculated and updated dynamically to track the membership of individual groups.

When a packet arrives on an interface, the reverse path back to the source of the packet is determined by examining a DVMRP routing table of known source networks. If the packet arrived on an upstream interface that would be used to transmit packets back to the source, it is forwarded to the appropriate list of downstream interfaces. Otherwise, it is not on the optimal delivery tree and is discarded. In this way duplicate packets can be filtered when loops exist in the network topology.

Neighbor Discovery

DVMRP routers must maintain a database of DVMRP adjacencies with other DVMRP routers. A DVMRP router must be aware of its DVMRP neighbors on each interface. To gather this information, DVMRP routers use a neighbor discovery mechanism and periodically multicast DVMRP *Probe messages* to the All-DVMRP-Routers group address (224.0.0.4). Each Probe message includes a Neighbor List of DVMRP routers known to the transmitting router.

When a DVMRP router (let's call it "router B") receives a Probe (let's say from "router A"), it adds the IP address of router A to its own internal list of DVMRP neighbors on that interface. It then sends a Probe of its own with the IP address of router A included in the Probe's Neighbor List. When a DVMRP router receives a Probe with its own IP address included in the Neighbor List, the router knows that a two-way adjacency has been successfully formed between itself and the neighbor that sent the Probe.

Probes effectively serve three main purposes:

- Probes provide a mechanism for DVMRP routers to locate each other as described above.
- Probes provide a way for DVMRP routers to determine each others' capabilities. This is deduced from the major and minor version numbers in the Probe packet and directly from the capability flags in the Probe packet.
- Probes provide a keep-alive function in order to quickly detect neighbor loss.

A DVMRP router sends periodic *Route Report* messages to its DVMRP neighbors (by default, every 60 seconds). A Route Report message contains the sender's current routing table, which contains entries that advertise a source network (with a mask) and a hop-count that is used as the routing metric.This routing information is used to build source distribution trees and to perform multicast forwarding. The DVMRP neighbor that advertises the route with the lowest metric will be used for forwarding. (In case of a tie, the DVMRP neighbor with the lowest IP address will be used.)

In DVMRPv3, a router will not accept a Route Report from another DVMRP router until it has established adjacency with that neighboring router.

Note. Older versions of DVMRP use Route Report messages to perform neighbor discovery rather than the Probe messages used in DVMRP Version 3.

Multicast Source Location, Route Report Messages, and Metrics

When an IP multicast packet is received by a router running DVMRP, it first looks up the source network in the DVMRP routing table. The interface that provides the best route back to the source of the packet is called the upstream interface. If the packet arrived on that upstream interface, then it is a candidate for forwarding to one or more downstream interfaces. If the packet did not arrive on that anticipated upstream interface, then it is discarded. This check is known as a *reverse path forwarding check* and is performed by all DVMRP routers.

Note. Under normal, stable DVMRP operation, packets would not arrive on the wrong interface because the upstream router would not forward the packet unless the downstream router poison-reversed the route in the first place (as explained below). However, there are cases—such as immediately after a network topology change—when DVMRP routing has not yet converged across all routers where this can occur. It can also occur when loops exist in the network topology.

In order to ensure that all DVMRP routers have a consistent view of the path back to a source, routing tables are propagated by all DVMRP routers in *Route Report messages*. Each router transmits a Route Report message at specified intervals. The Route Report message advertises the network numbers and masks of those interfaces to which the router is directly connected. It also relays the routes received from neighboring routers.

DVMRP requires an interface metric (i.e., a hop count) to be configured on all physical and tunnel interfaces. When a route is received from a neighboring router via a Route Report message, the metric of the interface over which the packet was received is added to the metric of the route being advertised. This adjusted metric is used when comparing metrics to determine the most efficient upstream interface.

Dependent Downstream Routers and Poison Reverse

In addition to providing a consistent view of source networks, the exchange of routes in DVMRP Route Report messages provides one other important feature. DVMRP uses the route exchange as a mechanism for upstream routers to determine if any downstream routers depend on them for forwarding packets from particular source networks.

DVMRP accomplishes this by using a technique called *poison reverse*. If a downstream router selects an upstream router as the best next hop to a particular source network, it indicates this by echoing back the route on the upstream interface with a metric equal to the original metric plus infinity. (DVMRP uses a metric of 32 as infinity.) When the upstream router receives the report and sees a metric that lies between infinity and twice infinity (that is, between 32 and 64), it adds the downstream router from which it received the report to a list of dependent routers for this source network.

The list of dependent routers per source network built by the poison reverse technique provides the foundation necessary to determine when it is appropriate to prune back the IP source-specific multicast trees.

Note. Poison reverse is used differently in DVMRP than in most unicast distance vector routing protocols (such as RIP), which use poison reverse to advertise that a particular route is unreachable.

Pruning Multicast Traffic Delivery

Initially, all interfaces with downstream-dependent neighbors are included in the downstream interface list and multicast traffic is flooded down the truncated broadcast tree to all possible receivers. This allows the downstream routers to be aware of traffic destined for a particular Source, Group (S, G) pair. The downstream routers then have the option to send prunes (and subsequent grafts) for this (S, G) pair as requirements change.

A DVMRP router will remove an interface from its forwarding list that has no group members associated with an IP multicast packet. If a router removes all of its downstream interfaces, it notifies the upstream router that it no longer wants traffic destined for that particular (S, G) pair. This is accomplished by sending a DVMRP Prune message upstream to the router expected to forward packets from that particular source.

A downstream router will inform an upstream router that it depends on the upstream router to receive packets from particular source networks by using the poison reverse technique during the exchange of Route Report messages. This method allows the upstream router to build a list of downstream routers on each interface that are dependent upon it for packets from a particular source. If the upstream router receives Prune messages from each one of the dependent downstream routers on an interface, then the upstream router can in turn remove this interface from its downstream interface list. If the upstream router is able to remove all of its downstream interfaces in this manner, it can then send a DVMRP Prune message to its upstream router. This continues until all unneeded branches are removed. Refer to "Pruning" on page 3-15 for more specific information on pruning.

Grafting Branches Back onto the Multicast Delivery Tree

A pruned branch will be automatically reattached to the multicast delivery tree when the prune times out. However, the graft mechanism provides a quicker method to reattach a pruned branch than waiting for the prune to time out. Without the graft mechanism, the join latency for new hosts in the group might be unacceptably great, because the prunes in the upstream routers would have to time out before multicast traffic could again begin to flow to the pruned branches. Depending on the number of routers along the pruned branch and the timeout values in use, several minutes might elapse before the host could begin to receive multicast traffic. By using a graft mechanism, DVMRP reduces the join latency to a few milliseconds.

The graft mechanism is made reliable through the use of Graft-Ack (Graft Acknowledgment) messages. A Graft-Ack message is returned by the upstream router in response to a Graft message. If the Graft-Ack message is not received, the downstream router will resend the Graft message. This prevents the loss of a Graft message due to congestion.

The **ip dvmrp graft-timeout** command enables you to set the Graft message retransmission value. This value defines the duration of time that the router will wait before retransmitting a Graft message if it has not received a Graft-Ack message. Refer to "Grafting" on page 3-17 for more information.

DVMRP Tunnels

Because not all IP routers support native multicast routing, DVMRP includes direct support for tunneling IP multicast packets through routers. Tunnel interfaces are used when routers incapable of supporting multicast traffic exist between DVMRP neighbors. In tunnel interfaces, IP multicast packets are encapsulated in unicast IP packets and addressed directly to the routers that do not support native multicast routing. DVMRP protocol messages (such as Route Reports, Probes for neighbor discovery, etc.) and multicast traffic are sent between tunnel endpoints using unicast, rather than multicast, packets.

Multicast data is encapsulated using a standard IP-IP encapsulation method. The unicast IP addresses of the tunnel endpoints are used as the source and destination IP addresses in the outer IP header. The inner IP header remains unchanged from the original multicast packet.

Configuring DVMRP

Before configuring DVMRP, consider the following:

- The **Kadvrout.img** file must be present in the switch's current running directory (i.e., Working or Certified) before DVMRP can be enabled or configured.
- DVMRP requires that IP Multicast Switching (IPMS) is enabled. IPMS is automatically enabled when a multicast routing protocol (either PIM-SM or DVMRP) is enabled globally and on an interface *and* when the operational status of the interface is up. However, if you wish to manually enable IPMS on the switch, use the **ip multicast switching** command.
- You can configure DVMRP parameters when the protocol is not running *as long as DVMRP is loaded into memory* (see "Loading DVMRP into Memory" below).
- The DVMRP parameters will *not* take effect until the protocol is enabled globally *and* on specific IP interfaces.

Enabling DVMRP on the Switch

By default, the DVMRP protocol is disabled on the switch. Before running DVMRP, you must enable the protocol by completing the following steps:

- Loading DVMRP into memory
- Enabling DVMRP on desired IP interfaces
- Enabling DVMRP globally on the switch

Note. Once loaded and enabled, DVMRP is typically ready to use because its factory default values are appropriate for the majority of installations. Note, however, if neighbors in the DVMRP domain have difficulty handling large initial bursts of traffic, it is recommended that the subordinate neighbor status is changed to false. For more information on the subordinate neighbor status, refer to the **ip dvmrp subord-default** command in the *OmniSwitch CLI Reference Guide*.

For information on completing these steps, refer to the sections below.

Loading DVMRP into Memory

You must load DVMRP into memory before you can begin configuring the protocol on the switch. If DVMRP is not loaded and you enter a configuration command, the following message displays:

```
ERROR: The specified application is not loaded
```

To dynamically load DVMRP into memory, enter the following command:

```
-> ip load dvmrp
```

Enabling DVMRP on a Specific Interface

Note. It does not matter whether DVMRP is first enabled globally or on specific interfaces. However, DVMRP will not run on an interface until it is enabled both globally and on the interface.

DVMRP must be enabled on an interface before any other interface-specific DVMRP command can be executed (e.g, the **ip dvmrp interface metric** command). An interface can be any IP router port that has been assigned to an existing VLAN. For information on assigning a router port to a VLAN, refer to the "Configuring VLANs" chapter in the *OmniSwitch 6800 Network Configuration Guide*.

To enable DVMRP on a specific interface, use the **ip dvmrp interface** command. The interface identifier used in the command syntax is the valid IP address of an existing VLAN router port. For example:

```
-> ip dvmrp interface 172.22.2.115
```

Note. Only one multicast routing protocol is supported per interface. This means that you cannot enable both PIM-SM and DVMRP on the same interface.

Disabling DVMRP on a Specific Interface

To disable DVMRP on a specific IP interface, use the **no ip dvmrp interface** command. Be sure to include the interface IP address. For example:

```
-> no ip dvmrp interface 172.22.2.115
```

Specifying a Distance Metric on a Specific Interface

The **ip dvmrp interface metric** command enables you to specify the distance metric for an interface. The default interface distance metric value is 1. DVMRP uses the metric value to determine the most cost-effective way of passing data. The higher an interface's metric value, the higher the cost of passing data over that interface. DVMRP will transmit data over the interface with the lowest available metric. Note that, just as in RIP, the metric of an incoming route advertisement is automatically incremented by the metric of the incoming interface (typically one hop). You can assign an interface any distance metric from 1 to 31.

To assign a distance metric to a specific interface, use the **ip dvmrp interface metric** command. The command syntax must include the IP address for the VLAN router port (i.e., interface), as well as a distance metric value. For example:

```
-> ip dvmrp interface 172.22.2.115 metric 3
```

Viewing DVMRP Status and Parameters for a Specific Interface

To view current DVMRP interfaces, including their operational status and assigned metrics, use the **show ip dvmrp interface** command. For example:

```
-> show ip dvmrp interface
 Address            Vlan   Tunnel   Metric   Admin-Status   Oper-Status
-----------------+------+--------+--------+--------------+-------------
172.22.2.115         2      No       3         Enabled       Disabled
```

Current assigned metric is shown as 3.

The corresponding interface is configured for DVMRP (i.e., it is DVMRP-enabled).

The interface is operationally down because there are no ports operationally up in VLAN 2.

Note. The **show ip dvmrp interface** command displays information for *all multicast-capable interfaces* (i.e., DVMRP).

Globally Enabling DVMRP on the Switch

To globally enable DVMRP on the switch, enter the following command:

```
-> ip dvmrp status enable
```

Globally Disabling DVMRP

The following command will globally disable DVMRP on the switch:

```
-> ip dvmrp status disable
```

Checking the Current Global DVMRP Status

To view current global DVMRP enable/disable status, as well as additional global DVMRP settings, use the **show ip dvmrp** command. For example:

```
-> show ip dvmrp
DVMRP Admin Status = enabled,
Flash Interval     = 5,
Graft Timeout      = 5,
Neighbor Interval  = 10,
Neighbor Timeout   = 35,
Prune Lifetime     = 7200,
Prune Timeout      = 30,
Report Interval    = 60,
Route Holddown     = 120,
Route Timeout      = 140,
Subord Default     = true,

Number of Routes           = 20,
Number of Reachable Routes = 18
```

Current global DVMRP status is shown as enabled.

Automatic Loading and Enabling of DVMRP Following a System Boot

If *any* DVMRP command is saved to the **boot.cfg** file in the post-boot running directory, DVMRP will be loaded into memory automatically. The post-boot running directory refers to the directory the switch will use as its running directory following the next system boot (i.e., Working or Certified). If the command syntax **ip dvmrp status enable** is saved to the **boot.cfg** file in the post-boot running directory, DVMRP will be automatically loaded into memory *and* globally enabled following the next system boot. For detailed information on the Working and Certified directories and how they are used during system boot, see the “CMM Directory Management” chapter in the *OmniSwitch 6800 Switch Management Guide*.

Neighbor Communications

Probe messages are sent out periodically on all the DVMRP interfaces. However, only on the non-tunnel interfaces are they sent out to the multicast group address 224.0.0.4.

Note. Older versions of DVMRP use Route Report messages to perform neighbor discovery rather than the Probe messages used in DVMRP Version 3.

The **ip dvmrp neighbor-interval** command enables you to configure the interval, in seconds, at which Probe messages are transmitted. For example, to configure the Probe interval to ten seconds, enter the following command:

```
-> ip dvmrp neighbor-interval 10
```

The **ip dvmrp neighbor-timeout** command enables you to configure the number of seconds that the DVMRP router will wait for activity from a neighboring DVMRP router before assuming the neighbor is down. For example, to configure the neighbor timeout period to 35 seconds, enter the following command:

```
-> ip dvmrp neighbor-timeout 35
```

When the neighbor timeout expires and it is assumed that the neighbor is down, the following occurs:

- All routes learned from the neighbor are immediately placed in hold down.
- If the neighbor is considered to be the designated forwarder for any of the routes it is advertising, a new designated forwarder for each source network is selected.
- If the neighbor is upstream, any cache entries based upon this upstream neighbor are flushed.
- Any outstanding grafts awaiting acknowledgments from this neighbor are flushed.
- All downstream dependencies received from this neighbor are removed.

The **ip dvmrp neighbor-interval** should be set to 10 seconds and the **ip dvmrp neighbor-timeout** should be set to 35 seconds. This allows fairly early detection of a lost neighbor yet provides tolerance for busy multicast routers. Both of these values must be coordinated between all DVMRP routers on a physical network segment.

Note. Current global DVMRP parameter values—including the **ip dvmrp neighbor-interval** value and the **ip dvmrp neighbor-timeout** value—can be viewed via the **show ip dvmrp** command. The DVMRP neighbor table can be viewed via the **show ip dvmrp neighbor** command.

Routes

In DVMRP, source network routing information is exchanged in the same basic manner as it is in RIP. That is to say, periodic Route Report messages are sent between DVMRP neighbors (by default, every 60 seconds). A Route Report contains the sender's current routing table. The routing table contains entries that advertise a source network (with a mask) and a hop-count that is used as the routing metric. (The key difference between the way routing information is exchanged in DVMRP and in RIP is that DVMRP routes are advertised with a subnet mask, which makes DVMRP effectively a classless protocol.)

The routing information stored in a DVMRP routing table is separate from the unicast routing table and is used to build source distribution trees and to perform multicast forwarding (that is, Reverse Path Forwarding checks).

The **ip dvmrp report-interval** command enables you to specify the number of seconds between transmission of Route Report messages. For example, the following command specifies that a Route Report message be sent every 60 seconds:

```
-> ip dvmrp report-interval 60
```

The **ip dvmrp flash-interval** command enables you to specify the number of seconds between transmission of Routing Table Change messages. Routing Table Change messages are sent between transmissions of the complete routing tables contained in Route Report messages. For this reason, the Flash Interval value must be lower than the Route Report interval. For example:

```
-> ip dvmrp flash-interval 5
```

The **ip dvmrp route-timeout** command enables you to specify the route expiration timeout value. The route expiration timeout value determines the number of seconds before a route to an inactive network is aged out. For example, the following command specifies that the route to an inactive network age out in 140 seconds:

```
-> ip dvmrp route-timeout 140
```

The **ip dvmrp route-holddown** command enables you to specify the number of seconds that DVMRP routes are kept in a holddown state. A holddown state refers to the period of time that a route to an inactive network continues to be advertised as unreachable. When a route is deleted (because it expires, the neighbor it was learned from goes down, etc.) a router may be able to reach the source network described by the route through an alternate gateway. However, in the presence of complex topologies, often the alternate gateway may only be echoing back the same route learned via a different path. If this occurs, the route will continue to be propagated long after it is no longer valid.

In order to prevent this, it is common in distance vector protocols to continue to advertise a route that has been deleted with a metric of infinity for one or more report intervals. This is a holddown. While it is in holddown, a route must only be advertised with an infinity metric. The hold down period is usually two report intervals.

For example, the following command specifies that the route to an inactive network continue to be advertised for 120 seconds:

```
-> ip dvmrp route-holddown 120
```

Note. Current global DVMRP parameter values—including the **ip dvmrp report-interval**, **ip dvmrp flash-interval**, **ip dvmrp route-timeout**, and **ip dvmrp route-holddown** values—can be viewed via the **show ip dvmrp** command. The DVMRP routes that are being advertised to other routers can be viewed via the **show ip dvmrp route** command.

Pruning

DVMRP uses a flood-and-prune mechanism that starts by delivering multicast traffic to all routers in the network. This means that, initially, traffic is flooded down a multicast delivery tree. DVMRP routers then prune this flow where the traffic is unwanted. Routers that have no use for the traffic send DVMRP Prune messages up the delivery tree to stop the flow of unwanted multicast traffic, thus pruning the unwanted branches of the tree. After pruning, a source distribution tree for that specific source exists.

However, the source distribution tree that results from DVMRP pruning reverts back to the original delivery tree when the prunes time out. When a prune times out, traffic is again flooded down the branch.

The **ip dvmrp prune-lifetime** command sets the period of time that a prune will be in effect — essentially, the prune's lifetime. When the prune-lifetime period expires, the interface is joined back onto the multicast delivery tree. (If unwanted multicast traffic continues to arrive at the interface, the prune mechanism is reinitiated and the cycle continues.) For example, the following command sets a prune's lifetime to 7200 seconds:

```
-> ip dvmrp prune-lifetime 7200
```

Refer to "More About Prunes" below for further information on the **ip dvmrp prune-lifetime** command and how it affects the lifetime of prunes sent and, in some cases, received.

The **ip dvmrp prune-timeout** command sets the Prune packet retransmission interval. This is the duration of time that the router will wait before retransmitting a Prune message if it continues to receive unwanted multicast traffic. For example, the following command sets the Prune packet retransmission interval to forty seconds:

```
-> ip dvmrp prune-timeout 40
```

Note. Current global DVMRP parameter values—including the **ip dvmrp prune-lifetime** value and the **ip dvmrp prune-timeout** value—can be viewed via the **show ip dvmrp** command. Current DVMRP prunes can be viewed via the **show ip dvmrp prune** command.

More About Prunes

Prune-Lifetime Values in Sent Prune Packets

The value of **ip dvmrp prune-lifetime** is set to 7200 seconds (two hours) by default. On leaf routers (that is, routers that have no further downstream dependent routers), the value of **ip dvmrp prune-lifetime** is inserted into prune packets sent upstream as their lifetime value.

However, when a branch router (that is, a router that does have further downstream dependent routers) sends a prune upstream, the prune-lifetime value inserted into the prune packet is the smallest of the following values:

- the value of **ip dvmrp prune-lifetime** on the sending device
- the amount of lifetime that remains for each individual prune on the router's timer queue that was received for the pruned group. (When a prune is queued on the router's timer queue, its lifetime value decrements until the prune expires.)

As an example, let's say that the following situation exists on a branch router: **ip dvmrp prune-lifetime** is set to 7200 seconds and three prunes for the pruned group exist on the router's timer queue. These three prunes have remaining lifetimes of 7000 seconds, 5000 seconds, and 4500 seconds. When the branch router sends a prune upstream for this group, a prune-lifetime value of 4500 seconds will be inserted into the prune packet.

Prune-Lifetime Expiration Value

You can view the prunes that have been sent via the **show ip dvmrp prune** command. (However, note that this command does not display received prunes.) The expiration time displayed by the **show ip dvmrp prune** command is the earliest time that the router expects multicast traffic for the pruned group to start arriving. If the expiration time displays as **expired**, the prune has expired but no further multicast traffic has been received. The expiration value may be reset if multicast traffic is received and another prune was sent because no stations downstream want the traffic.

Received Prunes

When prune packets are received, a timer is set up on the receiving device that halts traffic sent to the pruned group on the neighbor that originated the prune. The timer value used is the prune-lifetime value found in the received prune packet. The setting of **ip dvmrp prune-lifetime** on the device that received the prune is not normally taken into consideration in this situation.

However, there are times when the setting of **ip dvmrp prune-lifetime** can affect the timeout value used for received prunes. This occurs if the setting of **ip dvmrp prune-lifetime** is modified after prunes have been received. If the new prune-lifetime value is less than the period of time a received prune has been on the router's timer queue, the router will treat the prune as if it just expired. This means that multicast traffic may flow to the neighbor even though the neighbor does not expect the prune to have expired.

Even in cases where modification of the **ip dvmrp prune-lifetime** setting does not cause the received prunes to expire earlier than specified by their internal prune-lifetime value, such modification will still cause the prune-lifetime value of received prunes to be adjusted to the new value. This means that received prunes may expire sooner or later than the neighbor expects.

Once the lifetime value of received prunes on the router's timer queue have been modified per the new setting of **ip dvmrp prune-lifetime**, all future incoming prunes will experience normal timer operation and the prune-lifetime value in the received prune packet will be used without modification. Outgoing prunes will use the new value of **ip dvmrp prune-lifetime**.

For the reasons explained, the value of **ip dvmrp prune-lifetime** should only be modified with caution.

Grafting

A pruned branch will be automatically reattached to the multicast delivery tree when the prune times out. However, the graft mechanism provides a quicker method to reattach a pruned branch than waiting for the prune to time out. As traffic is forwarded, routers that do not want multicast traffic send Prune messages to signal the upstream router to stop sending the traffic. If new IGMP membership requests are later received by the downstream router, the router can send Graft messages to the upstream router and wait for acknowledgment (a Graft Ack).

The **ip dvmrp graft-timeout** command enables you to set the Graft message retransmission value. This value defines the duration of time that the router will wait before retransmitting a Graft message if it has not received a Graft-Ack message acknowledging that a previously transmitted Graft message was received. For example, enter the following to set the Graft message retransmission value to 5 seconds:

```
-> ip dvmrp graft-timeout 5
```

Note. Current global DVMRP parameter values, including the **ip dvmrp graft-timeout** value, can be viewed via the **show ip dvmrp** command.

Tunnels

DVMRP networks may use DVMRP tunnels to interconnect two multicast-enabled networks across non-multicast networks. In a DVMRP tunnel, IP multicast packets are encapsulated in unicast IP packets so that the multicast traffic can traverse a non-multicast network.

The **ip dvmrp tunnel** command enables you to add or delete a DVMRP tunnel between a specified local and remote address. Any packets sent through the tunnel will be encapsulated in an outer IP header. For example, the following command would create a tunnel between local address 172.22.2.115 and remote address 172.22.2.120:

```
-> ip dvmrp tunnel 172.22.2.115 172.22.2.120
```

The local tunnel address must match an existing IP interface on a router that has been configured for DVMRP. The tunnel's remote address must be the IP address of the remote DVMRP router to which the tunnel is connected.

Important. The tunnel will be operational only when the DVMRP interface is also operational. To enable DVMRP on an interface, use the **ip dvmrp interface**. For more information, refer to "Enabling DVMRP on a Specific Interface" on page 3-11.

The **ip dvmrp tunnel ttl** command sets the tunnel's Time-To-Live (TTL) value. For example:

```
-> ip dvmrp tunnel 172.22.2.115 172.22.2.120 ttl 255
```

Note. Current DVMRP tunnels, including the tunnels' operational (OPER) status and TTL values, can be viewed via the **show ip dvmrp tunnel** command. The status of the DVMRP interface can be viewed via the **show ip dvmrp interface** command.

Verifying the DVMRP Configuration

A summary of the show commands used for verifying the DVMRP configuration is given here:

show ip dvmrp	Displays global DVMRP parameters such as admin status, flash interval value, graft timeout value, neighbor interval value, subordinate neighbor status, number of routes, number of routes reachable, etc.
show ip dvmrp interface	Displays the DVMRP interface table, which lists all multicast-capable interfaces.
show ip dvmrp neighbor	Displays the DVMRP neighbor table, which lists adjacent DVMRP routers.
show ip dvmrp nexthop	Displays the DVMRP next hop entries table. The next hop entries table lists which VLANs will receive traffic forwarded from a designated multicast source. The table also lists whether a VLAN is considered a DVMRP branch or leaf for the multicast traffic (i.e., its *hop type*).
show ip dvmrp prune	Displays the prune table. Each entry in the prune table lists a pruned branch of the multicast delivery tree and includes the time interval remaining before the current prune state expires.
show ip dvmrp route	Displays the DVMRP routes that are being advertised to other routers in Route Report messages.
show ip dvmrp tunnel	Displays DVMRP tunnels. This command lists DVMRP tunnel interfaces, including both active and inactive tunnels.

For more information about the displays that result from these commands, see the *OmniSwitch CLI Reference Guide*.

4 Configuring PIM-SM

Protocol-Independent Multicast (PIM) is an IP multicast routing protocol that uses routing information provided by unicast routing protocols such as RIP and OSPF. PIM is "protocol-independent" because it does not rely on any particular unicast routing protocol. Sparse mode PIM (PIM-SM) contrasts with flood-and-prune dense mode multicast protocols such as DVMRP and PIM Dense Mode (PIM-DM) in that multicast forwarding in PIM-SM is initiated only via specific requests, referred to as *Join messages*.

Source-Specific Multicast (PIM-SSM). The current implementation of PIM-SM includes support for Source-Specific Multicast (PIM-SSM). For more information on PIM-SSM support, refer to "PIM-SSM Support" on page 4-26.

In This Chapter

This chapter describes the basic components of PIM-SM and how to configure them through the Command Line Interface (CLI). CLI commands are used in the configuration examples; for more details about the syntax of commands, see the *OmniSwitch CLI Reference Guide*.

Configuration procedures described in this chapter include:

- Enabling PIM-SM on the switch—see page 4-14.
- Enabling PIM-SM on a specific interface—see page 4-16.
- Configuring Candidate Rendezvous Points (C-RPs)—see page 4-18.
- Configuring Candidate Bootstrap Routers (C-BSRs)—see page 4-21.
- Verifying the PIM-SM configuration—see page 4-25.

For detailed information about PIM-SM commands, see the "PIM-SM Commands" chapter in the *OmniSwitch CLI Reference Guide*.

PIM-SM Specifications

RFCs Supported	2362—Protocol Independent Multicast-Sparse Mode (PIM-SM) Protocol Specification 2934—Protocol Independent Multicast MIB for Ipv4 2932—Ipv4 Multicast Routing MIB
Internet Drafts Supported	draft-ietf-pim-sm-v2-new-05.txt—Protocol Independent Multicast – Sparse Mode PIM-SM draft-ietf-pim-mib-v2-00.txt—Protocol Independent Multicast MIB draft-ietf-pim-sm-bsr-02.txt—Bootstrap Router (BSR) Mechanism for PIM Sparse Mode
PIM-SM Version Supported	PIM-SMv2
PIM-SM Attributes Supported	Shared trees (also referred to as RP trees), Designated Routers (DRs), Bootstrap Routers (BSRs), Candidate Bootstrap Routers (C-BSRs), Rendezvous Points (RPs) Candidate Rendezvous Points (C-RPs)
PIM-SM Timers Supported	C-RP expiry, C-RP holdtime, C-RP advertisement, Join/Prune, Probe, Register suppression, Hello, Expiry, Assert, Neighbor liveness
Maximum Rendezvous Point (RP) routers allowed in a PIM-SM domain	100 (default value is 32)
Maximum Bootstrap Routers (BSRs) allowed in a PIM-SM domain	1
Multicast Protocols per Interface	1 (e.g., you cannot enable both PIM-SM and DVMRP on the same IP interface)

PIM-SM Defaults

The following table lists the defaults for PIM-SM configuration:

Parameter Description	Command	Default Value/Comments
PIM-SM status	**ip load pimsm**	Disabled
PIM-SM load status	**ip load pimsm**	Unloaded
C-BSR mask length	**ip pimsm cbsr-masklength**	30 bits
Static RP configuration	**ip pimsm static-rp status**	Disabled
RP threshold	**ip pimsm rp-threshold**	65536
C-RP expiry time	**ip pimsm crp-expirytime**	300 seconds
C-RP holdtime	**ip pimsm crp-holdtime**	150 seconds
C-RP advertisement interval	**ip pimsm crp-interval**	60 seconds
C-RP priority	**ip pimsm crp-priority**	0
Source, group data timeout	**ip pimsm data-timeout**	210 seconds
Global Join/Prune interval	**ip pimsm joinprune-interval**	60 seconds
Maximum RP routers allowed	**ip pimsm max-rps**	32
Probe timer	**ip pimsm probe-time**	5 seconds
Register checksum value	**ip pimsm register checksum**	header
Register suppression timer	**ip pimsm registersuppress-timeout**	60 seconds
Switchover to Shortest Path Tree (SPT)	**ip pimsm spt status**	Enabled
PIM-SM interface status	**ip pimsm interface**	Disabled on all interfaces
Interface Hello message interval	**ip pimsm interface hello-interval**	30 seconds
Interface Join/Prune interval	**ip pimsm interface joinprune-interval**	60 seconds; this value automatically matches the configured global Join/Prune interval.
Interface C-BSR preference	**ip pimsm interface joinprune-interval**	0
Interface DR priority	**ip pimsm interface dr-priority**	1
Interface LAN prune-delay status	**ip pimsm interface prune-delay status**	Disabled
Interface LAN prune-delay	**ip pimsm interface prune-delay**	500 milliseconds
Interface override interval	**ip pimsm interface override-interval**	2500 milliseconds
Interface triggered hello time	**ip pimsm interface triggered-hello**	5 seconds
Interface hello hold time	**ip pimsm interface hello-holdtime**	105 seconds
Interface generation ID status	**ip pimsm interface genid**	Enabled
Interface Join/Prune hold time	**ip pimsm interface joinprune-hold-time**	210 seconds

Quick Steps for Configuring PIM-SM

Note. PIM-SM requires that IP Multicast Switching (IPMS) is enabled. IPMS is automatically enabled when a multicast routing protocol (either PIM-SM or DVMRP) is enabled globally and on an interface *and* when the operational status of the interface is *up*. However, if you wish to manually enable IPMS on the switch, use the **ip multicast switching** command.

1 Manually load PIM-SM into memory by entering the following command:

```
-> ip load pimsm
```

2 Create a router port (i.e., *interface*) on an existing VLAN by specifying a valid IP address. To do this, use the **vlan router ip** command. For example:

```
-> vlan 2 router ip 178.14.1.43
```

3 Enable the PIM-SM protocol on the interface via the **ip pimsm interface** command. For example:

```
-> ip pimsm interface 178.14.1.43
```

4 Globally enable the PIM-SM protocol by entering the following command:

```
-> ip pimsm status enable
```

5 Save your changes to the Working directory's **boot.cfg** file by entering the following command:

```
-> write memory
```

Note. *Optional*. To verify PIM-SM interface status, enter the **show ip pimsm interface** command. The display is similar to the one shown here:

```
Address          Designated       Hello    Join/Prune  CBSR  DR       Oper
                 Router           Interval Interval    Pref  Priority Status
---------------+---------------+--------+-----------+-----+--------+--------
178.14.1.43      178.14.1.43      30       60          0     1        enabled
```

To verify global PIM-SM status, enter the **show ip pimsm** command. The display is similar to the one shown here:

```
Status                        = enabled,
BSR Address                   = 0.0.0.0,
BSR Expiry Time               = 00h:00m:00s,
CBSR Address                  = 178.14.1.43,
CBSR Mask Length              = 30,
CBSR Priority                 = 0,
CRP Address                   = 0.0.0.0,
CRP Hold Time                 = 150,
CRP Expiry Time               = 00h:05m:00s,
CRP Interval                  = 60,
```

(additional table output not shown)

For more information about these displays, see the "PIM-SM Commands" chapter in the *OmniSwitch CLI Reference Guide*.

PIM-SM Overview

Protocol-Independent Multicast (PIM) is an IP multicast routing protocol that uses routing information provided by unicast routing protocols such as RIP and OSPF. Note that PIM is not dependent on any particular unicast routing protocol. Sparse mode PIM (PIM-SM) contrasts with flood-and-prune dense mode multicast protocols such as DVMRP and PIM Dense Mode (PIM-DM) in that multicast forwarding in PIM-SM is initiated only via specific requests, referred to as *Join messages*.

Downstream routers must explicitly join PIM-SM distribution trees in order to receive multicast streams on behalf of receivers or other downstream PIM-SM routers. This paradigm of receiver-initiated forwarding makes PIM-SM ideal for network environments where receiver groups are thinly populated and bandwidth conservation is a concern, such as in wide area networks (WANs).

Note. OmniSwitch 6800 switches support PIM-SMv2 and are not compatible with PIM-SMv1.

The following sections provide basic descriptions for key components used when configuring a PIM-SM network. These components include:

- Rendezvous Points (RPs) and Candidate Rendezvous Points (C-RPs)
- Bootstrap Routers (BSRs) and Candidate Bootstrap Routers (C-BSRs)
- Designated Routers (DRs)
- Shared Trees, also referred to as Rendezvous Point Trees (RPTs)
- Avoiding Register Encapsulation

Rendezvous Points (RPs)

In PIM-SM, shared distribution trees are rooted at a common forwarding router termed a Rendezvous Point (RP). The RP unencapsulates Register messages and forwards multicast packets natively down established distribution trees to receivers. The resulting topology is referred to as the RP Tree (RPT).

For an illustrated example of an RPT and the RP's role in a simple PIM-SM environment, refer to "Shared (or RP) Trees" on page 4-7.

Candidate Rendezvous Points (C-RPs)

A *Candidate* Rendezvous Point (C-RP) is a PIM-enabled router that sends periodic C-RP advertisements to the Bootstrap Router (BSR). When a BSR receives a C-RP advertisement, it may include the C-RP in its RP-set. For more information on the BSR and RP-set, refer to page 4-6.

Bootstrap Routers (BSRs)

The role of a Bootstrap Router (BSR) is to keep routers in the network up to date on reachable C-RPs. The BSR's list of reachable C-RPs is also referred to as an *RP set*. There is only one BSR per PIM domain. This allows all PIM routers in the PIM domain to view the same RP set.

A C-RP periodically sends out messages, known as *C-RP advertisements*. When a BSR receives one of these advertisements, the associated C-RP is considered reachable (if it has a valid route). The BSR then periodically sends its RP set to neighboring routers in the form of a *Bootstrap message*.

Note. For information on viewing the current RP set, see page 4-23.

BSRs are elected from the Candidate Bootstrap Routers (C-BSRs) in the PIM domain. For information on C-BSRs, refer to the section below.

Candidate Bootstrap Routers (C-BSRs)

A *Candidate* Bootstrap Router (C-BSR) is a PIM-enabled router that is eligible for BSR status. To become a BSR, a C-BSR must become *elected*. A C-BSR sends Bootstrap messages to all neighboring routers. The messages include its IP address—which is used as an identifier—and its priority level. The C-BSR with the highest priority level is elected as the BSR by its neighboring routers. If two or more C-BSRs have the same priority value, the C-BSR with the highest IP address is elected as the BSR.

For information on configuring C-BSRs, including C-BSR priority levels, refer to "Configuring Candidate Bootstrap Routers (C-BSRs)" on page 4-21.

Designated Routers (DRs)

There is only one Designated Router (DR) used per LAN. When a DR receives multicast data from the source, it encapsulates the data packets into the Register messages, which are in turn sent to the RP. Downstream PIM-SM routers express interest in receiving multicast streams on behalf of a host via explicit Join/Prune messages originating from the DR and directed to the RP.

The DR for a LAN is selected by an election process. This election process takes into account the DR priority of each PIM-SM neighbor on the LAN. If multiple neighbors share the same DR priority, the neighbor with the highest IP address is elected. The **ip pimsm interface dr-priority** command is used to specify the DR priority on a specific PIM-enabled interface. Note that the DR priority is taken into account only if all of the PIM neighbors on the LAN are using the DR priority option in their Hello packets.

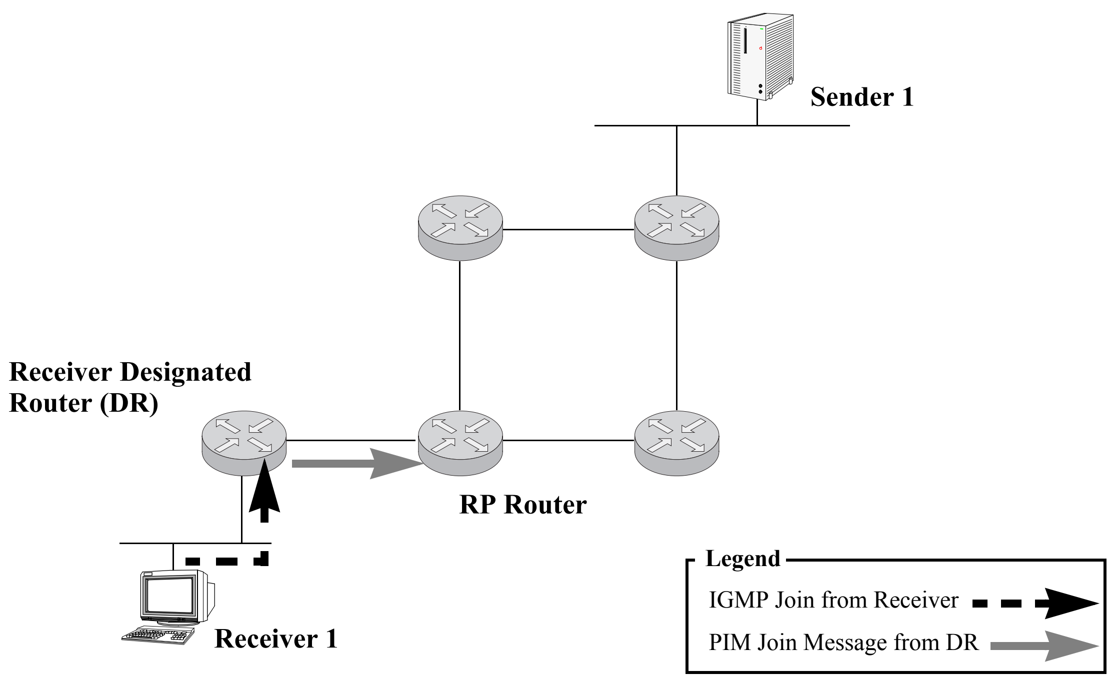
For an illustrated example of the DR's role in a simple PIM-SM environment, refer to "Shared (or RP) Trees" on page 4-7.

Shared (or RP) Trees

Shared distribution trees are also referred to as RP trees (or RPTs) because the routers in the distribution tree share a common Rendezvous Point (RP). The following diagrams illustrate a simple RP tree in a PIM-SM domain.

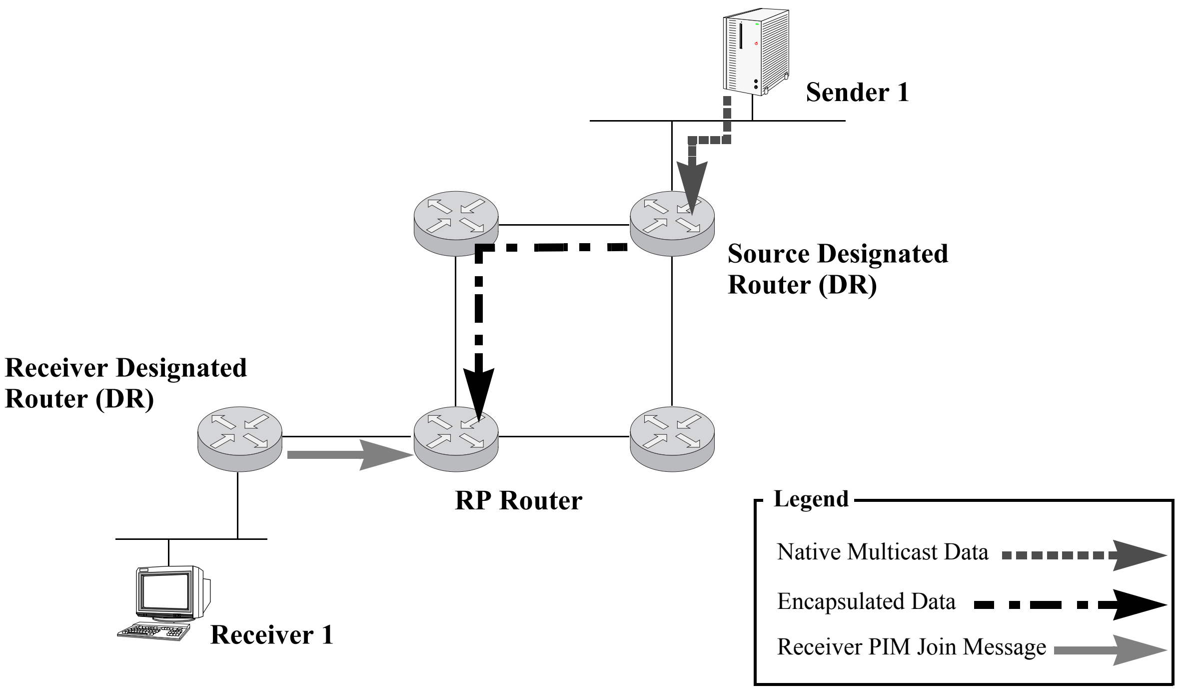
In this example, a multicast receiver (Receiver 1) uses IGMP to express interest in receiving multicast traffic destined for a particular multicast group. After getting the IGMP Join request, the receiver's Designated Router (DR) then passes on the request, in the form of a PIM *Join message*, to the RP.

Note. The Join message is known as a (*,G) join because it joins group G for all sources to that group.

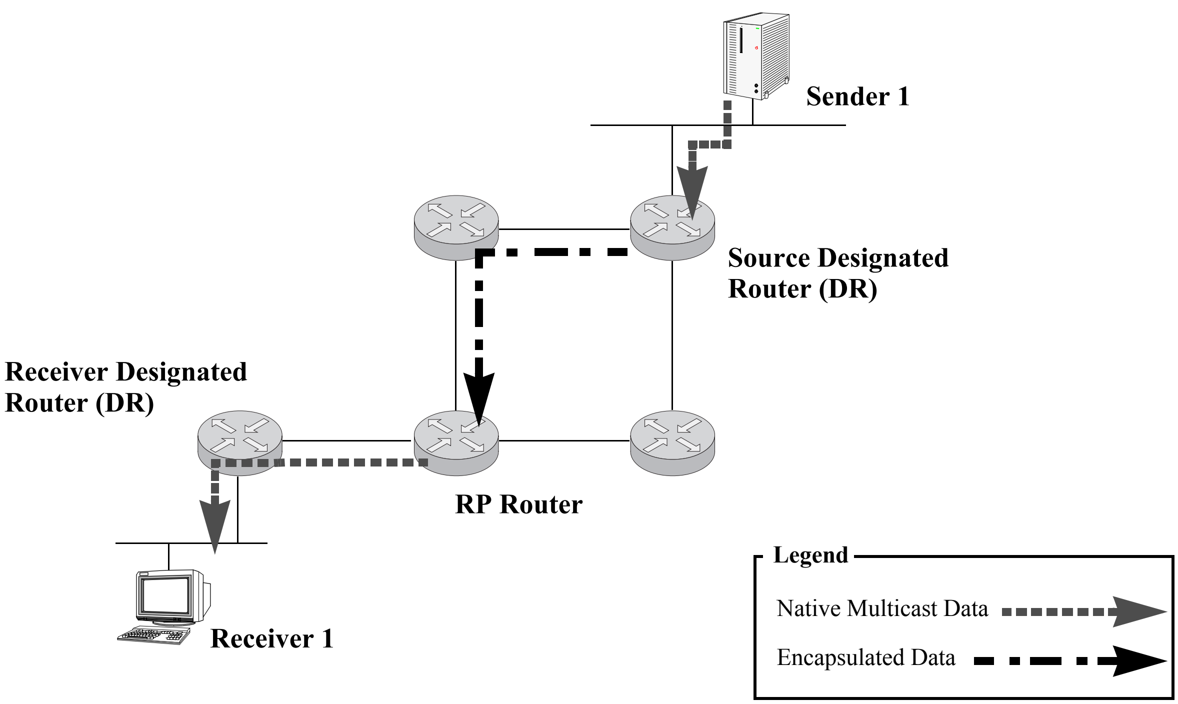


Note. Depending on the network configuration, multiple routers may exist between the receiver's DR and the RP router. In this case, the (*, G) Join message travels hop-by-hop toward the RP. In each router along the way, the multicast tree state for group G is instantiated. These Join messages converge on the RP to form a distribution tree for group G that is rooted at the RP.

Sender 1 sends multicast data to its Designated Router (DR). The source DR then *unicast-encapsulates* the data into PIM-SM Register messages and sends it on to the RP.



Once the distribution tree for group G is learned at the RP, the encapsulated data being sent from the source DR is now unencapsulated at the RP and forwarded natively to the Receiver.



Avoiding Register Encapsulation

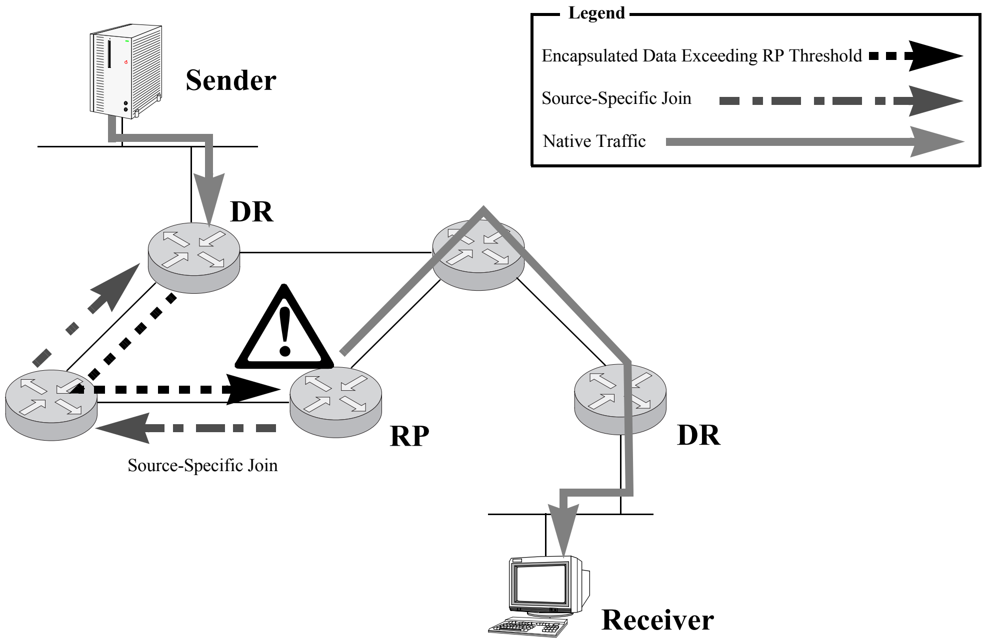
Switching to a Shortest Path Tree (SPT) topology allows PIM routers to avoid Register encapsulation of data packets that occurs in an RPT. Register encapsulation is inefficient for the following reasons:

- The encapsulation and unencapsulation of Register messages taxes router resources. Hardware routing does not support encapsulation and unencapsulation.
- Register encapsulation may require that data travel unnecessarily over long distances. For example, data may have to travel “out of its way” to the RP before turning back down the shared tree in order to reach a receiver.

For some applications, this increased latency is undesirable. There are two methods for avoiding register encapsulation: RP initiation of (S, G) source-specific Join messages, and switchover to a Shortest Path Tree (SPT). For more information, refer to the sections below.

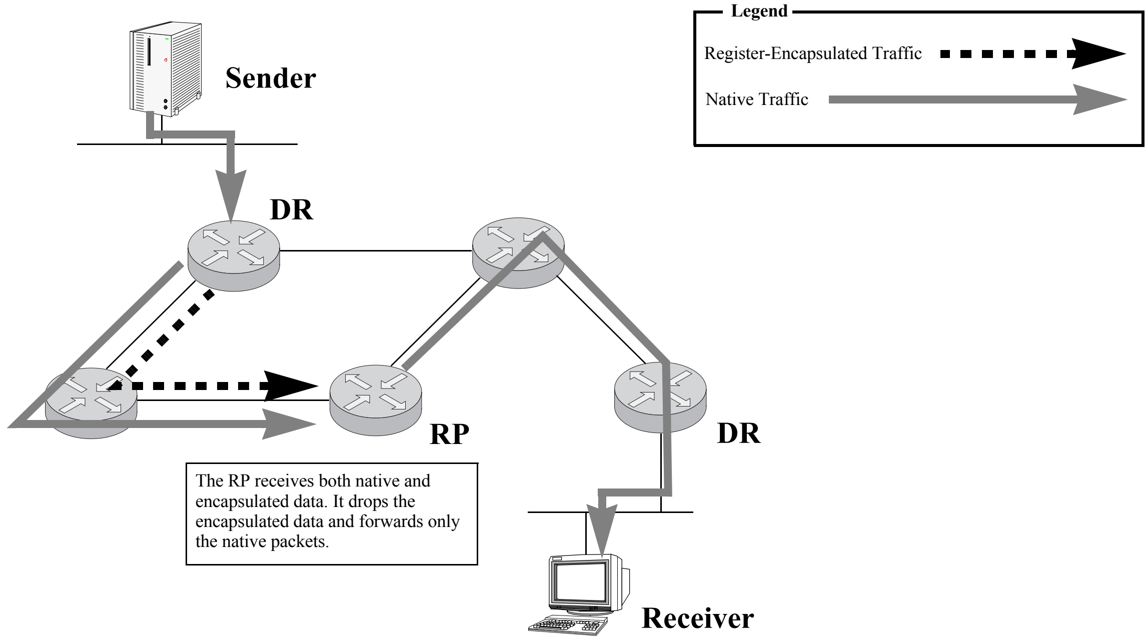
RP Initiation of (S, G) Source-Specific Join Message

When the data rate at the Rendezvous Point (RP) exceeds the configured RP threshold value, the RP will initiate a (S, G) source-specific Join message toward the source.

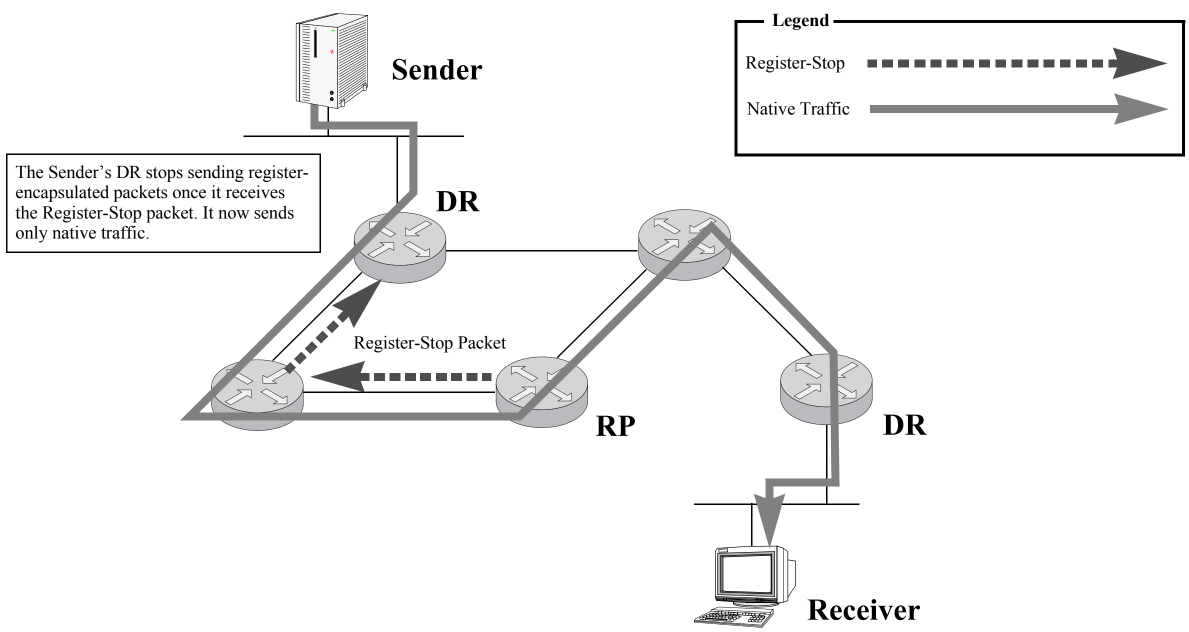


Note. To configure the RP threshold value, use the **ip pimsm rp-threshold** command.

When the Sender's DR receives the (S,G) Join, it sends data natively as well. When these data packets arrive natively at the RP, the RP will be receiving *two copies* of each of these packets—one natively and one encapsulated. The RP drops the register-encapsulated packets and forwards only the native packets.



A register-stop packet is sent back to the sender's DR to prevent the DR from unnecessarily encapsulating the packets. Once the register-encapsulated packets are discontinued, the packets are flowing natively from the sender to the RP—along the source-specific tree to the RP and, from there, along the shared tree to all receivers.



Because packets are still forwarded along the shared tree from the RP to all of the receivers, this does not constitute a true Shortest Path Tree (SPT). For many receivers, the route via the RP may involve a significant detour when compared with the shortest path from the source to the receivers.

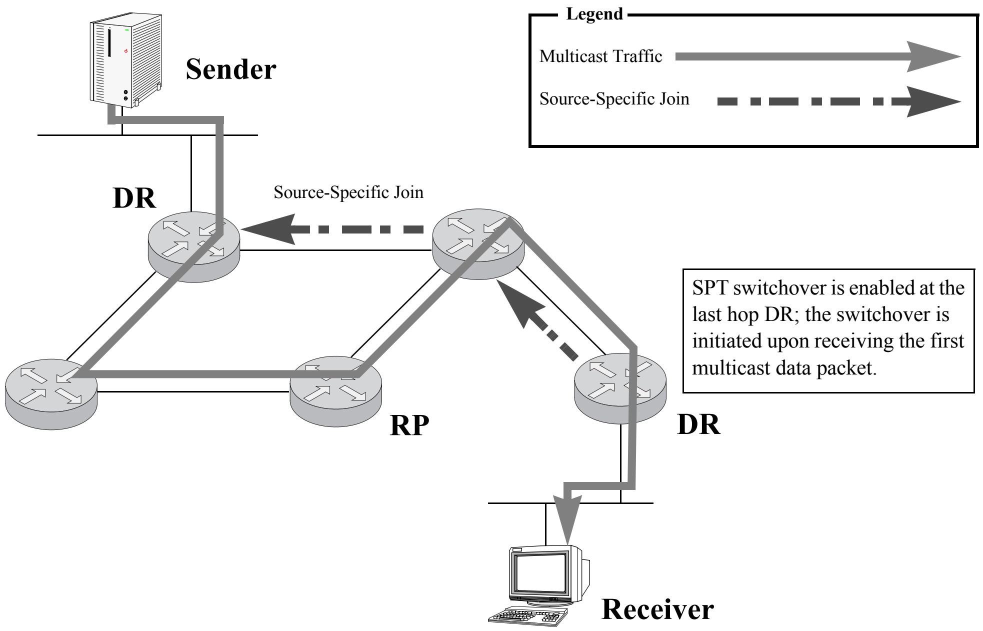
SPT Switchover

It is the last hop Designated Router (DR) that initiates the switchover to a true Shortest Path Tree (SPT) once it receives the first multicast data packet. This method does not use any preconfigured thresholds, such as RP threshold (as described above). Instead, the switchover is initiated automatically, *as long as the SPT status is enabled on the switch*.

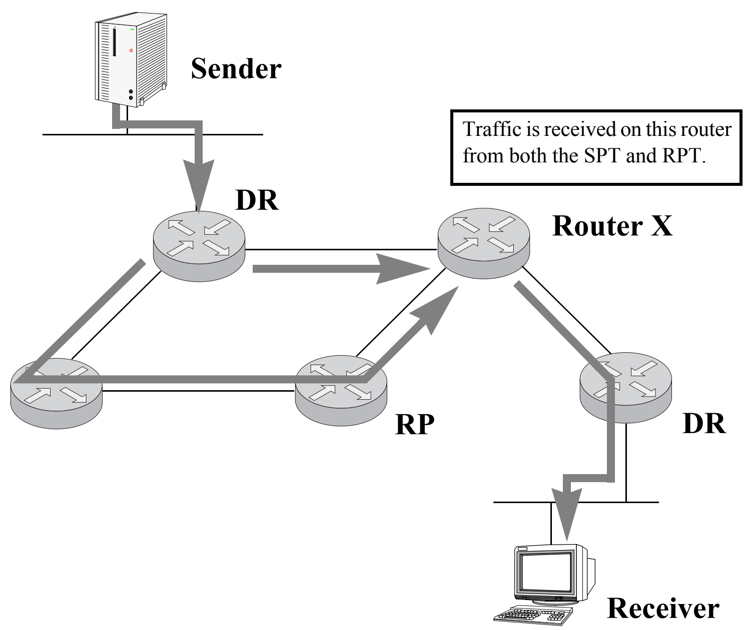
Important. SPT status must be enabled for SPT switchover to occur. SPT status is enabled by default. If the SPT status is disabled, the SPT switchover will not occur. The SPT status is configured via the **ip pimsm spt status** command. To view the current SPT status, use the **show ip pimsm** command

---

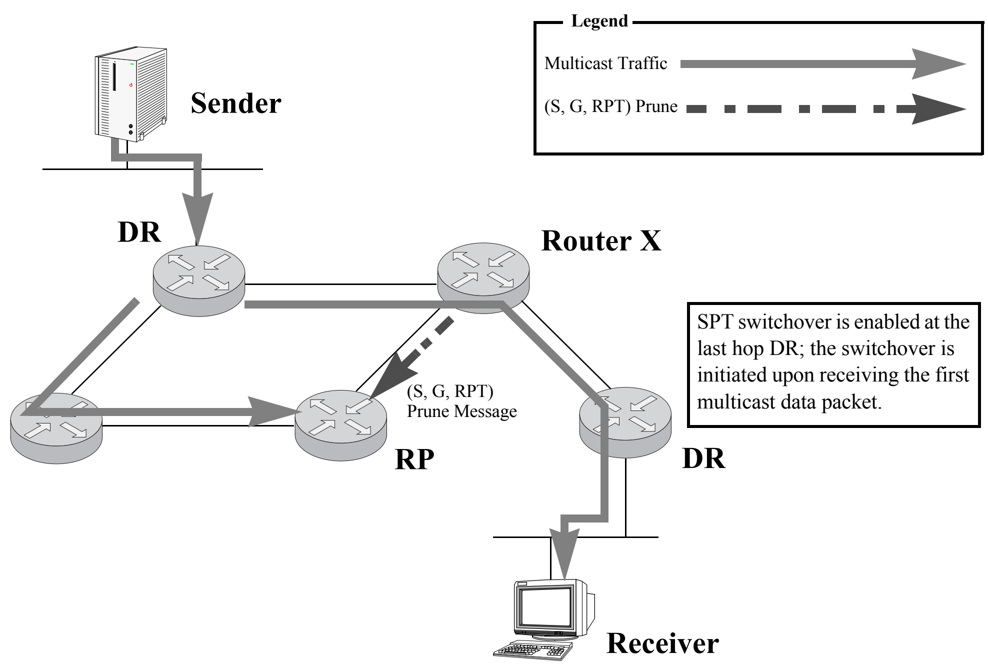
Upon receiving the first multicast data packet, the last hop DR issues a (S, G) source-specific Join message toward the source.



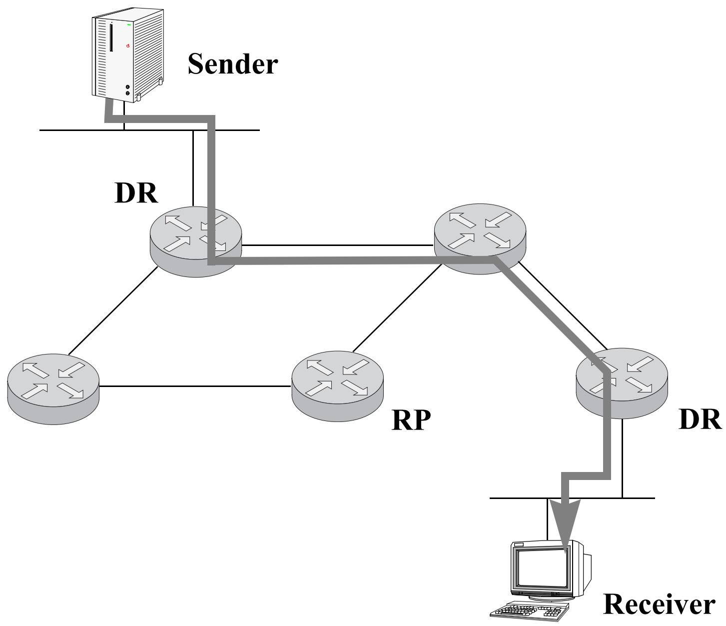
Once the Sender's DR receives the (S,G) Join message, it sends the multicast packets natively along the Shortest Path Tree. At this point, Router X (the router shown between the Sender's DR and the Receiver's DR) will be receiving two copies of the multicast data—one from the SPT, and one from the RPT. This router drops the packets arriving via the RP tree and forwards only those packets arriving via the SPT.



An (S, G, RPT) Prune message is sent toward the RP. As a result, traffic destined for this group from this particular source will no longer be forwarded along the RPT. The RP will still receive traffic from the Source. If there are no other routers wishing to receive data from the source, the RP will send an (S, G) Prune message toward the source to stop this unrequested traffic.



The Receiver is now receiving multicast traffic along the Shortest Path Tree between the Receiver and the Source.



Configuring PIM-SM

Enabling PIM-SM on the Switch

By default, the PIM-SM protocol is disabled on the switch. Before running PIM-SM, you must enable the protocol by completing the following steps:

- Verifying the software
- Loading PIM-SM into memory
- Enabling PIM-SM on desired IP interfaces
- Enabling PIM-SM globally on the switch

For information on completing these steps, refer to the sections below.

Verifying the Software

Before you can begin configuring PIM-SM, the **Kadvrout.img** file must be present in an OmniSwitch 6800 switch's current running directory (i.e., Working or Certified). The **Kadvrout.img** file is part of the OmniSwitch 6800 Advanced Routing software package.

To identify the current running directory (also referred to as *running configuration*), use the **show running-directory** command. For example:

```
-> show running-directory
CONFIGURATION STATUS
   Running CMM                : PRIMARY,
   CMM Mode                   : MONO CMM,
   Current CMM Slot           : A,
   Running configuration      : WORKING,
   Certify/Restore Status     : CERTIFY NEEDED
```

(additional table output not shown)

View the software contents of the current running directory using the **ls** command. If you are currently in the root flash, be sure to include the current running directory in the command line. In this example, the current running directory is the Working directory:

```
-> ls working
Listing Directory /flash/working:

drw      2048 Jan  1 04:37 ./
drw      2048 Jan  1 05:58 ../
-rw       164 Jan  1 04:32 boot.cfg
-rw    662998 Jan  1 04:36 Kadvrout.img
-rw   2791518 Jan  1 04:36 Kbase.img
-rw    296839 Jan  1 04:36 Kdiag.img
-rw    698267 Jan  1 04:37 Keni.img
-rw    876163 Jan  1 04:37 Kos.img
```

The **Kadvrout.img** file is present in the current running configuration (in this case, Working).

(additional table output not shown)

Loading PIM-SM into Memory

You must load PIM-SM into memory before you can begin configuring the protocol on the switch. If PIM-SM is not loaded and you enter a configuration command, the following message displays:

```
ERROR: The specified application is not loaded
```

To dynamically load PIM-SM into memory, enter the following command:

```
-> ip load pimsm
```

Enabling IPMS

PIM-SM requires that IP Multicast Switching (IPMS) is enabled. IPMS is automatically enabled when a multicast routing protocol (either PIM-SM or DVMRP) is enabled globally and on an interface *and* the operational status of the interface is up. If you wish to manually enable IPMS on the switch, use the **ip multicast switching** command.

Checking the Current IPMS Status

To view the current status of IPMS on the switch, use the **show ip multicast switching** command. For example:

```
IPMS Configuration

IPMS State:             Disabled,
Hardware Routing:       Enabled,
Priority:               high,
Max Ingress Bandwidth: 10,
Leave Timeout:          1,
Membership Timeout:     260,
Neighbor Timeout:       90,
Querier Timeout:        260,
Other Querier Timeout: 255,
Query Interval:         125,
Default Proxy Version: IGMPv2
```

Enabling PIM-SM on a Specific Interface

PIM-SM must be enabled on an interface before any other interface-specific PIM-SM command can be executed (e.g, the **ip pimsm interface hello-interval** command). An interface can be any IP router port that has been assigned to an existing VLAN. For information on assigning a router port to a VLAN, refer to the “Configuring VLANs” chapter in the *OmniSwitch 6800 Network Configuration Guide*.

To enable PIM-SM on a specific interface, use the **ip pimsm interface** command. The interface identifier used in the command syntax is the valid IP address of an existing VLAN router port. For example:

```
-> ip pimsm interface 172.22.2.115
```

Note. Only one multicast routing protocol is supported per interface. This means that you cannot enable both DVMRP and PIM-SM on the same interface.

Disabling PIM-SM on a Specific Interface

To disable PIM-SM on a specific IP interface, use the **no ip pimsm interface** command. Be sure to include the interface IP address. For example:

```
-> no ip pimsm interface 172.22.2.115
```

Viewing PIM-SM Status and Parameters for a Specific Interface

To view current PIM-SM interface information—which includes IP addresses for PIM-SM-enabled interfaces, Hello and Join/Prune intervals, and Candidate Bootstrap Router (C-BSR) preferences—use the **show ip pimsm interface** command. For example:

```
-> show ip pimsm interface
Address         Designated      Hello    Join/Prune  CBSR  DR       Oper
                Router          Interval Interval    Pref  Priority Status
---------------+---------------+--------+-----------+-----+--------+--------
178.14.1.43     178.14.1.43     30       60          0     1        enabled
```

The IP address of the Designated Router for the interface is displayed.

The IP address used to identify the PIM-SM-enabled interface is listed in the PIM-SM interface table.

Globally Enabling PIM-SM on the Switch

To globally enable PIM-SM on the switch, use the **ip load pimsm** command. Enter the command syntax as shown below:

```
-> ip pimsm status enable
```

Globally Disabling PIM-SM

The following command will globally disable PIM-SM on the switch:

```
-> ip pimsm status disable
```

Checking the Current Global PIM-SM Status

To view current global PIM-SM enable/disable status, as well as additional global PIM-SM settings, use the **show ip pimsm** command. For example:

```
-> show ip pimsm
Status                      = enabled,
BSR Address                 = 212.61.74.154,
BSR Expiry Time             = 00h:01m:21s,
CBSR Address                = 212.61.60.254,
CBSR Mask Length            = 30,
CBSR Priority               = 0,
CRP Address                 = 0.0.0.0,
CRP Hold Time               = 0,
CRP Expiry Time             = 00h:05m:00s,
CRP Interval                = 60,
CRP Priority                = 0,
Data Timeout                = 210,
Join/Prune Interval         = 60,
Max RPs                     = 32,
Probe Time                  = 5,
Register Checksum           = header,
Register Suppress Timeout   = 60,
RP Threshold                = 65536,
SPT Status                  = enabled,
Static RP Configuration     = disabled
```

Current global PIM-SM status is shown as enabled.

Automatic Loading and Enabling of PIM-SM Following a System Boot

If *any* PIM-SM command is saved to the **boot.cfg** file in the post-boot running directory, PIM-SM will be loaded into memory automatically. The post-boot running directory refers to the directory the switch will use as its running directory following the next system boot (i.e., Working or Certified). If the command syntax **ip pimsm status enable** is saved to the **boot.cfg** file in the post-boot running directory, PIM-SM will be automatically loaded into memory *and* globally enabled following the next system boot. For detailed information on the Working and Certified directories and how they are used during system boot, see the “CMM Directory Management” chapter in the *OmniSwitch 6800 Switch Management Guide*.

PIM Bootstrap and RP Discovery

Before configuring PIM-SM parameters, please consider the following important guidelines:

For correct operation, every PIM router within a PIM domain must be able to map a particular multicast group address to the same Rendezvous Point (RP). Otherwise, some receivers in the domain will not receive some groups. Two mechanisms are supported for multicast group address mapping:

- Bootstrap Router (BSR) Mechanism
- Static RP Configuration

The chosen multicast group address mapping mechanism should be used consistently throughout the PIM domain. Any RP address configured or learned *must* be a domain-wide reachable address.

Configuring a C-RP on an Interface

Note. If you attempt to configure a C-RP on an interface that is not PIM-SM-enabled, you will receive the following error message:

```
ERROR: PIM-SM is not enabled on this Interface
```

For information on enabling PIM-SM on an interface, refer to page 4-16.

To configure an interface to be a C-RP, use the **ip pimsm crp-address** command. For example:

```
-> ip pimsm crp-address 188.22.2.1
```

This specifies that router interface 188.22.2.1 will be advertised as a C-RP when periodic C-RP advertisements are sent to the Bootstrap Router.

If no C-RP address is defined on the switch, then no C-RP advertisements will be sent to the BSR.

Specifying a Multicast Group

When configuring a C-RP on an interface, you may also want to define an explicit multicast group for the C-RP. This is accomplished using the **ip pimsm rp-candidate** command. The command requires the following parameters (in the order shown):

- A valid 32-bit multicast group number with which the C-RP will be associated
- A corresponding multicast group mask (255.255.255.255)
- The IP address of an existing PIM-SM-enabled interface; this interface IP address provides a unique identifier for the C-RP.

For example:

```
-> ip pimsm rp-candidate 224.16.1.1 255.255.255.255 188.22.2.1
```

If you define a multicast group using the **ip pimsm rp-candidate** command, then the switch will advertise itself as a C-RP for only those multicast groups specified (in this example, 224.16.1.1 with a mask of 255.255.255.255).

Note. If a C-RP address is defined on the switch and no explicit entries are defined, then the switch will advertise itself as a C-RP for *all* multicast groups (i.e., 224.0.0.0 with a mask of 240.0.0.0). If no C-RP address is defined, the switch will not advertise itself as a C-RP for any groups.

The IP address specified in the command line must be equal to the C-RP address defined via the **ip pimsm crp-address** command (if applicable). If no C-RP address was previously defined, the IP address that is specified here in the **ip pimsm rp-candidate** command line will automatically become the global C-RP address.

Modifying the C-RP Priority

The C-RP priority is used by a Designated Router in determining the RP for a particular group. The priority level may range from 0 to 128. The lower the numerical value, the higher the priority. The default priority level for a C-RP is 0 (highest).

You can modify the C-RP priority with the **ip pimsm crp-priority** command. For example:

```
-> ip pimsm crp-priority 3
```

If two or more C-RPs have the same priority value, *as well as the same hash value*, the C-RP with the highest IP address is selected by the DR.

Specifying the Maximum Number of RPs

You can specify the maximum number of RPs allowed in a PIM-SM domain. (The switch's default value is 32.)

Important. PIM-SM must be globally disabled on the switch before changing the maximum number of RPs. To disable PIM-SM, use the **ip pimsm status** command. See page 4-16 for more information.

The maximum number of allowed RPs can range from 1 to 100. To specify a maximum number of RPs, use the **ip pimsm max-rps** command. For example:

```
-> ip pimsm max-rps 12
```

Verifying your Changes

Note. Check the C-RP address, priority level, and maximum number of RPs using the **show ip pimsm** command. For example:

```
-> show ip pimsm
Status                        = enabled,
BSR Address                   = 212.61.74.154,
BSR Expiry Time               = 00h:01m:21s,
CBSR Address                  = 212.61.60.254,
CBSR Mask Length              = 30,
CBSR Priority                 = 0,
CRP Address                   = 188.22.2.1,
CRP Hold Time                 = 0,
CRP Expiry Time               = 00h:05m:00s,
CRP Interval                  = 60,
CRP Priority                  = 3,
Data Timeout                  = 210,
Join/Prune Interval           = 60,
Max RPs                       = 12,
Probe Time                    = 5,
Register Checksum             = header,
Register Suppress Timeout     = 60,
RP Threshold                  = 65536,
SPT Status                    = enabled,
Static RP Configuration       = disabled
```

The C-RP address is shown as router interface 188.22.2.1.

The Candidate RP priority level is shown as 3.

The maximum number of RPs allowed is displayed as 12.

Check C-RP and explicit multicast group information using the **show ip pimsm rp-candidate** command:

```
-> show ip pimsm rp-candidate

Group Address      RP Address      Status
------------------+---------------+--------
224.16.1.1/32      188.22.2.1      enabled
```

The group address is listed as 224.16.1.1. The class D group mask (255.255.255.255) has been translated into the Classless Inter-Domain Routing (CIDR) prefix length of /32. The C-RP is listed as 188.22.2.1. The status is enabled.

For more information about these displays, see the "PIM-SM Commands" chapter in the *OmniSwitch CLI Reference Guide*.

Configuring Candidate Bootstrap Routers (C-BSRs)

Candidate Bootstrap Routers (C-BSRs)

A Candidate Bootstrap Router (C-BSR) is a PIM-enabled router that is eligible for Bootstrap Router (BSR) status. To become a BSR, a C-BSR must become *elected*. A C-BSR sends Bootstrap messages to all neighboring routers. The messages include its IP address—which is used as an identifier—and its priority level. The C-BSR with the highest priority level is elected as the BSR by its neighboring routers. If there are multiple C-BSRs with the same highest priority, the C-BSR with the highest IP address will become the BSR.

For information on configuring a C-BSR, refer to "Configuring a C-BSR on an Interface" below.

Configuring a C-BSR on an Interface

By default, all PIM-enabled interfaces have a C-BSR preference of 0. When determining the C-BSR for the switch, the PIM-enabled interface with the highest IP address is selected. However, if you want a particular PIM-enabled interface to become the C-BSR for the switch, the **ip pimsm interface cbsr-preference** command can be used to force the C-BSR selection. When entering the command, you must include the IP address of an existing interface (i.e., VLAN router port), as well as a C-BSR preference value. Preference values may range from -1 to 255. Note that the higher the C-BSR value, the higher the preference. For example:

```
-> ip pimsm interface 172.15.202.1 cbsr-preference 255
```

In this example, interface 172.15.202.1 has been configured to be a C-BSR, with the highest possible priority value of 255.

Similarly, if you *do not* want a particular interface to be considered as a C-BSR, you can use this command to set the C-BSR preference value to -1. For example:

```
-> ip pimsm interface 172.15.202.1 cbsr-preference -1
```

In this example, interface 172.15.202.1 has been assigned a priority level of -1; the interface *will not* be considered a C-BSR.

Note. If an entire switch is *not* to be considered as C-BSR at all, set the C-BSR preference to -1 for all PIM-enabled interfaces.

For detailed information on the **ip pimsm interface joinprune-interval** command, refer to the *CLI Command Reference Guide*.

Verifying your Changes

Note. You can check the current configuration using the **show ip pimsm** command:

```
-> show ip pimsm
Status                       = enabled,
BSR Address                  = 212.61.74.154,
BSR Expiry Time              = 00h:01m:21s,
CBSR Address                 = 172.15.202.1,
CBSR Mask Length             = 30,
CBSR Priority                = 3,
CRP Address                  = 188.22.2.1,
CRP Hold Time                = 0,
CRP Expiry Time              = 00h:05m:00s,
CRP Interval                 = 60,
CRP Priority                 = 3,
Data Timeout                 = 210,
Join/Prune Interval          = 60,
Max RPs                      = 12,
Probe Time                   = 5,
Register Checksum            = header,
Register Suppress Timeout    = 60,
RP Threshold                 = 65536,
SPT Status                   = enabled,
Static RP Configuration      = disabled
```

This entry indicates the PIM-SM interface that was chosen as the C-BSR for the switch. In this case, the interface IP address, 172.15.202.1, is shown as the C-BSR.

This entry indicates the C-BSR preference for C-BSR 172.15.202.1. In this case, the C-BSR priority is 3. This value is specified via the **ip pimsm interface cbsr-preference** command.

For more information about these displays, see the "PIM-SM Commands" chapter in the *OmniSwitch CLI Reference Guide*.

Bootstrap Routers (BSRs)

As described in the "PIM-SM Overview" section, the role of a Bootstrap Router (BSR) is to keep routers in the network "up to date" on reachable Candidate Rendezvous Points (C-RPs). BSRs are elected from a set of Candidate Bootstrap Routers (C-BSRs). Refer to page 4-6 for more information on C-BSRs.

Reminder. For correct operation, all PIM routers within a PIM domain must be able to map a particular multicast group address to the same Rendezvous Point (RP). PIM-SM provides two methods for group-to-RP mapping. One method is the Bootstrap Router mechanism, which also involves C-RP advertisements, as described in this section; the other method is static RP configuration. Note that, if static RP configuration is enabled, the Bootstrap mechanism and C-RP advertisements *are automatically disabled*. For more information on static RP status and configuration, refer to "Configuring Static RP Groups" below.

A C-RP periodically sends out messages, known as *C-RP advertisements*. When a BSR receives one of these advertisements, the associated C-RP is considered reachable (if a valid route to the network exists). The BSR then periodically sends an updated list of reachable C-RPs to all neighboring routers in the form of a *Bootstrap message*.

Note. The list of reachable C-RPs is also referred to as an *RP set*. To view the current RP set, use the **show ip pimsm rp-set** command. For example:

```
-> show ip pimsm rp-set

Group Address      Address         Holdtime Expires
------------------+---------------+--------+-----------
224.16.1.1/32      1.1.1.1         1        00h:00m:00s
```

For more information about these displays, see the "PIM-SM Commands" chapter in the *OmniSwitch CLI Reference Guide*.

Note. There is only one BSR per PIM domain. This allows all PIM routers in the PIM domain to view the same list of reachable C-RPs.

Configuring Static RP Groups

A static RP group is used in the group-to-RP mapping algorithm. To specify a static RP group, use the **ip pimsm static-rp** command. Be sure to enter a multicast group address, a corresponding group mask, and a 32-bit IP address for the static RP in the command line. For example:

```
-> ip pimsm static-rp 224.0.0.0 240.0.0.0 10.1.1.1
```

This command entry maps all multicast groups 224.0.0.0/4 to the static RP 10.1.1.1.

Note that, before static RP configuration changes will take effect, the global static RP status must be enabled. To enable static RP globally, use the **ip pimsm static-rp status** command. For example,

```
-> ip pimsm static-rp status enable
```

Note. If static RP status is enabled, the method for group-to-RP mapping provided by the Bootstrap mechanism and C-RP advertisements *is automatically disabled*. For more information on this alternate method of group-to-RP mapping, refer to page 4-23.

To view current Static RP Configuration settings, use the **show ip pimsm static-rp** command.

Group-to-RP Mapping

Using one of the mechanisms described in the sections above, a PIM router receives one or more possible group-range-to-RP mappings. Each mapping specifies a range of multicast groups (expressed as a group and mask), as well as the RP to which such groups should be mapped. Each mapping may also have an associated priority. It is possible to receive multiple mappings—all of which might match the same multicast group. This is the common case with the BSR mechanism. The algorithm for performing the group-to-RP mapping is as follows:

1 Perform longest match on group-range to obtain a list of RPs.

2 From this list of matching RPs, find the one with the highest priority. Eliminate any RPs from the list that have lower priorities.

3 If only one RP remains in the list, use that RP.

4 If multiple RPs are in the list, use the PIM hash function defined in the RFC to choose one. The RP with the highest resulting hash value is then chosen as the RP. If more than one RP has the same highest hash value, then the RP with the highest IP address is chosen.

This algorithm is invoked by a DR when it needs to determine an RP for a given group, such as when receiving a packet or an IGMP membership indication.

Verifying the PIM-SM Configuration

A summary of the show commands used for verifying the PIM-SM configuration is given here:

show ip pimsm	Displays global parameters for the PIM-SM domain.
show ip pimsm neighbor	Displays a list of active PIM-SM neighbors.
show ip pimsm rp-candidate	Displays the PIM-SM RP Candidate Table.
show ip pimsm rp-set	Displays the list of C-RPs for IP multicast groups. When the local router is the BSR, this information is obtained from received Candidate RP Advertisements. When the local router is not the BSR, this information is obtained from received Bootstrap messages.
show ip pimsm interface	Displays the current PIM-SM status for a specific interface or for all interfaces.
show ip pimsm nexthop	Displays the PIM-SM Next Hop Table.
show ip pimsm mroute	Displays the PIM-SM Multicast Routing Table.
show ip pimsm static-rp	Displays the PIM Static RP table, which includes group address/mask, the static Rendezvous Point (RP) address, and the current status of Static RP configuration (i.e., enabled or disabled).

For more information about the displays that result from these commands, see the *CLI Command Reference Guide*.

PIM-SSM Support

Protocol Independent Multicast Source-Specific Multicast (PIM-SSM) is a highly-efficient extension of PIM. SSM, using an explicit channel subscription model, allows receivers to receive multicast traffic directly from the source; an RP tree model is not used. In other words, a Shortest Path Tree (SPT) between the receiver and the source is created without the use of a Rendezvous Point (RP).

By default, PIM-SM software supports Source-Specific Multicast. No additional user configuration is required. PIM-SSM is automatically enabled and operational as long as PIM-SM is loaded (see page 4-4) and IGMPv3 source-specific joins are received within the SSM address range.

For detailed information on PIM-SSM and Source-Specific Multicast, refer to the IETF Internet Drafts draft-ietf-pim-sm-v2-new-05.txt and draft-ietf-ssm-arch-04.txt, as well as RFC 3569, “An Overview of Source-Specific Multicast (SSM).”

Note. For networks using IGMP proxy, be sure that the IGMP proxy version is set to Version 3. Otherwise, PIM-SSM will not function. For information on configuring the IGMP proxy version, refer to the **ip multicast igmp-proxy-version** command.

Source-Specific Multicast Addresses

Multicast addresses 232.0.0.0 through 232.255.255.255 have been reserved by the Internet Assigned Numbers Authority (IANA) as Source-Specific Multicast (SSM) destination addresses. Addresses within this range are reserved for use by source-specific applications and protocols (e.g., PIM-SSM) and cannot be used for any other functions or protocols.

PIM-SSM Specifications

RFCs Supported	3569—An Overview of Source-Specific Multicast (SSM)
Internet Drafts Supported	draft-ietf-pim-sm-v2-new-05.txt—Protocol Independent Multicast – Sparse Mode (PIM-SM) draft-ietf-ssm-arch-04.txt—An Overview of Source-Specific Multicast (SSM)
Valid SSM Address Range	232.0.0.0 to 232.255.255.255

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G. Random.c

PR 30872 B Kesner created May 5 2000
PR 30872 B Kesner June 16 2000 moved batch_entropy_process to own task iWhirlpool to make code more efficient

random.c -- A strong random number generator

Version 1.89, last modified 19-Sep-99

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