ExtremeWare™ Software User Guide

Software Version 7.0.0

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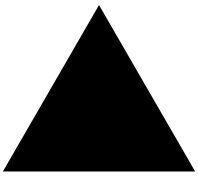

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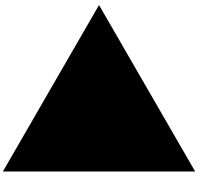


Preface

This preface provides an overview of this guide, describes guide conventions, and lists other publications that might be useful.

Introduction

This guide provides the required information to configure ExtremeWare® software running on either modular or stand-alone switches from Extreme Networks.

This guide is intended for use by network administrators who are responsible for installing and setting up network equipment. It assumes a basic working knowledge of:

- Local area networks (LANs)
- Ethernet concepts
- Ethernet switching and bridging concepts
- Routing concepts
- Internet Protocol (IP) concepts
- Routing Information Protocol (RIP) and Open Shortest Path First (OSPF).
- Border Gateway Protocol (BGP-4) concepts
- IP Multicast concepts
- Distance Vector Multicast Routing Protocol (DVMRP) concepts
- Protocol Independent Multicast (PIM) concepts
- Internet Packet Exchange (IPX) concepts
- Server Load Balancing (SLB) concepts
- Simple Network Management Protocol (SNMP)

NOTE

If the information in the release notes shipped with your switch differs from the information in this guide, follow the release notes.

Terminology

When features, functionality, or operation is specific to a modular or stand-alone switch family, the family name is used. Explanations about features and operations that are the same across all product families simply refer to the product as the “switch.”

When “configure” and “unconfigure” commands are discussed, those commands are truncated to “config” and “unconfig” in the text.

Conventions

Table 1 and Table 2 list conventions that are used throughout this guide.

Table 1: Notice Icons

Icon	Notice Type	Alerts you to...
	Note	Important features or instructions.
	Caution	Risk of personal injury, system damage, or loss of data.
	Warning	Risk of severe personal injury.

Table 2: Text Conventions

Convention	Description
`Screen displays`	This typeface indicates command syntax, or represents information as it appears on the screen.
The words “enter” and “type”	When you see the word “enter” in this guide, you must type something, and then press the Return or Enter key. Do not press the Return or Enter key when an instruction simply says “type.”
[Key] names	Key names are written with brackets, such as [Return] or [Esc]. If you must press two or more keys simultaneously, the key names are linked with a plus sign (+). Example: Press [Ctrl]+[Alt]+[Del].
Words in *italicized* type	Italics emphasize a point or denote new terms at the place where they are defined in the text.

Related Publications

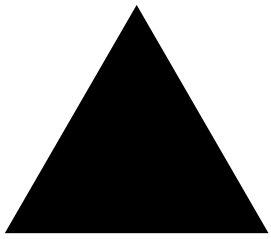
The publications related to this one are:

- ExtremeWare release notes
- *ExtremeWare Software Command Reference Guide*
- *ExtremeWare 7.0.0 Software Quick Reference Guide*

- *Extreme Networks Consolidated Hardware Guide*

Documentation for Extreme Networks products is available on the World Wide Web at the following location:

http://www.extremenetworks.com/



Part 1
Using ExtremeWare

1 ExtremeWare Overview

This chapter covers the following topics:

- Summary of Features on page 29
- Software Licensing on page 32
- Software Factory Defaults on page 34

ExtremeWare is the full-featured software operating system that is designed to run on the Extreme Networks families of modular and stand-alone Gigabit Ethernet switches.

NOTE

ExtremeWare 7.0.0 only supports Extreme Networks products that contain the "i" series chipset.

Summary of Features

The features of ExtremeWare include:

- Virtual local area networks (VLANs) including support for IEEE 802.1Q and IEEE 802.1p
- VLAN aggregation
- Spanning Tree Protocol (STP) (IEEE 802.1D) with multiple STP domains
- Policy-Based Quality of Service (PB-QoS)
- Wire-speed Internet Protocol (IP) routing
- IP Multinetting
- DHCP/BOOTP Relay
- Extreme Standby Router Protocol (ESRP)
- Virtual Router Redundancy Protocol (VRRP)
- Routing Information Protocol (RIP) version 1 and RIP version 2
- Open Shortest Path First (OSPF) routing protocol
- Border Gateway Protocol (BGP) version 4
- Wire-speed IP multicast routing support
- Diffserv support

- Access-policy support for routing protocols
- Access list support for packet filtering
- IGMP snooping to control IP multicast traffic
- Distance Vector Multicast Routing Protocol (DVMRP)
- Protocol Independent Multicast-Dense Mode (PIM-DM)
- Protocol Independent Multicast-Sparse Mode (PIM-SM)
- Wire-speed IPX, IPX/RIP, and IPX/SAP support
- Server Load Balancing (SLB) support
- Load sharing on multiple ports, across all blades (modular switches only)
- RADIUS client and per-command authentication support
- TACACS+ support
- Console command line interface (CLI) connection
- Telnet CLI connection
- SSH2 connection
- ExtremeWare Vista Web-based management interface
- Simple Network Management Protocol (SNMP) support
- Remote Monitoring (RMON)
- System Monitoring (SMON)
- Traffic mirroring
- NetLogin support
- Accounting and Routing Module (ARM) support
- Asynchronous Transfer Mode Module (ATM) support
- Packet over SONET (PoS) Module support
- WAN Module support
- MultiProtocol Label Switching (MPLS) support
- Destination-Sensitive Accounting (DSA) support

NOTE

For more information on Extreme Networks switch components (the BlackDiamond 6800 family, the Alpine 3800 family, or the Summit™ switch family), see the Extreme Networks Consolidated Hardware Guide*.*

Virtual LANs (VLANs)

ExtremeWare has a VLAN feature that enables you to construct your broadcast domains without being restricted by physical connections. A VLAN is a group of location- and topology-independent devices that communicate as if they were on the same physical local area network (LAN).

Implementing VLANs on your network has the following three advantages:

- VLANs help to control broadcast traffic. If a device in VLAN *Marketing* transmits a broadcast frame, only VLAN *Marketing* devices receive the frame.

- VLANs provide extra security. Devices in VLAN *Marketing* can only communicate with devices on VLAN *Sales* using routing services.
- VLANs ease the change and movement of devices on networks.

NOTE

For more information on VLANs, see Chapter 5.

Spanning Tree Protocol

The switch supports the IEEE 802.1D Spanning Tree Protocol (STP), which is a bridge-based mechanism for providing fault tolerance on networks. STP enables you to implement parallel paths for network traffic, and ensure that:

- Redundant paths are disabled when the main paths are operational.
- Redundant paths are enabled if the main traffic paths fail.

A single spanning tree can span multiple VLANs.

NOTE

For more information on STP, see Chapter 13.

Quality of Service

ExtremeWare has Policy-Based Quality of Service (QoS) features that enable you to specify service levels for different traffic groups. By default, all traffic is assigned the *normal* QoS policy profile. If needed, you can create other QoS policies and apply them to different traffic types so that they have different guaranteed minimum bandwidth, maximum bandwidth, and priority.

NOTE

For more information on Quality of Service, see Chapter 7.

Unicast Routing

The switch can route IP or IPX traffic between the VLANs that are configured as virtual router interfaces. Both dynamic and static IP routes are maintained in the routing table. The following routing protocols are supported:

- RIP version 1
- RIP version 2
- OSPF version 2
- IS-IS
- IPX/RIP
- BGP version 4

NOTE

For more information on IP unicast routing, see Chapter 16. For more information on IPX/RIP, see Chapter 20.

IP Multicast Routing

The switch can use IP multicasting to allow a single IP host to transmit a packet to a group of IP hosts. ExtremeWare supports multicast routes that are learned by way of the Distance Vector Multicast Routing Protocol (DVMRP) or the Protocol Independent Multicast (dense mode or sparse mode).

NOTE

For more information on IP multicast routing, see Chapter 19.

Load Sharing

Load sharing allows you to increase bandwidth and resiliency by using a group of ports to carry traffic in parallel between systems. The load sharing algorithm allows the switch to use multiple ports as a single logical port. For example, VLANs see the load-sharing group as a single virtual port. The algorithm also guarantees packet sequencing between clients.

NOTE

For information on load sharing, see Chapter 4.

Software Licensing

Some Extreme Networks products have capabilities that are enabled by using a license key. Keys are typically unique to the switch, and are not transferable. Keys are stored in NVRAM and, once entered, persist through reboots, software upgrades, and reconfigurations. The following sections describe the features that are associated with license keys.

Router Licensing

Some switches support software licensing for different levels of router functionality. In ExtremeWare version 6.0 and above, routing protocol support is separated into two sets: Basic and Full L3. Basic is a subset of Full L3.

Basic Functionality

Basic functionality requires *no license key.* All Extreme switches have Basic layer 3 functionality, without the requirement of a license key. Basic functionality includes all switching functions, and also includes all available layer 3 QoS, access list, and ESRP functions. Layer 3 routing functions include support for:

- IP routing using RIP version 1 and/or RIP version 2
- IP routing between directly attached VLANs
- IP routing using static routes

- Network Login
- VRRP

Full L3 Functionality

On switches that support router licensing, the Full L3 license enables support of additional routing protocols and functions, including:

- IP routing using OSPF
- IP multicast routing using DVMRP
- IP multicast routing using PIM (Dense Mode or Sparse Mode)
- IP routing using BGP
- IPX routing (direct, static, and dynamic using IPX/RIP and IPX/SAP)
- Server load balancing
- Web cache redirection
- EAPS
- NAT
- IS-IS
- MPLS
- ARM
- PoS
- ATM

Product Support

The Summit1i switch and all BlackDiamond 6800 series switches ship with Full L3 functionality. All other Summit models and the Alpine 3800 series switches are available with either Basic or Full L3 functionality.

Verifying the Router License

To verify the router license, use the `show switch` command.

Obtaining a Router License

You can order the desired functionality from the factory, using the appropriate model of the desired product. If you order licensing from the factory, the switch arrives packaged with a certificate that contains the unique license key(s), and instructions for enabling the correct functionality on the switch. The certificate is typically packaged with the switch documentation. Once the license key is entered, it should not be necessary to enter the information again. However, we recommend keeping the certificate for your records.

You can upgrade the router licensing of an existing product by purchasing a voucher for the desired product and functionality. Please contact your supplier to purchase a voucher.

The voucher contains information and instructions on obtaining a license key for the switch using the Extreme Networks Support website at:

http://www.extremenetworks.com/support/techsupport.asp

or by phoning Extreme Networks Technical Support at:

- (800) 998-2408
- (408) 579-2826

Security Licensing

Certain additional ExtremeWare security features, such as the use of Secure Shell (SSH2) encryption, may be under United States export restriction control. Extreme Networks ships these security features in a disabled state. You can obtain information on enabling these features at no charge from Extreme Networks.

Obtaining a Security License

To obtain information on enabling features that require export restriction, access the Extreme Networks Support website at:

http://www.extremenetworks.com/go/security.htm

Fill out a contact form to indicate compliance or noncompliance with the export restrictions. If you are in compliance, you will be given information that will allow you to enable security features.

Security Features Under License Control

ExtremeWare version 6.0 and above supports the SSH2 protocol. SSH2 allows the encryption of Telnet session data between an SSH2 client and an Extreme Networks switch. ExtremeWare version 6.2.1 and later also enables the switch to function as an SSH2 client, sending encrypted data to an SSH2 server on a remote system. ExtremeWare 6.2.1 also supports the Secure Copy Protocol (SCP). The encryption methods used are under U.S. export restriction control.

Software Factory Defaults

Table 3 shows factory defaults for global ExtremeWare features.

Table 3: ExtremeWare Global Factory Defaults

Item	Default Setting
Serial or Telnet user account	*admin* with no password and *user* with no password
Web network management	Enabled
Telnet	Enabled
SSH2	Disabled
SNMP	Enabled
SNMP read community string	*public*
SNMP write community string	*private*
RMON	Disabled
BOOTP	Enabled on the default VLAN (*default*)
QoS	All traffic is part of the default queue
QoS monitoring	Automatic roving
802.1p priority	Recognition enabled

Table 3: ExtremeWare Global Factory Defaults (continued)

Item	Default Setting
802.3x flow control	Enabled on Gigabit Ethernet ports
Virtual LANs	Three VLANs predefined. VLAN named *default* contains all ports and belongs to the STPD named *s0.* VLAN *mgmt* exists only on switches that have an Ethernet management port, and contains only that port. The Ethernet management port is DTE only, and is not capable of switching or routing. VLAN *MacVLanDiscover* is used only when using the MAC VLAN feature.
802.1Q tagging	All packets are untagged on the default VLAN (*default).*
Spanning Tree Protocol	Disabled for the switch; enabled for each port in the STPD.
Forwarding database aging period	300 seconds (5 minutes)
IP Routing	Disabled
RIP	Disabled
OSPF	Disabled
IP multicast routing	Disabled
IGMP	Enabled
IGMP snooping	Enabled
DVMRP	Disabled
GVRP	Disabled
PIM-DM	Disabled
IPX routing	Disabled
NTP	Disabled
DNS	Disabled
Port mirroring	Disabled
MPLS	Disabled

NOTE

For default settings of individual ExtremeWare features, see individual chapters in this guide.

2 Accessing the Switch

This chapter covers the following topics:

- Understanding the Command Syntax on page 37
- Line-Editing Keys on page 40
- Command History on page 41
- Common Commands on page 41
- Configuring Management Access on page 43
- Domain Name Service Client Services on page 46
- Checking Basic Connectivity on page 46

Understanding the Command Syntax

This section describes the steps to take when entering a command. Refer to the sections that follow for detailed information on using the command line interface.

ExtremeWare command syntax is described in detail in the *ExtremeWare Software Command Reference Guide*. Some commands are also described in this user guide, in order to describe how to use the features of the ExtremeWare software. However, only a subset of commands are described here, and in some cases only a subset of the options that a command supports. The *ExtremeWare Software Command Reference Guide* should be considered the definitive source for information on ExtremeWare commands.

When entering a command at the prompt, ensure that you have the appropriate privilege level. Most configuration commands require you to have the administrator privilege level. To use the command line interface (CLI), follow these steps:

1 Enter the command name.

If the command does not include a parameter or values, skip to step 3. If the command requires more information, continue to step 2.

2 If the command includes a parameter, enter the parameter name and values.

3 The value part of the command specifies how you want the parameter to be set. Values include numerics, strings, or addresses, depending on the parameter.

4 After entering the complete command, press [Return].

NOTE

If an asterisk (*) appears in front of the command-line prompt, it indicates that you have outstanding configuration changes that have not been saved. For more information on saving configuration changes, see Appendix A.

Syntax Helper

The CLI has a built-in syntax helper. If you are unsure of the complete syntax for a particular command, enter as much of the command as possible and press [Tab]. The syntax helper provides a list of options for the remainder of the command, and places the cursor at the end of the command you have entered so far, ready for the next option.

If the command is one where the next option is a named component, such as a VLAN, access profile, or route map, the syntax helper will also list any currently configured names that might be used as the next option. In situations where this list might be very long, the syntax helper will list only one line of names, followed by an ellipses to indicate that there are more names than can be displayed.

The syntax helper also provides assistance if you have entered an incorrect command.

Abbreviated Syntax

Abbreviated syntax is the shortest unambiguous allowable abbreviation of a command or parameter. Typically, this is the first three letters of the command. If you do not enter enough letters to allow the switch to determine which command you mean, the syntax helper will provide a list of the options based on the portion of the command you have entered.

NOTE

When using abbreviated syntax, you must enter enough characters to make the command unambiguous and distinguishable to the switch.

Command Shortcuts

All named components of the switch configuration must have a unique name. Components are typically named using the `create` command. When you enter a command to configure a named component, you do not need to use the keyword of the component. For example, to create a VLAN, you must enter a unique VLAN name:

```
create vlan engineering
```

Once you have created the VLAN with a unique name, you can then eliminate the keyword `vlan` from all other commands that require the name to be entered. For example, instead of entering the modular switch command

```
configure vlan engineering delete port 1:3,4:6
```

you could enter the following shortcut:

```
configure engineering delete port 1:3,4:6
```

Similarly, on the stand-alone switch, instead of entering the command

```
configure vlan engineering delete port 1-3,6
```

you could enter the following shortcut:

```
configure engineering delete port 1-3,6
```

Modular Switch Numerical Ranges

Commands that require you to enter one or more port numbers on a modular switch use the parameter <portlist> in the syntax. A <portlist> can be one port on a particular slot. For example,

```
port 3:1
```

A <portlist> can be a range of numbers. For example,

```
port 3:1-3:3
```

You can add additional slot and port numbers to the list, separated by a comma:

```
port 3:1,4:8,6:10
```

You can specify all ports on a particular slot. For example,

```
port 3:*
```

indicates all ports on slot 3.

You can specify a range of slots and ports. For example,

```
port 2:3-4:5
```

indicates slot 2, port 3 through slot 4, port 5.

Stand-alone Switch Numerical Ranges

Commands that require you to enter one or more port numbers on a stand-alone switch use the parameter <portlist> in the syntax. A portlist can be a range of numbers, for example:

```
port 1-3
```

You can add additional port numbers to the list, separated by a comma:

```
port 1-3,6,8
```

Names

All named components of the switch configuration must have a unique name. Names must begin with an alphabetical character and are delimited by whitespace, unless enclosed in quotation marks. Names are not case-sensitive. Names cannot be tokens used on the switch.

Symbols

You may see a variety of symbols shown as part of the command syntax. These symbols explain how to enter the command, and you do not type them as part of the command itself. Table 4 summarizes command syntax symbols.

Table 4: Command Syntax Symbols

Symbol	Description
angle brackets < >	Enclose a variable or value. You must specify the variable or value. For example, in the syntax `config vlan <vlan name> ipaddress <ip_address>` you must supply a VLAN name for `<vlan name>` and an address for `<ip_address>` when entering the command. Do not type the angle brackets.
square brackets [ ]	Enclose a required value or list of required arguments. One or more values or arguments can be specified. For example, in the syntax `use image [primary | secondary]` you must specify either the primary or secondary image when entering the command. Do not type the square brackets.
vertical bar |	Separates mutually exclusive items in a list, one of which must be entered. For example, in the syntax `config snmp community [read-only | read-write] <string>` you must specify either the read or write community string in the command. Do not type the vertical bar.
braces { }	Enclose an optional value or a list of optional arguments. One or more values or arguments can be specified. For example, in the syntax `reboot {<date> <time> | cancel}` you can specify either a particular date and time combination, or the keyword `cancel` to cancel a previously scheduled reboot. If you do not specify an argument, the command will prompt, asking if you want to reboot the switch now. Do not type the braces.

Limits

The command line can process up to 200 characters, including spaces. If you enter more than 200 characters, the switch generates a stack overflow error and processes the first 200 characters.

Line-Editing Keys

Table 5 describes the line-editing keys available using the CLI.

Table 5: Line-Editing Keys

Key(s)	Description
Backspace	Deletes character to left of cursor and shifts remainder of line to left.
Delete or [Ctrl] + D	Deletes character under cursor and shifts remainder of line to left.
[Ctrl] + K	Deletes characters from under cursor to end of line.
Insert	Toggles on and off. When toggled on, inserts text and shifts previous text to right.
Left Arrow	Moves cursor to left.

Table 5: Line-Editing Keys (continued)

Key(s)	Description
Right Arrow	Moves cursor to right.
Home or [Ctrl] + A	Moves cursor to first character in line.
End or [Ctrl] + E	Moves cursor to last character in line.
[Ctrl] + L	Clears screen and movers cursor to beginning of line.
[Ctrl] + P or Up Arrow	Displays previous command in command history buffer and places cursor at end of command.
[Ctrl] + N or Down Arrow	Displays next command in command history buffer and places cursor at end of command.
[Ctrl] + U	Clears all characters typed from cursor to beginning of line.
[Ctrl] + W	Deletes previous word.

Command History

ExtremeWare "remembers" the last 49 commands you entered. You can display a list of these commands by using the following command:

```
history
```

Common Commands

Table 6 describes some of the common commands used to manage the switch. Commands specific to a particular feature may also be described in other chapters of this guide. For a detailed description of the commands and their options, see the *ExtremeWare Software Command Reference Guide.*

Table 6: Common Commands

Command	Description
clear session <number>	Terminates a Telnet session from the switch.
config account <username>	Configures a user account password. The switch will interactively prompt for a new password, and for reentry of the password to verify it. Passwords must have a minimum of 1 character and can have a maximum of 32 characters. Passwords are case-sensitive; user names are not case sensitive.
config banner	Configures the banner string. You can enter up to 24 rows of 79-column text that is displayed before the login prompt of each session. Press [Return] at the beginning of a line to terminate the command and apply the banner. To clear the banner, press [Return] at the beginning of the first line.
config banner netlogin	Configures the network login banner string. You can enter up to 1024 characters to be displayed before the login prompt of each session.
config ports <portlist> auto off {speed [10 | 100 | 1000]} duplex [half | full]	Manually configures the port speed and duplex setting of one or more ports on a switch.
config slot <slot number> module <module name>	Configures a slot for a particular I/O module card.

Table 6: Common Commands (continued)

Command	Description
config ssh2 key {pregenerated}	Generates the SSH2 host key.
config sys-recovery-level [none | [critical | all] [shutdown | reboot | msm-failover]]	Configures a recovery option for instances where an exception occurs in ExtremeWare. The `msm-failover` option is available on BlackDiamond® switches only. If `msm-failover` is specified, a software exception triggers a slave MSM failover to master.
config time <date> <time>	Configures the system date and time. The format is as follows: `mm/dd/yyyy hh:mm:ss` The time uses a 24-hour clock format. You cannot set the year past 2036.
config timezone <gmt_offset> {autodst | noautodst}	Configures the time zone information to the configured offset from GMT time. The format of `gmt_offset` is +/- minutes from GMT time. The `autodst` and `noautodst` options enable and disable automatic Daylight Saving Time change based on the North American standard. Additional options are described in the *ExtremeWare Software Command Reference Guide*.
config vlan <vlan name> ipaddress <ip_address> {<mask>}	Configures an IP address and subnet mask for a VLAN.
create account [admin | user] <username> {<password>}	Creates a user account. This command is available to admin-level users and to users with RADIUS command authorization. The username is between 1 and 32 characters, the password is between 0 and 32 characters.
create vlan <vlan name>	Creates a VLAN.
delete account <username>	Deletes a user account.
delete vlan <vlan name>	Deletes a VLAN.
disable bootp vlan [<vlan name> | all]	Disables BOOTP for one or more VLANs.
disable cli-config-logging	Disables logging of CLI commands to the Syslog.
disable clipaging	Disables pausing of the screen display when a show command output reaches the end of the page.
disable idletimeouts	Disables the timer that disconnects all sessions. Once disabled, console sessions remain open until the switch is rebooted or you logoff. Telnet sessions remain open until you close the Telnet client.
disable ports [<portlist> | all]	Disables a port on the switch.
disable ssh2	Disables SSH2 Telnet access to the switch.
disable telnet	Disables Telnet access to the switch.
disable web	Disables web access to the switch.
enable bootp vlan [<vlan name> | all]	Enables BOOTP for one or more VLANs.
enable cli-config-logging	Enables the logging of CLI configuration commands to the Syslog for auditing purposes. The default setting is enabled.
enable clipaging	Enables pausing of the screen display when `show` command output reaches the end of the page. The default setting is enabled.
enable idletimeouts	Enables a timer that disconnects all sessions (both Telnet and console) after 20 minutes of inactivity. The default setting is disabled.

Table 6: Common Commands (continued)

Command	Description
enable license fullL3 <license_key>	Enables a particular software feature license. Specify <license_key> as an integer. The command unconfig switch all does not clear licensing information. This license cannot be disabled once it is enabled on the switch.
enable ssh2 {access-profile [<access_profile> | none]} {port <tcp_port_number>}	Enables SSH2 sessions. By default, SSH2 is enabled with no access profile, and uses TCP port number 22. To cancel a previously configured access-profile, use the none option.
enable telnet {access-profile [<access_profile> | none]} {port <tcp_port_number>}	Enables Telnet access to the switch. By default, Telnet is enabled with no access profile, and uses TCP port number 23. To cancel a previously configured access-profile, use the none option.
enable web {access-profile [<access_profile> | none]} {port <tcp_port_number>}	Enables ExtremeWare Vista™ web access to the switch. By default, web access is enabled with no access profile, using TCP port number 80. Use the none option to cancel a previously configured access-profile. You must reboot the switch for this command to take effect.
history	Displays the previous 49 commands entered on the switch.
show banner	Displays the user-configured banner.
unconfig switch {all}	Resets all switch parameters (with the exception of defined user accounts, and date and time information) to the factory defaults. If you specify the keyword all, the switch erases the currently selected configuration image in flash memory and reboots. As a result, all parameters are reset to default settings.

Configuring Management Access

ExtremeWare supports the following two levels of management:

- User
- Administrator

In addition to the management levels, you can optionally use an external RADIUS server to provide CLI command authorization checking for each command. For more information on RADIUS, see "RADIUS Client" in Chapter 3.

User Account

A user-level account has viewing access to all manageable parameters, with the exception of:

- User account database.
- SNMP community strings.

A user-level account can use the ping command to test device reachability, and change the password assigned to the account name. If you have logged on with user capabilities, the command-line prompt ends with a (>) sign. For example:

```
Summit1:2>
```

Administrator Account

An administrator-level account can view and change all switch parameters. It can also add and delete users, and change the password associated with any account name. The administrator can disconnect a management session that has been established by way of a Telnet connection. If this happens, the user logged on by way of the Telnet connection is notified that the session has been terminated.

If you have logged on with administrator capabilities, the command-line prompt ends with a (#) sign. For example:

```
Summit1:18#
```

Prompt Text

The prompt text is taken from the SNMP sysname setting. The number that follows the colon indicates the sequential line/command number.

If an asterisk (*) appears in front of the command-line prompt, it indicates that you have outstanding configuration changes that have not been saved. For example:

```
*Summit1:19#
```

Default Accounts

By default, the switch is configured with two accounts, as shown in Table 7.

Table 7: Default Accounts

Account Name	Access Level
admin	This user can access and change all manageable parameters. The admin account cannot be deleted.
user	This user can view (but not change) all manageable parameters, with the following exceptions: • This user cannot view the user account database. • This user cannot view the SNMP community strings.

Changing the Default Password

Default accounts do not have passwords assigned to them. Passwords can have a minimum of zero characters and can have a maximum of 32 characters.

NOTE

Passwords are case-sensitive; user names are not case-sensitive.

To add a password to the default admin account, follow these steps:

1. Log in to the switch using the name *admin*.
2. At the password prompt, press [Return].
3. Add a default admin password by entering the following command:

   ```
   config account admin
   ```

4. Enter the new password at the prompt.

5 Re-enter the new password at the prompt.

To add a password to the default user account, follow these steps:

1 Log in to the switch using the name *admin*.

2 At the password prompt, press [Return], or enter the password that you have configured for the *admin* account.

3 Add a default user password by entering the following command:

```
config account user
```

4 Enter the new password at the prompt.

5 Re-enter the new password at the prompt.

NOTE

If you forget your password while logged out of the command line interface, contact your local technical support representative, who will advise on your next course of action.

Creating a Management Account

The switch can have a total of 16 management accounts. You can use the default names (*admin* and *user*), or you can create new names and passwords for the accounts. Passwords can have a minimum of 0 characters and can have a maximum of 32 characters.

To create a new account, follow these steps:

1 Log in to the switch as *admin*.

2 At the password prompt, press [Return], or enter the password that you have configured for the *admin* account.

3 Add a new user by using the following command:

```
create account [admin | pppuser | user] <username>
```

4 Enter the password at the prompt.

5 Re-enter the password at the prompt.

Viewing Accounts

To view the accounts that have been created, you must have administrator privileges. Use the following command to see the accounts:

```
show accounts
```

Deleting an Account

To delete a account, you must have administrator privileges. To delete an account, use the following command:

```
delete account <username>
```

NOTE

Do not delete the default administrator account. If you do, it is automatically restored, with no password, the next time you download a configuration. To ensure security, change the password on the default account, but do not delete it. The changed password will remain intact through configuration uploads and downloads.

If you must *delete the default account, first create another administrator-level account. Remember to manually delete the default account again every time you download a configuration.*

Domain Name Service Client Services

The Domain Name Service (DNS) client in ExtremeWare augments the following commands to allow them to accept either IP addresses or host names:

- `telnet`
- `download [bootrom | configuration | image]`
- `upload configuration`
- `ping`
- `traceroute`

In addition, the `nslookup` utility can be used to return the IP address of a hostname.

You can specify up to eight DNS servers for use by the DNS client using the following command:

```
config dns-client add <ipaddress>
```

You can specify a default domain for use when a host name is used without a domain. Use the following command:

```
config dns-client default-domain <domain name>
```

For example, if you specify the domain “xyz-inc.com” as the default domain, then a command such as `ping accounting1` will be taken as if it had been entered `ping accounting1.xyz-inc.com`.

Checking Basic Connectivity

The switch offers the following commands for checking basic connectivity:

- `ping`
- `traceroute`

Ping

The ping command enables you to send Internet Control Message Protocol (ICMP) echo messages to a remote IP device. The ping command is available for both the user and administrator privilege level.

The ping command syntax is:

```
ping {udp} {continuous} {size <start_size> {- <end_size>}} [<ip_address> | <hostname>]
{from <src_address> | with record-route | from <src_ipaddress> with record-route}
```

Options for the ping command are described in Table 8.

Table 8: Ping Command Parameters

Parameter	Description
udp	Specifies that UDP messages should be sent instead of ICMP echo messages. When specified, from and with record-route options are not supported.
continuous	Specifies ICMP echo messages to be sent continuously. This option can be interrupted by pressing any key.
size	Specifies the size of the ICMP request. If both the start_size and end_size are specified, transmits ICMP requests using 1 byte increments, per packet. If no end_size is specified, packets of start_size are sent.
<ipaddress>	Specifies the IP address of the host.
<hostname>	Specifies the name of the host. To use the hostname, you must first configure DNS.
from	Uses the specified source address in the ICMP packet. If not specified, the address of the transmitting interface is used.
with record-route	Decodes the list of recorded routes and displays them when the ICMP echo reply is received.

If a ping request fails, the switch continues to send ping messages until interrupted. Press any key to interrupt a ping request. The statistics are tabulated after the ping is interrupted.

Traceroute

The traceroute command enables you to trace the routed path between the switch and a destination endstation. The traceroute command syntax is:

```
traceroute [<ip_address> | <hostname>] {from <src_ipaddress>} {ttl <TTL>} {port
<port>}
```

where:

- ip_address is the IP address of the destination endstation.
- hostname is the hostname of the destination endstation. To use the hostname, you must first configure DNS.
- from uses the specified source address in the ICMP packet. If not specified, the address of the transmitting interface is used.
- ttl configures the switch to trace the hops until the time-to-live has been exceeded for the switch.
- port uses the specified UDP port number.

3 Managing the Switch

This chapter covers the following topics:

- Overview on page 49
- Using the Console Interface on page 50
- Using the 10/100 Ethernet Management Port on page 50
- Using Telnet on page 51
- Using Secure Shell 2 (SSH2) on page 54
- Using ExtremeWare Vista on page 54
- Using SNMP on page 59
- Authenticating Users on page 61
- Using Network Login on page 62
- Using the Simple Network Time Protocol on page 62

Overview

Using ExtremeWare, you can manage the switch using the following methods:

- Access the CLI by connecting a terminal (or workstation with terminal-emulation software) to the console port.
- Access the switch remotely using TCP/IP through one of the switch ports or through the dedicated 10/100 unshielded twisted pair (UTP) Ethernet management port (on switches that are so equipped). Remote access includes:
  - Telnet using the CLI interface.
  - SSH2 using the CLI interface.
  - ExtremeWare Vista web access using a standard web browser.
  - SNMP access using EPICenter or another SNMP manager.
- Download software updates and upgrades. For more information, see Appendix B, Software Upgrade and Boot Options.

The switch supports up to the following number of concurrent user sessions:

- One console session
  - Two console sessions are available on a modular switch that has two management modules installed.
- Eight Telnet sessions
- Eight SSH2 sessions
- One web session

Using the Console Interface

The CLI built into the switch is accessible by way of the 9-pin, RS-232 port labeled *console*, located on the back of the stand-alone switch, or on the front of the modular switch management module.

NOTE

For more information on the console port pinouts, see the hardware installation guide that shipped with your switch.

After the connection has been established, you will see the switch prompt and you can log in.

Using the 10/100 Ethernet Management Port

Some Extreme switch models provide a dedicated 10/100 Ethernet management port. This port provides dedicated remote access to the switch using TCP/IP. It supports the following management methods:

- Telnet using the CLI interface
- ExtremeWare Vista web access using a standard web browser
- SNMP access using EPICenter or another SNMP manager

The management port is a DTE port, and is not capable of supporting switching or routing functions. The TCP/IP configuration for the management port is done using the same syntax as used for VLAN configuration. The VLAN *mgmt* comes preconfigured with only the 10/100 UTP management port as a member.

You can configure the IP address, subnet mask, and default router for the VLAN *mgmt*, using the following commands:

```
config vlan mgmt ipaddress <ip_address>/<subnet_mask>
config iproute add default <gateway>
```

Using Telnet

Any workstation with a Telnet facility should be able to communicate with the switch over a TCP/IP network.

Up to eight active Telnet sessions can access the switch concurrently. If `idletimeouts` are enabled, the Telnet connection will time out after 20 minutes of inactivity. If a connection to a Telnet session is lost inadvertently, the switch terminates the session within two hours.

Before you can start a Telnet session, you must set up the IP parameters described in "Configuring Switch IP Parameters" later in this chapter. Telnet is enabled by default.

To open the Telnet session, you must specify the IP address of the device that you want to manage. Check the user manual supplied with the Telnet facility if you are unsure of how to do this.

After the connection is established, you will see the switch prompt and you may log in.

Connecting to Another Host Using Telnet

You can Telnet from the current CLI session to another host using the following command:

```
telnet [<ipaddress> | <hostname>] {<port_number>}
```

If the TCP port number is not specified, the Telnet session defaults to port 23. Only VT100 emulation is supported.

Configuring Switch IP Parameters

To manage the switch by way of a Telnet connection or by using an SNMP Network Manager, you must first configure the switch IP parameters.

Using a BOOTP Server

If you are using IP and you have a Bootstrap Protocol (BOOTP) server set up correctly on your network, you must provide the following information to the BOOTP server:

- Switch Media Access Control (MAC) address, found on the rear label of the switch
- IP address
- Subnet address mask (optional)

After this is done, the IP address and subnet mask for the switch will be downloaded automatically. You can then start managing the switch using this addressing information without further configuration.

You can enable BOOTP on a per-VLAN basis by using the following command:

```
enable bootp vlan [<vlan name> | all]
```

By default, BOOTP is enabled on the *default* VLAN.

If you configure the switch to use BOOTP, the switch IP address is not retained through a power cycle, even if the configuration has been saved. To retain the IP address through a power cycle, you must configure the IP address of the VLAN using the command-line interface, Telnet, or web interface.

All VLANs within a switch that are configured to use BOOTP to get their IP address use the same MAC address. Therefore, if you are using BOOTP relay through a router, the BOOTP server relays packets based on the gateway portion of the BOOTP packet.

NOTE

For more information on DHCP/BOOTP relay, see Chapter 16.

Manually Configuring the IP Settings

If you are using IP without a BOOTP server, you must enter the IP parameters for the switch in order for the SNMP Network Manager, Telnet software, or web interface to communicate with the device. To assign IP parameters to the switch, you must perform the following tasks:

- Log in to the switch with administrator privileges using the console interface.
- Assign an IP address and subnet mask to a VLAN.

  The switch comes configured with a default VLAN named *default*. To use Telnet or an SNMP Network Manager, you must have at least one VLAN on the switch, and it must be assigned an IP address and subnet mask. IP addresses are always assigned to each VLAN. The switch can be assigned multiple IP addresses.

NOTE

For information on creating and configuring VLANs, see Chapter 5.

To manually configure the IP settings, follow these steps:

1. Connect a terminal or workstation running terminal-emulation software to the console port, as detailed in "Using the Console Interface" on page 50.
2. At your terminal, press [Return] one or more times until you see the login prompt.
3. At the login prompt, enter your user name and password. Note that they are both case-sensitive. Ensure that you have entered a user name and password with administrator privileges.
   - If you are logging in for the first time, use the default user name *admin* to log in with administrator privileges. For example:

     ```
     login: admin
     ```

     Administrator capabilities enable you to access all switch functions. The default user names have no passwords assigned.
   - If you have been assigned a user name and password with administrator privileges, enter them at the login prompt.
4. At the password prompt, enter the password and press [Return].

   When you have successfully logged in to the switch, the command-line prompt displays the name of the switch in its prompt.
5. Assign an IP address and subnetwork mask for the default VLAN by using the following command:

   ```
   config vlan <vlan name> ipaddress <ipaddress> {<subnet_mask>}
   ```

   For example:

   ```
   config vlan default ipaddress 123.45.67.8 255.255.255.0
   ```

   Your changes take effect immediately.

NOTE

As a general rule, when configuring any IP addresses for the switch, you can express a subnet mask by using dotted decimal notation, or by using classless inter-domain routing notation (CIDR). CIDR uses a forward slash plus the number of bits in the subnet mask. Using CIDR notation, the command identical to the one above would be:

```
config vlan default ipaddress 123.45.67.8 / 24
```

6 Configure the default route for the switch using the following command:

```
config iproute add default <gateway> {<metric>}
```

For example:

```
config iproute add default 123.45.67.1
```

7 Save your configuration changes so that they will be in effect after the next switch reboot, by typing:

```
save
```

8 When you are finished using the facility, log out of the switch by typing:

`logout` or `quit`

Disconnecting a Telnet Session

An administrator-level account can disconnect a Telnet management session. If this happens, the user logged in by way of the Telnet connection is notified that the session has been terminated.

To terminate a Telnet session, follow these steps:

1 Log in to the switch with administrator privileges.

2 Determine the session number of the session you want to terminate by using the following command:

```
show session
```

3 Terminate the session by using the following command:

```
clear session <session_number>
```

Controlling Telnet Access

By default, Telnet services are enabled on the switch. Telnet access can be restricted by the use of an access profile. An access profile permits or denies a named list of IP addresses and subnet masks. To configure Telnet to use an access profile, use the following command:

```
enable telnet {access-profile [<access_profile> | none]} {port <tcp_port_number>}
```

Use the `none` option to remove a previously configured access profile.

To display the status of Telnet, use the following command:

```
show management
```

You can choose to disable Telnet by using the following command:

```
disable telnet
```

To re-enable Telnet on the switch, at the console port use the following:

```
enable telnet
```

You must be logged in as an administrator to enable or disable Telnet.

NOTE

For more information on Access Profiles, see Chapter 11.

Using Secure Shell 2 (SSH2)

Secure Shell 2 (SSH2) is a feature of ExtremeWare that allows you to encrypt Telnet session data between a network administrator using SSH2 client software and the switch, or to send encrypted data from the switch to an SSH2 client on a remote system. Image and configuration files may also be transferred to the switch using the Secure Copy Protocol 2 (SCP2). The ExtremeWare CLI provides a command that enable the switch to function as an SSH2 client, sending commands to a remote system via an SSH2 session. It also provides commands to copy image and configuration files to the switch using the SCP2.

For detailed information about SSH2 and SCP2, see Chapter 11, “Security”.

Using ExtremeWare Vista

The ExtremeWare Vista device-management software that runs on the switch allows you to access the switch over a TCP/IP network using a standard web browser. Any properly configured standard web browser that supports frames and JavaScript (such as Netscape Navigator 3.0 or above, or Microsoft Internet Explorer 3.0 or above) can be used to manage the switch.

ExtremeWare Vista provides a subset of the command-line interface (CLI) commands available for configuring and monitoring the switch. If a particular command is not available using ExtremeWare Vista, you must use the CLI to access the desired functionality.

To use ExtremeWare Vista, at least one VLAN must be assigned an IP address.

NOTE

For more information on assigning an IP address, see “Configuring Switch IP Parameters” on page 51.

The default home page of the switch can be accessed using the following command:

```
http://<ipaddress>
```

When you access the home page of the switch, you are presented with the Logon screen.

Controlling Web Access

By default, web access is disabled on the switch (for ExtremeWare versions previous to 6.2.2 build 18, the default was enabled). Use of ExtremeWare Vista web access can be restricted through the use of an access profile. An access profile permits or denies a named list of IP addresses and subnet masks. To configure Vista web access to use an access profile, use the following command:

```
enable web {access-profile <access-profile> | none} {port <tcp_port_number>}
```

Use the none option to remove a previously configured access profile. Apply an access profile only when ExtremeWare Vista is enabled.

To display the status of web access, use the following command:

```
show management
```

To disable ExtremeWare Vista, use the following command:

```
disable web
```

To re-enable web access, use the `enable web` command.

By default, web access uses TCP port 80. To specify a different port, use the `port` option in the `enable web` command.

To configure the timeout for user to enter username/password in the pop-up window use the following command:

```
config web login-timeout <seconds>
```

By default this timeout is set to 30 seconds.

You will need to reboot the system in order for these changes to take effect.

NOTE

For more information on rebooting, see Appendix A.

Setting Up Your Browser

In general, the default settings that come configured on your browser work well with ExtremeWare Vista. The following are recommended settings that you can use to improve the display features and functionality of ExtremeWare Vista:

- After downloading a newer version of the switch image, clear the browser disk and memory cache to see the updated menu screens. You must clear the cache while at the main ExtremeWare Vista Logon screen, so that all underlying .GIF files are updated.
- Check for newer versions of stored pages. Every visit to the page should be selected as a cache setting.

  If you are using Netscape Navigator, configure the cache option to check for changes “Every Time” you request a page.

  If you are using Microsoft Internet Explorer, configure the Temporary Internet Files setting to check for newer versions of stored pages by selecting “Every visit to the page.”
- Images must be auto-loaded.

- Use a high-resolution monitor to maximize the amount of information displayed in the content frame. The recommended resolution is 1024 x 768 pixels. You can also use 800 x 600 pixels.
- Turn off one or more of the browser toolbars to maximize the viewing space of the ExtremeWare Vista content screen.
- If you will be using ExtremeWare Vista to send an email to the Extreme Networks Technical Support department, configure the email settings in your browser.
- Configure the browser to use the following recommended fonts:
  - Proportional font—Times New Roman
  - Fixed-width font—Courier New

Accessing ExtremeWare Vista

To access the default home page of the switch, enter the following URL in your browser:

http://<ip_address>

When you access the home page of the system, you are presented with the Login screen. Enter your user name and password in the appropriate fields, and click OK.

If you have entered the name and password of an administrator-level account, you have access to all ExtremeWare Vista pages. If you have used a user-level account name and password, you only have access to the Statistics and Support information.

If multiple people access the same switch using ExtremeWare Vista, you might see the following error message:

```
Web:server busy
```

To correct this situation, log out of the switch and log in again.

Navigating ExtremeWare Vista

After logging in to the switch, the ExtremeWare Vista home page is displayed.

ExtremeWare Vista divides the browser screen into the following sections:

- Task frame
- Content frame
- Standalone buttons

Task Frame

The task frame has two sections: menu buttons and submenu links. The four task menu buttons are:

- Configuration
- Statistics
- Support
- Logout

Below the task buttons are options. Options are specific to the task button that you select. When you select an option, the information displayed in the content frame changes. However, when you select a new task button, the content frame does not change until you select a new option.

NOTE

Submitting a configuration page with no change will result in an asterisk (*) appearing at the CLI prompt, even though actual configuration values have not changed.

Content Frame

The content frame contains the main body of information in ExtremeWare Vista. For example, if you select an option from the Configuration task button, enter configuration parameters in the content frame. If you select the Statistics task button, statistics are displayed in the content frame.

Browser Controls. Browser controls include drop-down list boxes, check boxes, and multiselect list boxes. A multiselect list box has a scrollbar on the right side of the box. Using a multiselect list box, you can select a single item, all items, a set of contiguous items, or multiple noncontiguous items. Table 9 describes how to make selections from a multiselect list box.

Table 9: Multiselect List Box Key Definitions

Selection Type	Key Sequence
Single item	Click the item using the mouse.
All items	Click the first item, and drag to the last item.
Contiguous items	Click the first desired item, and drag to the last desired item.
Selected noncontiguous items	Hold down [Ctrl], click the first desired item, click the next desired item, and so on.

Status Messages

Status messages are displayed at the top of the content frame. The four types of status messages are:

- **Information**—Displays information that is useful to know prior to, or as a result of, changing configuration options.
- **Warning**—Displays warnings about the switch configuration.
- **Error**—Displays errors caused by incorrectly configured settings.
- **Success**—Displays informational messages after you click Submit. The message displayed reads, “Request was submitted successfully.”

Standalone Buttons

At the bottom of some of the content frames is a section that contains standalone buttons. Standalone buttons are used to perform tasks that are not associated with a particular configuration option. An example of this is the Reboot Switch button.

Saving Changes

You can save your changes to nonvolatile storage in either of two ways using ExtremeWare Vista:

- Select Save Configuration from the Configuration task button, Switch option.

  This field contains a drop-down list box that allows you to select either the primary or secondary configuration area. After you select the configuration area, click Submit to save the changes.

- Click the Logout button.

  If you attempt to log out without saving your changes, ExtremeWare Vista prompts you to save your changes.

  If you select Yes, the changes are saved to the selected configuration area. To change the selected configuration area, you must go to the Configuration task button, Switch option.

Filtering Information

Some pages have a Filter button. The Filter button is used to display a subset of information on a given page. For example, on the OSPF configuration page, you can configure authentication based on the VLAN, area identifier, or virtual link. Once you select a filtering option and click the Filter button, the form that provides the configuration options displays the available interfaces in the drop-down menu, based on your filtering selection.

Similarly, in certain Configuration and Statistics pages, information is shown based on a particular slot.

Because modular switches allow you to preconfigure modules without having them physically available in the chassis, the configuration pages offer a drop-down menu to select any module card that has been configured on the system, whether or not the module is physically available. By default, information for the first configured module that is found in the chassis is displayed on the page. You can configure available slots and ports by filtering on a selected module from the Sort by Slot drop-down menu.

On the Statistics pages, you can only view information for cards that are configured and physically inserted into the chassis. On these pages, the Sort by Slot drop-down menu displays only these modules.

Do a GET When Configuring a VLAN

When configuring a VLAN using ExtremeWare Vista, prior to editing the VLAN configuration, you must first click the `get` button to ensure that subsequent edits are applied to the correct VLAN. If you do not click the `get` button and you submit the changes, the changes will be made to the VLAN that was previously displayed.

If you configure a VLAN and then delete it, the *default* VLAN is shown in the VLAN name window, but the VLAN information contained in the lower portion of the page is not updated. Click the `get` button to update the display.

Sending Screen Output to Extreme Networks

If Extreme Networks requests that you email the output of a particular ExtremeWare Vista screen, follow these steps:

1. Click on the content frame of the screen that you must send.
2. From Netscape Navigator, select Save Frame As from the File menu, and enter a name for the file.

   From Microsoft Internet Explorer 3.0, select Save As File from the File menu, and enter a name for the file.

   From Microsoft Internet Explorer 4.0, right-click in the content frame, select View Source, and save the HTML text by copying it and pasting it into a text editor.
3. Attach the file to the email message that you are sending to Extreme Networks.

Using SNMP

Any Network Manager running the Simple Network Management Protocol (SNMP) can manage the switch, provided the Management Information Base (MIB) is installed correctly on the management station. Each Network Manager provides its own user interface to the management facilities.

The following sections describe how to get started if you want to use an SNMP manager. It assumes you are already familiar with SNMP management. If not, refer to the following publication:

The Simple Book
by Marshall T. Rose
ISBN 0-13-8121611-9
Published by Prentice Hall.

Accessing Switch Agents

To have access to the SNMP agent residing in the switch, at least one VLAN must have an IP address assigned to it.

By default, SNMP access and SNMP traps are enabled. SNMP access and SNMP traps can be disabled and enabled independently—you can disable SNMP access but still allow SNMP traps to be sent, or vice versa.

Supported MIBs

In addition to private MIBs, the switch supports the standard MIBs listed in Appendix C.

Configuring SNMP Settings

The following SNMP parameters can be configured on the switch:

- **Authorized trap receivers**—An authorized trap receiver can be one or more network management stations on your network. The switch sends SNMP traps to all trap receivers. You can have a maximum of 16 trap receivers configured for each switch, and you can specify a community string and UDP port for individually for each trap receiver. All community strings must also be added to the switch using the `config snmp add community` command.

To configure a trap receiver on a switch, use the following command:

```
config snmp add trapreceiver <ip address> {port <udp_port>} community <community
string> {from <source ip address>} {mode [enhanced | standard]}
```

You can delete a trap receiver using the `config snmp delete trapreceiver` command.

Entries in the trap receiver list can also be created, modified, and deleted using the RMON2 trapDestTable MIB variable, as described in RFC 2021.

- **SNMP read access**—The ability to read SNMP information can be restricted through the use of an access profile. An access profile permits or denies a named list of IP addresses and subnet masks.

  To configure SNMP read access to use an access profile, use the following command:

  ```
  config snmp access-profile readonly [<access_profile> | none]
  ```

  Use the none option to remove a previously configured access profile.

- **SNMP read/write access**—The ability to read and write SNMP information can be restricted through the use of an access profile. An access profile permits or denies a named list of IP addresses and subnet masks.

  To configure SNMP read / write access to use an access profile, use the following command:

  ```
  config snmp access-profile readwrite [<access_profile> | none]
  ```

  Use the none option to remove a previously configured access-profile.

- **Community strings**—The community strings allow a simple method of authentication between the switch and the remote Network Manager. There are two types of community strings on the switch. Read community strings provide read-only access to the switch. The default read-only community string is *public*. Read-write community strings provide read and write access to the switch. The default read-write community string is *private*. Up to 16 read and 16 read-write community strings, including the defaults, can be configured on the switch. The community string for all authorized trap receivers must be configured on the switch for the trap receiver to receive switch-generated traps. SNMP community strings can contain up to 127 characters. To add a community string, use the command:

  ```
  config snmp add community [readonly | readwrite] <string>
  ```

  You can also change the value of the default community strings using the command:

  config snmp community [readonly | readwrite] <string>

- **System contact** (optional)—The system contact is a text field that enables you to enter the name of the person(s) responsible for managing the switch.

- **System name**—The system name is the name that you have assigned to this switch. The default name is the model name of the switch (for example, Summit1 switch).

- **System location** (optional)—Using the system location field, you can enter an optional location for this switch.

- **Enabling/disabling link up and link down traps** (optional)—By default, link up and link down traps (also called port-up-down traps) are enabled on the switch for all ports. You can disable or re-enable the sending of these traps on a per port basis, by using the following commands:

  ```
  disable snmp traps port-up-down ports [all | mgmt | <portlist>]
  ```

  ```
  enable snmp traps port-up-down ports [all | mgmt | <portlist>]
  ```

  The mgmt option will only appear on platforms having a management port.

- **Enabling/disabling MAC-security traps** (optional)—MAC-security traps are sent on ports when limit-learning is configured and a new MAC address appears on the port after the port has already learned MAC addresses up to the configured limit. At such instants, a log message is generated in the syslog, a trap is sent out and the port is blackholed. By default, MAC-security traps are disabled on the switch. To enable or re-disable them, the following commands must be used:

  ```
  enable snmp traps mac-security
  disable snmp traps mac-security
  ```

NOTE

To configure learning limits on a set of ports, the command config ports <portlist> limit-learning can be used.

Displaying SNMP Settings

To display the SNMP settings configured on the switch, use the following command:

```
show management
```

This command displays the following information:

- Enable / disable state for Telnet, SSH2, SNMP, and web access, along with access profile information
- SNMP community strings
- Authorized SNMP station list
- SNMP MAC-security traps
- Link up / link down traps enabled on ports
- SNMP trap receiver list
- RMON polling configuration
- Login statistics
- Enable / disable status of link up and link down traps
- Enable / disable status of MAC-security traps.

Authenticating Users

ExtremeWare provides two methods to authenticate users who login to the switch:

- RADIUS client
- TACACS+

NOTE

You cannot configure RADIUS and TACACS+ at the same time.

RADIUS Client

Remote Authentication Dial In User Service (RADIUS, RFC 2138) is a mechanism for authenticating and centrally administrating access to network nodes. The ExtremeWare RADIUS client implementation allows authentication for Telnet, Vista, or console access to the switch.

TACACS+

Terminal Access Controller Access Control System Plus (TACACS+) is a mechanism for providing authentication, authorization, and accounting on a centralized server, similar in function to the RADIUS client. The ExtremeWare version of TACACS+ is used to authenticate prospective users who are attempting to administer the switch. TACACS+ is used to communicate between the switch and an authentication database.

Configuring RADIUS Client and TACACS+

For detailed information about configuring a RADIUS client or TACACS+, see Chapter 11.

Using Network Login

Network login is a feature designed to control the admission of user packets into a network by giving addresses only to users that have been properly authenticated. Network login is controlled by an administrator on a per port, per VLAN basis and uses an integration of DHCP, user authentication over the web interface, and, sometimes, a RADIUS server to provide a user database or specific configuration details.

When network login is enabled on a port in a VLAN, that port will not forward any packets until authentication takes place.

For detailed information about using Network login, see Chapter 11.

Using the Simple Network Time Protocol

ExtremeWare supports the client portion of the Simple Network Time Protocol (SNTP) Version 3 based on RFC1769. SNTP can be used by the switch to update and synchronize its internal clock from a Network Time Protocol (NTP) server. When enabled, the switch sends out a periodic query to the indicated NTP server, or the switch listens to broadcast NTP updates. In addition, the switch supports the configured setting for Greenwich Mean time (GMT) offset and the use of Daylight Saving Time. These features have been tested for year 2000 compliance.

Configuring and Using SNTP

To use SNTP, follow these steps:

1. Identify the host(s) that are configured as NTP server(s). Additionally, identify the preferred method for obtaining NTP updates. The options are for the NTP server to send out broadcasts, or for switches using NTP to query the NTP server(s) directly. A combination of both methods is possible. You must identify the method that should be used for the switch being configured.
2. Configure the Greenwich Mean Time (GMT) offset and Daylight Saving Time preference. The command syntax to configure GMT offset and usage of Daylight Saving Time is as follows:

```
config timezone {name <std_timezone_ID>} <GMT_offset>
{autodst {name <dst_timezone_ID>} {<dst_offset>}
{begins [every <floatingday> | on <absoluteday>] {at <time_of_day>}
{ends [every <floatingday> | on <absoluteday>] {at <time_of_day>}}}
```

By default, Daylight Saving Time is assumed to begin on the first Sunday in April at 2:00 AM, and end the last Sunday in October at 2:00 AM, and be offset from standard time by one hour. If this is the case in your timezone, you can set up automatic daylight savings adjustment with the command:

```
config timezone <GMT_offset> autodst
```

If your timezone uses starting and ending dates and times that differ from the default, you can specify the starting and ending date and time in terms of a floating day, as follows:

```
config timezone name MET 60 autodst name MDT begins every last sunday march at 1
ends every last sunday october at 1
```

You can also specify a specific date and time, as shown in the following command.

```
config timezone name NZST 720 autodst name NZDT 60 begins every first sunday
october at 2 ends on 3/16/2002 at 2
```

The optional timezone IDs are used to identify the timezone in display commands such as `show switch`.

Table 10 describes the command options in detail:

Table 10: Time Zone Configuration Command Options

GMT_offset	Specifies a Greenwich Mean Time (GMT) offset, in + or - minutes.
std-timezone-ID	Specifies an optional name for this timezone specification. May be up to six characters in length. The default is an empty string.
autodst	Enables automatic Daylight Savings Time.
dst-timezone-ID	Specifies an optional name for this DST specification. May be up to six characters in length. The default is an empty string.
dst_offset	Specifies an offset from standard time, in minutes. Value is in the range of 1 to 60. Default is 60 minutes.
floating_day	Specifies the day, week, and month of the year to begin or end DST each year. Format is: <week><day><month> where: • <week> is specified as [first | second | third | fourth | last] or 1-5 • <day> is specified as [sunday | monday | tuesday | wednesday | thursday | friday | saturday] or 1-7 (where 1 is Sunday) • <month> is specified as [january | february | march | april | may | june | july | august | september | october | november | december] or 1-12 Default for beginning is first sunday april; default for ending is last sunday october.
absolute_day	Specifies a specific day of a specific year on which to begin or end DST. Format is: <month>/<day>/<year> where: • <month> is specified as 1-12 • <day> is specified as 1-31 • <year> is specified as 1970 - 2035 The year must be the same for the begin and end dates.
time_of_day	Specifies the time of day to begin or end Daylight Savings Time. May be specified as an hour (0-23) or as hour:minutes. Default is 2:00.
noautodst	Disables automatic Daylight Savings Time.

Automatic Daylight Savings Time (DST) changes can be enabled or disabled. The default setting is enabled. To disable automatic DST, use the command:

```
config timezone {name <std_timezone_ID>} <GMT_offset> noautodst
```

3 Enable the SNTP client using the following command:

```
enable sntp-client
```

Once enabled, the switch sends out a periodic query to the NTP servers defined later (if configured) or listens to broadcast NTP updates from the network. The network time information is automatically saved into the on-board real-time clock.

4 If you would like this switch to use a directed query to the NTP server, configure the switch to use the NTP server(s). If the switch listens to NTP broadcasts, skip this step. To configure the switch to use a directed query, use the following command:

```
config sntp-client [primary | secondary] server [<ip_address> | <hostname>]
```

NTP queries are first sent to the primary server. If the primary server does not respond within 1 second, or if it is not synchronized, the switch queries the secondary server (if one is configured). If the switch cannot obtain the time, it restarts the query process. Otherwise, the switch waits for the `sntp-client update interval` before querying again.

5 Optionally, the interval for which the SNTP client updates the real-time clock of the switch can be changed using the following command:

```
config sntp-client update-interval <seconds>
```

The default `sntp-client update-interval` value is 64 seconds.

6 You can verify the configuration using the following commands:

— `show sntp-client`

This command provides configuration and statistics associated with SNTP and its connectivity to the NTP server.

— `show switch`

This command indicates the GMT offset, the Daylight Savings Time configuration and status, and the current local time.

NTP updates are distributed using GMT time. To properly display the local time in logs and other timestamp information, the switch should be configured with the appropriate offset to GMT based on geographical location. Table 11 describes GMT offsets.

Table 11: Greenwich Mean Time Offsets

GMT Offset in Hours	GMT Offset in Minutes	Common Time Zone References	Cities
+0:00	+0	GMT - Greenwich Mean UT or UTC - Universal (Coordinated) WET - Western European	London, England; Dublin, Ireland; Edinburgh, Scotland; Lisbon, Portugal; Reykjavik, Iceland; Casablanca, Morocco
-1:00	-60	WAT - West Africa	Azores, Cape Verde Islands
-2:00	-120	AT - Azores	
-3:00	-180		Brasilia, Brazil; Buenos Aires, Argentina; Georgetown, Guyana;
-4:00	-240	AST - Atlantic Standard	Caracas; La Paz
-5:00	-300	EST - Eastern Standard	Bogota, Columbia; Lima, Peru; New York, NY, Trevor City, MI USA
-6:00	-360	CST - Central Standard	Mexico City, Mexico
-7:00	-420	MST - Mountain Standard	Saskatchewan, Canada

Table 11: Greenwich Mean Time Offsets (continued)

GMT Offset in Hours	GMT Offset in Minutes	Common Time Zone References	Cities
-8:00	-480	PST - Pacific Standard	Los Angeles, CA, Cupertino, CA, Seattle, WA USA
-9:00	-540	YST - Yukon Standard	
-10:00	-600	AHST - Alaska-Hawaii Standard	
		CAT - Central Alaska	
		HST - Hawaii Standard	
-11:00	-660	NT - Nome	
-12:00	-720	IDLW - International Date Line West	
+1:00	+60	CET - Central European	Paris, France; Berlin, Germany; Amsterdam, The Netherlands; Brussels, Belgium; Vienna, Austria; Madrid, Spain; Rome, Italy; Bern, Switzerland; Stockholm, Sweden; Oslo, Norway
		FWT - French Winter	
		MET - Middle European	
		MEWT - Middle European Winter	
		SWT - Swedish Winter	
+2:00	+120	EET - Eastern European, Russia Zone 1	Athens, Greece; Helsinki, Finland; Istanbul, Turkey; Jerusalem, Israel; Harare, Zimbabwe
+3:00	+180	BT - Baghdad, Russia Zone 2	Kuwait; Nairobi, Kenya; Riyadh, Saudi Arabia; Moscow, Russia; Tehran, Iran
+4:00	+240	ZP4 - Russia Zone 3	Abu Dhabi, UAE; Muscat; Tblisi; Volgograd; Kabul
+5:00	+300	ZP5 - Russia Zone 4	
+5:30	+330	IST – India Standard Time	New Delhi, Pune, Allahabad, India
+6:00	+360	ZP6 - Russia Zone 5	
+7:00	+420	WAST - West Australian Standard	
+8:00	+480	CCT - China Coast, Russia Zone 7	
+9:00	+540	JST - Japan Standard, Russia Zone 8	
+10:00	+600	EAST - East Australian Standard	
		GST - Guam Standard	
		Russia Zone 9	
+11:00	+660		
+12:00	+720	IDLE - International Date Line East	Wellington, New Zealand; Fiji, Marshall Islands
		NZST - New Zealand Standard	
		NZT - New Zealand	

SNTP Example

In this example, the switch queries a specific NTP server and a backup NTP server. The switch is located in Cupertino, CA, and an update occurs every 20 minutes. The commands to configure the switch are as follows:

```
config timezone -480 autodst
config sntp-client update interval 1200
enable sntp-client
config sntp-client primary server 10.0.1.1
config sntp-client secondary server 10.0.1.2
```

4 Configuring Slots and Ports on a Switch

This chapter covers the following topics:

- Configuring a Slot on a Modular Switch on page 67
- Configuring Ports on a Switch on page 68
- Jumbo Frames on page 70
- Load Sharing on the Switch on page 73
- Switch Port-Mirroring on page 76
- Extreme Discovery Protocol on page 77
- Software-Controlled Redundant Port on page 78
- Performance Enhancements for Load Sharing on page 81

Configuring a Slot on a Modular Switch

If a slot has not been configured for a particular type of module, then any type of module is accepted in that slot, and a default port and VLAN configuration is automatically generated.

Once any port on the module is configured (for example, a VLAN association, a VLAN tag configuration, or port parameters), all the port information and the module type for that slot must be saved to non-volatile storage. Otherwise, if the modular switch is rebooted or the module is removed from the slot, the port, VLAN, and module configuration information is not saved.

NOTE

For information on saving the configuration, see Appendix A.

You can configure the modular switch with the type of I/O module that is installed in each slot. To do this , use the following command:

```
config slot <slot number> module
```

You can also preconfigure the slot before inserting the module. This allows you to begin configuring the module and ports before installing the module in the chassis.

If a slot is configured for one type of module, and a different type of module is inserted, the inserted module is put into a mismatch state, and is not brought online. To use the new module type in a slot,

the slot configuration must be cleared or configured for the new module type. To clear the slot of a previously assigned module type, use the following command:

```
clear slot <slot number>
```

All configuration information related to the slot and the ports on the module is erased. If a module is present when you issue this command, the module is reset to default settings.

To display information about a particular slot, use the following command:

```
show slot {<slot number>}
```

Information displayed includes:

- Card type, serial number, part number.
- Current state (power down, operational, diagnostic, mismatch).
- Port information.

If no slot is specified, information for all slots is displayed.

Configuring Ports on a Switch

On a modular switch, the port number is a combination of the slot number and the port number. The nomenclature for the port number is as follows:

```
slot:port
```

For example, if a G4X I/O module (having a total of four ports) is installed in slot 2 of the BlackDiamond 6808 chassis, the following ports are valid:

- `2:1`
- `2:2`
- `2:3`
- `2:4`

You can also use wildcard combinations (*) to specify multiple modular slot and port combinations. The following wildcard combinations are allowed:

- `slot:*`—Specifies all ports on a particular I/O module.
- `slot:`*x*`-slot:`*y*—Specifies a contiguous series of ports on a particular I/O module.
- `slot`*a*`:`*x*`-slot`*b*`:`*y*—Specifies a contiguous series of ports that begin on one I/O module and end on another I/O module.

Enabling and Disabling Switch Ports

By default, all ports are enabled. To enable or disable one or more ports on a modular switch, use the following command:

```
[enable | disable] ports [all | mgmt | <portlist>]
```

To enable or disable one or more ports on a stand-alone switch, use the following command:

```
[enable | disable] ports [ all | <portlist>]
```

For example, to disable slot 7, ports 3, 5, and 12 through 15 on a modular switch, use the following command:

```
disable ports 7:3,7:5,7:12-7:15
```

For example, to disable ports 3, 5, and 12 through 15 on a stand-alone switch, use the following command:

```
disable ports 3,5,12-15
```

Even though a port is disabled, the link remains enabled for diagnostic purposes.

Configuring Switch Port Speed and Duplex Setting

By default, the switch is configured to use autonegotiation to determine the port speed and duplex setting for each port. You can manually configure the duplex setting and the speed of 10/100 Mbps ports, and you can manually configure the duplex setting of Gigabit Ethernet ports.

10BASE-T and 100BASE-TX ports can connect to either 10BASE-T or 100BASE-T networks. By default, the ports autonegotiate port speed. You can also configure each port for a particular speed (either 10 Mbps or 100 Mbps).

Gigabit Ethernet ports are statically set to 1 Gbps, and their speed cannot be modified.

All ports on a stand-alone switch can be configured for half-duplex or full-duplex operation. By default, the ports autonegotiate the duplex setting.

To configure port speed and duplex setting, use the following command:

```
config ports <portlist> auto off {speed [10 | 100 | 1000 | 10000]} duplex [half |
full]
```

To configure the system to autonegotiate, use the following command:

```
config ports <portlist> auto on
```

Flow control is fully supported only on Gigabit Ethernet ports. Gigabit ports both advertise support and respond to pause frames. 10/100 Mbps Ethernet ports also respond to pause frames, but do not advertise support. Neither 10/100 Mbps or Gigabit Ethernet ports initiate pause frames.

Flow Control is enabled or disabled as part of autonegotiation. If autonegotiation is set to off, flow control is disabled. When autonegotiation is turned on, flow control is enabled.

Turning Off Autonegotiation for a Gigabit Ethernet Port

In certain interoperability situations, you may need to turn autonegotiation off on a Gigabit Ethernet port. Even though a Gigabit Ethernet port runs only at full duplex, you must specify the duplex setting.

NOTE

1000BASE-TX ports support only autonegotiation.

The following example turns autonegotiation off for port 1 on a G4X or G6X module located in slot 1 of a modular switch:

```
config ports 1:1 auto off duplex full
```

The following example turns autonegotiation off for port 4 (a Gigabit Ethernet port) on a stand-alone switch:

```
config ports 4 auto off duplex full
```

Configuring Link Detection

ExtremeWare contains an interrupt service routine (ISR) that sends interrupts when links transition. If a link continuously transitions, causing the ISR to send continuous interrupts, the middle layer filter filters out the continuous interrupt messages. You can configure the interaction between these functions using the following command:

```
config port <portlist> link-detection-level <link detection level>
```

Configuring Interpacket Gap for 10 Gigabit Ethernet Ports

You can configure the Interpacket Gap for 10 Gigabit Ethernet ports only. The Interpacket Gap, sometimes referred to as the Interframe Gap, is the transmit packet byte-time delay between successive data packets mandated by the IEEE for Ethernet networks. Byte-time is the amount of time it takes to transmit one byte on the link at the specified or negotiated link speed. The configured Interpacket Gap value has no effect on received packets. The default value is 12. The minimum and maximum values allowed are 12 and 1023, respectively.

The standard compliant Interpacket Gap for 10 Gigabit Ethernet interfaces is 12. Some vendors' 10 Gigabit Ethernet interfaces drop packets when packets are transmitted using a value of 12. Thus, by increasing the Interpacket Gap, packet transmission is slowed and packet loss can be minimized or prevented. The Interpacket Gap value need not be modified when interconnecting Extreme Networks switches over 10 Gigabit Ethernet links. Use the following command to modify the Interpacket Gap:

```
config port <slot:port> interpacket-gap <byte_time>
```

Jumbo Frames

Jumbo frames are Ethernet frames that are larger than 1522 bytes, including four bytes used for the cyclic redundancy check (CRC). Extreme products support switching and routing of jumbo frames at wire-speed on all ports.

Jumbo frames are used between endstations that support larger frame sizes for more efficient transfers of bulk data. Both endstations involved in the transfer must be capable of supporting jumbo frames. The switch does not perform IP fragmentation, or participate in MTU negotiation on behalf of devices that do not support jumbo frames.

Enabling Jumbo Frames

To enable jumbo frame support, enable jumbo-frame on the desired ports. To set the maximum jumbo frame size, use the following command:

```
config jumbo-frame size <jumbo_frame_size>
```

The jumbo_frame_mtu range is 1523 to 9216. The value describes the maximum size “on the wire,” and includes 4 bytes of CRC plus another 4 bytes if 802.1Q tagging is being used.

Set the MTU size for the VLAN, using the following command:

```
config ip-mtu <size> vlan <vlan name>
```

The ip-mtu default is 1500. The range is 1500-9194.

NOTE

PoS or ATM must be rebooted if the IP-MTU configuration is changed.

Next, enable support on the physical ports that will carry jumbo frames using the following command:

```
enable jumbo-frame ports [<portlist> | all]
```

NOTE

Some network interface cards (NICs) have a configured maximum MTU size that does not include the additional 4 bytes of CRC. Ensure that the NIC maximum MTU size is at or below the maximum MTU size configured on the switch. Frames that are larger than the MTU size configured on the switch are dropped at the ingress port.

Path MTU Discovery

Using path MTU discovery, a source host assumes that the path MTU is the MTU of the first hop (which is known). The host sends all datagrams on that path with the “don’t fragment” (DF) bit set, which restricts fragmentation. If any of the datagrams must be fragmented by an Extreme switch along the path, the Extreme switch discards the datagrams and returns an ICMP Destination Unreachable message to the sending host, with a code meaning "fragmentation needed and DF set". When the source host receives the message (sometimes called a "Datagram Too Big" message), the source host reduces its assumed path MTU and retransmits the datagrams.

The path MTU discovery process ends when one of the following is true:

- The source host sets the path MTU low enough that its datagrams can be delivered without fragmentation.
- The source host does not set the DF bit in the datagram headers.

If it is willing to have datagrams fragmented, a source host can choose not to set the DF bit in datagram headers. Normally, the host continues to set DF in all datagrams, so that if the route changes and the new path MTU is lower, the host can perform path MTU discovery again.

IP Fragmentation with Jumbo Frames

ExtremeWare supports the fragmenting of IP packets. If an IP packet originates in a local network that allows large packets and those packets traverse a network that limits packets to a smaller size, the packets are fragmented instead of discarded.

This feature is designed to be used in conjunction with jumbo frames. Frames that are fragmented are not processed at wire-speed within the switch fabric.

NOTE

Jumbo frame-to-jumbo frame fragmentation is not supported. Only jumbo frame-to-normal frame fragmentation is supported.

To configure VLANs for IP fragmentation, follow these steps:

1. Enable jumbo frames on the incoming port.
2. Add the port to a VLAN.
3. Assign an IP address to the VLAN.
4. Enable ipforwarding on the VLAN.
5. Set the MTU size for the VLAN, using the following command:

   `config ip-mtu <size> vlan <vlan name>`

   The ip-mtu value can be 1500 or 9194, with 1500 the default.

NOTE

To set the MTU size greater than 1500, all ports in the VLAN must have jumbo frames enabled.

IP Fragmentation within a VLAN

ExtremeWare supports IP fragmentation within a VLAN. This feature does not require you to configure the MTU size. To use IP fragmentation within a VLAN, follow these steps:

1. Enable jumbo frames on the incoming port.
2. Add the port to a VLAN.
3. Assign an IP address to the VLAN.
4. Enable ipforwarding on the VLAN.

If you leave the MTU size configured to the default value, when you enable jumbo frame support on a port on the VLAN you will receive a warning that the ip-mtu size for the VLAN is not set at maximum jumbo frame size. You can ignore this warning if you want IP fragmentation within the VLAN, only. However, if you do not use jumbo frames, IP fragmentation can only be used for traffic that stays within the same VLAN. For traffic that is set to other VLANs, to use IP fragmentation, all ports in the VLAN must be configured for jumbo frame support.

Load Sharing on the Switch

Load sharing with switches allows you to increase bandwidth and resiliency by using a group of ports to carry traffic in parallel between switches. The sharing algorithm allows the switch to use multiple ports as a single logical port. For example, VLANs see the load-sharing group as a single logical port. Most load-sharing algorithms guarantee packet sequencing between clients.

If a port in a load-sharing group fails, traffic is redistributed to the remaining ports in the load-sharing group. If the failed port becomes active again, traffic is redistributed to include that port.

NOTE

Load sharing must be enabled on both ends of the link or a network loop may result. The load-sharing algorithms do not need to be the same on both ends.

Dynamic Versus Static Load Sharing

The two broad categories of load sharing supported on Extreme Network switches are dynamic load sharing and static load sharing:

- **Dynamic load sharing**—A grouping of ports that use IEEE 802.3ad load sharing to dynamically determine if load sharing is possible, and automatically configure load sharing when possible. Uses Link Aggregation Control Protocol (LACP), part of the IEEE 802.3ad standard, to allow the switch to dynamically reconfigure the sharing groups. The group is only enabled when LACP detects that the other side is also using LACP, and wants these ports to be in a group.
- **Static load sharing**—A grouping of ports specifically configured to load share. The switch ports at each end must be configured as part of a load-sharing group. Additionally, you can choose the load-sharing algorithm used by the group. This feature is supported between Extreme Networks switches only, but may be compatible with third-party trunking or link-aggregation algorithms. Check with an Extreme Networks technical representative for more information.

Load-Sharing Algorithms

Load-sharing algorithms allow you to select the distribution technique used by the load-sharing group to determine the output port selection. Algorithm selection is not intended for use in predictive traffic engineering. You can only choose the algorithm used in static load sharing. There is no option to choose an algorithm when you use dynamic load sharing.

You can configure one of three load-sharing algorithms on the switch, as follows:

- **Port-based**—Uses the ingress port to determine which physical port in the load-sharing group is used to forward traffic out of the switch.
- **Address-based**—Uses addressing information to determine which physical port in the load-sharing group to use for forwarding traffic out of the switch. Addressing information is based on the packet protocol, as follows:
  - **IP packets**—Uses the source and destination MAC and IP addresses, and the TCP port number.
  - **IPX packets**—Uses the source and destination MAC address, and IPX network identifiers.
  - **All other packets**—Uses the source and destination MAC address.

- **Round-robin**—When the switch receives a stream of packets, it forwards one packet out of each physical port in the load-sharing group using a round-robin scheme.

NOTE

Using the round-robin algorithm, packet sequencing between clients is not guaranteed.

If you do not explicitly select an algorithm, the port-based scheme is used. However, the address-based algorithm has a more even distribution and is the recommended choice, except when running MPLS, in which case port-based is recommended.

Configured IP Address-Based Load Sharing

When you configure load sharing, the switch examines a specific place in the packet to determine which egress port to use for forwarding traffic:

- For layer 2 load sharing, the switch uses the MAC source address and destination address.
- For layer 3 load sharing, the switch uses the IP source address and destination address.
- For layer 4 load sharing, the switch using the UDP or TCP well-known port number.

You can control the field examined by the switch for IP address-based load sharing, using the following command:

```
config sharing address-based <l2 | l2_l3 | l2_l3_l4>
```

where:

- `l2`—Indicates that the switch should examine the MAC source and destination address.
- `l3`—Indicates that the switch should examine the IP source and destination address.
- `l4`—Indicates that the switch should examine the UDP or TCP well-known port number.

This feature is available for the address-based load-sharing algorithm, only.

To verify your configuration, use the following command:

```
show sharing address-based
```

Configuring Switch Load Sharing

To set up a switch to load share among ports, you must create a load-sharing group of ports. The first port in the load-sharing group is configured to be the “master” logical port. This is the reference port used in configuration commands. It can be thought of as the logical port representing the entire port group.

All the ports in a load sharing group must have the same exact configuration, including auto negotiation, duplex setting, ESRP host attach or don’t-count, and so on.

On BlackDiamond modules, the following rules apply:

- One group can contain up to 8 ports.
- The ports in the group must be on the same I/O module.
- The ports in the group do not need to be contiguous.

To define a load-sharing group, you assign a group of ports to a single, logical port number. To enable or disable a load-sharing group, use the following commands:

```
enable sharing <port> grouping <portlist> {dynamic | algorithm {port-based |
address-based | round-robin}}

disable sharing <port>
```

Loopback Detection

Each port may enable loop detection. This optional feature detects that a port has been looped back to the local system. If a loopback is detected, the port is disabled. Note that loopbacks may exist between different ports. The feature will disable any port that both has the feature enabled, and receives an LACP message that was sent from the local system.

To enable or disable loopback detection, use the following commands:

```
enable lbdetect port <portlist> [retry-timeout<seconds>]

disable lbdetect port <portlist>
```

Load-Sharing Examples

This section provides examples of how to define load-sharing on modular and stand-alone switches.

Load Sharing on a Modular Switch

The following example defines a load-sharing group on slot 3 that contains ports 9 through 12, and uses the first port in the group as the master logical port 9:

```
enable sharing 3:9 grouping 3:9-3:12
```

In this example, logical port 3:9 represents physical ports 3:9 through 3:12.

When using load sharing, you should always reference the master logical port of the load-sharing group (port 3:9 in the previous example) when configuring or viewing VLANs. VLANs configured to use other ports in the load-sharing group will have those ports deleted from the VLAN when load sharing becomes enabled.

NOTE

Do not disable a port that is part of a load-sharing group. Disabling the port prevents it from forwarding traffic, but still allows the link to initialize. As a result, a partner switch does not receive a valid indication that the port is not in a forwarding state, and the partner switch will continue to forward packets.

Load Sharing on a Stand-Alone Switch

The following example defines a load-sharing group that contains ports 9 through 12, and uses the first port in the group as the master logical port 9:

```
enable sharing 9 grouping 9-12
```

In this example, logical port 9 represents physical ports 9 through 12.

When using load sharing, you should always reference the master logical port of the load-sharing group (port 9 in the previous example) when configuring or viewing VLANs. VLANs configured to use other ports in the load-sharing group will have those ports deleted from the VLAN when load sharing becomes enabled.

NOTE

Do not disable a port that is part of a load-sharing group. Disabling the port prevents it from forwarding traffic, but still allows the link to initialize. As a result, a partner switch does not receive a valid indication that the port is not in a forwarding state, and the partner switch will continue to forward packets.

Verifying the Load-Sharing Configuration

The screen output resulting from the `show ports configuration` command lists the ports that are involved in load sharing and the master logical port identity.

Switch Port-Mirroring

Port-mirroring configures the switch to copy all traffic associated with one or more ports. The monitor port can be connected to a network analyzer or RMON probe for packet analysis. The system uses a traffic filter that copies a group of traffic to the monitor port.

The traffic filter can be defined based on one of the following criteria:

- **Physical port**—All data that traverses the port, regardless of VLAN configuration, is copied to the monitor port.
- **VLAN**—All data to and from a particular VLAN, regardless of the physical port configuration, is copied to the monitor port.
- **Virtual port**—All data specific to a VLAN on a specific port is copied to the monitor port.

Up to eight mirroring filters and one monitor port can be configured. Once a port is specified as a monitor port, it cannot be used for any other function.

NOTE

Frames that contain errors are not mirrored.

The mirrored port transmits tagged or untagged frames. This allows you to mirror multiple ports or VLANs to a mirror port, while preserving the ability of a single protocol analyzer to track and differentiate traffic within a broadcast domain (VLAN) and across broadcast domains (for example, across VLANs when routing).

NOTE

On switches that do not support the "i" chipset, mirrored frames that are transmitted from the switch do not contain 802.1Q VLAN tagging information.

Modular Switch Port-Mirroring Example

The following example selects slot 7, port 3 as the mirror port, and sends all traffic coming into or out of a modular switch on slot 7, port 1 to the mirror port:

```
config mirroring add port 7:1
enable mirroring to port 7:3
```

The following example sends all traffic coming into or out of the system on slot 8, port 1 and the VLAN *default* to the mirror port:

```
enable mirroring to port 8:4
config mirroring add port 8:1 vlan default
```

Stand-alone Switch Port-Mirroring Example

The following example selects port 3 as the mirror port and sends all traffic coming into or out of the switch on port 1 to the mirror port:

```
enable mirroring to port 3
config mirroring add port 1
```

The following example sends all traffic coming into or out of the switch on port 1 and the VLAN *default* to the mirror port:

```
config mirroring add port 1 vlan default
```

Extreme Discovery Protocol

The Extreme Discovery Protocol (EDP) is used to gather information about neighbor Extreme Networks switches. EDP is used to by the switches to exchange topology information. EDP is also used by the Extreme Standby Router Protocol (ESRP), described in Chapter 14. Information communicated using EDP includes:

- Switch MAC address (switch ID).
- Switch software version information.
- Switch IP address.
- Switch VLAN-IP information.
- Switch port number.

EDP is enabled on all ports by default.

To disable EDP on one or more ports, use the following command:

```
disable edp ports <portlist>
```

To enable EDP on specified ports, use the following command:

```
enable edp ports <portlist>
```

To view EDP port information on the switch, use the following command:

```
show edp
```

Software-Controlled Redundant Port

Using software-controlled redundant port you can back up a specified Ethernet port with a redundant, dedicated Ethernet port. If the active port fails, the backup port establishes a link and takes over for the failed port.

A load-shared group of Ethernet ports can be backed up with a set of load-shared redundant Ethernet ports. If a link in the active load-shared group fails, the entire group fails over to the redundant group.

Typical configurations of software-controlled redundant ports include dual-homing from a single switch to two different switches (shown in Figure 1) and redundant links between two switches (shown in Figure 2).

Figure 1: Dual-homed redundant link

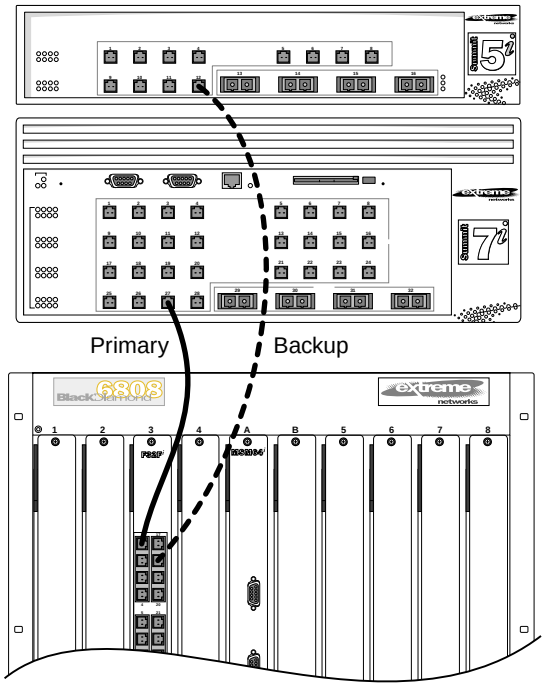
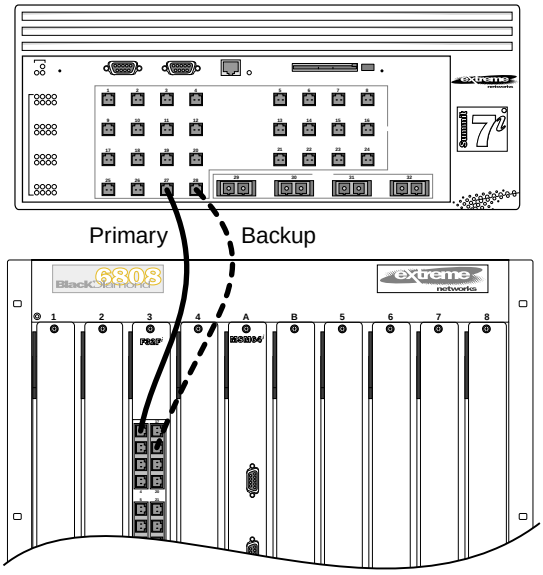


Figure 2: Redundant link between two switches



Only one side of the link needs to be configured as redundant, since the redundant port link is held in standby state on both sides of the link.

Theory of Operation

A software-controlled redundant port is configured to backup a specified primary port. The redundant port tracks the link state of the associated primary port, and if the link on the primary port fails, the redundant port establishes a link and becomes active. You must manually configure the primary and redundant ports identically in terms of VLANs, QoS settings, access lists, and so on.

While the redundant port is inactive, the link between the primary port and the redundant port is held down by forcing an auto-negotiation error. Because of this, auto-negotiation must be enabled on both the primary and redundant port.

When the redundant port is activated, the primary port is ready to accept a link. After a link is established on the primary port, any link present on the redundant port is taken down.

Smart Redundancy and Software Redundant Port

The primary port will only take over for an active redundant port if the smart redundancy feature is enabled, which is the default setting. When smart redundancy is enabled, the primary port (or primary group of load-shared ports) becomes the “preferred” path, provided that the primary port link is active (or in the case of load sharing, the number of active links in the primary group is greater than or equal to the number of links active on the redundant group).

If smart redundancy is disabled, the active path remains the first path to establish a link (or in the case of load sharing, the first group to establish the highest number of active links). For example, if the primary port is active and fails, the redundant port takes over. If the primary is then reconnected and smart redundancy is disabled, the active path remains on the redundant port. If smart redundancy is enabled, the active path switches back to the primary (original) port.

Software Redundant Port and Load Sharing

A load-shared group of ports can be backed up with a redundant group of ports. Each port in the primary group is configured with a unique redundant port. The redundant ports must be grouped together as a separate load-shared group (independent from the primary load-shared group).

If the primary group is active and one or more links in that group fail, each port in the group fails over to its redundant port in the backup group, provided that enough links can be established on the redundant ports to be greater than the number of active links remaining in the primary group.

If one link in the redundant group of load shared ports fails, and the corresponding primary port is down, there will be no fail-back to the primary group of load shared ports.

It is possible for the primary group of load shared ports to be up when the number of active primary ports is less than that of the redundant group of load shared ports. For example, assume ports 4, 5, and 6 are configured as a redundant group of load shared ports for the primary group of load shared ports 1, 2, and 3. If primary port 1 fails, the primary group of load shared ports will fail-over to redundant group of load shared ports with ports 4, 5, and 6 up. Then, if primary port 2 fails, the redundant group of load shared ports (ports 4, 5, and 6) will remain up. However, if redundant port 6 fails, the redundant group of load shared ports will fail-back to the primary group of load shared ports because the corresponding primary port (port 3) for redundant port 6 is still up.

Limitations

The following lists the limitations of the software redundant port feature:

- Software redundant port only cover failures where both the TX and RX paths fail. If a single strand of a fiber is pulled, the software redundant port cannot correctly recover from the failure.
- Auto-negotiation must be enabled on the primary and redundant ports (except for 10 Gigabit Ethernet ports, which do not support auto-negotiation).
- You cannot configure hardware redundant ports (such as ports 49 and 50 on a Summit48i) as software controlled redundant ports.
- You must configure the software redundant port. VLANs, QoS, access control lists, and so on must be configured separately on both the primary and redundant ports.
- Only one side of the link should be configured as redundant. For example if ports 1 and 2 are connected between switches A and B, only switch A should be configured with redundant ports.
- The port speeds of software controlled redundant ports must be identical.
- You can configure only one redundant port for each primary port.

Configuring Software-Controlled Redundant Port

To configure a software-controlled redundant port, use the following command:

```
config ports <portlist> redundant <portlist>
```

The first specified port is the primary port. The second specified port is the redundant port. For load-shared groups, this command must be entered for each port in the group. If a redundant port is not specified for a port in a load-shared group, it will not fail over, which could then result in a split group.

To unconfigure the port, use the following command:

```
unconfig ports <portlist> redundant
```

Any additional port-specific configuration (for example, VLANs, Spanning Tree, QoS, access lists, and so on) must be independently configured.

Performance Enhancements for Load Sharing

You can modify the backplane load-sharing policy for more robust support of multicast streams. The round-robin algorithm is not supported on modules that do not have the "*i*" series chipset. The default backplane load-sharing policy is port-based. You must save for changes to be saved across reboots.

To configure the switch backplane load-sharing policy, use the following command:

```
config backplane-ls-policy <address-based | port-based | round-robin>
```

5 Virtual LANs (VLANs)

This chapter covers the following topics:

- Overview of Virtual LANs on page 83
- Types of VLANs on page 84
- VLAN Names on page 92
- Configuring VLANs on the Switch on page 93
- Displaying VLAN Settings on page 94
- VLAN Tunneling (VMANs) on page 96
- MAC-Based VLANs on page 98

Setting up Virtual Local Area Networks (VLANs) on the switch eases many time-consuming tasks of network administration while increasing efficiency in network operations.

Overview of Virtual LANs

The term “VLAN” is used to refer to a collection of devices that communicate as if they were on the same physical LAN. Any set of ports (including all ports on the switch) is considered a VLAN. LAN segments are not restricted by the hardware that physically connects them. The segments are defined by flexible user groups you create with the command line interface.

Benefits

Implementing VLANs on your networks has the following advantages:

- **VLANs help to control traffic—**With traditional networks, congestion can be caused by broadcast traffic that is directed to all network devices, regardless of whether they require it. VLANs increase the efficiency of your network because each VLAN can be set up to contain only those devices that must communicate with each other.
- **VLANs provide extra security—**Devices within each VLAN can only communicate with member devices in the same VLAN. If a device in VLAN *Marketing* must communicate with devices in VLAN *Sales*, the traffic must cross a routing device.
- **VLANs ease the change and movement of devices—**With traditional networks, network administrators spend much of their time dealing with moves and changes. If users move to a different subnetwork, the addresses of each endstation must be updated manually.

Types of VLANs

VLANs can be created according to the following criteria:

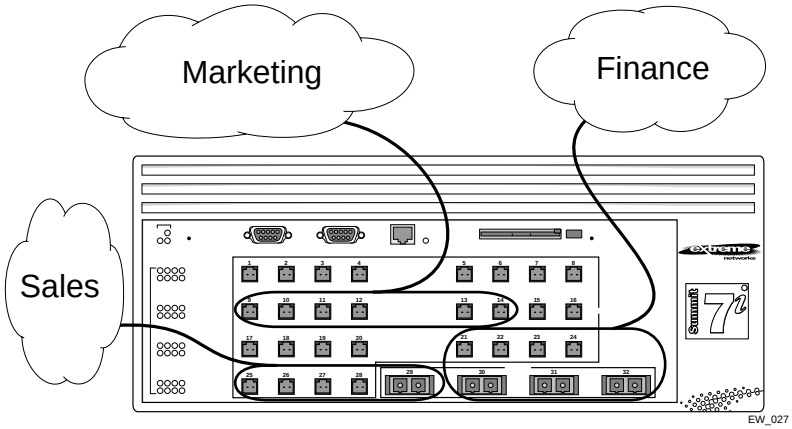
- Physical port
- 802.1Q tag
- Ethernet, LLC SAP, or LLC/SNAP Ethernet protocol type
- MAC address
- A combination of these criteria

Port-Based VLANs

In a port-based VLAN, a VLAN name is given to a group of one or more ports on the switch. All ports are members of the port-based VLAN *default*. Before you can add any port to another port-based VLAN, you must remove it from the default VLAN, unless the new VLAN uses a protocol other than the default protocol *any*. A port can be a member of only one port-based VLAN.

On the Summit7i switch in Figure 3, ports 9 through 14 are part of VLAN *Marketing*; ports 25 through 29 are part of VLAN *Sales*; and ports 21 through 24 and 30 through 32 are in VLAN *Finance*.

Figure 3: Example of a port-based VLAN on the Summit7i switch



For the members of the different IP VLANs to communicate, the traffic must be routed by the switch, even if they are physically part of the same I/O module. This means that each VLAN must be configured as a router interface with a unique IP address.

Spanning Switches with Port-Based VLANs

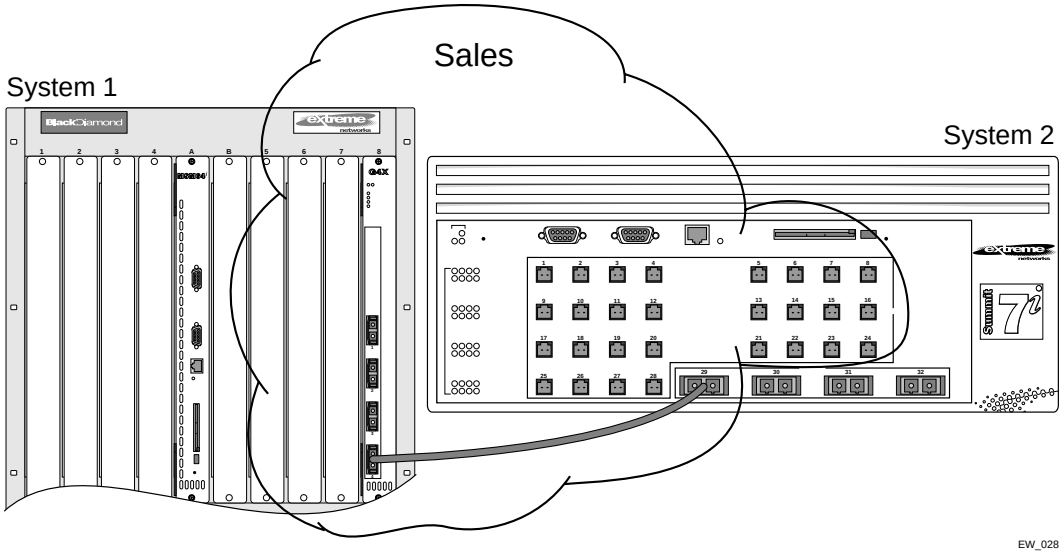
To create a port-based VLAN that spans two switches, you must do two things:

1 Assign the port on each switch to the VLAN.

2 Cable the two switches together using one port on each switch per VLAN.

Figure 4 illustrates a single VLAN that spans a BlackDiamond switch and a Summit7i switch. All ports on the BlackDiamond switch belong to VLAN *Sales*. Ports 1 through 29 on the Summit 7i switch also belong to VLAN *Sales*. The two switches are connected using slot 8, port 4 on system 1 (the BlackDiamond switch), and port 29 on system 2 (the Summit7i switch).

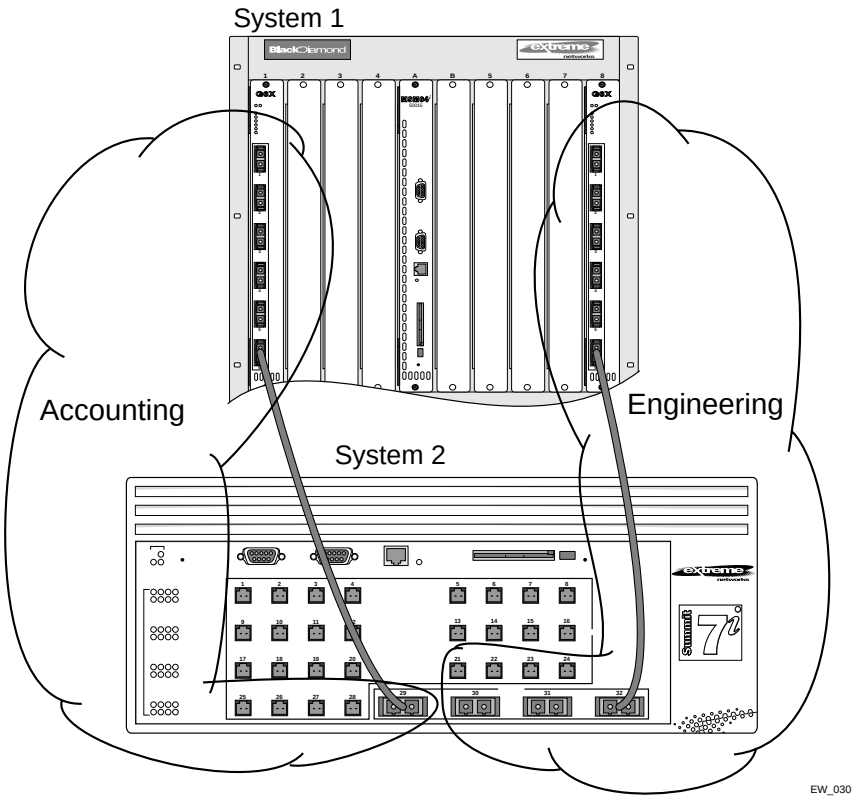
Figure 4: Single port-based VLAN spanning two switches



To create multiple VLANs that span two switches in a port-based VLAN, a port on system 1 must be cabled to a port on system 2 for each VLAN you want to have span across the switches. At least one port on each switch must be a member of the corresponding VLANs, as well.

Figure 5 illustrates two VLANs spanning two switches. On system 2, ports 25 through 29 are part of VLAN *Accounting*; ports 21 through 24 and ports 30 through 32 are part of VLAN *Engineering*. On system 1, all port on slot 1 are part of VLAN *Accounting*; all ports on slot 8 are part of VLAN *Engineering*.

Figure 5: Two port-based VLANs spanning two switches



VLAN *Accounting* spans system 1 and system 2 by way of a connection between system 2, port 29 and system 1, slot 1, port 6. VLAN *Engineering* spans system 1 and system 2 by way of a connection between system 2, port 32, and system 1, slot 8, port 6.

Using this configuration, you can create multiple VLANs that span multiple switches, in a daisy-chained fashion. Each switch must have a dedicated port for each VLAN. Each dedicated port must be connected to a port that is a member of its VLAN on the next switch.

Tagged VLANs

Tagging is a process that inserts a marker (called a *tag*) into the Ethernet frame. The tag contains the identification number of a specific VLAN, called the *VLANid*.

NOTE

The use of 802.1Q tagged packets may lead to the appearance of packets slightly bigger than the current IEEE 802.3/Ethernet maximum of 1,518 bytes. This may affect packet error counters in other devices, and may also lead to connectivity problems if non-802.1Q bridges or routers are placed in the path.

Uses of Tagged VLANs

Tagging is most commonly used to create VLANs that span switches. The switch-to-switch connections are typically called *trunks*. Using tags, multiple VLANs can span multiple switches using one or more trunks. In a port-based VLAN, each VLAN requires its own pair of trunk ports, as shown in Figure 5. Using tags, multiple VLANs can span two switches with a single trunk.

Another benefit of tagged VLANs is the ability to have a port be a member of multiple VLANs. This is particularly useful if you have a device (such as a server) that must belong to multiple VLANs. The device must have a NIC that supports 802.1Q tagging.

A single port can be a member of only one port-based VLAN. All additional VLAN membership for the port must be accompanied by tags. In addition to configuring the VLAN tag for the port, the server must have a *Network Interface Card (NIC)* that supports 802.1Q tagging.

Assigning a VLAN Tag

Each VLAN may be assigned an 802.1Q VLAN tag. As ports are added to a VLAN with an 802.1Q tag defined, you decide whether each port will use tagging for that VLAN. The default mode of the switch is to have all ports assigned to the VLAN named *default* with an 802.1Q VLAN tag (VLANid) of 1 assigned.

Not all ports in the VLAN must be tagged. As traffic from a port is forwarded out of the switch, the switch determines (in real time) if each destination port should use tagged or untagged packet formats for that VLAN. The switch adds and strips tags, as required, by the port configuration for that VLAN.

NOTE

Packets arriving tagged with a VLANid that is not configured on a port will be discarded.

Figure 6 illustrates the physical view of a network that uses tagged and untagged traffic.

Figure 6: Physical diagram of tagged and untagged traffic

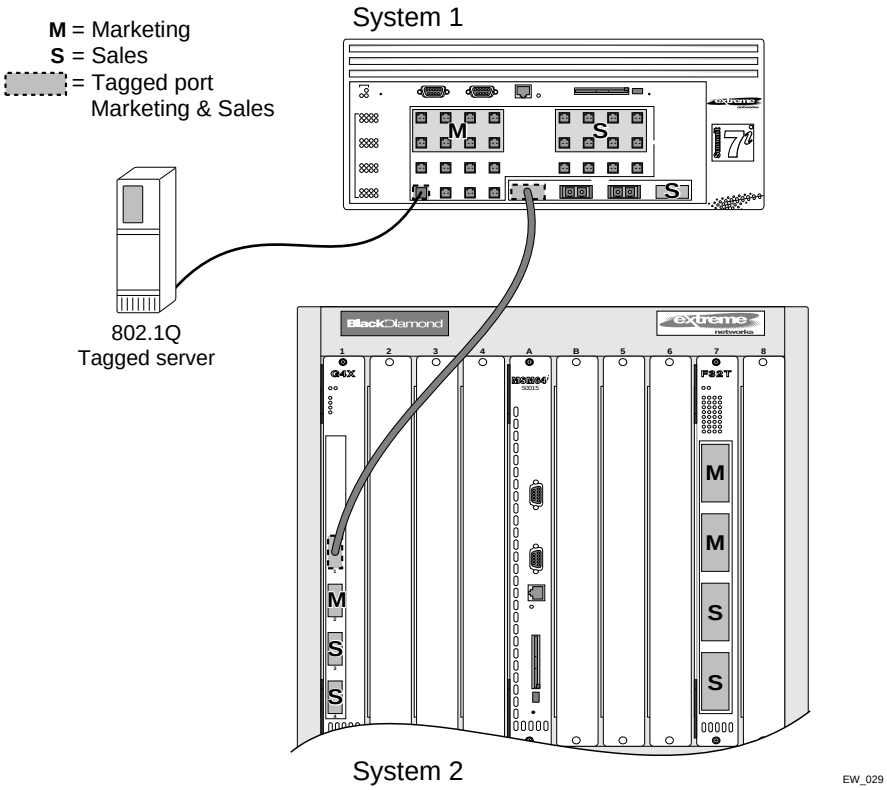
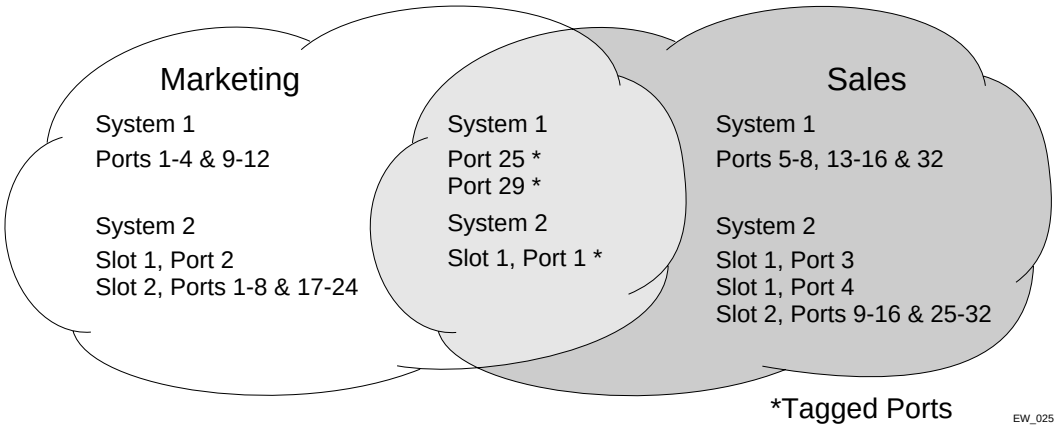


Figure 7 is a logical diagram of the same network.

Figure 7: Logical diagram of tagged and untagged traffic



In Figure 6 and Figure 7:

- The trunk port on each switch carries traffic for both VLAN *Marketing* and VLAN *Sales*.
- The trunk port on each switch is tagged.

- The server connected to port 25 on system 1 has a NIC that supports 802.1Q tagging.
- The server connected to port 25 on system 1 is a member of both VLAN *Marketing* and VLAN *Sales*.
- All other stations use untagged traffic.

As data passes out of the switch, the switch determines if the destination port requires the frames to be tagged or untagged. All traffic coming from and going to the server is tagged. Traffic coming from and going to the trunk ports is tagged. The traffic that comes from and goes to the other stations on this network is not tagged.

Mixing Port-Based and Tagged VLANs

You can configure the switch using a combination of port-based and tagged VLANs. A given port can be a member of multiple VLANs, with the stipulation that only one of its VLANs uses untagged traffic. In other words, a port can simultaneously be a member of one port-based VLAN and multiple tag-based VLANs.

NOTE

For the purposes of VLAN classification, packets arriving on a port with an 802.1Q tag containing a VLANid of zero are treated as untagged.

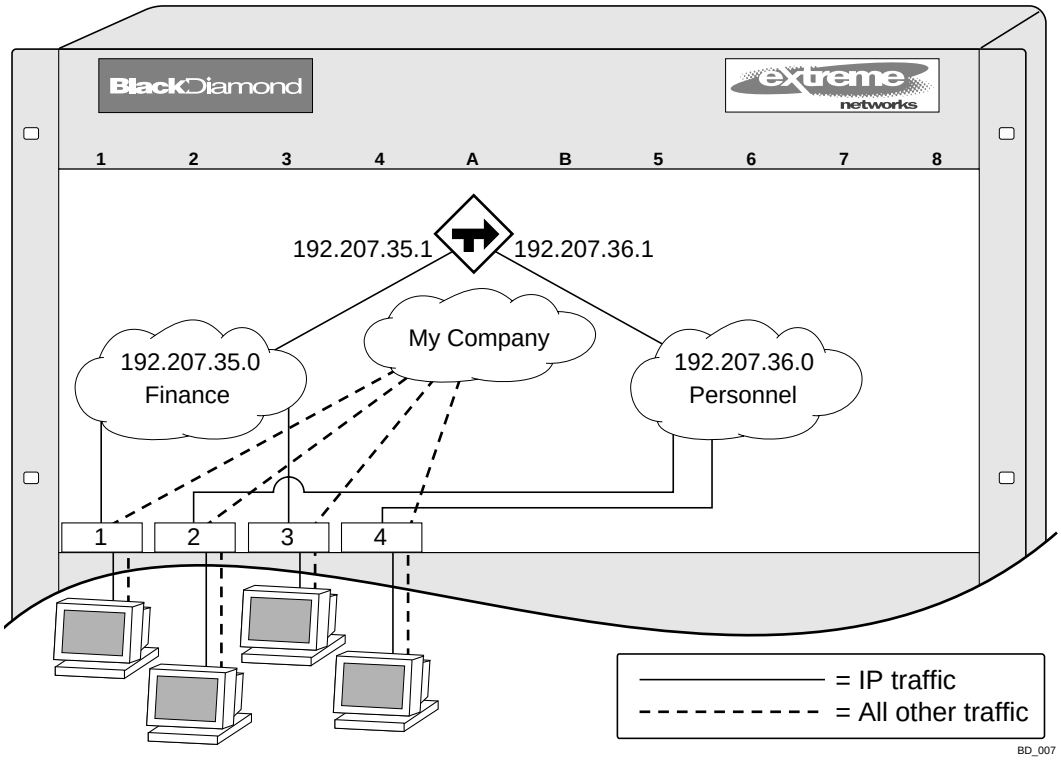
Protocol-Based VLANs

Protocol-based VLANs enable you to define a packet filter that the switch uses as the matching criteria to determine if a particular packet belongs to a particular VLAN.

Protocol-based VLANs are most often used in situations where network segments contain hosts running multiple protocols. For example, in Figure 8, the hosts are running both the IP and NetBIOS protocols.

The IP traffic has been divided into two IP subnets, 192.207.35.0 and 192.207.36.0. The subnets are internally routed by the switch. The subnets are assigned different VLAN names, *Finance* and *Personnel*, respectively. The remainder of the traffic belongs to the VLAN named *MyCompany*. All ports are members of the VLAN *MyCompany*.

Figure 8: Protocol-based VLANs



Predefined Protocol Filters

The following protocol filters are predefined on the switch:

- IP
- IPX
- NetBIOS
- DECNet
- IPX_8022
- IPX_SNAP
- AppleTalk

Defining Protocol Filters

If necessary, you can define a customized protocol filter based on EtherType, Logical Link Control (LLC), and/or Subnetwork Access Protocol (SNAP). Up to six protocols may be part of a protocol filter. To define a protocol filter, follow these steps:

1 Create a protocol using the following command:

```
create protocol <protocol_name>
```

For example:

```
create protocol fred
```

The protocol name can have a maximum of 32 characters.

2 Configure the protocol using the following command:

```
config protocol <protocol_name> add <protocol_type> <hex_value>
```

Supported protocol types include:

— `etype`—EtherType.

The values for `etype` are four-digit hexadecimal numbers taken from a list maintained by the IEEE. This list can be found at the following URL:

```
http://standards.ieee.org/regauth/ethertype/index.html
```

— `llc`—LLC Service Advertising Protocol (SAP).

The values for `llc` are four-digit hexadecimal numbers that are created by concatenating a two-digit LLC Destination SAP (DSAP) and a two-digit LLC Source SAP (SSAP).

— `snap`—Ethertype inside an IEEE SNAP packet encapsulation.

The values for `snap` are the same as the values for `etype`, described previously.

For example:

```
config protocol fred add llc feff
config protocol fred add snap 9999
```

A maximum of 15 protocol filters, each containing a maximum of six protocols, can be defined. On products that use the Inferno chip set, all 15 protocol filters can be active and configured for use. On all other platforms, no more than seven protocols can be active and configured for use.

NOTE

For more information on SNAP for Ethernet protocol types, see TR 11802-5:1997 (ISO/IEC) [ANSI/IEEE std. 802.1H, 1997 Edition].

Deleting a Protocol Filter

If a protocol filter is deleted from a VLAN, the VLAN is assigned a protocol filter of none. You can continue to configure the VLAN. However, no traffic is forwarded to the VLAN until a protocol is assigned to it.

Precedence of Tagged Packets Over Protocol Filters

If a VLAN is configured to accept tagged packets on a particular port, incoming packets that match the tag configuration take precedence over any protocol filters associated with the VLAN.

VLAN Names

Each VLAN is given a name that can be up to 32 characters. VLAN names can use standard alphanumeric characters. The following characters are not permitted in a VLAN name:

- Space
- Comma
- Quotation mark

VLAN names must begin with an alphabetical letter. Quotation marks can be used to enclose a VLAN name that includes special characters, including single quotation marks or commas. Spaces may not be included, even within quotation marks. For example, the names *test*, *test1*, and *test_15* are acceptable VLAN names. The names "*test&5*" and "*joe's*" may be used if enclosed in quotation marks. Names such as "*5test*" or "*test 5*" are not permitted.

VLAN names can be specified using the tab key for command completion.

VLAN names are locally significant. That is, VLAN names used on one switch are only meaningful to that switch. If another switch is connected to it, the VLAN names have no significance to the other switch.

NOTE

You should use VLAN names consistently across your entire network.

Default VLAN

The switch ships with one default VLAN that has the following properties:

- The VLAN name is *default*.
- It contains all the ports on a new or initialized switch.
- The default VLAN is untagged on all ports. It has an internal VLANid of 1.

Renaming a VLAN

To rename an existing VLAN, use the following command:

```
config vlan <old_name> name <new_name>
```

The following rules apply to renaming VLANs:

- Once you change the name of the default VLAN, it cannot be changed back to *default*.
- You cannot create a new VLAN named *default*.
- You cannot change the VLAN name *MacVlanDiscover*. Although the switch accepts a name change, once it is rebooted, the original name is recreated.

Configuring VLANs on the Switch

This section describes the commands associated with setting up VLANs on the switch. Configuring a VLAN involves the following steps:

1. Create and name the VLAN.
2. Assign an IP address and mask (if applicable) to the VLAN, if needed.

NOTE

Each IP address and mask assigned to a VLAN must represent a unique IP subnet. You cannot configure the same IP subnet on different VLANs.

NOTE

If you plan to use this VLAN as a control VLAN for an EAPS domain, do NOT assign an IP address to the VLAN.

3. Assign a VLANid, if any ports in this VLAN will use a tag.
4. Assign one or more ports to the VLAN.

   As you add each port to the VLAN, decide if the port will use an 802.1Q tag.

VLAN Configuration Examples

The following modular switch example creates a port-based VLAN named *accounting*, assigns the IP address 132.15.121.1, and assigns slot 2, ports 1, 2, 3, and 6, and slot 4, ports 1 and 2 to it:

```
create vlan accounting
config accounting ipaddress 132.15.121.1
config default delete port 2:1-2:3,2:6,4:1,4:2
config accounting add port 2:1-2:3,2:6,4:1,4:2
```

NOTE

Because VLAN names are unique, you do not need to enter the keyword `vlan` *after you have created the unique VLAN name. You can use the VLAN name alone.*

The following stand-alone switch example creates a tag-based VLAN named *video*. It assigns the VLANid 1000. Ports 4 through 8 are added as tagged ports to the VLAN.

```
create vlan video
config video tag 1000
config video add port 4-8 tagged
```

The following stand-alone switch example creates a VLAN named *sales*, with the VLANid 120. The VLAN uses both tagged and untagged ports. Ports 1 through 3 are tagged, and ports 4 and 7 are untagged. Note that when not explicitly specified, ports are added as untagged.

```
create vlan sales
config sales tag 120
config sales add port 1-3 tagged
```

```
config default delete port 4,7
config sales add port 4,7
```

The following modular switch example creates a protocol-based VLAN named *ipsales*. Slot 5, ports 6 through 8, and slot 6, ports 1, 3, and 4-6 are assigned to the VLAN. In this example, you can add untagged ports to a new VLAN without first deleting them from the default VLAN, because the new VLAN uses a protocol other than the default protocol.

```
create vlan ipsales
config ipsales protocol ip
config ipsales add port 5:6-5:8,6:1,6:3-6:6
```

The following modular switch example defines a protocol filter, *myprotocol* and applies it to the VLAN named *myvlan*. This is an example only, and has no real-world application.

```
create protocol myprotocol
config protocol myprotocol add etype 0xf0f0
config protocol myprotocol add etype 0xffff
create vlan myvlan
config myvlan protocol myprotocol
```

Displaying VLAN Settings

To display VLAN settings, use the following command:

```
show vlan {<vlan name> | detail}
```

The `show` command displays summary information about each VLAN, which includes:

- Name.
- VLANid.
- How the VLAN was created.
- IP address.
- IPX address (if configured).
- STPD information.
- Protocol information.
- QoS profile information.
- Ports assigned.
- Tagged / untagged status for each port.
- How the ports were added to the VLAN.
- Number of VLANs configured on the switch.

Use the `detail` option to display the detailed format.

Displaying VLAN Statistics

To display VLAN statistics, use the following command:

```
show vlan stats vlan <vlan name> ... <vlan name>
```

The information displayed includes:

- Transmitted and received unicast packets.
- Transmitted and received multicast packets.
- Transmitted and received broadcast packets.
- Transmitted and received bytes.

You can display statistics for multiple VLANs by entering the name of each VLAN on the command line.

Displaying VLAN Statistics Per Port

In addition to displaying VLAN statistics on a per-VLAN basis, you can display VLAN statistics on a per-port basis, using the following command:

```
config ports <portlist> monitor vlan <vlan name>
```

You can monitor up to four VLANs on the same port by issuing the command four times. For example, if you want to monitor VLAN dog1, dog2, dog3, and dog4 on port 1, use the following command configuration:

```
config ports 1:* monitor vlan dog1
config ports 1:* monitor vlan dog2
config ports 1:* monitor vlan dog3
config ports 1:* monitor vlan dog4
```

After you configure the port, you can use this command to display information for the configured port:

```
show ports <portlist> vlan statistics
```

After you have configured per-port monitoring, every time you issue the `show ports` command, the latest statistics are displayed directly from the hardware in real-time. This information is not logged.

To remove the port mask, use the following command:

```
unconfig ports <portlist> monitor vlan <vlan name>
```

You must issue the unconfig command for each VLAN you have configured for the port. For example:

```
unconfig ports 1:* monitor vlan dog1
unconfig ports 1:* monitor vlan dog2
unconfig ports 1:* monitor vlan dog3
unconfig ports 1:* monitor vlan dog4
```

Displaying Protocol Information

To display protocol information, use the following command:

```
show protocol {<protocol>}
```

This show command displays protocol information, which includes:

- Protocol name.
- List of protocol fields.
- VLANs that use the protocol.

VLAN Tunneling (VMANs)

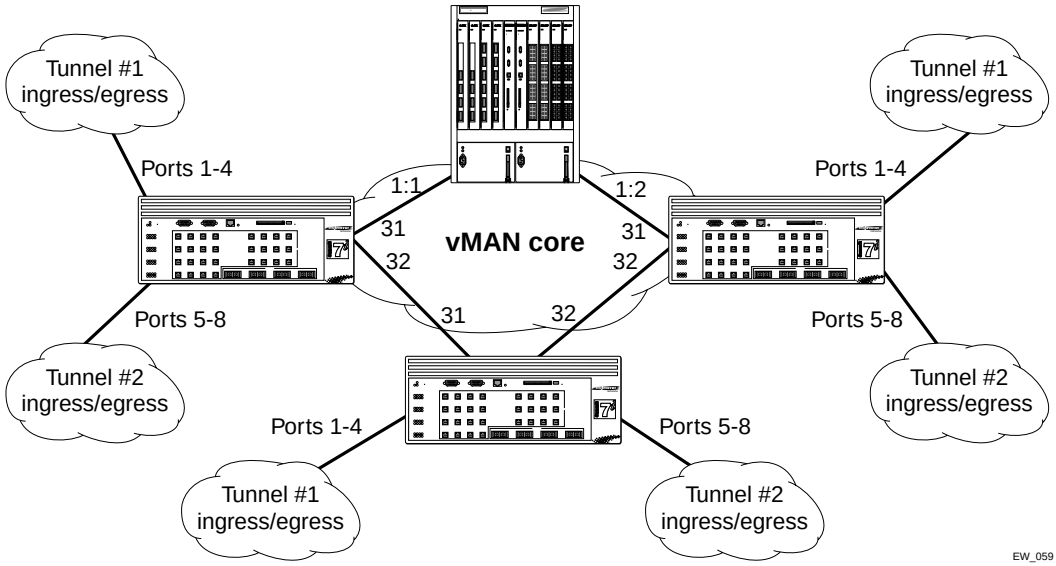
You can “tunnel” any number of 802.1Q and/or Cisco ISL VLANs into a single VLAN that can be switched through an Extreme Ethernet infrastructure. A given tunnel is completely isolated from other tunnels or VLANs. This feature is useful in building transparent private networks (VMANs) that need point-to-point or point-to-multipoint connectivity across an Ethernet infrastructure. The VLAN tagging methods used within the VMAN tunnel are transparent to the tunnel. For the MAN provider, the tagging numbers and methods used by the customer are transparent to the provider.

To configure a VMAN tunnel, follow these steps:

1. Modify the 802.1Q Ethertype the switch uses to recognize tagged frames. Extreme Networks recommends the use of IEEE registered ethertype 0x88a8 for deploying vMANs.
2. Configure the switch to accept larger MTU size frames (jumbo frames).
3. Create tunnels by creating VLANs and configuring member ports as tagged on switch-to-switch ports and untagged on the ingress/egress ports of the tunnel.

Figure 9 illustrates a configuration with VMANs.

Figure 9: VMAN example



Two tunnels are depicted that have ingress/egress ports on each Summit7i switch.

The configuration for the Summit7i switches shown in Figure 9 is:

```
config dot1q ethertype 88a8
enable jumbo-frame ports 31,32
config jumbo-frame size 1530
create vlan Tunnel1
config vlan Tunnel1 tag 50
config vlan Tunnel1 add port 1-4 untag
config vlan Tunnel1 add port 31,32 tagged
create vlan Tunnel2
config vlan Tunnel2 tag 60
config vlan Tunnel2 add port 5-8 untag
create vlan Tunnel2 add port 31,32 tagged
```

On the BlackDiamond switch, the configuration is:

```
config dot1q ethertype 88a8
enable jumbo-frame ports all
config jumbo-frame size 1530
create vlan tunnel1
config vlan tunnel1 tag 50
config vlan tunnel1 add port 1:1-1:2 tagged
create vlan tunnel2
config vlan tunnel2 tag 60
config vlan tunnel2 add port 1:1-1:2 tagged
```

Specific to this configuration, a layer 1 or layer 2 redundancy method would also be employed, such as Spanning Tree or other methods ExtremeWare offers.

MAC-Based VLANs

MAC-Based VLANs allow physical ports to be mapped to a VLAN based on the source MAC address learned in the FDB. This feature allows you to designate a set of ports that have their VLAN membership dynamically determined by the MAC address of the end station that plugs into the physical port. You can configure the source MAC address-to-VLAN mapping either offline or dynamically on the switch. For example, you could use this application for a roaming user who wants to connect to a network from a conference room. In each room, the user plugs into one of the designated ports on the switch and is mapped to the appropriate VLAN. Connectivity is maintained to the network with all of the benefits of the configured VLAN in terms of QoS, routing, and protocol support.

MAC-Based VLAN Guidelines

When using the MAC-to-VLAN mapping, consider the following guidelines:

- A port can only accept connections from an endstation/host and should not be connected to a layer-2 repeater device. Connecting to a layer-2 repeater device can cause certain addresses to not be mapped to their respective VLAN if they are not correctly configured in the MAC-VLAN configuration database. If a repeater device is connected to a MAC-Based VLAN port, and the configured MAC-to-VLAN mapped station enters on the repeater, any endstation that is attached to the repeater can be mapped to that VLAN while the configured endstation is active in that VLAN. Upon removal of the configured MAC-to-VLAN endstation, all other endstations lose connectivity.
- Groups are used as a security measure to allow a MAC address to enter into a VLAN only when the group mapping matches the port mapping.

  As an example, the following configuration allows MAC 00:00:00:00:00:aa to enter into the VLAN only on ports 10 and 11 because of membership in group 100:

```
* Summit48:50 # show mac
Port    Vlan                Group         State
10      MacVlanDiscover     100           Discover
11      MacVlanDiscover     100           Discover
12      MacVlanDiscover     any           Discover
13      MacVlanDiscover     any           Discover
14      MacVlanDiscover     any           Discover
Total Entries in Database:2
 Mac                Vlan     Group
00:00:00:00:00:aa   sales    100
00:00:00:00:00:01   sales    any
2 matching entries
```

- The group “any” is equivalent to the group “0”. Ports that are configured as “any” allow any MAC address to be assigned to a VLAN, regardless of group association.
- Partial configurations of the MAC to VLAN database can be downloaded to the switch using the timed download configuration feature.

MAC-Based VLAN Limitations

The following list contains the limitations of MAC-based VLANs:

- Ports participating in MAC VLANs must first be removed from any static VLANs.
- The MAC- to-VLAN mapping can only be associated with VLANs that exist on the switch.
- A MAC address cannot be configured to associate with more than 1 VLAN. If this is attempted, the MAC address is associated with the most recent VLAN entry in the MAC-to-VLAN database.
- The feature is intended to support one client per physical port. Once a client MAC address has successfully registered, the VLAN association remains until the port connection is dropped or the FDB entry ages out.

MAC-Based VLAN Example

In this following example, three VLANs are created: *engineering*, *marketing*, and *sales*. A single MAC address is associated with each VLAN. The MAC address 00:00:00:00:00:02 has a group number of "any" or "0" associated with it, allowing it to be plugged into any port that is in MacVlanDiscover mode (ports 10-15 in this case). The MAC address 00:00:00:00:00:01 has a group number of 10 associated with it, and can only be assigned to a VLAN if inserted into ports 16 or 17. The MAC address 00:00:00:00:00:03 has a group number of 200 associated with it and can only be inserted into ports 18 through 20.

```
enable mac-vlan mac-group any ports 10-15
enable mac-vlan mac-group 10 ports 16-17
enable mac-vlan mac-group 200 ports 18-20
config mac-vlan add mac-address 00:00:00:00:00:01 mac-group 10 engineering
config mac-vlan add mac-address 00:00:00:00:00:02 mac-group any marketing
config mac-vlan add mac-address 00:00:00:00:00:03 mac-group 200 sales
```

Timed Configuration Download for MAC-Based VLANs

To allow centralized control of MAC-based VLANs over multiple switches, a timed TFTP configuration download allows you to download incremental configuration files from a primary or secondary server at specified time intervals. The timed downloads are configurable in 24 hour intervals. When a switch reboots, the configuration is automatically downloaded immediately after booting, per the configured primary and secondary servers.

To configure the primary and/or secondary server and file name, use the following command:

```
config download server [primary | secondary] [<host_name> | <ip_address>] <filename>
```

To enable timed interval downloads, use the following command:

```
download configuration every <hour:minute>
```

To display timed download information, use the following command:

```
show switch
```

Example

In relation to MAC-based VLANs, the downloaded file is an ASCII file that consists of CLI commands used to configure the most recent MAC-to-VLAN database. This feature is different from the normal download configuration command in that it allows incremental configuration without the automatic rebooting of the switch.

The following example shows an incremental configuration file for MAC-based VLAN information that updates the database and saves changes:

```
config mac-vlan add mac-address 00:00:00:00:00:01 mac-group any engineering
config mac-vlan add mac-address 00:00:00:00:ab:02 mac-group any engineering
config mac-vlan add mac-address 00:00:00:00:cd:04 mac-group any sales
.
.
config mac-vlan add mac-address 00:00:00:00:ab:50 mac-group any sales
config mac-vlan add mac-address 00:00:00:00:cd:60 mac-group any sales
save
```

6 Forwarding Database (FDB)

This chapter describes the following topics:

- Overview of the FDB on page 101
- Associating QoS Profiles with an FDB Entry on page 104
- FDB Configuration Examples on page 104
- Displaying FDB Entries on page 106
- Displaying FDB Entries on page 106

Overview of the FDB

The switch maintains a database of all media access control (MAC) addresses received on all of its ports. It uses the information in this database to decide whether a frame should be forwarded or filtered.

FDB Contents

Each FDB entry consists of the MAC address of the device, an identifier for the port and VLAN on which it was received, and the age of the entry. Frames destined for MAC addresses that are not in the FDB are flooded to all members of the VLAN.

How FDB Entries Get Added

Entries are added into the FDB in the following ways:

- The switch can learn entries by examining packets it receives. The system updates its FDB with the source MAC address from a packet, the VLAN, and the port identifier on which the source packet is received.

  The ability to learn MAC addresses can be enabled or disabled on a port-by-port basis. You can also limit the number of addresses that can be learned, or you can “lock down” the current entries and prevent additional MAC address learning.
- You can enter and update entries using the command line interface (CLI).
- Certain static entries are added by the system upon switch boot up.

FDB Entry Types

FDB entries may be dynamic or static, and may be permanent or non-permanent. The following describes the types of entries that can exist in the FDB:

- **Dynamic entries**—A dynamic entry is learned by the switch by examining packets to determine the source MAC address, VLAN, and port information. The switch then creates or updates an FDB entry for that MAC address. Initially, all entries in the database are dynamic, except for certain entries created by the switch at boot up.

  Dynamic entries are flushed and relearned (updated) when any of the following take place:

  — A VLAN is deleted.

  — A VLAN identifier (VLANid) is changed.

  — A port mode is changed (tagged / untagged).

  — A port is deleted from a VLAN.

  — A port is disabled.

  — A port enters blocking state.

  — A port QoS setting is changed.

  — A port goes down (link down).

  A *non-permanent dynamic entry* is initially created when the switch identifies a new source MAC address that does not yet have an entry in the FDB. The entry may then be updated as the switch continues to encounter the address in the packets it examines. These entries are identified by the "d" flag in `show fdb` output.

  A *permanent dynamic entry* is created by command through the CLI, but may then be updated as the switch encounters the MAC address in the packets that it examines. A permanent dynamic entry is typically used to associate QoS profiles with the FDB entry. Permanent dynamic entries are identified by the "p" and "d" flags in `show fdb` output.

  Both types of dynamic entries age—a dynamic entry will be removed from the FDB (aged-out) if the device does not transmit for a specified period of time (the aging time). This prevents the database from becoming full with obsolete entries by ensuring that when a device is removed from the network, its entry is deleted from the database. The aging time is configurable. For more information about setting the aging time, see "Configuring the FDB Aging Time" on page 105 later in this chapter.

- **Static entries**—A static entry does not age, and does not get updated through the learning process. It is maintained exactly as it was created. Conditions that cause dynamic entries to be updated, such as VLAN or port configuration changes, do not affect static entries.

  If the same MAC address is detected on another virtual port that is not defined in the static FDB entry for the MAC address, it is handled as a blackhole entry.

  A permanent static entry is created through the command line interface, and can be used to associate QoS profiles with a non-aging FDB entry. Permanent static entries are identified by the "s" and "p" flags in `show fdb` output.

  A *locked static entry* is an entry that was originally learned dynamically, but has been made static (locked) using the MAC address lock-down feature. It is identified by the "s" and "l" flags in `show fdb` output. See "MAC Address Lock Down" on page 195 for more information about MAC address lock-down.

Non-permanent static entries are created by the switch software for various reasons, typically upon switch boot up. They are identified by the "s" flag in `show fdb` output.

If the FDB entry aging time is set to zero, all entries in the database are considered static, non-aging entries. This means that they do not age, but they are still deleted if the switch is reset.

- **Permanent entries**—Permanent entries are retained in the database if the switch is reset or a power off/on cycle occurs. Permanent entries must be created by the system administrator through the command line interface. A permanent entry can either be a unicast or multicast MAC address.

  Permanent entries may be static, meaning they do not age or get updated, or they may be dynamic, meaning that they do age and can be updated via learning.

  Permanent entries can have QoS profiles associated with the MAC address. A different QoS profiles may be associated with the MAC address when it is a destination address (an egress QoS profile) than when it is a source address (ingress QoS profile).

  The stand-alone switches can support a maximum of 64 permanent entries, and the modular switches support a maximum of 254 permanent entries.

- **Blackhole entrie**s—A blackhole entry configures the switch to discard packets with a specified MAC address. Blackhole entries are useful as a security measure or in special circumstances where a specific source or destination address must be discarded. Blackhole entries may be created through the CLI, or they may be created by the switch when a port's learning limit has been exceeded.

  Blackhole entries are treated like permanent entries in the event of a switch reset or power off/on cycle. Blackhole entries are never aged out of the database.

Disabling MAC Address Learning

By default, MAC address learning is enabled on all ports. You can disable learning on specified ports using the following command:

```
disable learning {flood-list} ports <portlist>
```

If MAC address learning is disabled, only broadcast traffic, EDP traffic, and packets destined to a permanent MAC address matching that port number, are forwarded. Use this command in a secure environment where access is granted via permanent forwarding databases (FDBs) per port.

Using the `flood-list` option disables port learning and configures the ports to act like a hub. When flooding is enabled on a particular port, *all* frames and packets are passed on to other member ports that also have flooding enabled. This includes all broadcast, multicast, known and unknown unicast packets (including EPD). To make effective use of this feature you should have flooding enabled on more than one port.

Learning and flooding are mutually exclusive. To enable flooding, learning must be disabled. When ports are configured for flooding, the FDB will be flushed for the entire system, which means all the entries in the dynamic FDB must be relearned.

To disable flooding, enable port learning on the affected ports.

Associating QoS Profiles with an FDB Entry

You can associate QoS profiles with a MAC address (and VLAN) of a device by creating a permanent FDB entry and specifying QoS profiles for ingress or egress, or both. The permanent FDB entry can be either dynamic (it is learned and can be aged out) or static.

To associate a QoS profile with a dynamic FDB entry, use the following command:

```
create fdbentry [<mac_address> | any-mac] vlan <vlan name> dynamic
[qosprofile <qosprofile> {ingress-qosprofile <iqosprofile>} |
ingress-qosprofile <qosprofile> {qosprofile <qosprofile>}]
```

This command associates QoS profiles with packets received from or destined for the specified MAC address, while still allowing the FDB entry to be dynamically learned. If you specify only the ingress QoS profile, the egress QoS profile defaults to none, and vice-versa. If both profiles are specified, the source MAC address of an ingress packet and the destination MAC address of an egress packet are examined for QoS profile assignment.

The FDB entry is not actually created until the MAC address is encountered as the source MAC address in a packet. Thus, initially the entry may not appear in the `show fdb` output. Once the entry has been learned, it is created as a permanent dynamic entry, designated by "dpm" in the flags field of the `show fdb` output.

You can use the `show fdb permanent` command to display permanent FDB entries, including their QoS profile associations.

To associate a QoS profile with a permanent FDB entry, use the following command:

```
create fdbentry <mac_address> vlan <vlan name> ports [<portlist | all]
{qosprofile <qosprofile>} {ingress-qosprofile <iqosprofile>}
```

This entry will not be aged out, and no learning will occur. If the same MAC address is encountered through a virtual port not specified in the portlist, it will be handled as a blackhole entry.

Using the `any-mac` keyword, you can enable traffic from a QoS VLAN to have higher priority than 802.1p traffic. Normally, an 802.1p packet has a higher priority over the VLAN classification. In order to use this feature, you must create a wildcard permanent FDB entry named `any-mac` and apply the QoS profile to the individual MAC entry.

NOTE

For more information on QoS profiles, see Chapter 7.

FDB Configuration Examples

The following example adds a permanent static entry to the FDB:

```
create fdbentry 00:E0:2B:12:34:56 vlan marketing port 3:4
```

The permanent entry has the following characteristics:

- MAC address is 00:E0:2B:12:34:56.
- VLAN name is *marketing*.

- Slot number for this device is 3.
- Port number for this device is 4.

If the MAC address 00:E0:2B:12:34:56 is encountered on any port/VLAN other than VLAN *marketing*, port 3:4, it will be handled as a blackhole entry, and packets from that source will be dropped.

This example associates the QoS profile *qp2* with a dynamic entry for the device at MAC address 00:A0:23:12:34:56 on VLAN *net34* that will be learned by the FDB:

```
create fdbentry 00:A0:23:12:34:56 vlan net34 dynamic qosprofile qp2
```

This entry has the following characteristics:

- MAC address is 00:A0:23:12:34:56.
- VLAN name is *net34*.
- The entry will be learned dynamically.
- QoS profile *qp2* will be applied as an egress QoS profile when the entry is learned.

Overriding 802.1p Priority

This example associates the QoS profile *qp5* with the wildcard permanent FDB entry *any-mac* on VLAN v110:

```
create fdbentry any-mac vlan v110 dynamic ingress-qosprofile qp5
```

Configuring the FDB Aging Time

You can configure the again time for dynamic FDB entries using the following command:

```
config fdb agingtime <seconds>
```

If the aging time is set to zero, all aging entries in the database are defined as static, nonaging entries. This means they will not age out, but non-permanent static entries can be deleted if the switch is reset.

MAC-Based Security

MAC-based security allows you to control the way the FDB is learned and populated. By managing entries in the FDB, you can block, assign priority (queues), and control packet flows on a per-address basis.

MAC-based security allows you to limit the number of dynamically-learned MAC addresses allowed per virtual port. You can also “lock” the FDB entries for a virtual port, so that the current entries will not change, and no additional addresses can be learned on the port.

You can also prioritize or stop packet flows based on the source MAC address of the ingress VLAN or the destination MAC address of the egress VLAN.

For detailed information about MAC-based security, see Chapter 11.

Displaying FDB Entries

To display FDB entries, use the following command:

```
show fdb {<mac_address> | vlan <vlan name> | ports <portlist> | permanent}
```

where the following is true:

- `mac_address`—Displays the entry for a particular MAC address.
- `vlan <vlan name>`—Displays the entries for a VLAN.
- `ports <portlist>`—Displays the entries for a set of ports or slots and ports.
- `permanent`—Displays all permanent entries, including the ingress and egress QoS profiles.

With no options, the command displays all FDB entries.

See the *ExtremeWare Software Command Reference Guide* for details of the commands related to the FDB.

7 Quality of Service (QoS)

This chapter covers the following topics:

- Overview of Policy-Based Quality of Service on page 108
- Applications and Types of QoS on page 108
- Configuring QoS on page 110
- QoS Profiles on page 111
- Traffic Groupings on page 112
  - IP-Based Traffic Groupings on page 112
  - MAC-Based Traffic Groupings on page 113
  - Explicit Class of Service (802.1p and DiffServ) Traffic Groupings on page 114
  - Configuring DiffServ on page 116
  - Physical and Logical Groupings on page 119
- Configuring QoS Traffic Grouping Priorities on page 120
- Verifying Configuration and Performance on page 121
- Modifying a QoS Configuration on page 122
- Bi-Directional Rate Shaping on page 122
- Dynamic Link Context System on page 125

Policy-based Quality of Service (QoS) is a feature of ExtremeWare and the Extreme switch architecture that allows you to specify different service levels for traffic traversing the switch. Policy-based QoS is an effective control mechanism for networks that have heterogeneous traffic patterns. Using Policy-based QoS, you can specify the service level that a particular traffic type receives.

Overview of Policy-Based Quality of Service

Policy-based QoS allows you to protect bandwidth for important categories of applications or specifically limit the bandwidth associated with less critical traffic. For example, if voice–over-IP traffic requires a reserved amount of bandwidth to function properly, using policy-based QoS, you can reserve sufficient bandwidth critical to this type of application. Other applications deemed less critical can be limited so as to not consume excessive bandwidth. The switch contains separate hardware queues on every physical port. Each hardware queue is programmed by ExtremeWare with bandwidth management and prioritization parameters. The bandwidth management and prioritization parameters that modify the forwarding behavior of the switch affect how the switch transmits traffic for a given hardware queue on a physical port.

The switch tracks and enforces the minimum and maximum percentage of bandwidth utilization transmitted on every hardware queue for every port. When two or more hardware queues on the same physical port are contending for transmission, the switch prioritizes bandwidth use so long as their respective bandwidth management parameters are satisfied. Up to eight physical queues per port are available.

NOTE

Policy-based QoS has no impact on switch performance. Using even the most complex traffic groupings has no cost in terms of switch performance.

Policy-based QoS can be configured to perform per-port Random Early Detection (RED). Using this capability, the switch detects when traffic is filling up in any of the eight hardware queues, and performs a random discard on subsequent packets, based on the configured RED drop-probability.

Instead of dropping sessions during times when the queue depth is exceeded, RED causes the switch to lower session throughput. The destination node detects the dropped packet, and, using standard TCP windowing mechanisms, slows the transmission from the source node. RED drop-probability is configured on a system-wide basis, and has a valid range from 0% to 100%.

Applications and Types of QoS

Different applications have different QoS requirements. The following applications are ones that you will most commonly encounter and need to prioritize:

- Voice applications
- Video applications
- Critical database applications
- Web browsing applications
- File server applications

General guidelines for each traffic type are given below and summarized in Table 12. Consider them as general guidelines and not strict recommendations. Once QoS parameters are set, you can monitor the performance of the application to determine if the actual behavior of the applications matches your expectations. It is very important to understand the needs and behavior of the particular applications you wish to protect or limit. Behavioral aspects to consider include bandwidth needs, sensitivity to latency and jitter, and sensitivity and impact of packet loss.

Voice Applications

Voice applications typically demand small amounts of bandwidth. However, the bandwidth must be constant and predictable because voice applications are typically sensitive to latency (inter-packet delay) and jitter (variation in inter-packet delay). The most important QoS parameter to establish for voice applications is minimum bandwidth, followed by priority.

Video Applications

Video applications are similar in needs to voice applications, with the exception that bandwidth requirements are somewhat larger, depending on the encoding. It is important to understand the behavior of the video application being used. For example, in the playback of stored video streams, some applications can transmit large amounts of data for multiple streams in one “spike,” with the expectation that the end-stations will buffer significant amounts of video-stream data. This can present a problem to the network infrastructure, because it must be capable of buffering the transmitted spikes where there are speed differences (for example, going from Gigabit Ethernet to Fast Ethernet). Key QoS parameters for video applications include minimum bandwidth, priority, and possibly buffering (depending upon the behavior of the application).

Critical Database Applications

Database applications, such as those associated with ERP, typically do not demand significant bandwidth and are tolerant of delay. You can establish a minimum bandwidth using a priority less than that of delay-sensitive applications.

Web Browsing Applications

QoS needs for Web browsing applications cannot be generalized into a single category. For example, ERP applications that use a browser front-end may be more important than retrieving daily news information. Traffic groupings can typically be distinguished from each other by their server source and destinations. Most browser-based applications are distinguished by the dataflow being asymmetric (small dataflows from the browser client, large dataflows from the server to the browser client).

An exception to this may be created by some Java™ -based applications. In addition, Web-based applications are generally tolerant of latency, jitter, and some packet loss, however small packet-loss may have a large impact on perceived performance due to the nature of TCP. The relevant parameter for protecting browser applications is minimum bandwidth. The relevant parameter for preventing non-critical browser applications from overwhelming the network is maximum bandwidth. In addition, RED can be used to reduce session loss if the queue that floods Web traffic becomes over-subscribed.

File Server Applications

With some dependencies on the network operating system, file serving typically poses the greatest demand on bandwidth, although file server applications are very tolerant of latency, jitter, and some packet loss, depending on the network operating system and the use of TCP or UDP.

NOTE

Full-duplex links should be used when deploying policy-based QoS. Half-duplex operation on links can make delivery of guaranteed minimum bandwidth impossible.

Table 12 summarizes QoS guidelines for the different types of network traffic.

Table 12: Traffic Type and QoS Guidelines

Traffic Type	Key QoS Parameters
Voice	Minimum bandwidth, priority
Video	Minimum bandwidth, priority, buffering (varies)
Database	Minimum bandwidth
Web browsing	Minimum bandwidth for critical applications, maximum bandwidth for non-critical applications, RED
File server	Minimum bandwidth

Configuring QoS

To configure QoS, you define how your switch responds to different categories of traffic by creating and configuring QoS profiles. You then group traffic into categories (according to application, as previously discussed) and assign each category to a QoS profile. Configuring QoS is a three-step process:

1. Configure the QoS profile.

   QoS profile—A class of service that is defined through minimum and maximum bandwidth parameters, configuration of buffering and RED, and prioritization settings. The bandwidth and level of service that a particular type of traffic or traffic grouping receives is determined by assigning it to a QoS profile.

2. Create traffic groupings.

   Traffic grouping—A classification or traffic type that has one or more attributes in common. These can range from a physical port to a VLAN to IP layer 4 port information. You assign traffic groupings to QoS profiles to modify switch forwarding behavior. Traffic groupings transmitting out the same port that are assigned to a particular QoS profile share the assigned bandwidth and prioritization characteristics, and hence share the class of service.

3. Monitor the performance of the application with the QoS monitor to determine whether the policies are meeting the desired results.

The next sections describe each of these QoS components in detail.

QoS Profiles

A QoS profile defines a class of service by specifying traffic behavior attributes, such as bandwidth. The parameters that make up a QoS profile include:

- **Minimum bandwidth**—The minimum percentage of total link bandwidth that is reserved for use by a hardware queue on a physical port. Bandwidth unused by the queue can be used by other queues. The minimum bandwidth for all queues should add up to less than 90%. The default value on all minimum bandwidth parameters is 0%.
- **Maximum bandwidth**—The maximum percentage of total link bandwidth that can be transmitted by a hardware queue on a physical port. The default value on all maximum bandwidth parameters is 100%.
- **Priority**—The level of priority assigned to a hardware queue on a physical port. There are eight different available priority settings. By default, each of the default QoS profiles is assigned a unique priority. You would use prioritization when two or more hardware queues on the same physical port are contending for transmission on the same physical port, only after their respective bandwidth management parameters have been satisfied. If two hardware queues on the same physical port have the same priority, a round-robin algorithm is used for transmission, depending on the available link bandwidth.
  - When configured to do so, the priority of a QoS profile can determine the 802.1p bits used in the priority field of a transmitted packet (described later).
  - The priority of a QoS profile determines the DiffServ code point value used in an IP packet when the packet is transmitted (described later).
- **Buffer**—This parameter reserves buffer memory for use exclusively by a QoS profile across all affected ports. The default value for buffer settings is 0%. The sum of all QoS profile buffer parameters should not exceed 100%. The `maxbuf` parameter allows you to set a maximum buffer size (in Kbytes or Mbytes) for each queue, so that a single queue will not consume all of the un-allocated buffer space. The default buffer size is 256K. You should not modify the buffer parameter unless specific situations and application behavior indicate.

A QoS profile does not alter the behavior of the switch until it is assigned to a traffic grouping. Recall that QoS profiles are linked to hardware queues. There are multiple hardware queues per physical port. By default, a QoS profile links to the identical hardware queue across all the physical ports of the switch.

The default QoS profiles cannot be deleted. Also by default, a QoS profile maps directly to a specific hardware queue across all physical ports. The settings for the default QoS parameters are summarized in Table 13.

Table 13: QoS Parameters

Profile Name	Hardware Queue	Priority	Buffer	Minimum Bandwidth	Maximum Bandwidth
Qp1	Q0	Low	0	0%	100%
Qp2	Q1	Lowhi	0	0%	100%
Qp3	Q2	Normal	0	0%	100%
Qp4	Q3	Normalhi	0	0%	100%
Qp5	Q4	Medium	0	0%	100%
Qp6	Q5	Mediumhi	0	0%	100%

Table 13: QoS Parameters (continued)

Qp7	Q6	High	0	0%	100%
Qp8	Q7	Highhi	0	0%	100%

Traffic Groupings

Once a QoS profile is modified for bandwidth and priority, you assign traffic a grouping to the profile. A *traffic grouping* is a classification of traffic that has one or more attributes in common. Traffic is typically grouped based on the applications discussed starting on page 108.

Traffic groupings are separated into the following categories for discussion:

- IP-based information, such as IP source/destination and TCP/UDP port information
- Destination MAC (MAC QoS groupings)
- Explicit packet class of service information, such as 802.1p or DiffServ (IP TOS)
- Physical/logical configuration (physical source port or VLAN association)

In the event that a given packet matches two or more grouping criteria, there is a predetermined precedence for which traffic grouping will apply. In general, the more specific traffic grouping takes precedence. By default, all traffic groupings are placed in the QoS profile Qp1. The supported traffic groupings are listed in Table 14. The groupings are listed in order of precedence (highest to lowest). The four types of traffic groupings are described in detail on the following pages.

Table 14: Traffic Groupings by Precedence

IP Information (Access Lists) Groupings
• Access list precedence determined by user configuration
Destination Address MAC-Based Groupings
• Permanent
• Dynamic
• Blackhole
• Broadcast/unknown rate limiting
Explicit Packet Class of Service Groupings
• DiffServ (IP TOS)
• 802.1P
Physical/Logical Groupings
• VLAN
• Source port

IP-Based Traffic Groupings

IP-based traffic groupings are based on any combination of the following items:

- IP source or destination address
- TCP/UDP or other layer 4 protocol
- TCP/UDP port information

IP-based traffic groupings are defined using access lists. Access lists are discussed in detail in Chapter 11. By supplying a named QoS profile at the end of the access list command syntax, you can prescribe the bandwidth management and priority handling for that traffic grouping. This level of packet filtering has no impact on performance.

MAC-Based Traffic Groupings

QoS profiles can be assigned to destination MAC addresses. MAC-based traffic groupings are configured using the following command:

```
create fdbentry <mac_address> vlan <vlan name> [blackhole | port <portlist> | dynamic]
qosprofile <qosprofile>
```

The MAC address options, defined below, are as follows:

- Permanent
- Dynamic
- Blackhole
- Broadcast/unknown rate limiting

Permanent MAC addresses

Permanent MAC addresses can be assigned a QoS profile whenever traffic is destined to the MAC address. This can be done when you create a permanent FDB entry. For example:

```
create fdbentry 00:11:22:33:44:55 vlan default port 4:1 qosprofile qp2
```

Dynamic MAC Addresses

Dynamic MAC addresses can be assigned a QoS profile whenever traffic is destined to the MAC address. For any port on which the specified MAC address is learned in the specified VLAN, the port is assigned the specified QoS profile. For example:

```
create fdbentry 00:11:22:33:44:55 vlan default dynamic qosprofile qp3
```

The QoS profile is assigned when the MAC address is learned. If a client's location moves, the assigned QoS profile moves with the device. If the MAC address entry already exists in the FDB, you can clear the forwarding database so that the QoS profile can be applied when the entry is added again. Use the following command to clear the FDB:

```
clear fdb
```

Blackhole MAC Address

Using the `blackhole` option configures the switch to not forward any packets to the destination MAC address on any ports for the VLAN specified. The `blackhole` option is configured using the following command:

```
create fdbentry 00:11:22:33:44:55 vlan default blackhole
```

Broadcast/Unknown Rate Limiting MAC Address

It is possible to assign broadcast and unknown destination packets to a QoS profile that has the desired priority and bandwidth parameters. Broadcast/unknown rate limiting is an extension of the QoS feature used for destination MAC addresses.

For example, if you want to limit broadcast and unknown traffic on the VLAN *default* to the bandwidth and priority defined in QoS profile *qp3*, the command is:

```
create fdbentry ff:ff:ff:ff:ff:ff vlan default dynamic qp3
```

NOTE

P multicast traffic is subject to broadcast and unknown rate limiting only when IGMP snooping is disabled.

Verifying MAC-Based QoS Settings

To verify any of the MAC-based QoS settings, use either the command

```
show fdb permanent
```

or the command

```
show qosprofile <qosprofile>
```

Explicit Class of Service (802.1p and DiffServ) Traffic Groupings

This category of traffic groupings describes what is sometimes referred to as *explicit packet marking,* and refers to information contained within a packet intended to explicitly determine a class of service. That information includes:

- IP DiffServ code points, formerly known as IP TOS bits
- Prioritization bits used in IEEE 802.1p packets

An advantage of explicit packet marking is that the class of service information can be carried throughout the network infrastructure, without repeating what can be complex traffic grouping policies at each switch location. Another advantage is that end stations can perform their own packet marking on an application-specific basis. Extreme switch products have the capability of observing and manipulating packet marking information with no performance penalty.

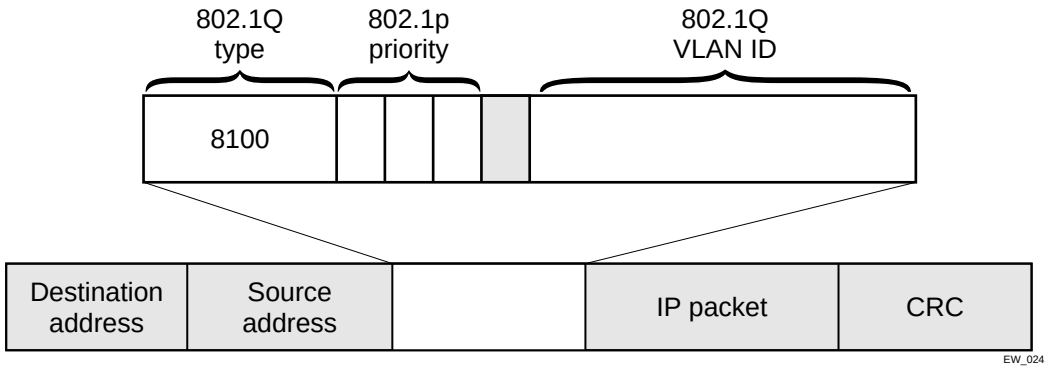
The documented capabilities for 802.1p priority markings or DiffServ capabilities (if supported) are not impacted by the switching or routing configuration of the switch. For example, 802.1p information can be preserved across a routed switch boundary and DiffServ code points can be observed or overwritten across a layer 2 switch boundary.

Configuring 802.1p Priority

Extreme switches support the standard 802.1p priority bits that are part of a tagged Ethernet packet. The 802.1p bits can be used to prioritize the packet, and assign it to a particular QoS profile.

When a packet arrives at the switch, the switch examines the 802.1p priority field maps it to a specific hardware queue when subsequently transmitting the packet. The 802.1p priority field is located directly following the 802.1Q type field, and preceding the 802.1Q VLAN ID, as shown in Figure 10.

Figure 10: Ethernet packet encapsulation



Observing 802.1p Information

When ingress traffic that contains 802.1p prioritization information is detected by the switch, the traffic is mapped to various hardware queues on the egress port of the switch. Eight hardware queues are supported. The transmitting hardware queue determines the bandwidth management and priority characteristics used when transmitting packets.

To control the mapping of 802.1p prioritization values to hardware queues, 802.1p prioritization values can be mapped to a QoS profile. The default mapping of each 802.1p priority value to QoS profile is shown in Table 15.

Table 15: 802.1p Priority Value-to-QoS Profile Default Mapping

Priority Value	QoS Profile
0	Qp1
1	Qp2
2	Qp3
3	Qp4
4	Qp5
5	Qp6
6	Qp7
7	Qp8

Changing the Default 802.1p Mapping

By default, a QoS profile is mapped to a hardware queue, and each QoS profile has configurable bandwidth parameters and priority. In this way, an 802.1p priority value seen on ingress can be mapped to a particular QoS profile and with specific bandwidth management and priority behavior.

To change the default mappings of QoS profiles to 802.1p priority values, use the following command:

```
config dot1p type <dot1p_priority> qosprofile <qosprofile>
```

Configuring 802.1p Priority For Slow Path Traffic

Some traffic can originate on the switch, for example Ping or Telnet packets. This traffic comes from the switch CPU and is referred to as slow path traffic. This traffic is internally tagged with an 802.1p

priority of 7, by default, and egresses the VLAN through the highest queue. If you want to set a different tag (and priority) use the following command to set the priority to a number between 0 and 7:

```
config vlan <vlan name> priority <number>
```

Other traffic transported across the switch and VLAN will not be changed, in other words, the 802.1p values will not be affected by the VLAN priority setting.

Replacing 802.1p Priority Information

By default, 802.1p priority information is not replaced or manipulated, and the information observed on ingress is preserved when transmitting the packet. This behavior is not affected by the switching or routing configuration of the switch.

However, the switch is capable of inserting and/or overwriting 802.1p priority information when it transmits an 802.1Q tagged frame. If 802.1p replacement is enabled, the 802.1p priority information that is transmitted is determined by the hardware queue that is used when transmitting the packet. To replace 802.1p priority information, use the following command:

```
enable dot1p replacement ports [<portlist> | all]
```

802.1p priority information is replaced according to the hardware queue that is used when transmitting from the switch. The mapping is described in Table 16. This mapping cannot be changed.

Table 16: Queue to 802.1p Priority Replacement Value

Hardware Queue	802.1p Priority Replacement Value
Q0	0
Q1	1
Q2	2
Q3	3
Q4	4
Q5	5
Q6	6
Q7	7

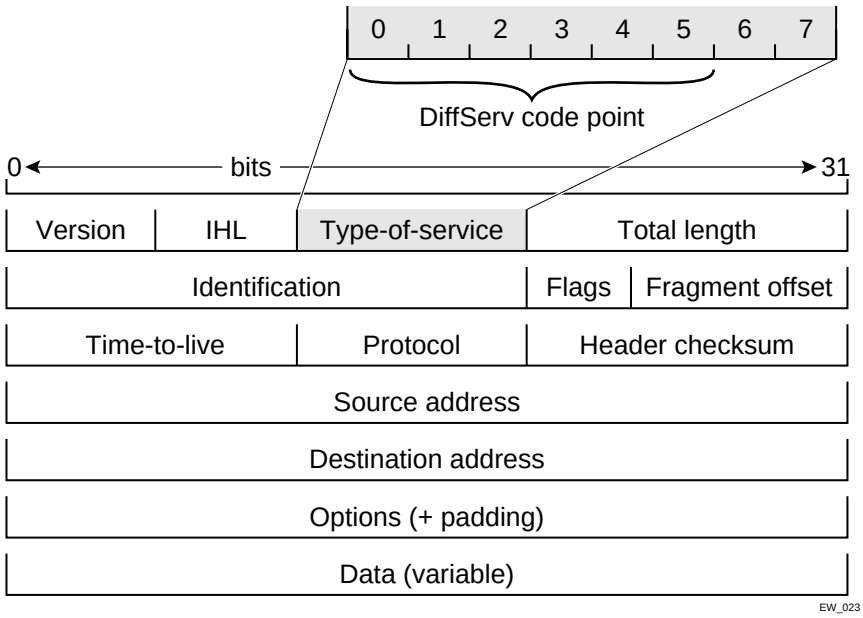
Configuring DiffServ

Contained in the header of every IP packet is a field for IP Type of Service (TOS), now also called the DiffServ field. The TOS field is used by the switch to determine the type of service provided to the packet.

Observing DiffServ code points as a traffic grouping mechanism for defining QoS policies and overwriting the Diffserv code point fields are supported.

Figure 11 shows the encapsulation of an IP packet header.

Figure 11: IP packet header encapsulation



Observing DiffServ Information

When a packet arrives at the switch on an ingress port, the switch examines the first six of eight TOS bits, called the *code point*. The switch can assign the QoS profile used to subsequently transmit the packet based on the code point. The QoS profile controls a hardware queue used when transmitting the packet out of the switch, and determines the forwarding characteristics of a particular code point. Viewing DiffServ information can be enabled or disabled; by default it is disabled. To view DiffServ information, use the following command:

```
enable diffserv examination ports [<portlist> | all]
```

Changing DiffServ Code point assignments in the Q0S Profile

Because the code point uses six bits, it has 64 possible values ($2^6 = 64$). Be default, the values are grouped and assigned to the default QoS profiles listed in Table 17.

Table 17: Default Code Point-to-QoS Profile Mapping

Code Point	QoS Profile
0-7	Qp1
8-15	Qp2
16-23	Qp3
24-31	Qp4
32-39	Qp5
40-47	Qp6
48-55	Qp7
56-63	Qp8

You can change the QoS profile assignment for all 64 code points using the following command:

```
config diffserv examination code-point <code_point> qosprofile <qosprofile> ports
[<portlist> | all]
```

Once assigned, the rest of the switches in the network prioritize the packet using the characteristics specified by the QoS profile.

Replacing DiffServ Code Points

The switch can be configured to change the DiffServ code point in the packet prior to the packet being transmitted by the switch. This is done with no impact on switch performance.

The DiffServ code point value used in overwriting a packet is determined by the 802.1p priority value. The 802.1p priority value is, in turn, determined by the hardware queue used when transmitting a packet, as described in “Replacing 802.1p Priority Information” on page 116.

It is not necessary to receive or transmit 802.1Q tagged frames, only to understand that the egress hardware queue, which also determines the 802.1p priority value, can also be configured to determine the DiffServ code point value if you want to replace the DiffServ code points.

To replace DiffServ code points you must enable both 802.1p replacement and DiffServ replacement using the following commands:

```
enable dot1p replacement ports [<portlist> | all]
enable diffserv replacement ports [<portlist> | all]
```

The default 802.1p priority value to code point mapping is described in Table 18.

Table 18: Default 802.1p Priority Value-to-Code Point Mapping

Hardware Queue	802.1p Priority value	Code Point
Q0	0	0
Q1	1	8
Q2	2	16
Q3	3	24
Q4	4	32
Q5	5	40
Q6	6	48
Q7	7	56

You then change the 802.1p priority to DiffServ code point mapping to any code point value using the following command:

```
config diffserv replacement priority <vpri> code_point <code_point> ports [<portlist>
| all]
```

By doing so, the hardware queue used to transmit a packet determines the DiffServ value replaced in the IP packet.

To verify the DiffServ configuration, use the following command:

```
show ports <portlist> info {detail}
```

DiffServ Example

In this example, we use DiffServ to signal a class of service throughput and assign any traffic coming from network 10.1.2.x with a specific DiffServ code point. This allows all other network switches to send and observe the Diffserv code point instead of repeating the same QoS configuration on every network switch.

To configure the switch that handles incoming traffic from network 10.1.2.x, follow these steps:

1. Configure parameters of the QoS profile QP3:

   ```
   config qp3 min 10 max 100
   ```

2. Assign a traffic grouping for traffic from network 10.1.2.x to qp3:

   ```
   create access-list TenOneTwo
   config TenOneTwo 10.1.2.0/24 permit qp3
   ```

3. To enable the switch to overwrite the DiffServ code point:

   ```
   enable dot1p replacement
   ```

   ```
   enable diffserv replacement
   ```

4. Configure the switch so that other switches can signal class of service that this switch should observe:

   ```
   enable diffserv examination
   ```

Table 13 indicates that qp3 is tied to hardware queue Q2. We also know that when replacement is enabled all traffic sent out Q2 will contain code point value 16 (according to Table 18). If this is the desired code point to use, all traffic from 10.1.2.x will be sent out QP3 (at 10% minimum and 100% maximum) with a code point value of 16.

Physical and Logical Groupings

Two traffic groupings exist in this category:

- Source port
- VLAN

Source port

A source port traffic grouping implies that any traffic sourced from this physical port uses the indicated QoS profile when the traffic is transmitted out to any other port. To configure a source port traffic grouping, use the following command:

```
config ports <portlist> qosprofile <qosprofile>
```

In the following modular switch example, all traffic sourced from slot 5 port 7 uses the QoS profile named *qp3* when being transmitted.

```
config ports 5:7 qosprofile qp3
```

VLAN

A VLAN traffic grouping indicates that all intra-VLAN switched traffic and all routed traffic sourced from the named VLAN uses the indicated QoS profile. To configure a VLAN traffic grouping, use the following command:

```
config vlan <vlan name> qosprofile <qosprofile>
```

For example, all devices on VLAN *servnet* require use of the QoS profile *qp4*. The command to configure this example is as follows:

```
config vlan servnet qosprofile qp4
```

Verifying Physical and Logical Groupings

To verify settings on ports or VLANs, use the following command:

```
show qosprofile <qosprofile>
```

The same information is also available for ports or VLANs using one of the following commands:

```
show ports <portlist> info {detail}
```

or

```
show vlan
```

Configuring QoS Traffic Grouping Priorities

Normally, there is a predetermined precedence for which traffic grouping applies to a given packet that matches two or more grouping criteria. In general, the more specific traffic grouping takes precedence. However, you can configure a new set of priorities using the following command:

```
config qostype priority [source-mac | dest-mac | access-list | vlan | diffserv |
dot1p] <priority>
```

The valid priority values are 0 - 15. The default values are shown in Table 19.

Table 19: Traffic Grouping Priority Default Values

QoS Type	Default Value
source-mac	7
dest-mac	8
access-list	11
vlan	1
diffserv	3
dot1p	2

QoS types with a greater value take higher precedence. For example, to force FDB source-mac QoS to take a higher precedence over FDB dest-mac QoS, use the commands:

```
config qostype priority source-mac 9
```

where 9 is greater than the default value assigned to the dest-mac QoS type.

Traffic groupings based on the source port always have the lowest priority, and all other traffic groupings take priority. You cannot change the priority for source port-based traffic groupings.

Verifying and Resetting QoS Traffic Grouping Priorities

To verify QoS traffic grouping priority settings, use the command:

```
show qostype priority
```

To reset priority settings to their default values, use the command:

```
unconfig qostype priority
```

Verifying Configuration and Performance

Once you have created QoS policies that manage the traffic through the switch, you can use the QoS monitor to determine whether the application performance meets your expectations.

QoS Monitor

The QOS monitor is a utility that monitors the hardware queues associated with any port(s). The QOS monitor keeps track of the number of frames and the frames per second that a specific queue is responsible for transmitting on a physical port. Two options are available: a real-time display, and a separate option for retrieving information in the background and writing it to the log.

Real-Time Performance Monitoring

The real-time display scrolls through the given portlist to provide statistics. You can choose screens for packet count and packets per second. The specific port being monitored is indicated by an asterisk (*) appearing after the port number in the display.

The view real-time switch per-port performance, use the following command:

```
show ports {<portlist>} qosmonitor
```

QoS monitor sampling is configured as follows:

- The port is monitored for 20 seconds before the switch moves on to the next port in the list.
- A port is sampled for five seconds before the packets per second (pps) value is displayed on the screen.

Background Performance Monitoring

Monitoring QoS in the background places transmit counter and any “overflow” information into the switch log. The log notification appears if one of the queues experiences an overflow condition since the last time it was sampled.

An overflow entry indicates that a queue was over-subscribed at least temporarily, and is useful for determining correct QoS settings and potential over-subscription issues.

Displaying QoS Profile Information

The QoS monitor can also be used to verify the QoS configuration and monitor the use of the QoS policies that are in place. To display QoS information on the switch, use the following command:

```
show qosprofile <qosprofile>
```

Displayed information includes:

- QoS profile name
- Minimum bandwidth
- Maximum bandwidth
- Priority
- A list of all traffic groups to which the QoS profile is applied

Additionally, QoS information can be displayed from the traffic grouping perspective by using one or more of the following commands:

- `show fdb permanent`—Displays destination MAC entries and their QoS profiles.
- `show switch`—Displays information including PACE enable / disable information.
- `show vlan`—Displays the QoS profile assignments to the VLAN.
- `show ports <portlist> info {detail}`—Displays information including QoS information for the port.

Modifying a QoS Configuration

If you make a change to the parameters of a QoS profile after implementing your configuration, the timing of the configuration change depends on the traffic grouping involved. The following rules apply:

- For destination MAC-based grouping (other than permanent), clear the MAC FDB using the command `clear fdb`. This command should also be issued after a configuration is implemented, as the configuration must be in place before an entry is made in the MAC FDB. For permanent destination MAC-based grouping, re-apply the QoS profile to the static FDB entry, as documented. You can also save and reboot the switch.
- For physical and logical groupings of a source port or VLAN, re-apply the QoS profile to the source port or VLAN, as documented. You can also save and reboot the switch.

Bi-Directional Rate Shaping

Bi-directional rate shaping allows you to manage bandwidth on layer 2 and layer 3 traffic flowing both to and from the switch. You can configure up to eight ingress queues per VLAN and up to eight egress queues per physical port. By defining minimum and maximum bandwidth for each queue, you define committed information rates for each queue. You can define different rates for ingress and egress queues.

You can then provide traffic groupings (such as physical port, VLAN, .1P, DiffServ, IP address, or layer 4 flow) for the predefined QoS Profiles, thereby directing specific types of traffic to the desired queue.

Configuring Bi-Directional Rate Shaping

Each VLAN requires a loopback port; all traffic from rate-shaped ports is directed through the loopback port for that VLAN. To rate-shape ingress traffic, configure QoS normally on the loopback port for the VLAN. The maximum bandwidth and traffic grouping defined in the QoS profile for the loopback port defines the rate limit for ingress traffic on rate-shaped ports in that VLAN.

Use the following guidelines for bi-directional rate shaping:

- You must configure a loopback port before adding rate-shaped ports.
- A loopback port cannot be used by an external device.
- You must configure the loopback port with a unique loopback VLAN tag ID.
- Ingress traffic on a port that is configured to use the loopback port will be rate-shaped.
- Ingress traffic on a port that is not configured to use the loopback port will not be rate-shaped.
- Unicast traffic from a non-rate-shaped port to a rate-shaped port within the VLAN will not be rate-shaped.
- The aggregate forwarding bandwidth of all rate-shaped ports in a VLAN is determined by the setting of the queue parameters of the loopback port.
- For 10/100 Mbps ports, you can configure the loopback port as a 10 Mbps port to achieve lower bandwidth values.

To remove the rate-shaping parameters of the loopback port, configure the QoS profile without specifying the buffer or portlist parameters.

Bandwidth Settings

You apply bandwidth settings to QoS profiles as a percentage of bandwidth. QoS profile bandwidth settings are in turn applied to queues on physical ports. The impact of the bandwidth setting is determined by the port speed (10, 100, or 1000 Mbps).

Maximum Bandwidth Settings

The maximum bandwidth settings determine the port bandwidth available to each queue. Use Table 20 to determine the bandwidth associated with each bandwidth setting at different port speeds.

Table 20: Maximum Bandwidth Settings

Bandwidth Setting (%)	Bandwidth at 10 Mbps	Bandwidth at 100 Mbps	Bandwidth at 1000 Mbps
2	200 Kbps	2 Mbps	20 Mbps
3	310 Kbps	31 Mbps	30 Mbps
5	490 Kbps	4.9 Mbps	50 Mbps
7	690 Kbps	6.9 Mbps	69 Mbps
8	790 Kbps	7.9 Mbps	79 Mbps
10	960 Kbps	9.6 Mbps	96 Mbps
11	1.12 Mbps	11.2 Mbps	112 Mbps
15	1.5 Mbps	15 Mbps	150 Mbps
20	1.9 Mbps	19 Mbps	190 Mbps
25	2.5 Mbps	25 Mbps	250 Mbps

Table 20: Maximum Bandwidth Settings (continued)

Bandwidth Setting (%)	Bandwidth at 10 Mbps	Bandwidth at 100 Mbps	Bandwidth at 1000 Mbps
30	3.3 Mbps	33 Mbps	330 Mbps
35	3.5 Mbps	35 Mbps	350 Mbps
40	4..2 Mbps	42 Mbps	420 Mbps
50	5 Mbps	50 Mbps	500 Mbps
60	5.7 Mbps	57 Mbps	570 Mbps
65	6.5 Mbps	65 Mbps	650 Mbps
70	7.3 Mbps	73 Mbps	730 Mbps
80	7.9 Mbps	79 Mbps	790 Mbps
95	9.5 Mbps	95 Mbps	950 Mbps
100	10 Mbps	100 Mbps	1000 Mbps

If you choose a setting not listed in Table 20, the setting is rounded up to the next value.

Minimum Bandwidth Settings

The minimum bandwidth settings determine the port bandwidth reserved for each queue. Use Table 21 to determine the bandwidth associated with each setting.

Table 21: Minimum Bandwidth Settings

Bandwidth Setting (%)	Bandwidth at 10 Mbps	Bandwidth at 100 Mbps	Bandwidth at 1000 Mbps
4	420 Kbps	4.2 Mbps	42 Mbps
6	570 Kbps	5.7 Mbps	57 Mbps
8	750 Kbps	7.5 Mbps	75 Mbps
9	930 Kbps	9.3 Mbps	93 Mbps
10	1 Mbps	10 Mbps	100 Mbps
20	1.87 Mbps	18.7 Mbps	187 Mbps
25	2.63 Mbps	26.3 Mbps	263 Mbps
35	3.4 Mbps	34 Mbps	340 Mbps
50	4.9 Mbps	49 Mbps	490 Mbps
60	6.3 Mbps	63 Mbps	630 Mbps
80	7.9 Mbps	79 Mbps	790 Mbps
89	9.4 Mbps	94 Mbps	940 Mbps

NOTE

Keep the sum of the minimum bandwidth values for the applied QoS profiles less than 90%. If the sum exceeds 90%, a lower priority queue might be unable to transmit in a sustained over-subscription situation.

If you choose a setting not listed in Table 21, the setting is rounded up to the next value. If the actual bandwidth used is below the minimum bandwidth, the additional bandwidth is available for other queues on that physical port.

Bi-Directional Rate Shaping Limitations

Consider the following limitations when configuring bi-directional rate shaping:

- You must delete all rate-shaped ports before deleting the loopback port.
- If rate-shaped ports within a VLAN use different bandwidth parameters, set the priority of the QoS profiles on the loopback port and rate-shaped ports to `low`.
- Layer 2 rate-shaping only affects a single VLAN.
- On a BlackDiamond switch, the loopback port must be on the same I/O module as the rate-shaped ports.
- You must enable IP forwarding on the VLAN prior to adding the loopback port to a VLAN for layer 2 rate shaping.
- You cannot use tagged ports for rate shaping.
- You cannot use load-shared ports for rate-shaping.
- You cannot run VRRP on a VLAN that is configured for ingress rate shaping.

Dynamic Link Context System

The Dynamic Link Context System (DLCS) is a feature that snoops WINS NetBIOS packets and creates a mapping between a user name, the IP address or MAC address, and the switch/port. Based on the information in the packet, DLCS can detect when an end station boots up or a user logs in or out, and dynamically maps the end station name to the current IP address and switch/port. This information is available for use by ExtremeWare Enterprise Manager (EEM) version 2.1 or later or ExtremeWare EPICenter in setting policies that can be applied to users and can dynamically follow a user's location. DLCS provides you with valuable information on a user’s location and associated network attributes. For DLCS to operate within ExtremeWare, the user or end station must allow for automatic DLCS updates.

This feature is intended for use in conjunction with the EPICenter 3.1 Policy System. Refer to the EPICenter 3.1 documentation for more information.

DLCS Guidelines

Follow these guidelines when using DLCS:

- Only one user is allowed on one workstation at a given time.
- A user can be logged into many workstations simultaneously.
- An IP-address can be learned on only one port in the network at a given time.
- Multiple IP-addresses can be learned on the same port.
- DLCS mapping is flushed when a user logs in or logs out, or when an end-station is shutdown.

DLCS Limitations

Consider the following limitations concerning data received from WINS snooping:

- DLCS does not work for the WINS server. This is because the WINS server does not send NETBIOS packets on the network (these packets are address to itself).
- When the IP address of a host is changed, and the host is not immediately rebooted, the old host-to-IP address mapping is never deleted. You must delete the mapping of the host-to-IP address through the EEM Policy Manager or ExtremeWare EPICenter Policy Manager.
- When the host is moved from one port to another port on a switch, the old entry does not age out unless the host is rebooted or a user login operation is performed after the host is moved.
- DLCS information is dynamic, therefore, if the switch is rebooted, the information is lost. This information is still stored in the policy-server. To delete the information from the policy system, you must explicitly delete configuration parameters from the EEM or ExtremeWare EPICenter Policy Applet user interface. As a workaround, you can delete the switch that was rebooted from the list of managed devices in the EEM or EPICenter Inventory Applet, and re-add the switch to the Inventory Manager.
- DLCS is not supported on hosts that have multiple NIC cards.
- IPQoS is not supported to a WINS server that is serving more than one VLAN. If you attempt to add a WINS server to serve more than one VLAN, and there are IPQoS rules defined for that server, the command to add the WINS server is rejected.

8 Network Address Translation (NAT)

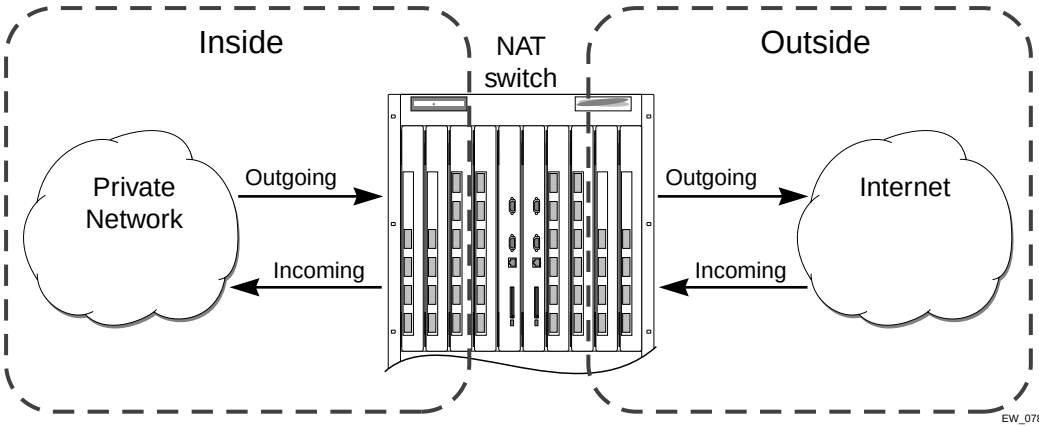
This chapter covers the following topics:

- Overview on page 127
- Internet IP Addressing on page 128
- Configuring VLANs for NAT on page 128
- Configuring NAT on page 130
- Creating NAT Rules on page 130
- Displaying NAT Settings on page 132
- Disabling NAT on page 133

Overview

NAT is a feature that allows one set of IP addresses, typically private IP addresses, to be converted to another set of IP addresses, typically public Internet IP addresses. This conversion is done transparently by having a NAT device (any Extreme Networks switch using the "*i*" chipset) rewrite the source IP address and Layer 4 port of the packets.

Figure 12: NAT Overview



You can configure NAT to conserve IP address space by mapping a large number of inside (private) addresses to a much smaller number of outside (public) addresses.

In implementing NAT, you must configure at least two separate VLANs involved. One VLAN is configured as inside, and corresponds to the private IP addresses you would like to translate into other IP addresses. The other type of VLAN is configured as outside, which corresponds to the public (probably Internet) IP addresses you want the inside addresses translated to. The mappings between inside and outside IP addresses are done via rules that specify the IP subnets involved and the algorithms used to translate the addresses.

NOTE

The NAT modes in ExtremeWare 7.0.0 support translating traffic initiating only from inside addresses.

NAT rules are associated with a single outside VLAN. Multiple rules per outside VLAN are allowed. The rules take effect in the order they are displayed using the `show` command. Any number of inside VLANs can use a single outside VLAN, assuming that you have created proper rules. Similarly, a single inside VLAN can use any number of different outside VLANs, assuming that the rules and routing are set up properly.

Both TCP and UDP have layer 4 port numbers ranging from 1 to 65535. These layer 4 ports, in combination with the IP addresses, form a unique identifier which allows hosts (as well as the NAT switch) to distinguish between separate conversations. NAT operates by replacing the inside IP packet's source IP and layer 4 port with an outside IP and layer 4 port. The NAT switch maintains a connection table to map the return packets on the outside VLAN back into their corresponding inside sessions.

Internet IP Addressing

When implementing NAT in an Internet environment, it is strongly recommended that you use one of the reserved private IP address ranges for your inside IP addresses. These ranges have been reserved specifically for networks not directly attached to the Internet. Using IP addresses within these ranges prevents addressing conflicts with public Internet sites to which you want to connect. The ranges are as follows:

- 10.0.0.0/8—Reserved Class A private address space
- 172.16.0.0/12—Reserved Class B private address space
- 192.168.0.0/16—Reserved Class C private address space

Configuring VLANs for NAT

You must configure each VLAN participating in NAT as either an inside or outside VLAN. To configure a VLAN as an inside or outside VLAN, use the following command:

```
config nat vlan <vlan name> [inside | outside | none]
```

When a VLAN is configured to be `inside`, traffic from that VLAN is translated only if it has a matching NAT rule. Any unmatched traffic will be routed normally and not be translated. Because all traffic runs through the central processing unit (CPU), it cannot run at line-rate.

When a VLAN is configured to be outside, it routes all traffic. Because all traffic runs through the CPU, it cannot run at line-rate. Normally, outside traffic will be able to initiate connections to the internal private IP addresses. If you want to prevent this, you can create IP and ICMP access-lists on the outside VLAN ports to deny traffic destined for the inside IP addresses. There is a NAT performance penalty when you do this.

When a VLAN is configured to be none, all NAT functions are disabled and the VLAN operates normally.

Below is a set of example ACL rules to deny outside traffic. These examples assume the inside network is 192.168.1.0/24 and the outside VLAN is on port 1.

```
create access-list deny_ip ip destination 192.168.1.0/24 source any deny ports 1
create access-list deny_icmp icmp destination 192.168.1.0/24 source any type any code
any deny ports 1
```

NAT Modes

There are 4 different modes used to determine how the outside IP addresses and layer 4 ports are assigned.

- Static mapping
- Dynamic mapping
- Port-mapping
- Auto-constraining

Static Mapping

When static mapping is used, each inside IP address uses a single outside IP address. The layer 4 ports are not changed, only the IP address is rewritten. Because this mode requires a 1:1 mapping of internal to external addresses, it does not make efficient use of the external address space. However, it is useful when you have a small number of hosts that need to have their IP addresses rewritten without conflicting with other hosts. Because this mode does not rely on layer 4 ports, ICMP traffic is translated and allowed to pass.

Dynamic Mapping

Dynamic mapping is similar to static mapping in that the layer 4 ports are not rewritten during translation. Dynamic mapping is different in that the number of inside hosts can be greater than the number of outside hosts. The outside IP addresses are allocated on a first-come, first-serve basis to the inside IP addresses. When the last session for a specific inside IP address closes, that outside IP address can be used by other hosts. Since this mode does not rely on layer 4 ports, ICMP traffic is translated and allowed to pass.

Port-mapping

Port-mapping gives you the most efficient use of the external address space. As each new connection is initiated from the inside, the NAT device picks the next available source layer 4 port on the first available outside IP address. When all ports on a given IP address are in use, the NAT device uses ports off of the next outside IP address. Some systems reserve certain port ranges for specific types of traffic, so it is possible to map specific source layer 4 port ranges on the inside to specific outside source ranges. However, this may cause a small performance penalty. In this case, you would need to make several rules using the same inside and outside IP addresses, one for each layer 4 port range. ICMP

traffic is not translated in this mode. You must add a dynamic NAT rule for the same IP address range to allow for ICMP traffic.

Auto-constraining

The auto-constraining algorithm for port-mapping limits the number of outside layer 4 ports a single inside host can use simultaneously. The limitation is based on the ratio of inside to outside IP addresses. The outside IP address and layer 4 port space is evenly distributed to all possible inside hosts. This guarantees that no single inside host can prevent other traffic from flowing through the NAT device. Because of the large number of simultaneous requests that can be made from a web browser, it is not recommended that this mode be used when a large number of inside hosts are being translated to a small number of outside IP addresses. ICMP traffic is not translated in this mode. You must add a dynamic NAT rule for the same IP address range to allow for ICMP traffic.

Configuring NAT

The behavior of NAT is determined by the rules you create to translate the IP addresses. You must attach each rule to a specific VLAN. All rules are processed in order. The options specified on the NAT rule determine the algorithm used to translate the inside IP addresses to the outside IP addresses. For outgoing (inside to outside) packets, the first rule to match is processed. All following rules are ignored. All return packets must arrive on the same outside VLAN on which the session went out. For most configurations, make sure that the outside IP addresses specified in the rule are part of the outside VLAN's subnet range, so that the switch can proxy the address resolution protocol (ARP) for those addresses.

To enable NAT functionality, use the following command:

```
enable nat
```

Creating NAT Rules

This section describes how to configure the various types of NAT (static, dynamic, portmap, and auto-constrain). In the examples in this section, advanced port and destination matching options have been removed. For information on how to use some of the more advanced rule matching features, see "Advanced Rule Matching" on page 132.

Creating Static and Dynamic NAT Rules

To create static or dynamic NAT rules, use this command:

```
config nat [add | delete] vlan <outside_vlan> map source [any | <ipaddress> [/<bits>|
<netmask>]] to <ipaddress> [/<mask> | <netmask> | - <ipaddress>]
```

This is the simplest NAT rule. You specify the outside vlan name, and a subnet of inside IP addresses, which get translated to the outside IP address using the specified mode (static in this case). For the outside IP addresses, you can either specify an IP address and netmask or a starting and ending IP range to determine the IP addresses the switch will translate the inside IP addresses to. If the netmask for both the source and NAT addresses is /32, the switch will use static NAT translation. If the netmask for both the source and NAT addresses are not both /32, the switch will use dynamic NAT translation.

Static NAT Rule Example

```
config nat add out_vlan_1 map source 192.168.1.12/32 to 216.52.8.32/32
```

Dynamic NAT Rule Example

```
config nat add out_vlan_1 map source 192.168.1.0/24 to 216.52.8.1 - 216.52.8.31
```

Creating Portmap NAT Rules

To configure portmap NAT rules, use this command:

```
config nat [add | delete] vlan <outside_vlan> map source [any | <ipaddress> [/<bits>|
<netmask>]] to <ip> [/<mask> | <netmask> | - <ipaddress>] {[tcp |udp | both] portmap
{<min> - <max>}}
```

The addition of an L4 protocol name and the `portmap` keyword tells the switch to use portmap mode. Optionally, you may specify the range of L4 ports the switch chooses on the translated IP addresses, but there is a performance penalty for doing this. Remember that portmap mode will only translate TCP and/or UDP, so a dynamic NAT rule must be specified after the portmap rule in order to allow ICMP packets through without interfering with the portmapping.

Portmap NAT Rule Example

```
config nat add out_vlan_2 map source 192.168.2.0/25 to 216.52.8.32 /28 both portmap
```

Portmap Min-Max Example

```
config nat add out_vlan_2 map source 192.168.2.128/25 to 216.52.8.64/28 tcp portmap
1024 - 8192
```

Creating Auto-Constrain NAT Rules

To create auto-constrain NAT rules, use the following command:

```
config nat [add | delete] vlan <outside_vlan> map source [any | <ipaddress> [/<bits>|
<netmask>]] to <ip> [/<mask> | <netmask> | - <ipaddress>] {[tcp |udp | both]
auto-constrain}
```

This rule uses auto-constrain NAT. Remember that each inside IP address will be restricted in the number of simultaneous connections. Most installations should use portmap mode.

Auto-Constrain Example

```
config nat add out_vlan_3 map source 192.168.3.0/24 to 216.52.8.64/32 both
auto-constrain
```

Advanced Rule Matching

By default, NAT rules only match connections based on the source IP address of the outgoing packets. Using the `L4-port` and `destination` keywords, you can further limit the scope of the NAT rule so that it only applied to specific TCP/UDP layer 4 port numbers, or specific outside destination IP addresses.

NOTE

Once a single rule is matched, no other rules are processed.

Destination Specific NAT

```
config nat [add | delete] vlan <outside_vlan> map source [any | <ipaddress> [/<bits>|
<netmask>]] {destination <ipaddress/mask> } to <ipaddress> [/<mask> | <netmask> | -
<ipaddress>]
```

The addition of the `destination` optional keyword after the source IP address and mask allows the NAT rule to be applied to only packets with a specific destination IP address.

L4-Port Specific NAT

The addition of the `L4-port` optional keyword after the source IP address and mask allows the NAT rule to be applied to only packets with a specific L4 source or destination port. If you use the L4-port command after the source IP/mask, the rule will only match if the port(s) specified are the source L4-ports. If you use the L4-port command after the destination IP/mask, the rule will only match if the port(s) specified are the destination L4-ports. Both options may be used together to further limit the rule.

Configuring Time-outs

When an inside host initiates a session, a session table entry is created. Depending on the type of traffic or the current TCP state, the table entries time out after the configured time-out expires.

Displaying NAT Settings

To display NAT rules, use the following command:

```
show nat rules {vlan <outside_vlan>}
```

This command displays the NAT rules for a specific VLAN. Rules are displayed in the order they are processed, starting with the first one.

To display NAT traffic statistics, use the following command:

```
show nat stats
```

This command displays statistics for the NAT traffic, and includes:

- The number of rules
- The number of current connections
- The number of translated packets on the inside and outside VLANs
- Information on missed translations

To display NAT connection information, use the following command:

```
show nat connections
```

This command displays the current NAT connection table, including source IP/layer 4 port mappings from inside to outside.

Disabling NAT

To disable NAT, use the following command:

```
disable nat
```

9 Server Load Balancing (SLB)

This chapter describes the following topics:

- Overview on page 135
- SLB Components on page 136
- SLB Traffic Types on page 139
- Forwarding Modes on page 140
- Load-Balancing Methods on page 145
- Advanced SLB Application Example on page 146
- Using Persistence on page 149
- Using High Availability System Features on page 152
- Health Checking on page 157
- Flow Redirection on page 160

Overview

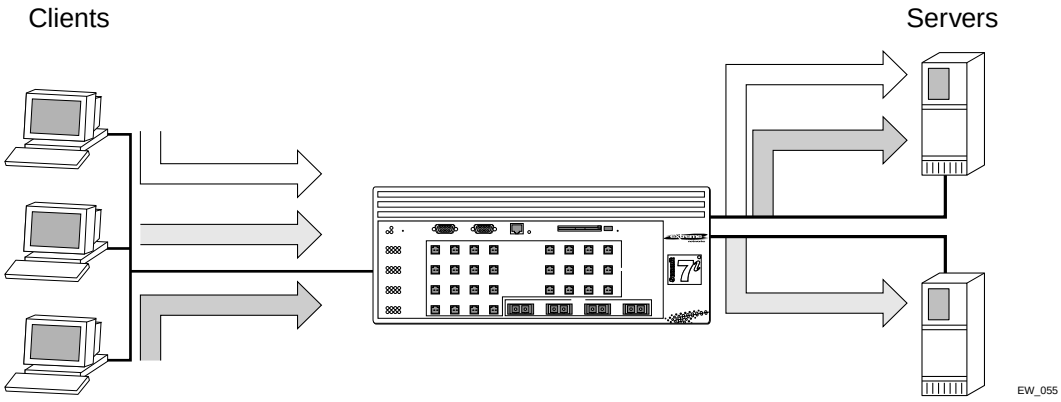
Server load balancing (SLB) transparently distributes client requests among several servers. The main use for SLB is for web hosting (using redundant servers to increase the performance and reliability of busy websites).

You can use SLB to manage and balance traffic for client equipment such as web servers, cache servers, routers, and proxy servers. SLB is especially useful for e-commerce sites, Internet service providers, and managers of large intranets.

Server load balancing (SLB), longest prefix matching (LPM), and destination-sensitive accounting (DSA) are mutually exclusive functions. None of these functions can be simultaneously enabled.

A basic SLB application is shown in Figure 13.

Figure 13: Basic SLB application



All content must be duplicated on all physical servers for server load balancing. To configure SLB, perform the following basic steps:

1. Create pools and configure the load balancing method for each pool.
2. Add nodes to the pools.
3. Create virtual servers and select the forwarding mode for each virtual server.
4. Assign an SLB traffic type to the server and client VLANs.
5. Enable IP forwarding on the server and client VLANs.
6. Enable SLB.

SLB Components

Three components comprise an SLB system:

- Nodes
- Pools
- Virtual servers

All three components are required for every SLB configuration.

Nodes

A *node* is an individual service on a physical server, and consists of an IP address and a port number. All nodes must have identical content. Nodes cannot belong to the same VLAN as the virtual servers they access.

Pools

A *pool* is a group of nodes that are mapped to a corresponding virtual server. You can use pools to easily scale large networks with many nodes.

Each pool contains its own load-balancing method. A pool must be associated with a virtual server to be used for load balancing. You must create pools before associating them with virtual servers, and must delete virtual servers before deleting their associated pools. You cannot delete pools that are still associated with a virtual server.

Virtual Servers

Virtual servers are the backbone of the SLB configuration. A virtual server is a virtual IP address that points to a group of servers. The switch then load balances those groups of servers (or other network equipment). Before you configure virtual servers, you need the following:

- The forwarding mode
- The name of the pool
- The virtual IP address
- The virtual port number

Virtual servers cannot belong to the same VLAN as the nodes in the pool they reference. Do not configure a virtual server with the same IP address as a VLAN.

Using Standard or Wildcard Virtual Servers

Each virtual server is associated with a single pool, which can be a group of content servers, routers, or cache servers.

You can configure two different types of virtual servers:

- Standard virtual servers

  A standard virtual server represents a site (such as a web site or an FTP site), and provides load balancing for content. Configure the virtual server IP address to be the same IP address as that of the site that the virtual server represents.

- Wildcard virtual servers

  A wildcard virtual server load balances transparent network devices such as routers or cache servers. Wildcard virtual servers use a special wildcard IP address (0.0.0.0), and require Transparent mode.

NOTE

For cache server applications, see “Web Cache Redirection” on page 161.

Network Advertisement

Three modes are available for controlling network connectivity to virtual servers. The switch will automatically select a method based on the virtual server's subnet.

- Proxy ARP

  If the virtual server is a member of an existing subnet to which the switch is directly attached, the switch will respond to ARP requests on behalf of the virtual server. This allows you to implement server load balancing on a layer 2 network. The VLAN containing the servers is in a different subnet than the client VLAN's subnet. The virtual server will appear to be a member of the client subnet.

- Host-Route

  If the virtual server is not a member of an existing subnet to which the switch is directly attached, the switch will add a host-route entry to the routing table. In this situation, all clients require a routed path (to the virtual server) that points to the switch's IP address on the client VLAN.

- Subnet-Route

  If the virtual server is separated from the switch by a router, the switch propagates the subnet containing the virtual server. You must create a loopback VLAN with the virtual server as a member of the loopback VLAN's subnet.

  When you enable the routing protocol to advertise the entire subnet to directly connected routers, a single entry is created in the routing table for each subnet advertised. For example, the following command enables RIP to advertise routes to all directly connected routers with a cost of 1:

  ```
  enable rip export direct cost 1
  ```

  When you enable the routing protocol to advertise specific virtual servers, an entry is created in the routing table for each virtual server you advertise. For example, the following command enables OSPF to advertise a specific virtual server with a cost of 1:

  ```
  enable ospf export vip cost 1
  ```

  This command exports the virtual servers to the entire network. Extreme Networks recommends this method to advertise virtual servers.

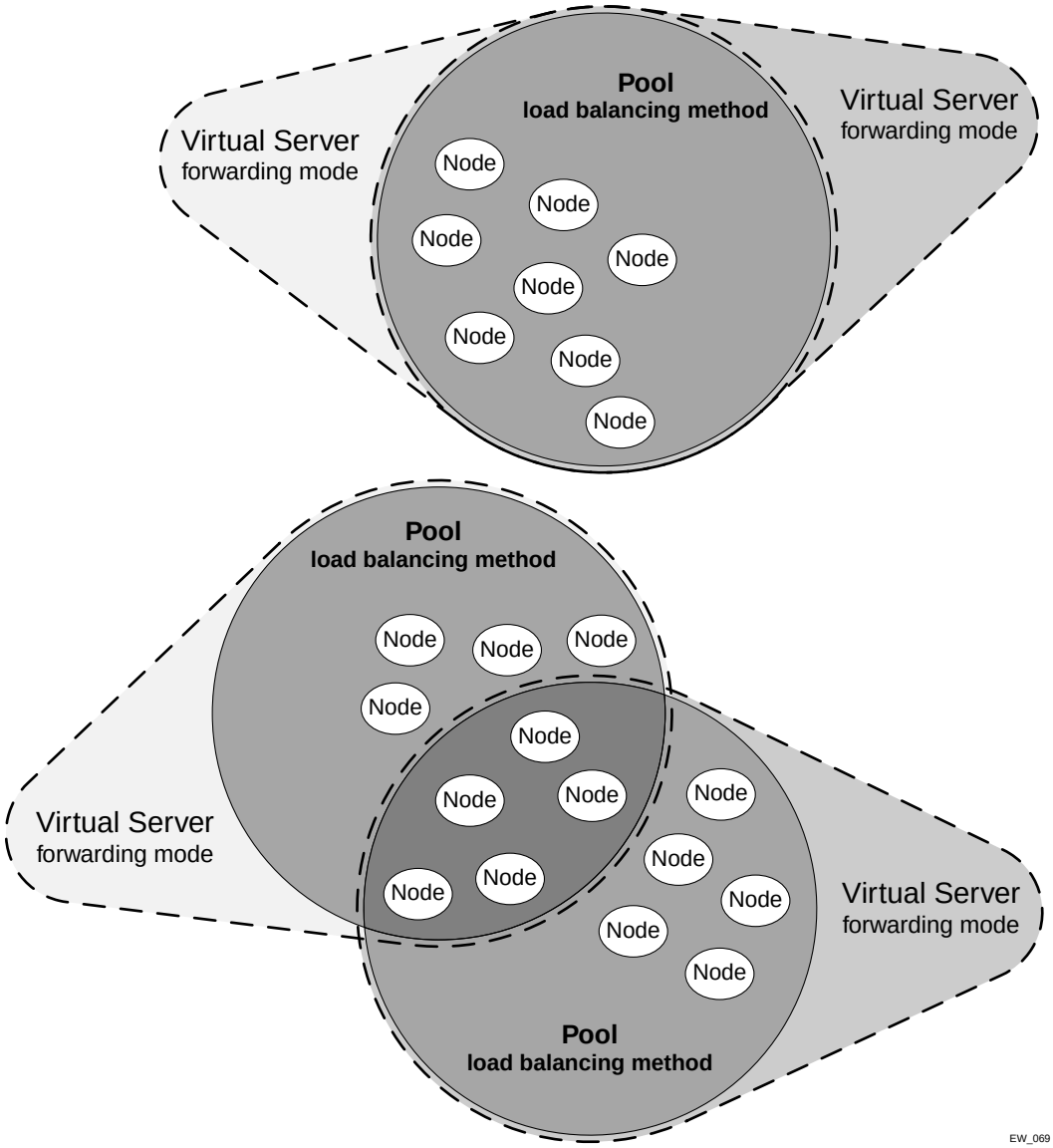
Node, Pool, and Virtual Server Relationships

Nodes, pools, and virtual servers have the following relationships:

- Nodes can belong to multiple pools
- Pools can contain multiple nodes
- Pools can be associated with multiple virtual servers
- Virtual servers can be associated with only a single pool

Figure 14 illustrates the relationships of these basic components.

Figure 14: Basic SLB components



SLB Traffic Types

SLB traffic must cross a routing boundary for SLB to work. To ensure that traffic crosses a routing boundary, assign clients and servers to separate VLANs. You must specify an SLB traffic type for each VLAN. The four SLB traffic types are:

- **None**—Disables SLB on the VLAN. This is the default setting.
- **Client**—Specifies that the VLAN contains clients, and originates requests for virtual servers.

- **Server**—Specifies that the VLAN contains nodes, and receives requests for virtual servers.
- **Both**—Specifies that the VLAN contains both clients and nodes. Clients in this VLAN can only access virtual servers whose nodes are outside this VLAN.

NOTE

You must enable IP forwarding on each VLAN involved in SLB.

You can assign the same SLB traffic type to as many different VLANs as necessary, up to the number of VLANs supported by the switch.

Forwarding Modes

The forwarding mode is the method the switch uses to forward traffic to the virtual servers. The forwarding mode determines what happens to the packets as they travel through the switch. The switch supports the following forwarding modes:

- Transparent
- Translation
- Port Translation
- GoGo

Table 22 summarizes the features supported by each forwarding mode.

Table 22: Forwarding Mode Feature Summary

	Transparent	Translation	Port Translation	GoGo
Performance	Hardware-based from server-to-client	CPU-based in both directions	CPU-based in both directions	Hardware-based in both directions
Load sharing algorithms	Round-robin, Ratio, Priority, Least Connections	Round-robin, Ratio, Priority, Least Connections	Round-robin, Ratio, Priority, Least Connections	Round-robin (hash)
Persistence	IPSA + Mask, IP list	IPSA + Mask, IP list	IPSA + Mask, IP list	IPSA
Health checking	Layer 3, 4, and 7	Layer 3, 4, and 7	Layer 3, 4, and 7	Layer 3, 4, and 7

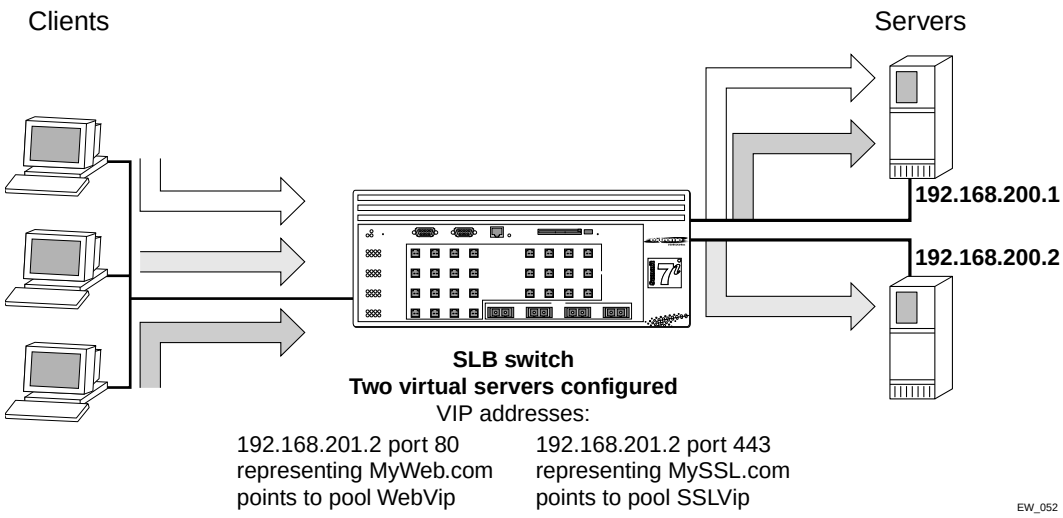
Transparent Mode

In transparent mode, the switch does not modify IP addresses before forwarding traffic to the servers. You must configure all physical servers with the virtual IP address associated with the virtual server. This virtual IP address is the address seen by clients. You must configure the physical servers with this address as a loopback address. Configure the loopback address with the most specific subnet mask that your operating system supports.

In transparent mode, you can directly attach servers or have a layer 2 switch between the SLB switch and the servers. You cannot have a router between the SLB switch and the servers.

Use transparent mode when you want a balance between features and performance. Figure 15 shows transparent mode.

Figure 15: Transparent mode



In Figure 15, the switch is configured to respond to requests for the virtual server by forwarding them to the load-balanced servers.

The servers are configured as follows:

- The interface for server 1 is 192.168.200.1.
- The interface for server 2 is 192.168.200.2.
- The loopback address on the servers is 192.168.201.1 (virtual server).
- The service is configured to use the appropriate address and port, as specified in the switch configuration.

Use the following commands to configure the VLANs and the switch IP addresses and subnets:

```
create vlan srvr
create vlan clnt
create vlan vips
config srvr ipaddress 192.168.200.10 /24
config clnt ipaddress 10.1.1.1 /24
config vips ipaddress 192.168.201.1 /24
config srvr add port 29-32
config client add port 1-4
enable ipforwarding
```

Use the following commands to create a round-robin pool (MyWeb) and add nodes to the new pool.

```
create slb pool MyWeb lb-method round
config slb pool MyWeb add 192.168.200.1:80
config slb pool MyWeb add 192.168.200.2:80
```

Use the following command to create a transparent mode virtual server for the website and assign MyWeb to it:

```
create slb vip WebVip pool MyWeb mode transparent 192.168.201.2:80
```

Use the following commands to create a round-robin pool, MySSL and add nodes to the new pool.

```
create slb pool MySSL lb-method round-robin
config slb pool MySSL add 192.168.200.1:443
config slb pool MySSL add 192.168.200.2:443
```

Use the following command to create a transparent mode virtual server for the website and assign MySSL to it.

```
create slb vip SSLVip pool MySSL mode transparent 192.168.201.2:443
```

Use the following commands to enable SLB, configure the server VLAN to act as the server side, and configure the client VLAN to act as the client side:

```
enable slb
config vlan srvr slb-type server
config vlan clnt slb-type client
```

You must configure a loopback address for each IP address to which the server will respond.

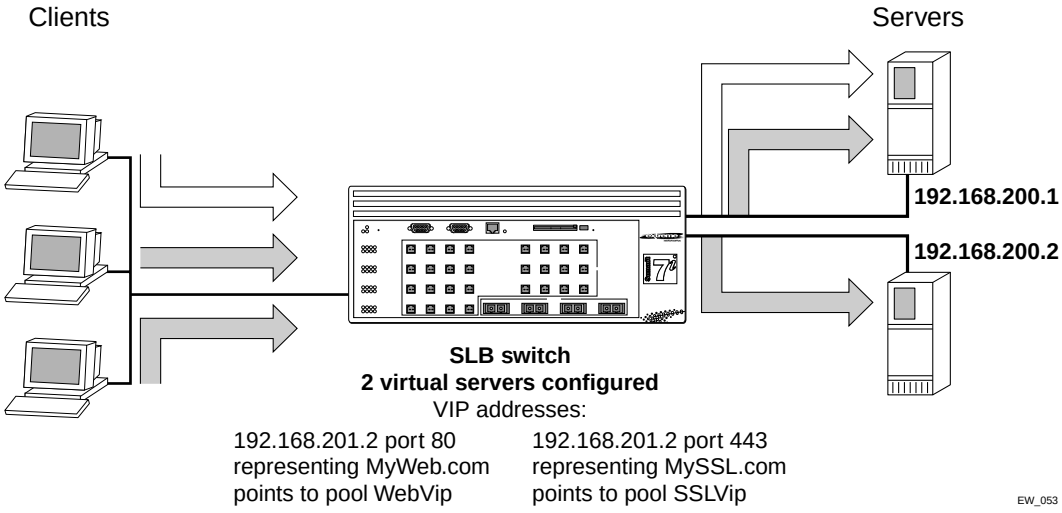
Translation Mode

In translation mode, the switch translates the IP address to that of the server to be balanced. You do not need to configure a loopback address for translation mode.

In translation mode, you can directly attach servers or have a layer 2 switch between the SLB switch and the servers. You cannot have a router between the SLB switch and the servers.

Use translation mode when you cannot have a loopback address. Figure 16 shows translation mode.

Figure 16: translation mode



In Figure 16, the switch is configured to respond to requests for the virtual server by translating them and forwarding them to the load balanced servers. No additional server configuration is needed.

Use the following commands to configure the VLANs and the switch IP addresses and subnets:

```
create vlan srvr
create vlan clnt
create vlan vips
config srvr ipaddress 192.168.200.10 /24
config clnt ipaddress 10.1.1.1 /24
config vips ipaddress 192.168.201.1 /24
config srvr add port 29-32
config client add port 1-4
enable ipforwarding
```

Use the following commands to create a round-robin pool, MyWeb, and add nodes to the new pool:

```
create slb pool MyWeb lb-method round
config slb pool MyWeb add 192.168.200.1:80
config slb pool MyWeb add 192.168.200.2:80
```

Use the following command to create a translation mode virtual server for the website and assign MyWeb to it:

```
create slb vip WebVip pool MyWeb mode translation 192.168.201.2:80
```

Use the following commands to create a round-robin pool, MySSL, and add nodes to the new pool:

```
create slb pool MySSL lb-method round
config slb pool MySSL add 192.168.200.1:443
config slb pool MySSL add 192.168.200.2:443
```

Use the following command to create a translation mode virtual server for the website and assign MySSL to it:

```
create slb vip SSLVip pool MySSL mode translation 192.168.201.2:443
```

Use the following commands to enable SLB, configure the server VLAN to act as the server side, and configure the client VLAN to act as the client side:

```
enable slb
config vlan srvr slb-type server
config vlan clnt slb-type client
```

Port Translation Mode

Port translation mode is similar to translation mode, except that the layer 4 port on the virtual server can be different from the layer 4 port on the nodes. The switch translates the IP address and port address to that of the severs to be balanced.

In port translation mode, you can directly attach servers or have a layer 2 switch between the SLB switch and the servers. You cannot have a router between the SLB switch and the servers.

Use port translation mode when you must translate layer 4 port numbers in addition to translating IP addresses.

GoGo Mode

GoGo mode is a line rate method of server load balancing that forwards traffic without changing packet content. You must directly attach servers to the SLB switch in GoGo mode.

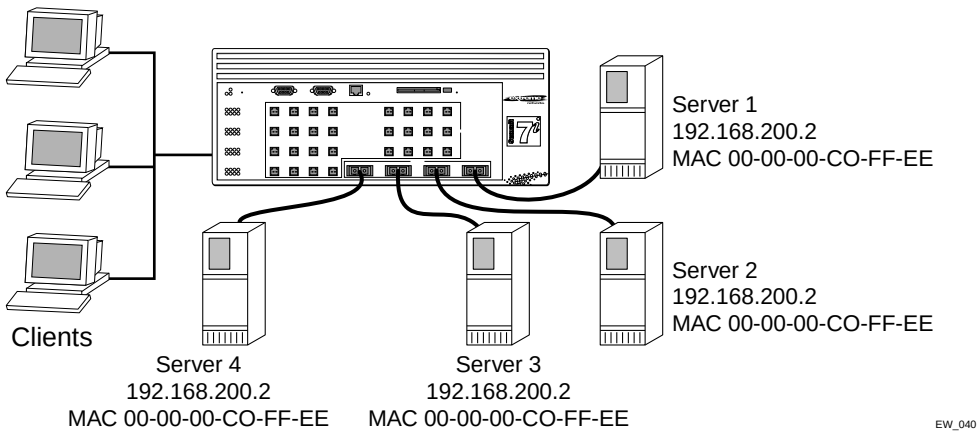
The optimal configuration is groups of 2, 4, or 8 servers. Because you must directly attach servers, you do not need to configure nodes, pools, or virtual servers. Instead, you configure all servers with the same MAC and IP addresses. Clients then see the group of servers as a single server, much like port-based load sharing.

As in port-based load sharing, the first port in the GoGo mode group is designated the “master” logical port. Use this port to represent the entire GoGo mode group when configuring health checks or VLAN membership.

In GoGo mode, the load balancing method is fixed, based on a hashing of the client IP address. GoGo mode persistence is based on source IP information: a given source address will map to one, and only one, physical server.

Use GoGo mode when you require performance without any traffic management features. Figure 17 shows GoGo mode.

Figure 17: GoGo mode



In Figure 17, the switch is configured to balance all traffic sent to the virtual server based on the client IP address.

The servers are configured as follows:

- All servers have the same MAC address.
- All servers have the same IP address.
- All servers have the same content.

To configure the switch as indicated in the example, use the following commands:

```
create vlan server
create vlan client
config server ipaddress 192.168.200.2 /24
config client ipaddress 1.1.1.1 /24
config server add port 29-32
```

```
config client add port 1-4
enable slb gogo 29 grouping 29-32
enable ipforwarding
```

In this example, port 29 is designated the master port.

GoGo mode requires you to place clients and servers into separate VLANs.

Load-Balancing Methods

Load-balancing methods are algorithms that determine which node receives a connection hosted by a particular virtual server. The forwarding mode determines *how* the switch forwards traffic; the load-balancing method determines *where* the switch forwards traffic.

Individual load-balancing methods take into account dynamic factors such as current connection count. Because each application of SLB is unique, node performance depends on a number of different factors. We recommend that you experiment with different load-balancing methods and choose the one that offers the best performance in your particular environment.

The switch supports the following load balancing methods:

- Round-robin
- Ratio
- Least connections
- Priority

Round-Robin

Round robin passes each new connection request to the next server in line. Because round robin is simple and predictable, it is the default load-balancing method.

Use round-robin if the equipment that you are load balancing is roughly equal in processing speed and memory.

Ratio

Ratio distributes connections among servers according to ratio weights that you set. The number of connections that each server receives is proportionate to the ratio weight you defined for each server.

Use ratio if the equipment that you are load balancing varies significantly in processing speed and memory. For example, if you have one new, high-speed server and two older servers, you can set the ratio so that the high-speed server receives twice as many connections as either of the two older servers.

A ratio of 2 results in twice as much traffic as a ratio of 1. If all nodes use the same weight, connections are distributed equally among the nodes. The default ratio is 1.

Least Connections

Least connections method passes a new connection to the node having the least number of active sessions. The number of active sessions includes only those sessions occurring within the same virtual server.

Use least connections when the equipment that you are load balancing has similar capabilities. Because least connections requires more processing, it works best with small pools (under 25 nodes) when you require intelligent distribution.

Priority

Priority is a variant of round-robin designed to provide redundant “standby” nodes within a pool. When you add a node to a pool, you can assign a priority level ranging from 1 - 65535, with a higher number indicating a higher priority.

In priority, the switch uses round-robin to distribute traffic among the active nodes with the highest priority. If all nodes at that priority level become inactive or reach a session limit maximum, all new sessions are directed to the nodes at the next lowest priority. The switch monitors the status of the inactive nodes. As each node becomes active, the switch redistributes traffic according to the priorities.

For example, in a pool with six nodes divided evenly into two priority levels (2 and 1), all sessions are evenly distributed to the priority 2 nodes. If one of the priority 2 nodes becomes inactive, all traffic is assigned to the remaining priority 2 nodes. If all of the priority 2 nodes become inactive, all sessions are directed to the priority 1 nodes. If one of the level 2 nodes becomes active, all new sessions are assigned to it.

Use priority when you want a set of servers held in reserve, as a back-up pool.

Advanced SLB Application Example

The advanced features described in this section are:

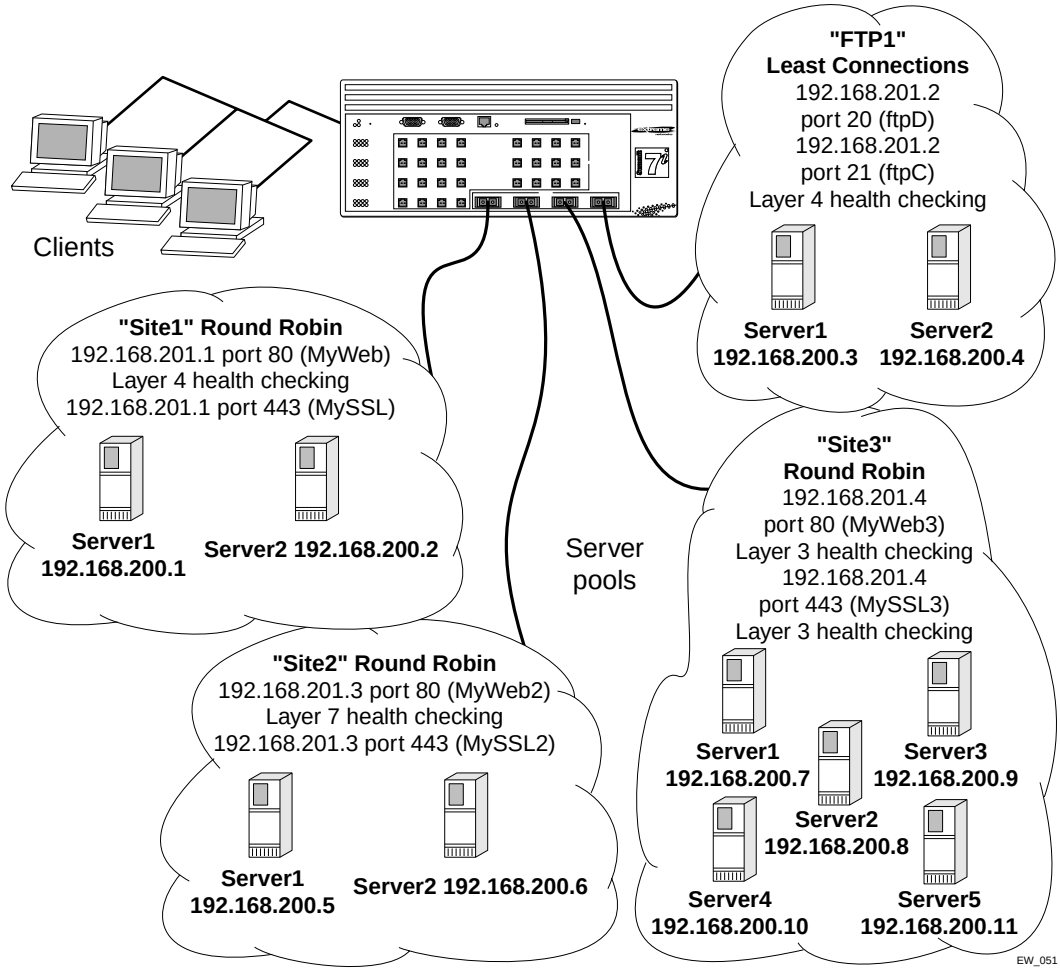
- Persistence
- High availability
- 3DNS support
- Flow redirection
- Health checking

The advanced SLB application example builds upon the basic SLB application example. The advanced concepts included in this example are:

- Multiple pools.
- Multiple virtual servers.
- Multiple balancing algorithms.
- Multiple types of health checking.

Figure 18 is an example of an advanced SLB application.

Figure 18: Advanced SLB configuration



To create the VLAN from which outside connections will come, use the following commands:

```
create vlan outside
config vlan outside ipaddress 172.16.0.1 /16
config vlan outside add ports 1-8
```

To create is the virtual IP VLAN, use the following commands:

```
create vlan sites
config vlan sites ipaddress 192.168.201.254 /24
```

All virtual servers will use this subnet. There are no ports associated with this VLAN.

Use the following commands to create the VLAN *servers* and enable IP forwarding:

```
create vlan servers
config vlan servers ipaddress 192.168.200.254 /24
config vlan servers add ports 9-16
enable ipforwarding
```

Use the following series of commands to create a web site. The site is defined as having two servers: 192.168.200.1 and 192.168.200.2, each with two services (HTTP and SSL). Two virtual servers point at the appropriate pools. The load-balancing method is round-robin. Both virtual servers use the same IP address; the difference is the port number. Finally, port checking is enabled to ensure fault tolerance on each of the servers.

```
create slb pool site1web
config slb site1 add 192.168.200.1:80
config slb site1 add 192.168.200.2:80
create slb pool site1ssl
config slb site1 add 192.168.200.1:443
config slb site1 add 192.168.200.2:443
create slb vip myweb pool site1web mode transparent 192.168.201.1:80
create slb vip myssl pool site1ssl mode transparent 192.168.201.1:443
enable slb node 192.168.200.1:80 tcp-port-check
enable slb node 192.168.200.2:80 tcp-port-check
enable slb node 192.168.200.1:443 tcp-port-check
enable slb node 192.168.200.2:443 tcp-port-check
```

Use the following series of commands to create a second web site. This site is similar to the first site, except that content checking is enabled on this site.

```
create slb pool site2web
config slb site2web add 192.168.200.5:80
config slb site2web add 192.168.200.6:80
create slb pool site2ssl
config slb site2ssl add 192.168.200.5:443
config slb site2ssl add 192.168.200.6:443
create slb vip myweb2 pool site2web mode transparent 192.168.201.3:80
create slb vip myssl2 pool site2ssl mode transparent 192.168.201.3:443
enable slb vip myweb2 service-check
config slb vip myweb2 service-check http url “/testpage.htm” match-string “test
successful”
```

Use the following series of commands to create a third web site. This example has one pool with a wildcard port. The wildcard port allows any port sent to it by the virtual server. All five servers respond to requests on both port 80 and port 443.

```
create slb pool site3web
config slb site3web add 192.168.200.7:0
config slb site3web add 192.168.200.8:0
config slb site3web add 192.168.200.9:0
config slb site3web add 192.168.200.10:0
config slb site3web add 192.168.200.11:0
create slb vip myweb3 pool site3web mode transparent 192.168.201.4:80
create slb vip myssl3 pool site3web mode transparent 192.168.201.4:443
```

Use the following series of commands to create an FTP site. The site has two servers: 192.168.200.3 and 192.168.200.4. The servers provide only FTP service. The two different virtual servers and port numbers refer to the control and data channels used by the FTP service. Two virtual servers point at the appropriate pools.

The load-balancing method is round-robin. Layer 7 health checking is enabled for the ftpc virtual server.

```
create slb pool ftp1c
config slb ftp1c add 192.168.200.3:21
config slb ftp1c add 192.168.200.4:21
create slb pool ftp1d
config slb ftp1d add 192.168.200.3:20
config slb ftp1d add 192.168.200.4:20
create slb vip ftpc pool ftp1c mode transparent 192.168.201.2:21
create slb vip ftpd pool ftp1d mode transparent 192.168.201.2:20
enable slb vip ftpc service-check
config slb vip ftpc service-check ftp user test password testpass
```

Finally, enable SLB and configure the VLANs to be either client or server, using the following commands.

```
enable slb
config vlan outside slb-type client
config vlan servers slb-type server
```

Using Persistence

Persistence ensures that subsequent connections from the same client attach to the same server. To configure persistence, you select:

- persistence method
- persistence level
- persistence type

Persistence is not affected by the load-balancing method unless you select GoGo mode, where the persistence is fixed, as described on page 144.

Persistence Methods

Persistence methods determine how the persistence table times-out entries. The persistence methods are:

- Per-session
- Per-packet

Per-Session Persistence

Per-session persistence creates a persistence entry when the first packet arrives from a client with the timeout value configured for the virtual server. The entry is removed after the timeout period. The entry is not refreshed. Per-session is the default persistence method.

Use per-session persistence when you want the smallest impact on performance and you can accurately gauge your total connection time.

Per-Packet Persistence

Per-packet persistence creates a persistence entry when the first packet arrives and refreshes that entry each time a new packet arrives. Thus, the entry remains as long as new packets continue to arrive.

Use per-packet persistence when you want to sacrifice a small amount of performance in return for a timeout period based on connection idle time instead of total connection time.

Persistence Levels

Persistence levels determine how the persistence entries affect multiple virtual servers. Use persistence levels if you have servers that provide multiple services to a single client (such as, HTTP and SSL). To use persistence levels, your virtual servers must contain the same physical servers.

The persistence levels are as follows:

- Same-VIP-same-port
- Same-VIP-any-port
- Any-VIP

Same-VIP-Same-Port Persistence

Same-VIP-same-port matches a new client request to a persistence entry only if the destination is the same virtual server and same port as the original client request. Same-VIP-same-port is the default persistence method.

Use same-VIP-same-port persistence to ensure that connections from a client are only persistent on the specific virtual server that is connecting to that client.

Same-VIP-Any-Port Persistence

Same-VIP-any-port persistence directs client requests to the same virtual server even if the port is different.

Use same-VIP-any-port persistence to ensure that connections from a client are persistent on the virtual server for all layer 4 services offered on that particular virtual server. For example, if you use HTTP (port 80) to build a shopping cart, then need to use SSL (port 443) for the credit card transaction at the end, use same-VIP-any-port persistence to preserve the client session.

If you have virtual servers with the same IP address but a different port, you must configure associated pools with identical nodes that can service requests on either port.

Any-VIP Persistence

Any-VIP persistence directs all connections from a client to the same virtual server regardless of the destination.

Use any-VIP persistence to ensure that connections from a client always go to the same server no matter what layer 4 service they connect to. When you use any-VIP persistence, you must ensure that all servers have the same content for all services.

Persistence Types

The switch supports the following types of persistence:

- Client persistence
- Proxy client persistence
- Sticky persistence

Client Persistence

Client persistence provides a persist mask feature. You can define a range of IP addresses that map to a persistent connection. Any client whose source IP address falls within the range is considered a match for the entry.

Use client persistence to ensure that transactions, from your defined range of IP addresses, that span multiple TCP sessions are always connected to the same virtual servers. For example, if you assume that a single client uses multiple sessions to fill a shopping cart, you can force all traffic from the same range of IP addresses (which you assume to be the same client) to connect to the same virtual server.

Proxy Client Persistence

Some networks translate addresses internally with an array of proxy servers. Proxy client persistence allows the switch to maintain connections for clients in these types of networks. You can define ranges of IP addresses that map to a persistent connection. Any client whose source IP address falls within one of the ranges is considered a match for the entry. You must add every range of possible source IP addresses.

Use proxy client persistence to provide persistence for users who are behind proxy servers that change the source IP address of client requests from session to session.

Sticky Persistence

Sticky persistence is available only on wildcard virtual servers and is especially useful for cache servers. Sticky persistence tracks destination IP addresses. When a client attempts to connect to a destination IP address, the switch directs the client to the same cache server previously used for that destination IP address. This helps you reduce the amount of duplicated content on cache servers in your network.

Use sticky persistence to provide persistence based on destination IP address. Sticky persistence is especially useful when you load balance caching proxy servers. A caching proxy server intercepts web requests and returns a cached web page (if that page is available). You can improve the efficiency of cache proxy servers by sending similar requests to the same server. Sticky persistence can cache a given web page on one proxy server instead of on every proxy server. This saves the other servers from duplicating the content.

NOTE

For additional cache server applications, see "Web Cache Redirection" on page 161.

Using High Availability System Features

The switch supports several advanced redundant system features. Advanced redundant system features provide additional assurance that your content remains available if a switch experiences a problem. The advanced redundant system options include:

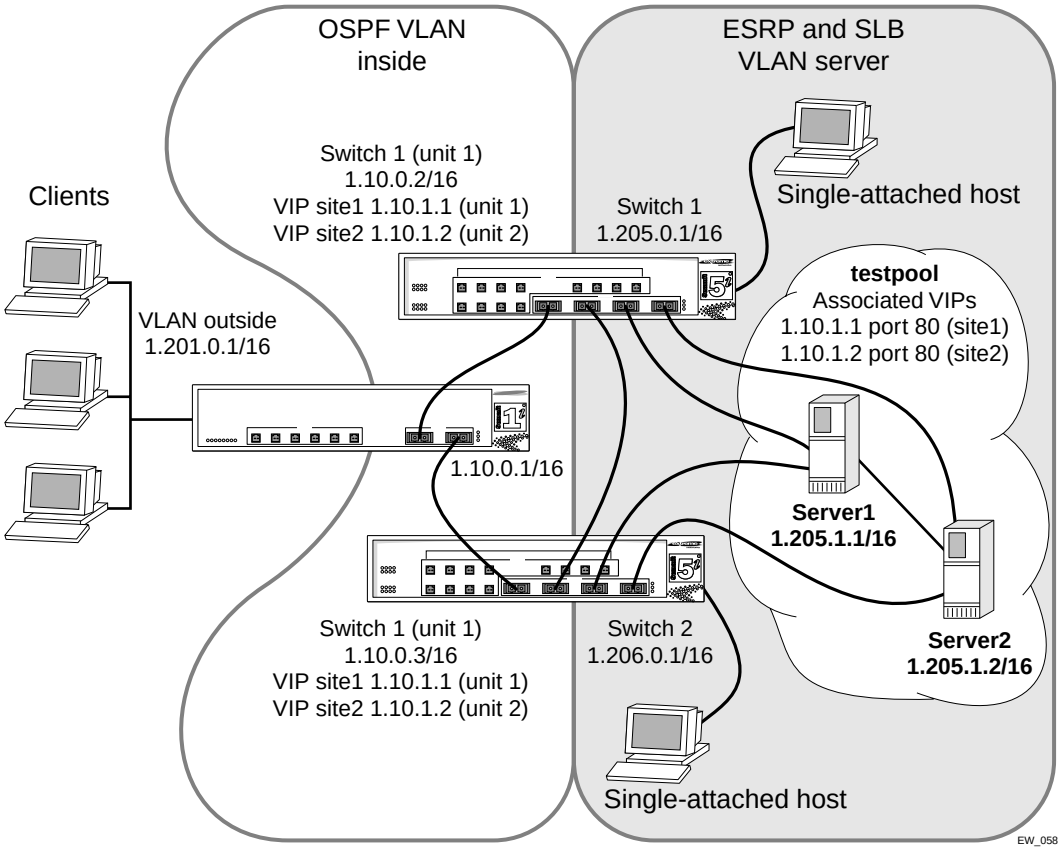
- SLB with ESRP
- Active-active operation

Server Load Balancing with ESRP

You can use ESRP to make SLB, along with the layer 2 and layer 3 services of the switch, redundant. SLB with ESRP allows single- or dual-attached servers to have redundant gateway services and very fast recovery from a fault. When you enable ESRP, all servers can be online simultaneously, and recovery from a switch failure occurs in less than 8 seconds.

Figure 19 shows SLB enabled using ESRP and dual-attached servers.

Figure 19: SLB using ESRP and dual-homed servers



Configuring the Switches for SLB and ESRP

To create the VLANs, use the following commands:

```
create vlan inside
create vlan server
```

To connect the gateway to the VLAN *inside*, use the following commands:

```
config inside ipaddress 1.10.0.2 /16
config inside add port 31
```

To configure the servers to connect to the VLAN *server* on ports 1-4, and configure port 32 to connect to the other ESRP switch, use the following commands:

```
configure server ipaddress 1.205.0.1 /16
configure server add port 1-4, 32
```

To enable ipforwarding, create a server pool called *testpool*, and add four servers to it using TCP port 80, use the following commands:

```
enable ipforwarding
create slb pool testpool
config slb pool testpool add 1.205.1.1:80
config slb pool testpool add 1.205.1.2:80
config slb pool testpool add 1.205.1.3:80
config slb pool testpool add 1.205.1.4:80
```

To create SLB virtual server addresses for the two websites (*site1* and *site2*) and associate the server pool *testpool* with it, use the following commands:

```
create slb vip site1 pool testpool mode transparent 1.10.1.1:80
create slb vip site2 pool testpool mode transparent 1.10.1.2:80
```

To enable SLB and configure it for the appropriate VLANs (client connections enter from the VLAN *inside*), use the following commands:

```
enable slb
config inside slb client
config server slb server
```

To enable OSPF, use the following command:

```
enable ospf
```

To enable ESRP on the VLAN *server* and configure the ESRP direct-attached hosts mode to allow the proper failover of services, use the following commands:

```
enable esrp server
config esrp port-mode host ports 1-4, 32
```

the interconnection between the switches is also configured as a host port.

To configure SLB to use ESRP, use the following command:

```
config slb esrp server add unit 1
```

Note the following about the configurations for the switches running SLB and ESRP:

- You must configure all switch ports connected directly to the servers as ESRP host ports.
- You must configure the link between the two switches as an ESRP host port.
- The configuration uses transparent mode and HTTP services, but can be configured to support any of the currently supported load-balancing protocols.
- Both switches are configured as unit 1.
- The SLB and ESRP port configurations are identical on both switches.

Web-Server Configuration

The services must match those configured on the switch; for example, HTTP services configured at TCP port 7080 on the switch require the servers to allow connections at port 7080. You must ensure that the SLB configuration is valid before trying to transfer the configuration to an ESRP / SLB configuration.

The two types of ESRP hosts that you can connect to the switches are single-attached hosts and dual-attached hosts. Single-attached hosts provide no server link redundancy, but allow hosts to be connected to the same VLAN as the web servers. Dual-attached hosts allow for redundant NICs in the servers, as well as connections to the switch. When configured as dual-attached hosts, the servers are supported fully by the ESRP redundant gateway services.

NOTE

For information on specific NIC card configurations, please contact your NIC vendor.

Active-Active Operation

Active-active operation is a redundant configuration of two switches. If one switch fails, the second switch takes over the SLB function. By preparing a redundant switch for the possibility of failover, you provide reliability and availability.

To create an active-active configuration, configure redundant switches with identical SLB configurations, except for the failover parameters.

Active-active operation uses a gateway ping-check to determine if the active SLB switch has network connectivity. If the specified IP address is unreachable for a specified duration, the gateway ping-check triggers a failover to the redundant switch.

NOTE

When you configure the gateway ping check, specify the IP address of a device other than the redundant SLB switch.

Configuring Active-Active Operation

Using active-active redundant SLB, you configure one switch as unit 1 and the other switch as unit 2. You then assign the virtual servers either to unit 1 or to unit 2 (unit 1 is the default). When both switches are active, each switch performs SLB only for the virtual servers assigned to it. If a switch fails, the remaining switch performs SLB for the virtual servers assigned to the failed switch.

Use the following command to assign the unit number:

```
config slb failover unit [1 | 2] remote-ip <ipaddress> local-ip <ipaddress>:<L4Port>
{alive-frequency <seconds> timeout <seconds>} {dead-frequency <seconds>}
```

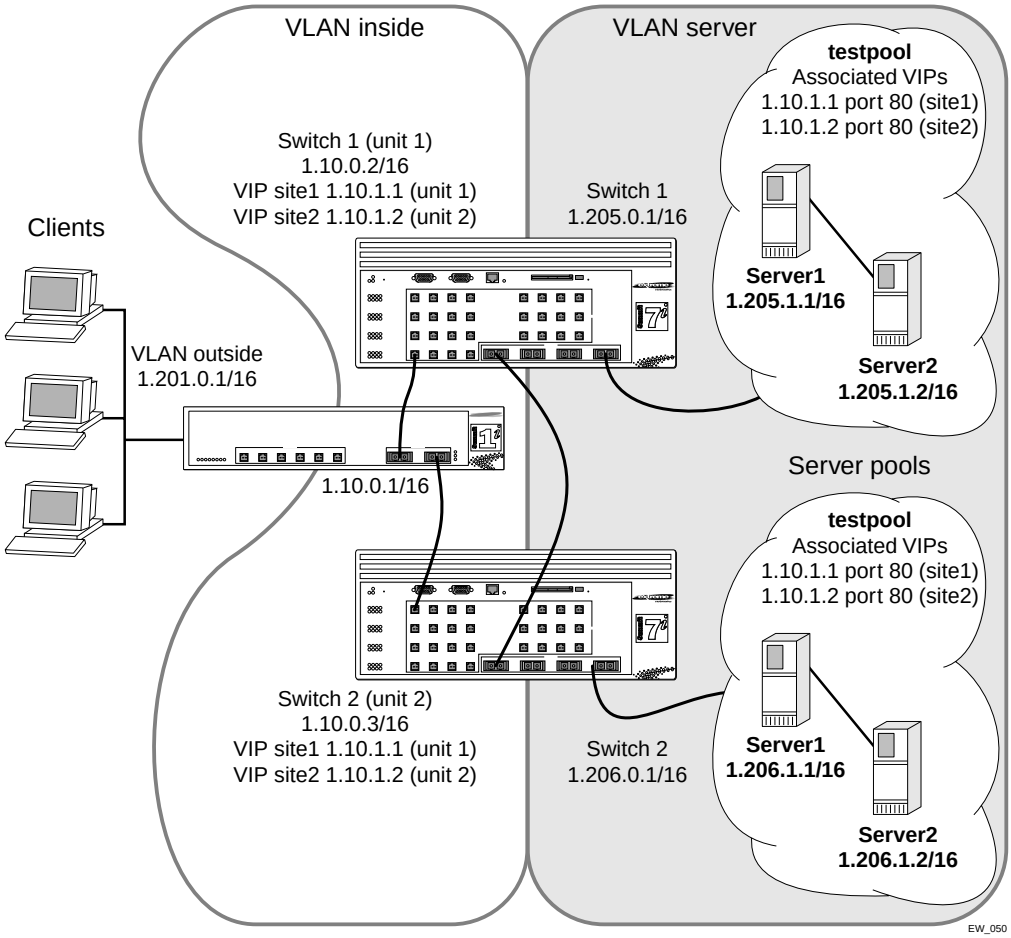
The `remote-ip` specifies the IP address of the redundant SLB switch. The `local-ip` specifies the IP address of the switch you are configuring.

You must assign virtual servers with the same virtual IP address to the same unit.

Sample Active-Active Configuration

Figure 20 is an example of an active-active failover configuration.

Figure 20: Active-active configuration



To configure this example on the first switch, use the following commands:

```
create vlan inside
create vlan server
config vlan inside ipaddress 1.10.0.2 /16
config vlan inside add port 31
config vlan server ipaddress 1.205.0.1 /16
```

```
config vlan server add port 29-30

enable ipforwarding

create slb pool testpool
config slb pool testpool add 1.205.1.1:80
config slb pool testpool add 1.205.1.2:80
create slb vip site1 pool testpool mode transparent 1.10.1.1:80
create slb vip site2 pool testpool mode transparent 1.10.1.2:80

enable slb
config vlan inside slb-type client
config vlan server slb-type server

config slb failover unit 1 remote 1.10.0.3 local 1.10.0.2:1028

enable slb failover

enable slb failover ping

config slb vip site1 unit 1
config slb vip site2 unit 2

config slb fail ping-check 1.10.0.1 freq 1
```

To configure this example on the second switch, use the following commands:

```
create vlan inside
create vlan server
config vlan inside ipaddress 1.10.0.3 /16
config vlan inside add port 31
config vlan server ipaddress 1.206.0.1 /16
config vlan server add port 29-30

enable ipforwarding

create slb pool testpool
config slb pool testpool add 1.206.1.1:80
config slb pool testpool add 1.206.1.2:80
create slb vip site1 pool testpool mode transparent 1.10.1.1:80
create slb vip site2 pool testpool mode transparent 1.10.1.2:80

enable slb
config vlan inside slb-type client
config vlan server slb-type server

config slb failover unit 2 remote 1.10.0.2 local 1.10.0.3:1028
enable slb failover
enable slb fail ping

config slb vip site1 unit 1
config slb vip site2 unit 2

config slb fail ping-check 1.10.0.1 freq 1
```

The differences between the configurations of these two switches are the IP addresses and the designation of the first switch as unit 1 of the active-active configuration.

If you use this configuration with only one virtual server, you have an active switch and a standby switch, because only one switch is actively performing SLB. This configuration is called "active-standby."

Active-Active Configuration Notes

Note the following about active-active configurations:

- In the design shown in Figure 20, only the servers directly connected to the switch that is actively servicing the virtual server are used in the load-balancing scheme. Without ESRP, you must have another switch interconnecting all the servers.
- One switch is designated as unit 1 and the other is unit 2. This designation determines which virtual servers are active on each switch in the failover pair.
- In this configuration, *site1* is serviced by switch 1 and has two servers that respond to client requests. *Site2* is be serviced by the remote switch (switch 2) and has two other servers that respond to client requests.
- If you enable ping-check, do not direct it at the remote switch. The ping-check works best when directed at a gateway to ensure that a path out of the network is available to the switch.
- The configuration uses transparent mode and HTTP services, but can be configured to support any of the currently supported load balancing protocols.
- The configurations for the switches are identical, with the exception of the failover command.
- The remote switch is set to unit 2, and the remote/local IP addresses are reversed to accurately describe the network.

Using Manual Fail-Back

With manual fail-back, fail-back occurs only when you enter the fail-back command. In an active-active configuration, fail-back occurs automatically. If the minor disruption of fail-back makes automatic fail-back undesirable, you can enable manual fail-back.

Health Checking

Health checking allows you to actively poll nodes to determine their health. The switch makes new connections only if the virtual server and node are both enabled and passing health checks. The switch considers a virtual server or node active unless a health check fails. If a health check fails, the switch considers the virtual server or node inactive. A virtual server or node is also considered inactive if it is disabled and has zero active connections. If it is inactive for this reason, the switch stops ping-checks and port-checks on the virtual server or node to conserve system resources. The switch resumes ping checks and port checks when you enable the virtual server or node.

The switch does not establish new connections with an inactive node until that node passes all configured health checks. If a health check fails and you have enabled the `ign-reset` parameter on an associated virtual server, the switch closes all existing connections for the virtual server by sending a TCP reset to the client and node.

The switch supports three types of health checking:

- Ping-check
- Port-check
- Service-check

The switch also supports 3DNS health checking.

Ping-Check

Ping-check operates at layer 3 and is the default health check. The switch sends an ICMP ping to the configured server or next hop. The default ping frequency is 10 seconds and the default timeout is 30 seconds (three pings). If the node does not respond within 30 seconds, it is considered down. If a server is configured not to respond to ICMP echo requests, the server will be marked "down" after the first ping check interval. Ping check is the only health check that will accept a wildcard as the IP port.

TCP-Port-Check

TCP-port-check operates at layer 4 and tests the physical node. The default frequency is 30 seconds and the default timeout is 90 seconds. If the node does not respond within 90 seconds, it is considered down. You can use TCP-port-checking to determine if a TCP service, such as httpd, is available. If a TCP-port-check fails, the IP / port combination is considered unavailable.

Service-Check

Service-check operates at layer 7 and is an application-dependent check defined on a virtual server. The switch performs a service-check on each node in the pool. The default frequency is 60 seconds and the default timeout is 180 seconds. Table 23 describes the service-check parameters.

Table 23: Service-Check Parameters

Service	Attribute	Global Default Value
HTTP	URL	"/"
	Match-string	Any-content
FTP	Userid	"anonymous"
	Password	"anonymous"
Telnet	Userid	"anonymous"
	Password	"anonymous"
SMTP	Dns-domain	Same as the switch DNS domain. If no DNS domain is configured for the switch, the value is "".
NNTP	Newsgroup	"ebusiness"
POP3	Userid	"anonymous"
	Password	"anonymous"

If you do not specify the service-check parameters, the switch uses the global default values. You can configure the global default values.

For HTTP, you can specify both the URL to be retrieved, and a `match-string`, such as "Welcome." If the switch finds the `match-string` in the first 1000 bytes of the retrieved URL, the service-check passes.

A `match-string` specified as `any-content` matches any retrieved text. Extreme Networks recommends that you create a text file that contains a single word, such as “ok.”

The FTP, Telnet, and POP3 service-checks establish a connection between the switch and the next hop. Service-check logs on and off using the specified `userid` and `password`.

For SMTP, service-check identifies the switch by providing the DNS domain you configure. Extreme Networks recommends that you specify a DNS domain that is used only for identification.

The NNTP service-check connects to the node, logs in, and attaches to the newsgroup specified.

You configure service-checks for each virtual server, and nodes can be members of multiple virtual servers. Therefore, because each node can have multiple service-checks, some service-checks can fail while others pass. So to accept a new connection for a virtual server, a node must have passed the service-check configured for that virtual server. When showing detailed virtual server information, the status for individual nodes is shown with respect to that virtual server.

3DNS Health Checking

3DNS is a global load balancing and site redundancy tool. Additional information concerning individual server health and performance is gathered by 3DNS when using Transparent or Translational modes. When you enable SLB, the switch reports health status to 3DNS using the iQuery™ protocol from F5 Networks®. The health status of the nodes within the server farm is based on layer 3, layer 4, layer 7, or external health check mechanisms. To enable 3DNS:

```
enable slb 3dns iquery-client
```

To see what 3DNS devices are currently communicating with the SLB enabled switch:

```
show slb 3dns members
```

To disable responses to 3DNS queries:

```
disable slb 3dns iquery-client
```

The switch responds to directed queries from 3DNS. To direct 3DNS queries to the switch, add a “Big/IP” device to the 3DNS configuration. Encrypted communications with 3DNS are currently not supported.

Maintenance Mode

You can put a node or virtual server into maintenance mode by disabling the node or virtual server. In maintenance mode, existing connections remain active, but no new connections are permitted. The existing connections are either closed by the client and server or are aged out if idle for more than 600 seconds.

Health Checking in GoGo Mode

GoGo mode does not use nodes, pools, or virtual servers. Therefore, to configure health checking when using GoGo mode, you must use the GoGo mode health checking commands.

Flow Redirection

Flow redirection overrides routing decisions to transparently redirect client requests to a target device (or group of devices). Unlike SLB, you do not duplicate content on the target device(s). Flow redirection traffic must come from an "*i*"-series switch running ExtremeWare 6.1 (or later).

The switch can only redirect traffic that crosses a VLAN boundary within the switch, because flow redirection operates at layer 3. If the clients and servers belong to the same subnet as the switch, use the proxy ARP feature with minimal configuration changes to clients or servers.

Flow redirection examines traffic and redirects it based on the following criteria, in order of priority:

1 Destination IP address and mask

2 Layer 4 port

3 Source IP address and mask

Multiple flow redirection rules can overlap. In these cases, the most specific redirection rule that satisfies the criteria takes precedence. In general, the following rules apply:

- If a flow with a better matching mask on an IP address satisfies the content of a packet, that flow will be observed.
- If one flow redirection rule contains "any" as a layer 4 protocol and a second flow redirection rule contains explicit layer 4 port information, the second takes precedence if the packet contains matching layer 4 information.
- If one flow has a better match on source information and a second flow has better match on destination information then the rule with the match on the destination information is selected.

For example, in the following 2 cases, the rule with the best match (using the above criteria) is selected.

Table 24: Flow rule example A

Rule #	Destination IP Address	Destination Port	Source IP Address	Priority Selection
A1	192.0.0.0/8	80	ANY	1
A2	192.168.0.0/16	ANY	ANY	2

In example A, rule A1 is the best match as it contains an explicit destination port, even though rule A2 has a more specific destination IP address mask.

Table 25: Flow rule example B

Rule #	Destination IP Address	Destination Port	Source IP Address	Priority Selection
B1	192.168.2.0/24	80	ANY	2
B2	192.168.0.0/16	ANY	10.10.10.0/24	4
B3	192.168.2.0/24	ANY	10.10.0.0/16	3
B4	192.168.2.0/24	80	10.10.0.0/16	1

In example B, rule B4 is the best match as it contains an explicit destination port and a better match on the source IP address mask than rule B1.

NOTE

Extreme Networks recommends that you use flow redirection and SLB on separate switches; do not use flow redirection and SLB on the same switch. If you must use SLB and flow redirection on the same switch, ensure that no overlapping layer 4 IP ports exist in the configuration.

You must prevent logical loops of redirected traffic. You can use flow redirection for the following:

- Web cache redirection
- Policy-based routing

Web Cache Redirection

Web cache redirection operates at line rate to redirect traffic from the requested server to a web cache server. If the web cache server has a copy of the requested content, it sends the content to the client. If the web cache server does not have the requested content, it queries the server for the data, stores it locally, and sends a copy to the client.

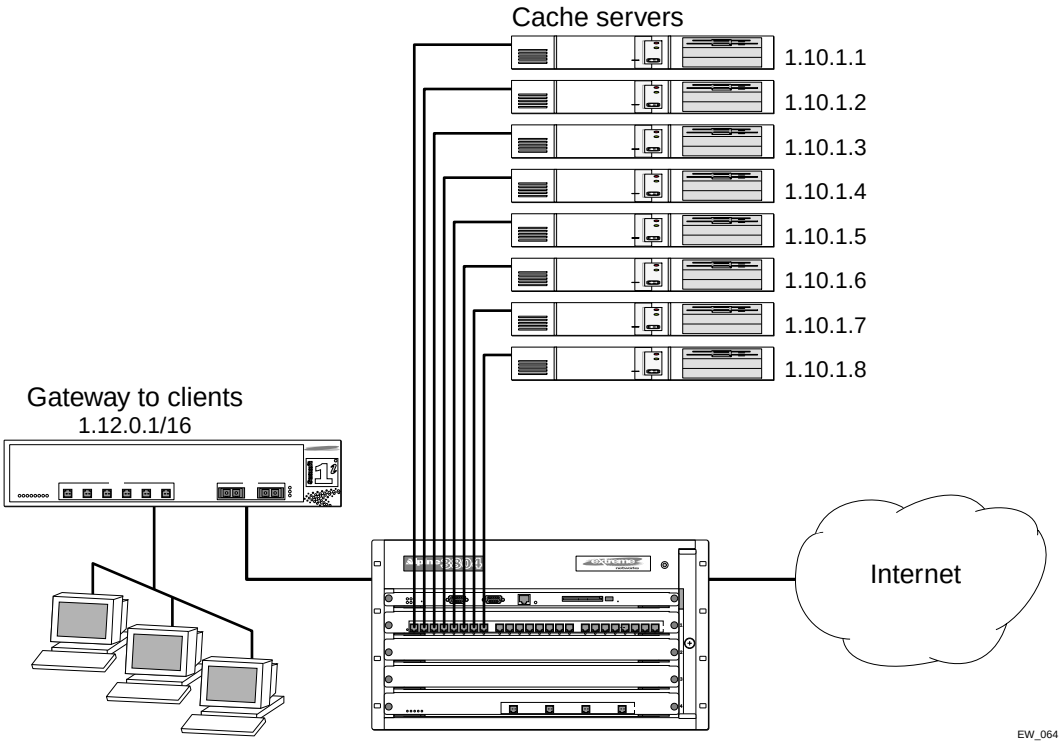
When you have web cache redirection enabled, clients connect exclusively to your web cache servers; clients never connect to the requested server.

The switch automatically load-balances your cache servers based on the destination IP address of the requested content. Thus, subsequent requests for a destination IP address are redirected to the same web cache server, because that web cache server is most likely to contain the requested content. This load-balancing reduces the amount of content duplication on your web cache servers.

Web Cache Redirection Example

Figure 21 uses flow redirection to redirect Web traffic to cache servers. In this example, the clients and the cache devices are located on different networks. This is done by creating a different VLAN for the clients and cache devices.

Figure 21: Web cache redirection example



To configure the switch in this example, use the following commands:

```
create vlan client
config vlan client add port 1
config vlan client ipaddress 1.12.0.1/16

create vlan cache
config vlan cache add port 2
config vlan cache ipaddress 1.10.1.1/24

create vlan internet
config vlan internet add port 3
config vlan internet ipaddress 1.11.1.1/16

enable ipforwarding

create flow-redirect flow1 tcp destination 1.11.1.0/24 ip-port 80 source any

config flow1 add next-hop 1.10.1.2
config flow1 add next-hop 1.10.1.3
config flow1 add next-hop 1.10.1.4
config flow1 add next-hop 1.10.1.5
config flow1 add next-hop 1.10.1.6
config flow1 add next-hop 1.10.1.7
config flow1 add next-hop 1.10.1.8
```

Policy-Based Routing

Policy based routing is an application of flow redirection that allows you to control routed traffic regardless of the routing protocol configured. For example, you can use policy-based routing to force SNMP traffic to follow a less efficient but more secure path.

As with web cache redirection, policy-based routing examines traffic and redirects it based on the following criteria (in order of priority):

1 Destination IP address and mask

2 Layer 4 port

3 Source IP address and mask

If the next-hop address is unavailable, the switch routes the traffic normally. You can define several rules; the precedence of rules is determined by the best match of the rule to the packet. If no rule is satisfied, no redirection occurs.

If you define multiple next-hop addresses, traffic satisfying the rule is load-shared across the next hop addresses based on destination IP address. If next hop addresses do not respond to ICMP pings, the switch resumes normal routing.

Policy-based routing has no impact on switch performance unless you use policy-based routing and SLB on the same switch.

10 Status Monitoring and Statistics

This chapter describes the following topics:

- Status Monitoring on page 165
- Slot Diagnostics on page 166
- Port Statistics on page 167
- Port Errors on page 168
- Port Monitoring Display Keys on page 169
- System Health Checking on page 169
- Setting the System Recovery Level on page 170
- Logging on page 171
- Configuring and Monitoring Flow Statistics on page 173
- RMON on page 182

Viewing statistics on a regular basis allows you to see how well your network is performing. If you keep simple daily records, you will see trends emerging and notice problems arising before they cause major network faults. In this way, statistics can help you get the best out of your network.

Status Monitoring

The status monitoring facility provides information about the switch. This information may be useful for your technical support representative if you have a problem. ExtremeWare includes many show commands that display information about different switch functions and facilities.

NOTE

For more information about show commands for a specific ExtremeWare feature, see the appropriate chapter in this guide.

Slot Diagnostics

The BlackDiamond switch provides a facility for running normal or extended diagnostics on an I/O module or a Management Switch Fabric Module (MSM) without affecting the operation of the rest of the system.

If you select to run the diagnostic routine on an I/O module, that module is taken off-line while the diagnostic test is performed. Traffic to and from the ports on the module are temporarily unavailable. Once the diagnostic test is completed, the I/O module is reset and becomes operational again.

You can run normal or extended diagnostics on the slave MSM. The normal diagnostic routing is a short series of tests that do not test all the internal Application-Specific Integrated Circuit (ASIC) functions. The extended diagnostic routine tests coverage of all MSM components including the internal ASIC functions. The slave MSM is taken off-line while the diagnostic test is performed. It is reset and operational once the test is completed.

If you want the diagnostic routine to run on the master MSM every time the system boots, use the following command:

```
config diagnostics on
```

To turn off the diagnostic routine, use the following command:

```
config diagnostics off
```

If you want the diagnostic routine to run one time (rather than with each system boot), use the following command:

```
run diagnostics [normal | extended] [<slot> | msm-a | msm-b]
```

where the following is true:

- `normal`—Takes the switch fabric and ports offline, and performs a simple ASIC and packet loopback test on all ports. The test is completed in 30 seconds. CPU and out-of-band management ports are not tested in this mode. As a result, console and Telnet access from the management port is available during this routine.
- `extended`—Takes the switch fabric and ports offline, and performs extensive ASIC, ASIC-memory, and packet loopback tests. Extended diagnostic tests take a maximum of 15 minutes. The CPU is not tested. Console access is available during extended diagnostics.
- `<slot>`—Specifies the slot number of an I/O module. Once the diagnostics test is complete, the system attempts to bring the I/O module back online. This parameter is applicable to the BlackDiamond switch, only.
- `msm-a | msm-b`—Specifies the slot letter of an MSM64i. If the master MSM is specified, the diagnostic routine is performed when the system reboots. Both switch fabric and management ports are taken offline during diagnostics. This parameter is applicable to the BlackDiamond switch, only.

Runtime Diagnostics (BlackDiamond Switches)

BlackDiamond switch runtime diagnostics perform a single test on a single I/O module. All error messages are logged. To perform diagnostics on an I/O module, use the following command:

```
run diagnostics [extended | normal] slot [<slot number> |
msm-a | msm-b]
```

Use the `normal` option when you want a fast (30 – 60 seconds) hardware status check. Use the `extended` option when you want a more thorough test. The `extended` option requires significantly more time to complete, depending on the number of ports on the blade.

You can also execute packet memory scanning for all packet memory associated with the specified I/O slot on a BlackDiamond 6804, 6808, or 6816 switches, using the following command:

```
run diagnostics packet-memory slot <slot number>
```

The packet memory diagnostic scans the specified blade to detect single bit-related memory defects and their associated buffer locations. If packet memory defects are detected, their locations are recorded in the blade's EEPROM. Up to eight occurrences can be recorded. If a defect was found during the scan process, the card is reset, the defective buffer is mapped out from further use, and the I/O card is returned to the operational state. If more than eight defects are detected, or if the defects cannot be mapped out, the card is treated as a failed card and left offline. The card should then be returned through the RMA process with Extreme Networks Technical Support.

NOTE

Only run extended or packet-memory diagnostics when the switch can be brought off-line. The tests conducted during these diagnostics are extensive and can affect traffic that must be processed by the system CPU.

To view results of the normal or extended diagnostics test, use the following command:

```
show diagnostics
```

To view the results of a packet memory scan, use the following command:

```
show diagnostics packet-memory slot <slot number>
```

Port Statistics

ExtremeWare provides a facility for viewing port statistic information. The summary information lists values for the current counter against each port on each operational module in the system, and it is refreshed approximately every 2 seconds. Values are displayed to nine digits of accuracy.

To view port statistics, use the following command:

```
show ports <portlist> stats
```

The following port statistic information is collected by the switch:

- **Link Status—**The current status of the link. Options are:
  - Ready (the port is ready to accept a link).
  - Active (the link is present at this port).
  - Chassis (the link is connected to a Summit Virtual Chassis).
- **Transmitted Packet Count (Tx Pkt Count)—**The number of packets that have been successfully transmitted by the port.
- **Transmitted Byte Count (Tx Byte Count)—**The total number of data bytes successfully transmitted by the port.

- **Received Packet Count (Rx Pkt Count)—**The total number of good packets that have been received by the port.
- **Received Byte Count (RX Byte Count)—**The total number of bytes that were received by the port, including bad or lost frames. This number includes bytes contained in the Frame Check Sequence (FCS), but excludes bytes in the preamble.
- **Received Broadcast (RX Bcast)—**The total number of frames received by the port that are addressed to a broadcast address.
- **Received Multicast (RX Mcast)—**The total number of frames received by the port that are addressed to a multicast address.

Port Errors

The switch keeps track of errors for each port.

To view port transmit errors, use the following command:

```
show ports <portlist> txerrors
```

The following port transmit error information is collected by the system:

- **Port Number**
- **Link Status—**The current status of the link. Options are:
  - Ready (the port is ready to accept a link).
  - Active (the link is present at this port).
- **Transmit Collisions (TX Coll)—**The total number of collisions seen by the port, regardless of whether a device connected to the port participated in any of the collisions.
- **Transmit Late Collisions (TX Late Coll)—**The total number of collisions that have occurred after the port's transmit window has expired.
- **Transmit Deferred Frames (TX Deferred)—**The total number of frames that were transmitted by the port after the first transmission attempt was deferred by other network traffic.
- **Transmit Errored Frames (TX Error)—**The total number of frames that were not completely transmitted by the port because of network errors (such as late collisions or excessive collisions).
- **Transmit Parity Frames (TX Parity)**—The bit summation has a parity mismatch.

To view port receive errors, use the following command:

```
show ports <portlist> rxerrors
```

The following port receive error information is collected by the switch:

- **Receive Bad CRC Frames (RX CRC)—**The total number of frames received by the port that were of the correct length, but contained a bad FCS value.
- **Receive Oversize Frames (RX Over)—**The total number of good frames received by the port greater than the supported maximum length of 1,522 bytes. For products that use the "*i*" chipset, ports with jumbo frames enabled do no increment this counter.
- **Receive Undersize Frames (RX Under)—**The total number of frames received by the port that were less than 64 bytes long.
- **Receive Fragmented Frames (RX Frag)—**The total number of frames received by the port were of incorrect length and contained a bad FCS value.

- **Receive Jabber Frames (RX Jab)—**The total number of frames received by the port that was of greater than the support maximum length and had a Cyclic Redundancy Check (CRC) error.
- **Receive Alignment Errors (RX Align)—**The total number of frames received by the port that occurs if a frame has a CRC error and does not contain an integral number of octets.
- **Receive Frames Lost (RX Lost)—**The total number of frames received by the port that were lost because of buffer overflow in the switch.

Port Monitoring Display Keys

Table 26 describes the keys used to control the displays that appear when you issue any of the `show port` commands.

Table 26: Port Monitoring Display Keys

Key(s)	Description
U	Displays the previous page of ports.
D	Displays the next page of ports.
[Esc] or [Return]	Exits from the screen.
0	Clears all counters.
[Space]	Cycles through the following screens: • Packets per second • Bytes per second • Percentage of bandwidth Available using the `show port utilization` command only.

System Health Checking

The system health checker tests the backplane, the CPU, and I/O modules by periodically forwarding packets and checking for the validity of the forwarded packets.

The system health checker can be configured to handle a failure as an error condition, logging the problem to the syslog, or it can attempt auto-recovery of the module that generated the errors.

The alarm-level and auto-recovery options are mutually exclusive.

To enable the system health checker, use the following command:

```
enable sys-health-check
```

To disable the system health checker, use the following command:

```
disable sys-health-check
```

To configure the switch to respond to a failed health check based on an alarm-level, use the following command:

```
config sys-health-check alarm-level [card-down | default | log | system-down | traps]
```

This command provides the following options:

- `card-down`—Posts a CRIT message to the log, sends a trap, and turns off the module.
- `log`—Posts a CRIT message to the log.
- `system-down`—Posts a CRIT message to the log, sends a trap, and turns off the system.
- `traps`—Posts a CRIT message to the log and sends a trap.

The default option is `log`.

To configure the switch for auto-recovery, use the following command:

```
config sys-health-check auto-recovery <number of tries>
```

The auto-recovery option is used to configure the number of times the system health checker attempts to automatically reset a faulty module and bring it online. If the module continues to fail more than the configured number of attempts, the system health checker sets the module to card-down.

When auto-recovery is configured, the occurrence of three consecutive checksum errors will cause a packet memory (PM) defect detection program to be run against the I/O module. Checksum errors can include internal and external MAC port parity errors, EDP checksum errors, and CPU packet or diagnostic packet checksum errors. If defects are detected, the card is taken offline, the memory defect information is recorded in the card EEPROM, the defective buffer is mapped out of further use, and the card is returned to operational state. A maximum of 8 defects can be stored in the EEPROM.

After the PM defect detection and mapping process has been run, a card is considered failed and is taken offline in the following circumstances:

- More than eight defects are detected.
- Three consecutive checksum errors were detected by the health checker, but no new PM defects were found by the PM defect detection process.
- After defects were detected and mapped out, the same checksum errors are again detected by the system health checker.

The auto-recovery repetition value is ignored in these cases. In any of these cases, please contact Extreme Technical Support.

To view the status of the system health checker, use the following command:

```
show diagnostics
```

Setting the System Recovery Level

You can configure the system to automatically reboot after a software task exception, using the following command:

```
config sys-recovery-level [none | critical | all]
```

Where the following is true:

- `none`—Configures the level to no recovery.
- `critical`—Configures ExtremeWare to log an error into the syslog and automatically reboot the system after a critical task exception.

- `all`—Configures ExtremeWare to log an error into the syslog and automatically reboot the system after any task exception.

The default setting is none.

Logging

The switch log tracks all configuration and fault information pertaining to the device. Each entry in the log contains the following information:

- **Timestamp—**The timestamp records the month and day of the event, along with the time (hours, minutes, and seconds) in the form HH:MM:SS. If the event was caused by a user, the user name is also provided.
- **Fault level**—Table 27 describes the three levels of importance that the system can assign to a fault.

Table 27: Fault Levels Assigned by the Switch

Level	Description
Critical	A desired switch function is inoperable. The switch may need to be reset.
Warning	A noncritical error that may lead to a function failure.
Informational	Actions and events that are consistent with expected behavior.
Debug	Information that is useful when performing detailed troubleshooting procedures.

By default, log entries that are assigned a critical or warning level remain in the log after a switch reboot. Issuing a clear log command does not remove these static entries. To remove log entries of all levels (including warning or critical), use the following command:

```
clear log static
```

- **Subsystem**—The subsystem refers to the specific functional area to which the error refers. Table 28 describes the subsystems.

Table 28: Fault Log Subsystems

Subsystem	Description
Syst	General system-related information. Examples include memory, power supply, security violations, fan failure, overheat condition, and configuration mode.
STP	STP information. Examples include an STP state change.
Brdg	Bridge-related functionality. Examples include low table space and queue overflow.
SNMP	SNMP information. Examples include community string violations.
Telnet	Information related to Telnet login and configuration performed by way of a Telnet session.
VLAN	VLAN-related configuration information.
Port	Port management-related configuration. Examples include port statistics and errors.

- **Message**—The message contains the log information with text that is specific to the problem.

Local Logging

The switch maintains 1,000 messages in its internal log. You can display a snapshot of the log at any time by using the following command:

```
show log {chronological} {<priority>} {time}
```

where the following is true:

- chronological—Specifies to show log entries in ascending chronological order.
- priority—Specifies a message priority. These can be one of the following:

  alert, critical, debug, emergency, error, info, notice, or warning.
- time—Specifies that the log entries should be displayed in chronological order, based on the timestamp.

Real-Time Display

In addition to viewing a snapshot of the log, you can configure the system to maintain a running real-time display of log messages on the console. To turn on the log display, use the following command:

```
enable log display
```

To configure the log display, use the following command:

```
config log display {<severity>}
```

If `severity` is not specified, only messages of critical priority are displayed.

If you enable the log display on a terminal connected to the console port, your settings will remain in effect even after your console session is ended (unless you explicitly disable the log display). The log display setting will be stored with the configuration upon a save.

You can enable a log display from a Telnet session using the `enable log display` command, but the log display will appear only on the console.

Remote Logging

In addition to maintaining an internal log, the switch supports remote logging by way of the UNIX syslog host facility. To enable remote logging, follow these steps:

1. Configure the syslog host to accept and log messages.
2. Enable remote logging by using the following command:

   ```
   enable syslog
   ```
3. Configure remote logging by using the following command:

   ```
   config syslog {add} <ipaddress> <facility> {<severity>}
   ```

   Specify the following:

   — `ipaddress`—The IP address of the syslog host.

   — `facility`—The syslog facility level for local use. Options include `local0` through `local7`.

   — `severity`—Filters the log to display message with the selected severity or higher (more critical). Severities include (in order) emergency, critical, alert, error, warning, notice, info, and debug. If not specified, all messages are sent to the syslog host.

NOTE

Refer to your UNIX documentation for more information about the syslog host facility.

Logging Configuration Changes

ExtremeWare allows you to record all configuration changes and their sources that are made using the CLI by way of Telnet or the local console. The changes are logged to the system log. Each log entry includes the user account name that performed the change and the source IP address of the client (if Telnet was used). Configuration logging applies only to commands that result in a configuration change. To enable configuration logging, use the following command:

```
enable cli-config-logging
```

To disable configuration logging, use the following command:

```
disable cli-config-logging
```

CLI configuration logging is enabled by default.

Configuring and Monitoring Flow Statistics

NOTE

This section describes the process of configuring and monitoring flow statistics on Ethernet links. If you plan to configure and monitor flow statistics on PoS links, see the Packet Over SONET Installation and User Guide *for more information.*

The broad growth in Internet and intranet usage has brought with it an increased demand for network bandwidth and performance that is based on predictable quality of service and security. This movement is paralleled by the related need for measurement technology that makes it possible to gather, analyze, and manipulate information about network and application use. NetFlow, originally developed by Cisco, provides a way for a switch to capture and export traffic classification or precedence information as data traverses, or flows, across portions of a network.

A network flow is defined as a unidirectional sequence of packets between a particular source device and destination device that share the same protocol and transport-layer information. Flows are defined by the following fields: source IP address, destination IP address, source port, destination port, and protocol type. Per-flow statistics are useful for many management purposes, including:

- Accounting and billing
- Network capacity planning and trend analysis
- Network monitoring
- Workload characterization
- User profiling
- Data warehousing and mining

Flow Statistics Background Information

Per-flow statistics are exported in the NetFlow Version 1 record format described in Table 29. NetFlow records are unidirectional in nature, which implies that two flow records are maintained for a typical TCP connection: one record for flow in the ingress direction; a second for the flow in the egress direction. Also, records are maintained only for TCP and UDP flows.

Table 29: NetFlow Version 1 Record Format

Field Name	Octets	Field Description
srcaddr	4	Source IP address.
dstaddr	4	Destination IP address.
nexthop	4	IP address of next-hop router; set to zero for per-flow statistics; set to xFFFF for filter-based aggregated statistics.
input	2	(Not supported.) Input interface index.
output	2	(Not supported.) Output interface index.
dPkts	4	Number of packets sent in this flow.
dOctets	4	(Not Supported.) Number of octets sent in this flow.
First	4	(Not supported.) SysUptime when flow record was created.
Last	4	(Not supported.) SysUptime at most-recent, or last packet of flow.
srcport	2	Source port number, valid only for TCP and UDP flows.
dstport	2	Destination port number, valid only for TCP and UDP flows.
pad	2	Unused field.
prot	1	Number identifying the IP protocol; for example, 6=TCP and 17=UDP.
tos	1	(Not supported.) IP Type-of-Service (TOS) field value from initial packet that caused this flow record to be created.
tcp_flags	1	(Not supported.) Cumulative OR of TCP flags field, valid only when *prot*=6.
pad	7	Unused field.

Flow records are grouped together into UDP datagrams for export to a flow-collector device. A NetFlow Version 1 export datagram can contain up to 25 flow records. Figure 22 shows the format of the export datagram; Table 30 describes the export datagram header.

Figure 22: Format of NetFlow export datagram

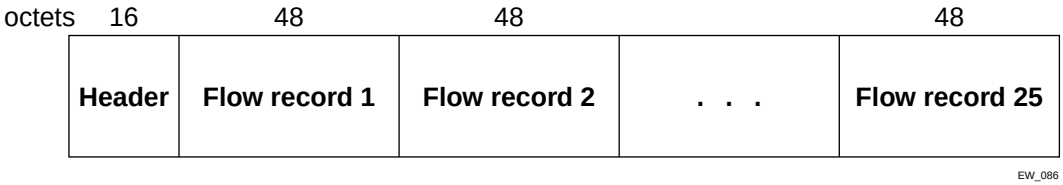
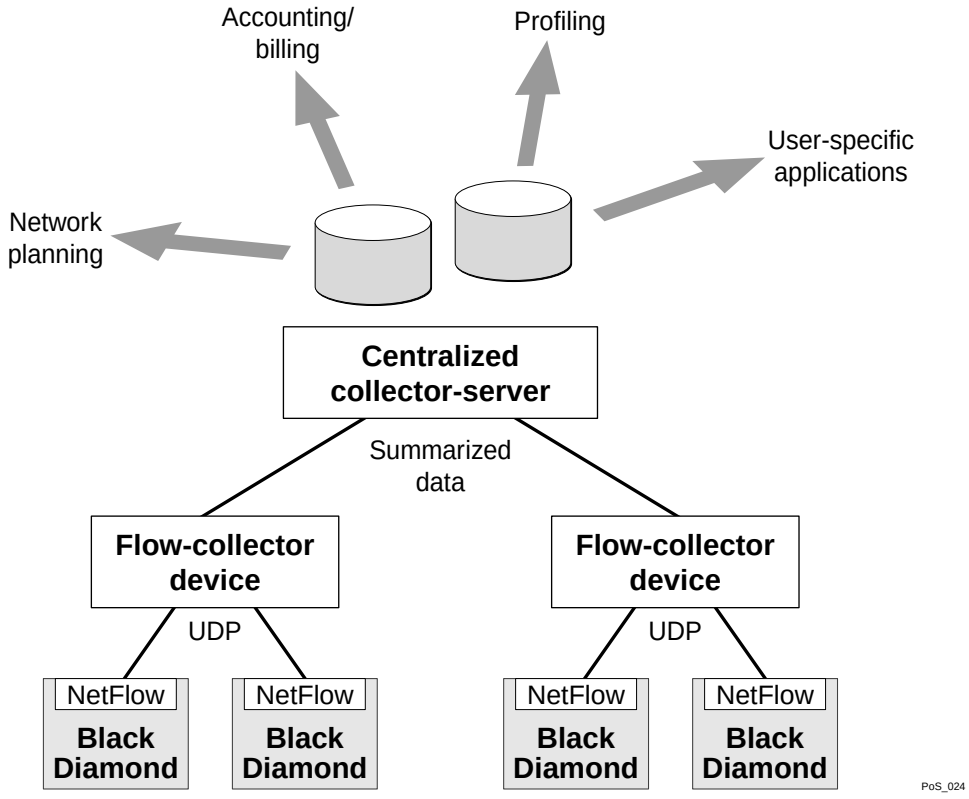


Table 30: Format of NetFlow Version 1 Export Datagram Header

Field Name	Octets	Field Description
version	2	Header version=1.
count	2	Number of flow records in datagram.
SysUptime	4	Current time in milliseconds since the switch booted.
unix_secs	4	(Not Supported.) Current count of seconds since 0000 UTC 1970.
unix_nsecs	4	(Not Supported.) Current count of residual nanoseconds since 0000 UTV 1970.

The IP addresses (or host names) and UDP port numbers of the available flow collectors can be configured on a per-switch basis. The flow collection architecture example in Figure 23 illustrates how multiple BlackDiamond switches might export flow records to flow-collector devices that, in turn, feed records into a central collector-server. Other flow-collector architectures are also possible. For example, each switch port configured for flow switching might export statistics to a dedicated flow-collector device.

Figure 23: NetFlow Collection Architecture Example



The ExtremeWare NetFlow implementation also enables a single port to distribute statistics across multiple groups of flow-collector devices. This NetFlow distribution feature enables a scalable collection architecture that is able to accommodate high volumes of exported data. The NetFlow distribution feature is enabled by configuring *export distribution groups* that contain the addresses of multiple flow-collector devices. The feature uses a distribution algorithm that ensures all of the records for a

given flow are exported to the same collector. The algorithm also ensures that the flow records of the ingress direction of a TCP or UDP connection are exported to the same collector. (For Ethernet applications, only ingress traffic is monitored on Ethernet ports.) For example, multiple filters can be assigned to a set of ports for the same group. The flow records that match the filters are then sent to one of the flow collector devices in that group. You can also establish redundancy by configuring multiple flow collector devices per group so that data is still collected as long as there is one working flow collector device in that group.

To implement flow-collector devices, you can choose from commercial software products and public-domain software packages.

Collection Port and Filtering Options

By default, each Ethernet port configured for flow switching maintains statistics for all the flows traversing the link in the ingress direction.

Generalized filtering options exist that enable you to configure an Ethernet port to maintain statistics selectively for only those flows that match a specified filter. For example, to monitor aggregated flow records on Ethernet ports, you could configure an aggregation filter that specifies a range of IP addresses or ports.

Up to eight filters are supported for each Ethernet port, with a total of 128 filters possible per each I/O module. The filters consist of a {*value, mask*} pair for each of the following flow components: destination IP address, source IP address, destination port, source port, and protocol. Conceptually, the filters work by logically ANDing the contents of each of these five components of a forwarded flow with the associated *masks* from the first filter. Statistics are maintained if the results of the AND operations match the configured filter values for all fields of the five flow components. If there is not a match on all fields of the five components, then the operation is repeated for the second filter, and so on. If there is no match for any of the filters, then statistics are not maintained for the flow.

Collection Architecture Scalability and Reliability

By supporting statistics distribution across groups of flow-collector devices, the NetFlow distribution function enables a scalable collection architecture that is able to accommodate high volumes of exported data. The function also includes a health-check feature that significantly improves the reliability of the collection architecture. The health-checker ensures that only responsive flow-collector devices are included in the effective export distribution lists.

Up to 32 export distribution groups can be configured on a Black Diamond 6800 series switch. Each of these groups can contain the addresses of up to eight flow-collector devices. A particular export group can then be specified for each filter, which provides a high-degree of flexibility.

A filter-based aggregation capability is also offered to further enhance scalability. Each filter can be configured to be either a *per-flow filter* or an *aggregation* filter. When a flow matches a filter that is configured as an aggregation, normal per-flow statistics are not maintained for the flow. Instead, a single set of statistics is maintained for all the flows that match the aggregation filter, which can substantially reduce the volume of exported data.

Aggregated flow statistics are also exported in the NetFlow Version 1 format. The *srcaddr*, *dstaddr*, *srcport*, *dstport*, and *prot* fields of an aggregated flow record are set to the corresponding value components of the associated filter specification.

Export Criteria

For Ethernet ports, flow records are exported on an age basis. If the age of the flow is greater than a configurable time, the record is exported.

An Ethernet port configured for flow switching transmits a NetFlow Export Datagram when 25 flow records are ready for export, or when at least one flow has been awaiting export for one second.

An Ethernet port configured for capturing flows transmits NetFlow export datagrams when the configured time-out expires and exports the data collected by the flow filters configured on that port. As the NetFlow on Ethernet links is modeled as port-based, individual ports maintain their configured time-outs and export the flows collected by the configured flow filters on the expiry of flow export time-out.

Enabling and Disabling the Flow Statistics Feature on a Switch

To enable the flow statistics feature on a switch, use the following command:

```
enable flowstats
```

The flow statistics feature is disabled by default.

To disable the flow statistics feature on a switch, use the following command:

```
disable flowstats
```

Enabling and Disabling Flow Statistics on a Port

To enable the flow statistics function on the specified port, use the following command:

```
enable flowstats ports <portlist>
```

The flow statistics function is disabled by default.

To disable the flow statistics function on the specified port, use the following command:

```
disable flowstats ports <portlist>
```

Configuring the Export Destination

A single port can distribute statistics across multiple groups of flow-collector devices. This NetFlow distribution capability makes it possible to create a collection architecture that scales to accommodate high volumes of exported data. It also offers a health-checking function that improves the reliability of the collection architecture by ensuring that only responsive flow-collector devices are included in active export distribution lists. The distribution algorithm also ensures that all the ingress flow records for a given flow are exported to the same collector.

NetFlow distribution is enabled by configuring export distribution groups that identify the addresses of multiple flow-collector devices. You can configure up to 32 export distribution groups on a BlackDiamond 6800 series switch, and each group can contain as many as eight flow-collector devices.

To configure the export groups and flow-collector devices to which NetFlow datagrams are exported, use the following command:

```
config flowstats export <group#> [add | delete] [<ipaddress> | <hostname>] <udp_port>
```

The `group#` parameter is an integer in the range from 1 through 32 that identifies the specific group for which the destination is being configured.

You can use the add and delete keywords to add or delete flow-collector destinations.

To export NetFlow datagrams to a group, you must configure at least one flow-collector destination. By default, no flow-collector destinations are configured. To configure a flow-collector destination, use either an IP address and UDP port number pair or a hostname and UDP port number pair to identify the flow-collector device to which NetFlow export datagrams are to be transmitted. You can configure up to eight flow-collector destinations for each group. When multiple flow-collectors are configured as members of the same group, the exported NetFlow datagrams are distributed across the available destinations.

Configuring the Source IP Address

To configure the IP address that is to be used as the source IP address for NetFlow datagrams to be exported, use the following command:

```
config flowstats source ipaddress <ipaddress>
```

By default, flow records are exported with the VLAN interface address that has a route to the configured flow-collector device. Depending on how it is configured, a flow-collector device can use the source IP address of received NetFlow datagrams to identify the switch that sent the information.

The following command example specifies that the IP address 192.168.100.1 is to be used as the source IP address for exported NetFlow datagrams.

```
config flowstats source ipaddress 192.168.100.1
```

Configuring Flow Record Time-out

Flow records are exported on an age basis. If the age of the flow record is greater than the configured time-out, the record is exported.

To configure the time-out value for flow records on the specified port, use the following command:

```
config flowstats timeout <minutes> ports [<portlist> | all]
```

The time-out value is the number of minutes to use in deciding when to export flow records. The default time-out is 5 minutes.

The following command example specifies a 10-minute time-out for exported NetFlow datagrams on port 1 of the Ethernet module installed in slot 8 of the BlackDiamond switch.

```
config flowstats timeout 10 ports 8:1
```

Configuring a Flow Record Filter

You can configure an Ethernet port to maintain statistics selectively for only those flows that match a specified filter. Each Ethernet port supports eight filters for ingress flows.

To configure a flow record filter for the specified Ethernet port, use the following command:

```
config flowstats filter <filter#> {aggregation} {export <group#>} ports <portlist>
[ingress | egress] <filterspec>
```

where:

filter#	The `filter#` parameter is an integer in the range from 1 to 8 that identifies the filter being defined.
<group#>	Specifies the group number that identifies the set of flow collector devices to which records for flows matching the filter are to be exported. If Group is not specified , then group # 1 will be used as default export group.
aggregation	To reduce the volume of exported data, use this optional keyword to maintain a single set of statistics for all the flows that match the specified filter.
filterspec	Specifies a set of five parameters (four are value/mask pairs) that define the criteria by which a flow is evaluated to determine if it should be exported. The parameters are: `[{dest-ip <ipaddress_value/mask ipaddress_filtermask>} {source-ip <ipaddress_value/mask ipaddress_filtermask> } {dest-port <port_value/port_filtermask> } {source-port <port_value/port_filtermask> } {protocol <tcp/udp/ip/protocol_value/protocol_filtermask>} | match-all-flows |match-no-flows ]` All five specifications must be included in the order specified. The range for port/port_mask is calculated using the following formula: (minport = port, maxport = 2^(32-port_mask)-1). Conceptually, the filters work by ANDing the contents of each of the five components of a forwarded flow with the associated masks from the first defined filter (filter #1). Statistics are maintained if the results of the AND operations match the configured filter values for all fields of the sequence. If there is no match, then the operation is repeated for filter #2, and so on. If there is no match for any of the filters, then statistics are not maintained for the flow. Filters for any or all of the sequence components can be configured with a single command.
match-all-flows	Specifies that the filter should match any flow.
match-no-flows	Specifies that the filter should discard all flow. This option is not valid for Ethernet blades.
egress	Specifies that the filter should capture only egress traffic. This option is not valid for Ethernet blades.
ingress	Specifies that the filter should capture only ingress traffic.

The following command example configures a filter to collect aggregate statistics for all traffic flowing through ports 1-8 from the 192.170.0.0/16 subnet to the 192.171.132.0/24 subnet:

```
config flowstats filter 2 aggregation export 1 ports 1-8 ingress dest-ip
192.171.132.0/24 source-ip 192.170.0.0/16 dest-port 0/0 source-port 0/0 protocol ip
```

Likewise, the following command example configures a filter to collect aggregate statistics for all ingress traffic flowing from the 192.171.0.0/16 subnet to the 192.170.0.0/16 subnet and export the flows to group 3 for ports 6:1, 7:9, and 8:42

```
config flowstats filter 2 aggregation export 3 ports  6:1,7:9,8:42 ingress dest-ip
192.170.0.0/16 source-ip 192.171.0.0/16 dest-port 0/0 source-port 0/0 protocol ip
```

Finally, the following command configures filter 3 to collect statistics on any flows for ports 4-32 that did not match the filters defined in the two previous commands:

```
config flowstats filter 3 aggregation export 1 ports 4-32 ingress match-all-flows
```

Enabling and Disabling a Flow Record Filter

To enable a specified flow record filter for the specified Ethernet port, use the following command:

```
enable flowstats filter <filter#> ports <portlist> {egress | ingress}
```

By default, all filters are enabled after they are configured.

To disable a specified flow record filter for the specified Ethernet port, use the following command:

```
disable flowstats filter <filter#> ports <portlist> {egress | ingress}
```

where:

filter#	The `filter#` parameter is an integer in the range from 1 to 8 that identifies the filter that is being enabled or disabled.

NOTE

Ethernet blades can capture ingress traffic only.

The following command example enables filter #2 on port 1 of the Ethernet module installed in slot 8 of the BlackDiamond switch.

```
enable flowstats filter 2 ports 8:1
```

The following command example disables filter #2 on port 1 of the Ethernet module installed in slot 8 of the BlackDiamond switch.

```
disable flowstats filter 2 ports 8:1
```

Enabling and Disabling Flow Statistics Ping-Check

To enable the flow statistics ping-check function for a specified group of collector devices, use the following command:

```
enable flowstats ping-check {<group#>}
```

The ping-check function is disabled by default. The group identifier is option. Not specifying a group identifier selects all groups.

When the ping-check function is enabled, each of the flow collector devices is pinged periodically to check its network connectivity. If a flow collector device is repetitively unresponsive, it is temporarily removed from the export distribution list for that group. The flow collector device will be returned to the export distribution list automatically when subsequent ping checks are consistently successful.

The following command example enables the ping-check function for export group 2.

```
enable flowstats ping-check 2
```

To disable the flow statistics ping-check function for a specified group of collector devices, use the following command:

```
disable flowstats ping-check {<group#>}
```

The following command example disables the ping-check function for export group 2.

```
disable flowstats ping-check 2
```

Unconfiguring Flow Statistics

To reset the flow statistics configuration parameters for a specified Ethernet port to their default values, use the following command:

```
unconfig flowstats  {filter <filter#> ports <portlist>} | {ports [<portlist> | all]}
```

NOTE

This command does not affect the enabled or disabled status of flow statistics collection, nor does it affect the configured export destinations.

The following command example resets the flow statistics configuration parameters for port 1 of the module installed in slot 8 of the BlackDiamond switch to their default values.

```
unconfig flowstats ports 8:1
```

Displaying Flow Statistics Status Information

To display status information for the flow statistics function, use the following command:

```
show flowstats {<portlist> | export {<group#>} {detail}}
```

where:

detail	Use this optional keyword to display detailed NetFlow configuration information.
group#	Use this optional parameter with the `group` keyword to display status information for a specific export group.
portlist	Use this optional parameter to specify one or more ports or slots and ports for which status information is to be displayed.

If you enter the `show flowstats` command with none of the optional keywords or parameters, the command displays a summary of status information for all ports.

The summary status display for a port shows the values for all flow statistics configuration parameters for the port.

The summary status display for an export group includes the following information:

- Values for all configuration parameters
- Status of each export destination device

An example of `show flowstats` output is shown below:

```
# show  flowstats
Flowstats enabled

Port      Filter     proto   timeout     group    OverflowPkts     flags
-------------------------------------------------------------------------
1:1         1         -           5         1         N/A            EIA
Dest/Src Info: match-all-flows

Flags:  E - Enable, D - Disable; I - Ingress, S - Egress; A - Aggregation
```

The detailed status display for an export group includes the summary information, plus the following management information:

- Counts of the number of times each flow collector destination has been taken out of service due to health-check (ping check) failures
- The source IP address configuration information

RMON

Using the Remote Monitoring (RMON) capabilities of the switch allows network administrators to improve system efficiency and reduce the load on the network.

The following sections explain more about the RMON concept and the RMON features supported by the switch.

NOTE

You can only use the RMON features of the system if you have an RMON management application, and have enabled RMON on the switch.

About RMON

RMON is the common abbreviation for the Remote Monitoring Management Information Base (MIB) system defined by the Internet Engineering Task Force (IETF) documents RFC 1271 and RFC 1757, which allows you to monitor LANs remotely.

A typical RMON setup consists of the following two components:

- **RMON probe**—An intelligent, remotely controlled device or software agent that continually collects statistics about a LAN segment or VLAN. The probe transfers the information to a management workstation on request, or when a predefined threshold is crossed.
- **Management workstation**—Communicates with the RMON probe and collects the statistics from it. The workstation does not have to be on the same network as the probe, and can manage the probe by in-band or out-of-band connections.

RMON Features of the Switch

The IETF defines nine groups of Ethernet RMON statistics. The switch supports the following four of these groups:

- Statistics
- History
- Alarms
- Events

This section describes these groups and discusses how they can be used.

Statistics

The RMON Ethernet Statistics group provides traffic and error statistics showing packets, bytes, broadcasts, multicasts, and errors on a LAN segment or VLAN.

Information from the Statistics group is used to detect changes in traffic and error patterns in critical areas of the network.

History

The History group provides historical views of network performance by taking periodic samples of the counters supplied by the Statistics group. The group features user-defined sample intervals and bucket counters for complete customization of trend analysis.

The group is useful for analysis of traffic patterns and trends on a LAN segment or VLAN, and to establish baseline information indicating normal operating parameters.

Alarms

The Alarms group provides a versatile, general mechanism for setting threshold and sampling intervals to generate events on any RMON variable. Both rising and falling thresholds are supported, and thresholds can be on the absolute value of a variable or its delta value. In addition, alarm thresholds can be autocalibrated or set manually.

Alarms inform you of a network performance problem and can trigger automated action responses through the Events group.

Events

The Events group creates entries in an event log and/or sends SNMP traps to the management workstation. An event is triggered by an RMON alarm. The action taken can be configured to ignore it, to log the event, to send an SNMP trap to the receivers listed in the trap receiver table, or to both log and send a trap. The RMON traps are defined in RFC 1757 for rising and falling thresholds.

Effective use of the Events group saves you time. Rather than having to watch real-time graphs for important occurrences, you can depend on the Event group for notification. Through the SNMP traps, events can trigger other actions, which provides a mechanism for an automated response to certain occurrences.

Configuring RMON

RMON requires one probe per LAN segment, and standalone RMON probes traditionally have been expensive. Therefore, Extreme's approach has been to build an inexpensive RMON probe into the agent of each system. This allows RMON to be widely deployed around the network without costing more than traditional network management. The switch accurately maintains RMON statistics at the maximum line rate of all of its ports.

For example, statistics can be related to individual ports. Also, because a probe must be able to see all traffic, a stand-alone probe must be attached to a nonsecure port. Implementing RMON in the switch means that all ports can have security features enabled.

To enable or disable the collection of RMON statistics on the switch, use the following command:

```
[enable | disable] rmon
```

By default, RMON is disabled. However, even in the disabled state, the switch response to RMON queries and sets for alarms and events. By enabling RMON, the switch begins the processes necessary for collecting switch statistics.

Event Actions

The actions that you can define for each alarm are shown in Table 31.

Table 31: Event Actions

Action	High Threshold
No action	
Notify only	Send trap to all trap receivers.
Notify and log	Send trap; place entry in RMON log.

To be notified of events using SNMP traps, you must configure one or more trap receivers, as described in Chapter 3.

11 Security

This chapter describes the following topics:

- Security Overview on page 185
- Network Access Security on page 185
  - MAC-Based VLANs on page 186
  - IP Access Lists (ACLs) on page 186
  - MAC Address Security on page 193
  - Network Login on page 196
- Switch Protection on page 203
  - Routing Access Profiles on page 203
  - Route Maps on page 212
  - Denial of Service Protection on page 217
- Management Access Security on page 219
  - Authenticating Users Using RADIUS or TACACS+ on page 219
  - Secure Shell 2 (SSH2) on page 226

Security Overview

Extreme Networks products incorporate a number of features designed to enhance the security of your network. No one feature can insure security, but by using a number of features in concert, you can substantially improve the security of your network. The features described in this chapter are part of an overall approach to network security

Network Access Security

Network access security features control devices accessing your network. In this category are the following features:

- MAC-Based VLANs
- IP Access Lists (ACLs)

- MAC Address Security
- Network Login

MAC-Based VLANs

MAC-Based VLANs allow physical ports to be mapped to a VLAN based on the source MAC address learned in the FDB. This feature allows you to designate a set of ports that have their VLAN membership dynamically determined by the MAC address of the end station that plugs into the physical port. You can configure the source MAC address-to-VLAN mapping either offline or dynamically on the switch. For example, you could use this application for a roaming user who wants to connect to a network from a conference room. In each room, the user plugs into one of the designated ports on the switch and is mapped to the appropriate VLAN. Connectivity is maintained to the network with all of the benefits of the configured VLAN in terms of QoS, routing, and protocol support.

Detailed information about configuring and using MAC-based VLANs can be found in Chapter 5.

IP Access Lists (ACLs)

IP access lists consist of IP access rules and are used to perform packet filtering and forwarding decisions on incoming traffic. Each packet arriving on an ingress port is compared to the access list in sequential order and is either forwarded to a specified QoS profile or dropped. Using access lists has no impact on switch performance.

Access lists are typically applied to traffic that crosses layer 3 router boundaries, but it is possible to use access lists within a layer 2 VLAN.

Access lists are often referred to as Access Control Lists (ACLs).

Using IP Access Lists

Each entry that makes up an IP access list contains a unique name. It can also contain an optional, unique precedence number. The rules of an IP access list consist of a combination of the following six components:

- IP source address and mask
- IP destination address and mask
- TCP or UDP source port range
- TCP or UDP destination port range
- Physical source port
- Precedence number (optional)

How IP Access Lists Work

When a packet arrives on an ingress port, the packet is compared with the access list rules to determine a match. When a match is found, the packet is processed. If the access list is of type deny, the packet is dropped. If the list is of type permit, the packet is forwarded. A permit access list can also apply a QoS profile to the packet.

Precedence Numbers

The precedence number is optional, and determines the order in which each rule is examined by the switch. Access list entries that contain a precedence number are evaluated from highest to lowest. Precedence numbers range from 1 to 25,600, with the *number 1 having the highest precedence*.

You can specify overlapping rules; however, if you are using precedence numbers, overlapping rules without precedence numbers are ignored. Therefore, the precedence numbers must be specified among all overlapping rules. If a new rule without a precedence number is entered, and this rule overlaps with already existing rules, the switch rejects the new rule and resolves the precedences among all remaining overlapping rules.

IP Access Rules

There are a number of different types of IP access rules and different limits apply to each type. This section describes the different types of IP access rules, what each rule is capable of supporting, and any limitations associated with each type of rule. The switch allows a maximum total of 5,120 rules to be stored in non-volatile configuration storage. This maximum is a sum of IP and ICMP access rule entries.

ICMP Access Rules

An access list for ICMP is only effective for traffic routed by the switch. ICMP traffic can either be forwarded (routed) by the switch or discarded, but can not contain options for assigning a QoS profile. Other configuration options for filtering ICMP include:

- IP source and destination address and mask.
- ICMP type code.
- Physical source port (optional).
- Numbered precedence (optional).

Flow Redirect Policies

IP traffic can either be forwarded (routed) by the switch or redirected to another next-hop MAC address. The switch will monitor the next-hop system using system health checks and will stop forwarding traffic to a device that is down. You can configure up to 64 flow redirect rules. Flow redirect rules are stored separately and therefore are not limited by other ACLs. These rules are identified by:

- IP source and destination address and mask
- Layer 4 source port
- Layer 4 destination port

If a flow redirect rule is specified with an IP source address mask of less than /20, the system automatically enables the subnet mode. Flow redirect rules with mask lengths greater than /20 automatically enable enumeration mode.

Use the `show flow-redirect` command to display whether the system is in subnet mode or enumeration mode.

Netflow Record Filters

Up to eight filters are supported for each Ethernet port, with a total of 128 filters for each switch. Netflow filters share the same space as ACLs. That means that the total number of ACLs allowed is

limited by the number of Netflow record filters configured. For example, if 128 filters are created, the numbers of ACLs allowed decreases by 128.

Specifying a Default Rule

To begin constructing an access list, you should specify a default rule. A *default rule* is a rule that contains wildcards for destination and source IP address, with no layer 4 information. A default rule determines if the behavior of the access list is an "implicit deny" or "implicit accept." If no access list entry is satisfied, the default rule is used to determine whether the packet is forwarded or dropped. If no default rule is specified, the default implicit behavior is to forward the packet.

The following example shows a default entry that is used to specify an explicit deny:

```
create access-list denyall ip dest 0.0.0.0/0 source 0.0.0.0/0 deny ports any
```

Once the default behavior of the access list is established, you can create additional entries using precedence numbers.

The following access-list example performs packet filtering in the following sequence, as determined by the precedence number:

- Deny UDP port 32 and TCP port 23 traffic to the 10.2.XX network.
- All other TCP port 23 traffic destined for other 10.X.X.X networks is permitted using QoS profile Qp4.
- All remaining traffic to 10.2.0.0 uses QoS profile Qp3.

With no default rule specified, all remaining traffic is allowed using the default QoS profile.

```
create access-list deny102_32 udp dest 10.2.0.0/16 ip-port 32 source any ip-port any
deny ports any precedence 10

create access-list deny102_23 tcp dest 10.2.0.0/16 ip-port 23 source any ip-port any
deny ports any precedence 20

create access-list allow10_23 tcp dest 10.0.0.0/8 ip-port 23 source any ip-port any
permit qosprofile qp4 ports any precedence 30

create access-list allow102 ip dest 10.2.0.0/16 source 0.0.0.0/0 permit qosprofile qp3
ports any precedence 40
```

The permit-established Keyword

The `permit-established` keyword is used to directionally control attempts to open a TCP session. The permit-established keyword denies all traffic that matches the TCP source/destination, and has the SYN=1 and ACK=0 flags set. Thus, TCP session initiation can be explicitly blocked using this keyword. Traffic from TCP sessions that are already established continue to be permitted.

NOTE

For an example of using the permit-established keyword, see "Using the Permit-Established Keyword" on page 190.

Adding and Deleting Access List Entries

Entries can be added and deleted to the access list. To add an entry, you must supply a unique name and, optionally, a unique precedence number. To modify an existing entry, you must delete the entry and retype it, or create a new entry with a new unique name.

To delete an access list entry, use the following command:

```
delete access-list <name>
```

Maximum Entries

A maximum of 255 entries with an assigned precedence can be used. In addition to the 255 entries, entries that do not use precedence can also be created, with the following restrictions:

- A source IP address must use wildcards or a completely specified mask.
- The layer 4 source and destination ports must use wildcards or be completely specified (no ranges).
- No physical source port can be specified.
- Access list rules that apply to all physical ports are implemented on all BlackDiamond I/O modules.

On a BlackDiamond switch, the maximum number of access list entries is 255 entries per I/O module. One way to economize on the number of entries on a BlackDiamond switch is to provide a physical ingress port as a component of an access list rule. In this case, the rule is implemented only on the I/O modules that contain the specified ports. By restricting rules to specific I/O modules, you can extend the number of access list rules to 5120 (NVRAM limit).

On BlackDiamond switches, there is a resource on each "*i*" series I/O module so that the total maximum number of ACL entries can be up to 4080 (255*16). Each ACL must specify an ingress physical port specific to a single I/O module to avoid using those resources on any other module.

On Alpine switches, a maximum of 255 ACL entries are supported.

Verifying Access List Configurations

To verify access list settings, you can view the access list configuration and see real-time statistics on which access list entries are being accessed when processing traffic.

To view the access list configuration and statistics screen, use the following command:

```
show access-list {<name> | port <portlist>}
```

To initiate and refresh a running display of access list statistics, use the following command:

```
show access-list-monitor
```

IP Access List Examples

This section presents two IP access list examples:

- Using the permit-establish keyword
- Filtering ICMP packets

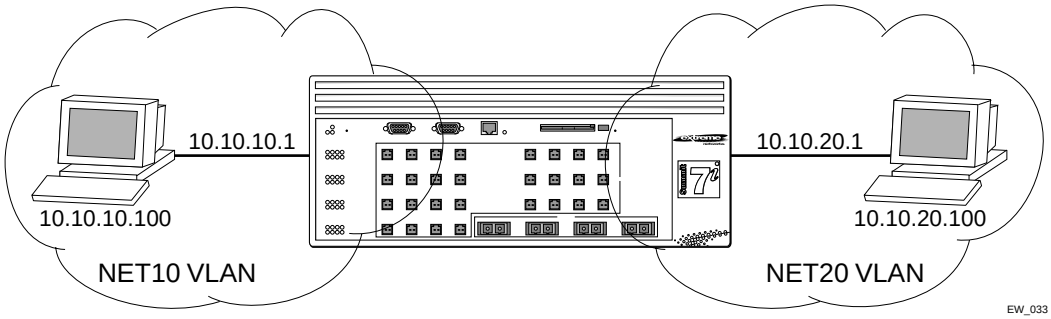
Using the Permit-Established Keyword

This example uses an access list that permits TCP sessions (Telnet, FTP, and HTTP) to be established in one direction.

The Summit7i, shown in Figure 24, is configured as follows:

- Two VLANs, NET10 VLAN and NET20 VLAN, are defined.
- The IP addresses for NET10 VLAN is 10.10.10.1/24.
- The IP address for NET20 VLAN is 10.10.20.1/24.
- The workstations are configured using addresses 10.10.10.100 and 10.10.20.100.
- IP Forwarding is enabled.

Figure 24: Permit-established access list example topology



The following sections describe the steps used to configure the example.

Step 1 – Deny IP Traffic.

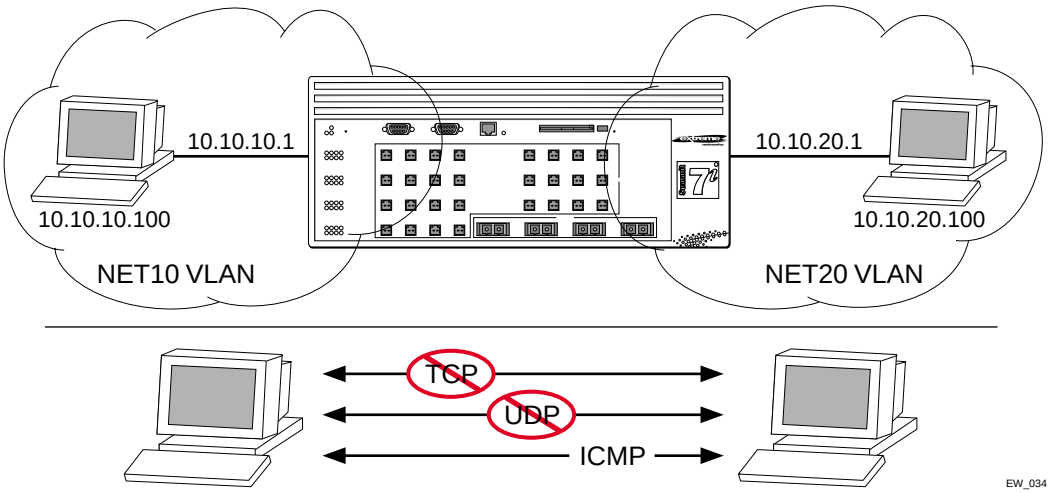
First, create an access-list that blocks all IP-related traffic. This includes any TCP- and UDP-based traffic. Although ICMP is used in conjunction with IP, it is technically not an IP data packet. Thus, ICMP data traffic, such as ping traffic, is not affected.

The following command creates the access list:

```
create access-list denyall ip destination any source any deny ports any
```

Figure 25 illustrates the outcome of the access list.

Figure 25: Access list denies all TCP and UDP traffic



Step 2 – Allow TCP traffic.

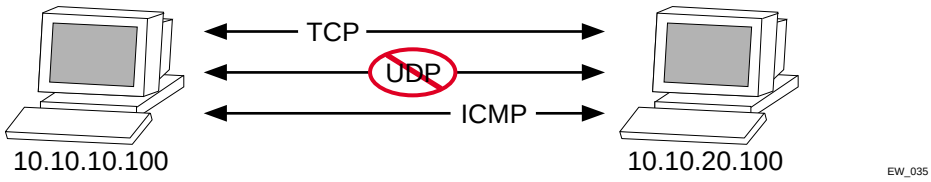
The next set of access list commands permits TCP-based traffic to flow. Because each session is bi-directional, an access list must be defined for each direction of the traffic flow. UDP traffic is still blocked.

The following commands create the access list:

```
create access-list tcp1 tcp destination 10.10.20.100/32 ip any source 10.10.10.100/32
ip any permit qp1 ports any precedence 20

create access-list tcp2 tcp destination 10.10.10.100/32 ip any source 10.10.20.100/32
ip any permit qp1 ports any precedence 21
```

Figure 26 illustrates the outcome of this access list.

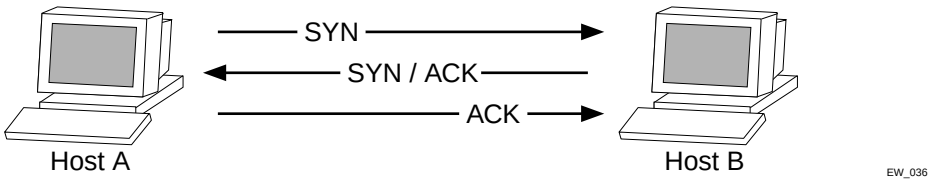
Figure 26: Access list allows TCP traffic



Step 3 - Permit-Established Access List.

When a TCP session begins, there is a three-way handshake that includes a sequence of a SYN, SYN / ACK, and ACK packets. Figure 27 shows an illustration of the handshake that occurs when host A initiates a TCP session to host B. After this sequence, actual data can be passed.

Figure 27: Host A initiates a TCP session to host B



An access list that uses the permit-established keyword filters the SYN packet in one direction.

Use the permit-established keyword to allow only host A to be able to establish a TCP session to host B and to prevent any TCP sessions from being initiated by host B, as illustrated in Figure 27. The syntax for this access list is as follows:

```
create access-list <name> tcp destination HostA ip-port 23 source HostB ip-port any
permit-established ports any pre 8
```

NOTE

This step may not be intuitive. Pay attention to the destination and source address, and the desired affect.

The exact command line entry for this example is as follows:

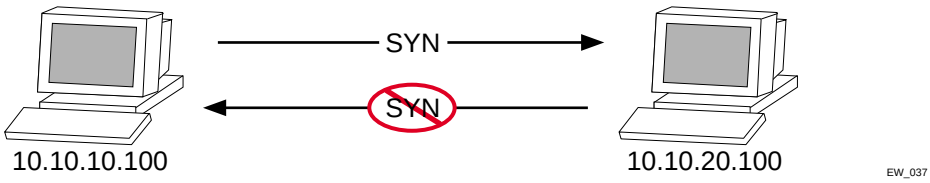
```
create access-list telnet-allow tcp destination 10.10.10.100/32 ip-port 23 source any
ip-port any permit-established ports any pre 8
```

NOTE

This rule has a higher precedence than the rule "tcp2."

Figure 28 shows the final outcome of this access list.

Figure 28: Permit-established access list filters out SYN packet to destination



Example 2: Filter ICMP Packets

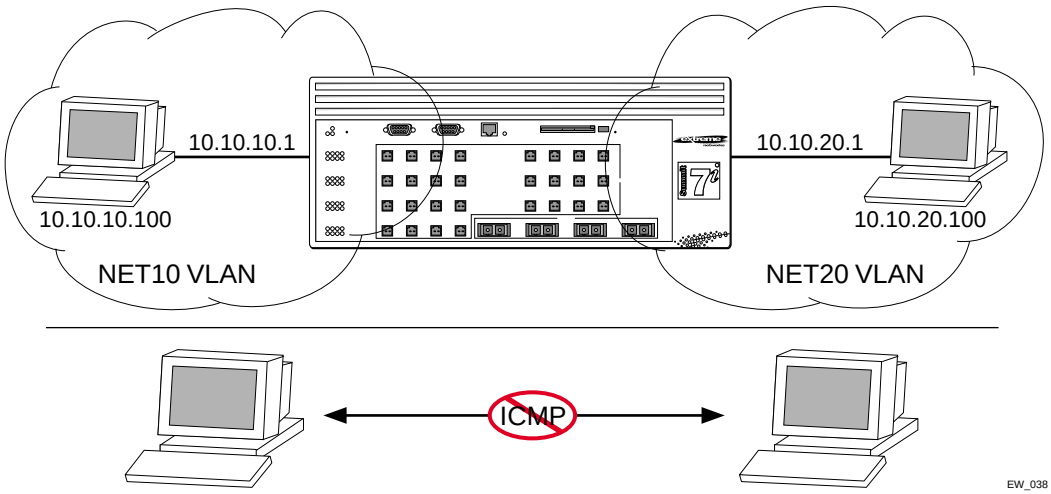
This example creates an access list that filters out ping (ICMP echo) packets. ICMP echo packets are defined as type 8 code 0.

The command line syntax to create this access list is as follows:

```
create access-list denyping icmp destination any source any type 8 code 0 deny ports
any
```

The output for this access list is shown in Figure 29.

Figure 29: ICMP packets are filtered out



MAC Address Security

The switch maintains a database of all media access control (MAC) addresses received on all of its ports. It uses the information in this database to decide whether a frame should be forwarded or filtered. MAC address security allows you to control the way the Forwarding Database (FDB) is learned and populated. By managing entries in the FDB, you can block, assign priority (queues), and control packet flows on a per-address basis.

MAC address security allows you to limit the number of dynamically-learned MAC addresses allowed per virtual port. You can also “lock” the FDB entries for a virtual port, so that the current entries will not change, and no additional addresses can be learned on the port.

NOTE

You can either limit dynamic MAC FDB entries, or lock down the current MAC FDB entries, but not both.

You can also prioritize or stop packet flows based on the source MAC address of the ingress VLAN or the destination MAC address of the egress VLAN.

Limiting Dynamic MAC Addresses

You can set a predefined limit on the number of dynamic MAC addresses that can participate in the network. After the FDB reaches the MAC limit, all new source MAC addresses are blackholed at both the ingress and egress points. These dynamic blackhole entries prevent the MAC addresses from learning and responding to Internet control message protocol (ICMP) and address resolution protocol (ARP) packets.

To limit the number of dynamic MAC addresses that can participate in the network, use the following command:

```
config ports [<portlist>  vlan <vlan name> | all]  limit-learning <number>
```

This command specifies the number of dynamically-learned MAC entries allowed for these ports in this VLAN. The range is 0 to 500,000 addresses.

When the learned limit is reached, all new source MAC addresses are blackholed at the ingress and egress points. This prevent these MAC addresses from learning and responding to Internet control message protocol (ICMP) and address resolution protocol (ARP) packets.

Dynamically learned entries still get aged and can be cleared. If entries are cleared or aged out after the learning limit has been reached, new entries will then be able to be learned until the limit is reached again.

Permanent static and permanent dynamic entries can still be added and deleted using the `create fdbentry` and `delete fdbentry` commands. These override any dynamically learned entries.

For ports that have a learning limit in place, the following traffic will still flow to the port:

- Packets destined for permanent MAC addresses and other non-blackholed MAC addresses
- Broadcast traffic
- EDP traffic

Traffic from the permanent MAC and any other non-blackholed MAC addresses will still flow from the virtual port.

To remove the learning limit, use the following command:

```
config ports [<portlist> vlan <vlan name>  | all] unlimited-learning
```

To verify the configuration, use the following commands:

```
show vlan <vlan name> security
```

This command displays the MAC security information for the specified VLAN.

```
show ports <portlist> info detail
```

This command displays detailed information, including MAC security information, for the specified port.

SNMP Traps and Syslog Messages For MAC Address Limits

To generate a syslog message and an SNMP trap when the limit is reached and a new source MAC address attempts to participate in the network, use the following command:

```
enable snmp traps mac-security
```

The information generated should help detect unauthorized devices that attempt to access the network. Enabling the trap also enables the syslog; there is no separate command for that. The command is a global command; there is no per port or per VLAN control.

To disable the generation of MAC address limit SNMP traps and syslog messages, use the following command:

```
disable snmp traps mac-security
```

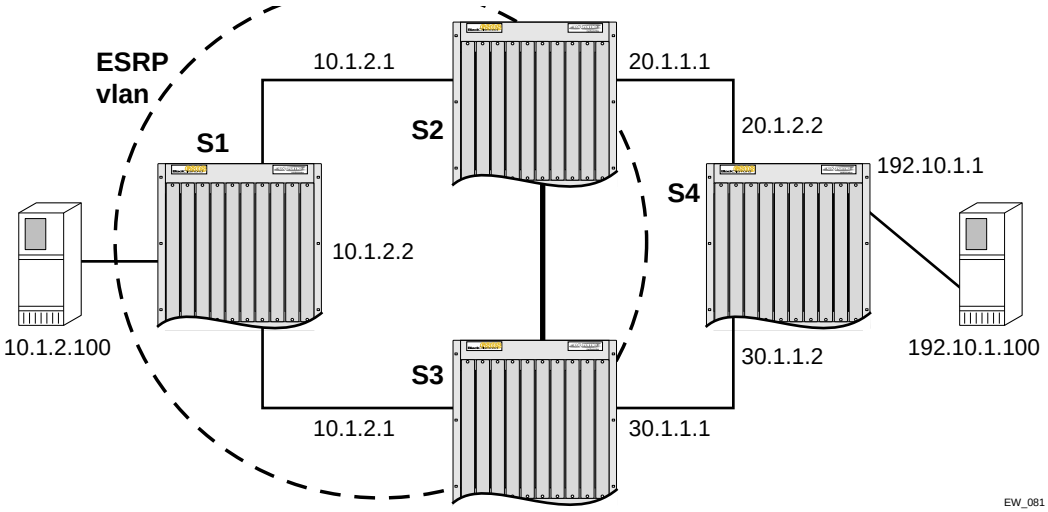
For more information about configuring SNMP and the MAC limit SNMP trap, see “Using SNMP” on page 59, in Chapter 3, “Managing the Switch”.

Limiting MAC Addresses with ESRP Enabled

If you configure a MAC address limit on VLANS that have ESRP enabled, you should add an additional back-to-back link (that has no MAC address limit on these ports) between the ESRP-enabled switches. Doing so prevents ESRP PDU from being dropped due to MAC address limit settings.

Figure 30 is an example of configuring a MAC address limit on an ESRP-enabled VLAN.

Figure 30: MAC address limits and ESRP-enabled VLANs



In Figure 30, S2 and S3 are ESRP-enabled switches, while S1 is an ESRP-aware (regular layer 2) switch. Configuring a MAC address limit on all S1 ports might prevent ESRP communication between S2 and S3. To resolve this, you should add a back-to-back link between S2 and S3. This link is not needed if MAC address limiting is configured only on S2 and S3, but not on S1.

MAC Address Lock Down

In contrast to limiting learning on virtual ports, you can lock down the existing dynamic FDB entries and prevent any additional learning using the following command:

```
config ports [<portlist> vlan <vlan name> | all] lock-learning
```

This command causes all dynamic FDB entries associated with the specified VLAN and ports to be converted to locked static entries. It also sets the learning limit to zero, so that no new entries can be learned. All new source MAC addresses are blackholed.

Locked entries do not get aged, but can be deleted like a regular permanent entry.

For ports that have lock-down in effect, the following traffic will still flow to the port:

- Packets destined for the permanent MAC and other non-blackholed MAC addresses
- Broadcast traffic

- EDP traffic

Traffic from the permanent MAC will still flow from the virtual port.

To remove MAC address lock down, use the following command:

```
config ports [<portlist>  vlan <vlan name> | all] unlock-learning
```

When you remove the lock down using the unlock-learning option, the learning-limit is reset to unlimited, and all associated entries in the FDB are flushed.

Network Login

Network Login is a feature designed to control the admission of user packets into a network by giving addresses only to users that have been properly authenticated. Network Login is controlled by an administrator on a per port, per VLAN basis and uses an integration of DHCP, user authentication over the web interface, and, sometimes, a RADIUS server to provide a user database or specific configuration details.

When Network Login is enabled on a port in a VLAN, that port will not forward any packets until authentication takes place.

NOTE

Windows authentication is not supported via network login.

You can create two types of accounts for authenticating Network Login users: netlogin-only enabled and netlogin-only disabled. A netlogin-only disabled user can log in using Network Login and can also access the switch using Telnet, SSH, or HTTP. A netlogin-only enabled user can only log in using Network Login and cannot access the switch using the same login.

Add the following line to the RADIUS server dictionary file for netlogin-only disabled users:

Extreme:Extreme-Netlogin-Only = Disabled

Add the following line to the RADIUS server dictionary file for netlogin-only enabled users:

Extreme:Extreme-Netlogin-Only = Enabled

Network login has two modes of operation:

- Campus mode

  Campus mode is used when a port in a VLAN will move to another VLAN when authentication has been completed successfully. This mode is for the roaming user who will not always be using the same port for authentication.

- ISP mode

  ISP mode is used when the port and VLAN used will remain constant. All network settings are configured for that VLAN.

These two network login modes have the following functional similarities:

- Until authentication takes place, ports on the VLAN are kept in a non-forwarding state.

- Each mode requires the user to open a web browser with the base-URL IP address of the switch. This is the only address that the client can reach in a non-authenticated state. Attempts to open other websites or IP addresses will be redirected to the Network Login base-URL for initial authentication.
- The web server on the switch provides user authentication.
- After authentication takes place, ports are moved into a forwarding state and moved to the VLAN configuration on the RADIUS server.

Using Network Login in Campus Mode

Campus mode requires:

- A DHCP server
- A RADIUS server configuration

  The RADIUS server must have the following options configured in its dictionary file for network login:

  ```
  Extreme. attr Extreme-Netlogin-Vlan 203 string (1, 0, ENCAPS)
  ```

  The following optional configuration parameters can also be specified:

  ```
  Extreme.attrExtreme-Netlogin-Url204 string (1, 0, ENCAPS)
  Extreme.attrExtreme-Netlogin-Url-Desc205 string (1, 0, ENCAPS)
  ```

NOTE

These settings are for the Merit 3.6 version of RADIUS. The syntax of these settings will vary based on the type of RADIUS server that you are using.

The RADIUS server must also contain entries in the user file for a permanent VLAN, the URL to be redirected to after authentication has taken place, and the description of that URL. For example:

```
auto Authentication-Type = Unix-PW, Service-Type = login
Filter-Id = “unlim”
Extreme:Extreme-Netlogin-Vlan = “corp”
Extreme:Extreme-Netlogin-Url = “http://192.207.37.16”
Extreme:Extreme-Netlogin-Url-Desc = “Extreme Networks Home”
```

In this example, the username is *auto*, the permanent VLAN is *corp*, and the URL to be redirected to is the Extreme Networks home page:

http://192.207.37.16.

Configuring Campus Mode

To configure the switch to use network login in campus mode, follow these steps:

1. Configure the switch as a RADIUS client. See “RADIUS Client” on page 220.
2. Configure a DHCP range for the port or ports in the VLAN on which you want to enable network login, using this command:

   ```
   config vlan <vlan name> dhcp-address-range <ipaddress1> - <ipaddress2>
   ```

   The switch will assign a temporary DHCP address within the DHCP range to the client.

3 Enable network login on the port, using the command:

```
enable netlogin ports <portlist> vlan <vlan name>
```

NOTE

Network login is used on a per port, per VLAN basis. A port that is tagged can belong to more than one VLAN. In this case, network login can be enabled on one port for each VLAN.

Example Configuration Using Campus Mode

This example creates a permanent VLAN named *corp* on the switch. This VLAN will be used for authentication through a RADIUS server. The RADIUS server is 10.201.26.243 and the IP address of the switch is 10.201.26.11. The secret is "secret". A temporary VLAN named *temporary* is created and port 9 is added. Network login is enabled on the port.

```
create vlan corp
config corp ipaddress 10.201.26.11/24
config radius primary server 10.201.26.243 client-ip 10.201.26.11
config radius primary shared-secret secret
enable radius
create vlan temporary
config temporary add port 9
config temporary ipaddress 192.168.0.1/24
config temporary dhcp-address-range 192.168.0.20 - 192.168.0.100
enable netlogin ports 9 vlan temporary
```

User Login Using Campus Mode

To log in as a user from the client, the user will follow these steps:

1 Set up the Windows IP configuration for DHCP.

2 Plug into the port that has network login enabled.

In this example, the user will plug into port 9.

3 Log in to Windows.

4 Release any old IP settings and renew the DHCP lease.

This is done differently depending on the version of Windows the user is running:

— **Windows 9x**—use the `winipcfg` tool. Choose the Ethernet adapter that is connected to the port on which network login is enabled. Use the buttons to release the IP configuration and renew the DHCP lease.

— **Windows NT/2000**—use the `ipconfig` command line utility. Use the command `ipconfig/release` to release the IP configuration and `ipconfig/renew` to get the temporary IP address from the switch. If you have more than one Ethernet adapter, specify the adapter by using a number for the adapter following the ipconfig command. You can find the adapter number using the command `ipconfig/all`.

At this point, the client will have its temporary IP address. In this example, the client should have obtained the IP address 192.168.0.20.

NOTE

The idea of explicit release/renew is required to bring the network login client machine in the same subnet as the connected VLAN. In Campus Mode this requirement is mandatory after every logout and before login again as the port moves back and forth between the temporary and permanent VLANs. On other hand in ISP Mode, release/renew of IPaddress is not required, as the network login client machine stays in the same subnet as the network login VLAN. In ISP mode, when the network login client connects for the first time, it has to make sure that the machine IPAddress is in the same subnet as the VLAN to which it is connected.

5 Bring up the browser and enter any URL as `http://www.123.net` or `http://1.2.3.4` or switch IPaddress as http://<IPAddress>/login (where IPAddress could be either temporary or Permanent VLAN Interface for Campus Mode). URL redirection redirects any URL and IPaddress to the network login page This is significant where secuity matters most, as no knowledege of VLAN interfaces is required to be provided to network login users, as they can login using a URL or IPaddress.

A page opens with a link for network login.

6 Click the network login link.

A dialog box opens requesting a username and password.

7 Enter the username and password configured on the RADIUS server.

After the user has successfully logged in, the user will be redirected to the URL configured on the RADIUS server.

During the user login process, the following takes place:

- Authentication is done through the RADIUS server.
- After successful authentication, the connection information configured on the RADIUS server is returned to the switch:
  - the permanent VLAN
  - the URL to be redirected to (optional)
  - the URL description (optional)
- The port is moved to the permanent VLAN.

  You can verify this using the `show vlan` command. For more information on the `show vlan` command, see “Displaying VLAN Settings” on page 94.

After a successful login has been achieved, there are several ways that a port can return to a non-authenticated, non-forwarding state:

- The user successfully logs out using the logout web browser window.
- The link from the user to the switch’s port is lost.
- There is no activity on the port for 20 minutes.
- An administrator changes the port state.

NOTE

Because network login is sensitive to state changes during the authentication process, Extreme Networks recommends that you do not log out until the login process is complete. The login process is complete when you receive a permanent address.

Using Network Login in ISP Mode

In ISP mode, a RADIUS server might be used to provide user authentication. No Extreme-specific lines are required for the dictionary or the user file.

In ISP Mode, the port stays in the permanent VLAN (or corporate VLAN) in a blocked state until the user is authenticated. This mode differs from Campus Mode mainly in these respects:

- In ISP Mode there is no port/VLAN movement
- In Campus Mode the port moves from a temporary to a permanent VLAN.
- ISP Mode can work with the switch's local database if no RADIUS server is available
- A RADIUS server is mandatory for Campus Mode

Configuring ISP Mode

In ISP Mode the port maintains the same VLAN from initial login through authentication. All network settings are configured for that VLAN. Authentication determines whether or not the port is actually placed into forwarding mode.

An external DHCP server must be configured for ISP Mode, but the use of an external RADIUS server is optional. The external DHCP server is used after authentication has occurred, and the DHCP server on the switch provides a temporary IP address to the user when requesting authentication.

Configure the switch to use network login in ISP mode, using this command:

```
enable netlogin ports <portlist> vlan <vlan name>
```

NOTE

Network login is used on a per port, per VLAN basis. A port that is tagged can belong to more than one VLAN. In this case, network login can be enabled on one port for each VLAN.

Example Configuration Using ISP Mode

This example creates a permanent VLAN named *corp* on the switch. This VLAN will be used for authentication through RADIUS. The radius server is 10.201.26.243 and the IP address of the switch is 10.201.26.11. The secret is “secret”. Port 9 is added to the VLAN *corp*. Network login is enabled on the port.

```
create vlan corp
config corp ipaddress 10.201.26.11/24
config radius primary server 10.201.26.243 client-ip 10.201.26.11
config radius primary shared-secret secret
enable radius
config corp add port 9
enable netlogin ports 9 vlan corp
```

DHCP Server on the Switch

A DHCP server with limited configuration capabilities is included in the switch to provide IP addresses to clients.

DHCP is enabled on a per port, per VLAN basis. To enable or disable DHCP on a port in a VLAN, use one of the following commands:

```
enable dhcp ports <portlist> vlan <vlan name>
disable dhcp ports <portlist> vlan <vlan name>
configure vlan <vlan name> netlogin-lease-timer <seconds>
```

Displaying DHCP Information

To display the DHCP configuration, including the DHCP range, DHCP lease timer, network login lease timer, DHCP-enabled ports, IP address, MAC address, and time assigned to each end device, use the following command:

```
show vlan <vlan name> [dhcp-address-allocation | dhcp-config]
```

Displaying Network Login Settings

To display the network login settings, use the following command:

```
show netlogin info {ports <portlist> vlan <vlan name>}
```

Example

```
#show netlogin info ports 9 vlan temporary
Port 9: VLAN: temporary
Port State: Not Authenticated
Temp IP: Unknown
DHCP: Not Enabled
User: Unknown MAC: Unknown
```

In this example, the user is using campus mode and no authentication has taken place. Therefore, the port state displays as not authenticated. No packets sent by the user on port 9 will get past the port until authentication takes place. After authentication has taken place and the permanent IP address is obtained, the show command displays the port state as authenticated.

```
#show netlogin info ports 9 vlan corp
Port 9: VLAN: corp
Port State: Authenticated
Temp IP: Unknown
DHCP: Not Enabled
User: auto MAC: 00:10:A4:A9:11:3B
```

Disabling Network Login

Network login must be disabled on a port before you can delete a VLAN that contains that port. To disable network login, use the following command:

```
disable netlogin ports <portlist> vlan <vlan name>
```

Additional Configuration Details

This section discussed additional configuration like switch DNS name, default redirect page, session refresh and logout-privilege. URL redirection requires the switch to be assigned a DNS name. The default name is `network-access.net`. Any DNS query coming to the switch to resolve switch DNS name in unauthenticated mode is resolved by the DNS server on the switch in terms of the interface (to which the network login port is connected to) IP-address.

To configure the network login base URL, use the following command:

```
config netlogin base-url <url>
```

Where <url> is the DNS name of the switch. For example, `config netlogin base-url network-access.net` makes the switch send DNS responses back to the netlogin clients when a DNS query is made for `network-access.net`.

To configure the netowk login redirect page, use the following command:

```
config  netlogin redirect-page <url>
```

Where `<url>` defines the redirection information for the users once logged in. This redirection information is used only in case the redirection info is missing from RADIUS server. For example, `config netlogin base-url http://www.extremenetworks.com` redirects all users to this URL after they get logged in.

To enable or diable the network login session refresh, use the following command:

```
[enable | disable]  netlogin session-refresh [<cr> |  <mins>]
```

Where `<mins>` ranges from 1 - 255. The default setting is 3 mins. `Enable netlogin session-refresh` makes the logout window refresh itself at every configured time interval. `Session -refresh` is disabled by default. When you configure the Network Login session refresh for the logout window on a BlackDiamond, ensure that the FDB aging timer is greater than the Network Login session refresh timer.

ensure that the FDB aging timer is greater than the Network Login session refresh timer

To enable or disable network login logout privilege, use the following command:

```
[enable | disable] netlogin logout-privilege
```

This command turns the privilege for netlogin users to logout by popping up (or not popping up) the logout window on or off. `Logout-privilege` is enabled by default.

To enable or disable network login, use the following command:

```
[enable | disable] netlogin
```

By default netlogin is enabled.

To show all network login parameters, use the following command:

```
# Show netlogin

Netlogin : Enabled
------------------------------

Base-URL                : "network-access.net"
Default-Redirect-Page: "http://www.extremenetworks.com"
Logout-privilege        : YES
Netlogin Session-Refresh : Disabled; 3 minutes
```

Switch Protection

Switch protection features enhance the robustness of switch performance. In this category are the following features:

- Routing Access Profiles
- Route Maps
- Denial of Service Protection

Routing Access Profiles

Routing access profiles are used to control the advertisement or recognition of routing protocols, such as RIP, OSPF, IS-IS, or BGP. Routing access profiles can be used to 'hide' entire networks, or to trust only specific sources for routes or ranges of routes. The capabilities of routing access profiles are specific to the type of routing protocol involved, but are sometimes more efficient and easier to implement than access lists.

Using Routing Access Profiles

To use routing access profiles, you must perform the following steps:

1. Create an access profile.
2. Configure the access profile to be of type *permit*, *deny*, or *none*.
3. Add entries to the access profile. Entries can be one of the following types:
   - IP addresses and subnet masks
   - IPX node, IPX RIP, and IPX SAP
   - Autonomous system path expressions (as-paths) (BGP only)
   - BGP communities (BGP only)
   - VLAN
4. Apply the access profile.

Creating an Access Profile

The first thing to do when using routing access profiles is to create an *access profile*. An access profile has a unique name and contains one of the following entry types:

- A list of IP addresses and associated subnet masks
- A list of IPX NetIDs
- A list of IPX node addresses
- A list of IPX SAP advertisements
- One or more autonomous system path expressions (BGP only)
- One or more BGP community numbers (BGP only)
- A VLAN

You must give the access profile a unique name (in the same manner as naming a VLAN, protocol filter, or Spanning Tree Domain). To create an access profile, use the following command:

```
create access-profile <access_profile> type [ipaddress | ipx-node | ipx-net | ipx-sap
| as-path | bgp-community | vlan]
```

Configuring an Access Profile Mode

After the access profile is created, you must configure the access profile mode. The access profile mode determines whether the items in the list are to be permitted access or denied access.

Three modes are available:

- **Permit**—The permit access profile mode permits the operation, as long as it matches any entry in the access profile. If the operation does not match any entries in the list, the operation is denied.
- **Deny**—The deny access profile mode denies the operation, as long as it matches any entry in the access profile. If it does not match all specified entries in the list, the operation is permitted.
- **None**—Using the none mode, the access profile can contain a combination of permit and deny entries. Each entry must have a permit or deny attribute. The operation is compared with each entry in the list. Once a match is found, the operation is either permitted or denied, depending on the configuration of the matched entry. If no match is found, the operation is implicitly denied.

To configure the access profile mode, use the following command:

```
config access-profile <access_profile> mode [permit | deny | none]
```

Adding an Access Profile Entry

Next, configure the access profile, using the following command:

```
config access-profile <access_profile> add {<seq_number>} {permit | deny} [ipaddress
<ipaddress> <mask> {exact} | ipx-node <net_id> <ipx_netid_mask> <ipx_nodeid> ipx-net
<ipx_netid> <ipx_netid_mask> | ipx-sap <ipx_sap_type> <ipx_name>| as-path
<path-expression> | bgp-community [internet | no-export | no-advertise |
no-export-subconfed | <as_no:number> | number <community>]]
```

The following sections describe the `config access-profile add` command.

Specifying Subnet Masks

The subnet mask specified in the access profile command is interpreted as a *reverse mask*. A reverse mask indicates the bits that are significant in the IP address. In other words, a reverse mask specifies the part of the address that must match the IP address to which the profile is applied.

If you configure an IP address that is an exact match that is specifically denied or permitted, use a mask of /32 (for example, 141.251.24.28/32). If the IP address represents all addresses in a subnet address that you want to deny or permit, then configure the mask to cover only the subnet portion (for example, 141.251.10.0/24). The keyword `exact` can be used when you wish to match only against the subnet address, and ignore all addresses within the subnet.

If you are using off-byte boundary subnet masking, the same logic applies, but the configuration is more tricky. For example, the network address 141.251.24.128/27 represents any host from subnet 141.251.24.128.

Sequence Numbering

You can specify the sequence number for each access profile entry. If you do not specify a sequence number, entries are sequenced in the order they are added. Each entry is assigned a value of 5 more than the sequence number of the last entry.

Permit and Deny Entries

If you have configured the access profile mode to be none, you must specify each entry type as either 'permit' or 'deny'. If you do not specify the entry type, it is added as a permit entry. If you have configured the access profile mode to be `permit` or deny, it is not necessary to specify a type for each entry.

IPX Access Profiles

IPX routing access profiles consist of access rules and are used to perform packet filtering and forwarding decisions on incoming traffic. Each IPX RIP or SAP packet arriving on an ingress port is compared to each access profile rule in sequential order and is either forwarded or dropped.

Autonomous System Expressions

The `AS-path` keyword uses a regular expression string to match against the AS path. Regular expression notation can include any of the characters listed in Table 32.

Table 32: Regular Expression Notation

Character	Definition
N	As number
N_1 - N_2	Range of AS numbers, where N_1 and N_2 are AS numbers and $N_1 < N_2$
[N_x ... N_y]	Group of AS numbers, where N_x and N_y are AS numbers or a range of AS numbers
[^N_x ... N_y]	Any AS numbers other than the ones in the group
.	Matches any number
^	Matches the beginning of the AS path
$	Matches the end of the AS path
–	Matches the beginning or end, or a space
-	Separates the beginning and end of a range of numbers
*	Matches 0 or more instances
+	Matches 1 or more instances
?	Matches 0 or 1 instance
{	Start of AS SET segment in the AS path
}	End of AS SET segment in the AS path
(	Start of a confederation segment in the AS path
)	End of a confederation segment in the AS path

Autonomous System Expression Example

The following example uses combinations of the autonomous system expressions to create a complicated access profile:

```
create access-profile AS1 type as-path
```

```
config access-profile AS1 mode none
```

These commands create the access profile.

```
config access-profile AS1 add 5 permit as-path “^65535$”
```

This command configures the access profile to permit AS paths that contain only (begin and end with) AS number 65535.

```
config access-profile AS1 add 10 permit as-path “^65535 14490$”
```

This command configures the access profile to permit AS paths beginning with AS number 65535, ending with AS number 14490, and containing no other AS paths.

```
config access-profile AS1 add 15 permit as-path “^1 2-8 [11 13 15]$”
```

This command configures the access profile to permit AS paths beginning with AS number 1, followed by any AS number from 2 - 8, and ending with either AS number 11, 13, or 15.

```
config access-profile AS1 add 20 deny as-path “111 [2-8]”
```

This command configures the access profile to deny AS paths beginning with AS number 111 and ending with any AS number from 2 - 8.

```
config access-profile AS1 add 25 permit as-path “111 .?”
```

This command configures the access profile to permit AS paths beginning with AS number 111 and ending with any additional AS number, or beginning and ending with AS number 111.

Deleting an Access Profile Entry

To delete an access profile entry, use the following command:

```
config access-profile <access_profile> delete <seq_number>
```

Applying Access Profiles

Once the access profile is defined, apply it to one or more routing protocols or VLANs. When an access profile is applied to a protocol function (for example, the export of RIP routes) or a VLAN, this forms an access policy. A profile can be used by multiple routing protocol functions or VLANs, but a protocol function or VLAN can use only one access profile.

Routing Profiles for RIP

If you are using the RIP protocol, the switch can be configured to use an access profile to determine:

- **Trusted Neighbor**—Use an access profile to determine trusted RIP router neighbors for the VLAN on the switch running RIP. To configure a trusted neighbor policy, use the following command:

  ```
  config rip vlan [<vlan name> | all] trusted-gateway [<access_profile> | none]
  ```

- **Import Filter**—Use an access profile to determine which RIP routes are accepted as valid routes. This policy can be combined with the trusted neighbor policy to accept selected routes only from a set of trusted neighbors. To configure an import filter policy, use the following command:

  ```
  config rip vlan [<vlan name> | all] import-filter [<access_profile> | none]
  ```

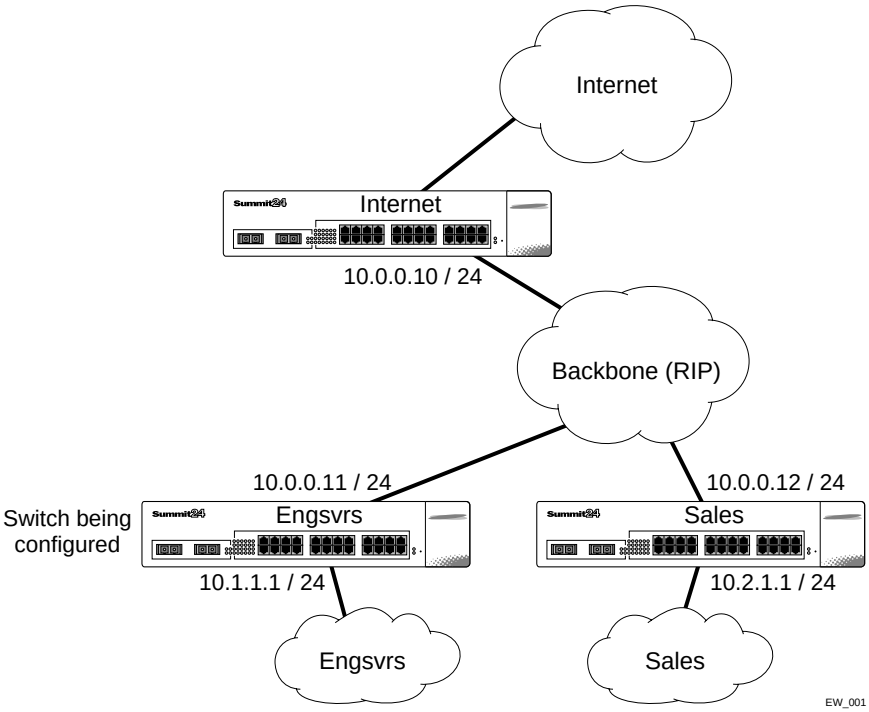
- **Export Filter**—Use an access profile to determine which RIP routes are advertised into a particular VLAN, using the following command:

  ```
  config rip vlan [<vlan name> | all] export-filter [<access_profile> | none]
  ```

Examples

In the example shown in Figure 31, a switch is configured with two VLANs, *Engsvrs* and *Backbone*. The RIP protocol is used to communicate with other routers on the network. The administrator wants to allow all internal access to the VLANs on the switch, but no access to the router that connects to the Internet. The remote router that connects to the Internet has a local interface connected to the corporate backbone. The IP address of the local interface connected to the corporate backbone is 10.0.0.10/24.

Figure 31: RIP access policy example



Assuming the backbone VLAN interconnects all the routers in the company (and, therefore, the Internet router does not have the best routes for other local subnets), the commands to build the access policy for the switch would be:

```
create access-profile nointernet ipaddress
config access-profile nointernet mode deny
config access-profile nointernet add 10.0.0.10/32
config rip vlan backbone trusted-gateway nointernet
```

In addition, if the administrator wants to restrict any user belonging to the VLAN *Engsvrs* from reaching the VLAN *Sales* (IP address 10.2.1.0/24), the additional access policy commands to build the access policy would be:

```
create access-profile nosales ipaddress
config access-profile nosales mode deny
```

```
config access-profile nosales add 10.2.1.0/24
config rip vlan backbone import-filter nosales
```

This configuration results in the switch having no route back to the VLAN *Sales.*

Routing Access Profiles for IPX

If you are using the IPX protocol, the switch can be configured to use an access profile to determine:

- **Import Filter**—Use an access profile to determine which IPX/RIP or IPX/SAP routes are accepted as valid routes. To configure an import filter policy, use the following command:

  ```
  config ipxrip vlan [<vlan name> | all] import-filter [<access_profile> | none]
  ```

  ```
  config ipxsap vlan [<vlan name> | all] import-filter [<access_profile> | none]
  ```

- **Export Filter**—Use an access profile to determine which IPX/RIP and IPX/SAP routes are advertised into a particular VLAN, using the following command:

  ```
  config ipxrip vlan [<vlan name> | all] export-filter [<access_profile> | none]
  ```

  ```
  config ipxsap vlan [<vlan name> | all] export-filter [<access_profile> | none]
  ```

Routing Access Profiles for OSPF

Because OSPF is a link-state protocol, the access profiles associated with OSPF are different in nature than those associated with RIP. Access profiles for OSPF are intended to extend the existing filtering and security capabilities of OSPF (for example, link authentication and the use of IP address ranges). If you are using the OSPF protocol, the switch can be configured to use an access profile to determine any of the following:

- **Inter-area Filter**—For switches configured to support multiple OSPF areas (an ABR function), an access profile can be applied to an OSPF area that filters a set of OSPF inter-area routes from being sourced from any other areas. To configure an inter-area filter policy, use the following command:

  ```
  config ospf area <area identifier> interarea-filter [<access_profile> | none]
  ```

- **External Filter**—For switches configured to support multiple OSPF areas (an ABR function), an access profile can be applied to an OSPF area that filters a set of OSPF external routes from being advertised into that area. To configure an external filter policy, use the following command:

  ```
  config ospf area <area identifier> external-filter [<access_profile> | none]
  ```

NOTE

If any of the external routes specified in the filter have already been advertised, those routes will remain until the associated LSAs in that area time-out.

- **ASBR Filter**—For switches configured to support RIP and static route re-distribution into OSPF, an access profile can be used to limit the routes that are advertised into OSPF for the switch as a whole. To configure an ASBR filter policy, use the following command:

  ```
  config ospf asbr-filter [<access_profile> | none]
  ```

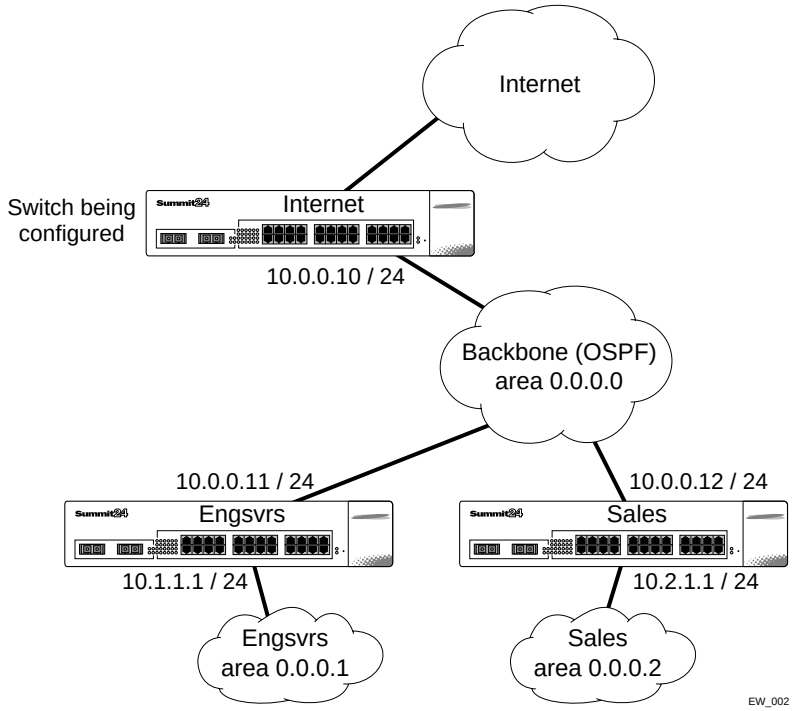
- **Direct Filter**—For switches configured to support direct route re-distribution into OSPF, an access profile can be used to limit the routes that are advertised into OSPF for the switch as a whole. To configure a direct filter policy, use the following command:

  ```
  config ospf direct-filter [<access_profile> | none]
  ```

Example

Figure 32 illustrates an OSPF network that is similar to the network used previously in the RIP example. In this example, access to the Internet is accomplished by using the ASBR function on the switch labeled Internet. As a result, all routes to the Internet will be done through external routes. Suppose the network administrator wishes to only allow access to certain internet addresses falling within the range 192.1.1.0/24 to the internal backbone.

Figure 32: OSPF access policy example



To configure the switch labeled Internet, the commands would be as follows:

```
create access-profile okinternet ipaddress
config access-profile okinternet mode permit
config access-profile okinternet add 192.1.1.0/24
config ospf asbr-filter okinternet
```

Routing Access Profiles for DVMRP

The access policy capabilities for DVMRP are very similar to those for RIP. If you are using the DVMRP protocol is used for routing IP multicast traffic, you can configure the switch to use an access profile to determine:

- **Trusted Neighbor**—Use an access profile to determine trusted DVMRP router neighbors for the VLAN on the switch running DVMRP. To configure a trusted neighbor policy, use the following command:

  ```
  config dvmrp vlan [<vlan name> | all] trusted-gateway [<access_profile> | none]
  ```

- **Import Filter**—Use an access profile to determine which DVMRP routes are accepted as valid routes. To configure an import filter policy, use the following command:

  ```
  config dvmrp vlan [<vlan name> | all] import-filter [<access_profile> | none]
  ```

- **Export Filter**—Use an access profile to determine which DVMRP routes are advertised into a particular VLAN, using the following command:

  ```
  config dvmrp vlan [<vlan name> | all] export-filter [<access_profile> | none]
  ```

Example

In this example, the network used in the previous RIP example is configured to run DVMRP. The network administrator wants to disallow Internet access for multicast traffic to users on the VLAN *Engsvrs*. This is accomplished by preventing the learning of routes that originate from the switch labeled Internet by way of DVMRP on the switch labeled Engsvrs.

To configure the switch labeled Engsvrs, use the following commands:

```
create access-profile nointernet ipaddress
config access-profile nointernet mode deny
config access-profile nointernet add 10.0.0.10/32
config dvmrp vlan backbone trusted-gateway nointernet
```

In addition, suppose the administrator wants to preclude users on the VLAN *Engsvrs* from seeing any multicast streams that are generated by the VLAN *Sales* across the backbone. The additional configuration of the switch labeled Engsvrs is as follows:

```
create access-profile nosales ipaddress
config access-profile nosales mode deny
config access-profile nosales add 10.2.1.0/24
config dvmrp vlan backbone import-filter nosales
```

Routing Access Profiles for PIM

Because PIM leverages the unicast routing capability that is already present in the switch, the access policy capabilities are, by nature, different. If you are using the PIM protocol for routing IP multicast traffic, you can configure the switch to use an access profile to determine:

- **Trusted Neighbor**—Use an access profile to determine trusted PIM router neighbors for the VLAN on the switch running PIM. To configure a trusted neighbor policy, use the following command:

  ```
  config pim vlan [<vlan name> | all] trusted-gateway [<access_profile> | none]
  ```

Example

Using PIM, the unicast access profiles can be used to restrict multicast traffic. In this example, a network similar to the example used in the previous RIP example is also running PIM. The network administrator wants to disallow Internet access for multicast traffic to users on the VLAN *Engsvrs*. This is accomplished by preventing the learning of routes that originate from the switch labeled Internet by way of PIM on the switch labeled Engsvrs.

To configure the switch labeled Engsvrs, the commands would be as follows:

```
create access-profile nointernet ipaddress
config access-profile nointernet mode deny
config access-profile nointernet add 10.0.0.10/32
config pim vlan backbone trusted-gateway nointernet
```

Routing Access Profiles for BGP

If the BGP protocol is being used, the switch can be configured to use an access profile to determine:

- **NLRI filter**—Use an access profile to determine the NLRI information that must be exchanged with a neighbor. To configure an NLRI filter policy, use the following command:

  `config bgp neighbor [<ipaddress> | all] nlri-filter [in | out] [<access_profile> | none]`

  The NLRI filter access policy can be applied to the ingress or egress updates, using the `in` and `out` keywords, respectively.

- **Autonomous system path filter**—Use an access profile to determine which NLRI information must be exchanged with a neighbor based on the AS path information present in the path attributes of the NLRI. To configure an autonomous system path filter policy, use the following command:

  `config bgp neighbor [<ipaddress> | all] as-path-filter [in | out] [<access_profile> | none]`

  The autonomous system path filter can be applied to the ingress or egress updates, using the `in` and `out` keywords, respectively.

Making Changes to a Routing Access Policy

You can change the routing access policy by changing the associated access profile. However, the propagation of the change depends on the protocol and policy involved. Propagation of changes applied to RIP, DVMRP, and PIM access profiles depend on the respective protocol timers to age-out entries.

In BGP, the change to the policy is immediately effective on the routing information exchanged after the policy changes. The changes can be applied on the routing information that had been exchanged before the policy changes by issuing a soft reset on the ingress or egress side, depending on the change. For soft resets to be applied on the ingress side, the changes must have been previously enabled on the neighbor.

NOTE

Changes to profiles applied to OSPF typically require rebooting the switch, or disabling and re-enabling OSPF on the switch.

Removing a Routing Access Policy

To remove a routing access policy, you must remove the access profile from the routing protocol or VLAN. All the commands that apply an access profile to form an access policy also have the option of choosing none as the access profile. Using the none option removes any access profile of that particular type from the protocol or VLAN, and, therefore, removes the access policy.

Route Maps

Route maps are used to modify or filter routes. They are also used to modify or filter routing information.

Using Route Maps

Route maps are a mechanism that can be used to conditionally control the redistribution of routes between two routing domains, and to modify the routing information that is redistributed.

Route maps are used in conjunction with the match and set operations. A match operation specifies a criteria that must be matched. A set operation specifies a change that is made to the route when the match operation is successful.

To create a route map, follow these steps:

1. Create a route map.
2. Add entries to the route map.
3. Add statements to the route map entries.

Creating a Route Map

To create a route map, use the following command:

```
create route-map <route-map>
```

Add Entries to the Route Map

To add entries to the route map, use the following command:

```
config route-map <route-map> add <sequence number> [permit | deny] {match-one |
match-all}
```

where the following is true:

- The sequence number uniquely identifies the entry, and determines the position of the entry in the route map. Route maps are evaluated sequentially.
- The permit keyword permits the route; the deny keyword denies the route and is applied only if the entry is successful.
- The match-one keyword is a logical “or”. The route map is successful as long as at least one of the matching statements is true.

- The match-all keyword is a logical “and”. The route map is successful when all match statements are true. This is the default setting.

Add Statements to the Route Map Entries

To add statements to the route map entries, use one of the following four commands:

```
config route-map <route-map> <sequence number> add match [nlri-list <access-profile> |
as-path [access-profile <access-profile> | <as no>] | community [access-profile
<access-profile> | <as no> : <number> | number <community> | no-advertise | no-export
| no-export-subconfed] | next-hop <ip address> | med <number> | origin [igp | egp |
incomplete] | tag <number> | origin [igp | egp | incomplete]]

config route-map <route-map> <sequence number> add set [as-path <as no> | community
[[access-profile <access-profile> | <as no> : <number> | number <community> |
no-advertise | no-export | no-export-subconfed] | remove | [add | delete]
[access-profile <access-profile> | <as no> : <number> | number <community> |
no-advertise | no-export | no-export-subconfed]] | next-hop <ip address> | med
[internal | <number> | remove | [add | delete] <number> ] | local-preference <number>
| weight <number> | origin [igp | egp | incomplete] | tag <number> | accounting index
<number> value <number> | cost <number> | cost-type [ase-type-1 | ase-type-2 ]]

config route-map <route-map> <sequence number> add goto <route-map>

config route-map <route-map> <sequence number> [add | delete] set accounting-index 1
value <bin_number>
```

where the following is true:

- The route-map is the name of the route map.
- The sequence number identifies the entry in the route map to which this statement is being added.
- The match, set, and goto keywords specify the operations to be performed. Within a entry, the statements are sequenced in the order of their operation. The match statements are first, followed by set, and then goto.
- The nlri-list, as-path, community, next-hop, med, origin, and weight keywords specify the type of values that must be applied using the specified operation against the corresponding attributes as described in Table 33 and Table 34.
- The accounting-index keyword specifies the bin number assigned to a specific route map as discussed in Table 35.

Table 33: Match Operation Keywords

Keyword	Description
nlri-list <access_profile>	Matches the NLRI against the specified access profile.
as-path [<access_profile> | <as-no>]	Matches the AS path in the path attributes against the specified access profile or AS number.
community [access-profile <access-profile> | <as no> : <number> | number <community> | no-advertise | no-export | no-export-subconfed]	Matches the communities in the path attribute against the specified BGP community access profile or the community number.

Table 33: Match Operation Keywords (continued)

Keyword	Description
next-hop <ipaddress>	Matches the next hop in the path attribute against the specified IP address.
med <number>	Matches the MED in the path attribute against the specified MED number.
origin [igp | egp | incomplete]	Matches the origin in the path attribute against the specified origin.
tag <number>	Matches the tag associated with the redistributed OSPF route.

Table 34: Set Operation Keywords

Keyword	Definition
as-path <as no>	Prepends the specified AS number to the AS path in the path attribute.
community [[access-profile <access-profile> | <as no> : <number> | number <community> | no-advertise | no-export | no-export-subconfed] | remove | [add | delete] [access-profile <access-profile> | <as no> : <number> | number <community> | no-advertise | no-export | no-export-subconfed]]	Adds the specified community to the existing community in the path attribute.
next-hop <ipaddress>	Sets the next hop in the path attribute to the specified IP address.
med [internal | <number> | remove | [add | delete] <number>]	Modifies the MED in the path attribute as specified: • `internal`—When used in the BGP neighbor output route map, the MED attribute is set to a value equal to the metric to reach the nexthop. • `<number>`—Sets the MED attribute to the specified value. • `remove`—Removes the MED attribute, if present. • [`add` | `delete`] `<number>`—Adds or deletes the specified value to or from the MED that is received. The final result is bound by 0 and 2147483647.
local-preference <number>	Sets the local preference in the path attribute to the specified local preference number.
weight <number>	Sets the weight associated with the NLRI to the specified number.
origin [igp | egp | incomplete]	Sets the origin in the path attributes to the specified origin.
tag <number>	Sets the tag in the route to the specified number.
cost <number>	Sets the cost of the route to the specified number
cost-type <number>	Sets the type of the cost associated with the route.
accounting index [ase-type-1 | ase-type-2]	Sets the specified accounting index to the specified number.

Table 35: Set Operation Keywords

Command	Description of Change
accounting-index <index> value <value>	Sets the accounting bin number for the route-mapped accounting index. The accounting index value is always set to 1 for Destination Sensitive Accounting.

Route Map Operation

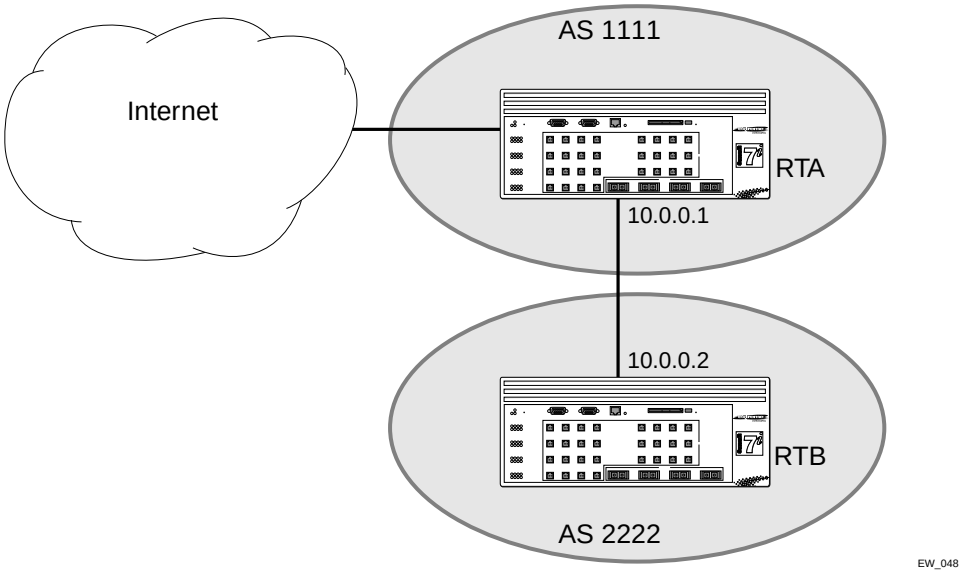
The entries in the route map are processed in the ascending order of the sequence number. Within the entry, the match statements are processed first. When the match operation is successful, the set and goto statements within the entry are processed, and the action associated with the entry is either applied, or else the next entry is processed. If the end of the route map is reached, it is implicitly denied.

When there are multiple match statement, the primitive match-one or match-all in the entry determines how many matches are required for success. When there are no match statements in an entry, the entry is considered a successful match.

Route Map Example

Figure 33 shows a topology in which route maps are used to filter or modify routing information that is exchanged between the neighbors RTA and RTB using BGP.

Figure 33: Route maps



The following points apply to this example:

- RTA is a member of in AS 1111 and peers with a router in the Internet to receive the entire Internet routing table.
- RTB is a member of AS 2222, and has an EBGP connection with RTA through which it receives the Internet routing table.
- AS 1111 is acting as a transit AS for all traffic between AS 2222 and the Internet. If the administrator of AS 1111 wants to filter out route information about network 221.1.1.0/24 and it's subnets from being passed on to AS 2222, the administrator can configure a route-map on the egress side of RTA's EBGP connection with RTB and filter out the routes.

To configure RTA, use the following commands:

```
create access-profile iplist type ipaddress
config iplist add ipaddress 221.1.1.0 / 24

create route-map bgp-out
config bgp-out add 10 deny
config bgp-out 10 add match nlri-list iplist
config bgp-out add 20 permit

config bgp neighbor 10.0.0.2 route-map-filter out bgp-out
config bgp neighbor 10.0.0.2 soft-reset out
```

If you wish to modify the routing information originated from AS 300 to include a MED value of 200, the sequence of commands would be:

```
create access-profile aslist type as-path
config aslist add as-path "^300"

config bgp-out add 15 permit
config bgp-out 15 add match as-path access-profile aslist
config bgp-out 15 add set med 200

config bgp neighbor 10.0.0.2 soft-reset out
```

Changes to Route Maps

Changes to the route maps used to modify or filter NLRI information exchanged with neighbors is immediately effective on the routing information exchanged after the policy changes. The changes can be applied on the NLRI information that had been exchanged before the policy changes by issuing a soft reset on the ingress or egress side, depending on the changes. For soft resets to be applied on the ingress side, the changes must be previously enabled on the neighbor.

Changes to the route maps associated with network aggregation or redistribution commands becomes effective after a maximum interval of 30 seconds. You can immediately apply them by using the soft reconfiguration command.

Route Maps in BGP

Route maps are used in BGP to modify/filter NLRI information exchanged with neighbors. They are also used NLRI information that originates by way of network command, aggregation, or redistribution.

Denial of Service Protection

A Denial-of-Service (DoS) attack occurs when a critical network or computing resource is overwhelmed and rendered inoperative in a way that legitimate requests for service cannot succeed. In its simplest form, a Denial of Service attack is indistinguishable from normal heavy traffic. Extreme Network switches are not vulnerable to this simple attack because they are all designed to process packets in hardware at wire speed. However, there are some operations in any switch or router that are more costly than others, and although normal traffic is not a problem, exception traffic must be handled by the switch's CPU in software.

Some packets that the switch processes in the CPU software include:

- learning new traffic
- routing and control protocols including ICMP, BGP and OSPF
- switch management traffic (switch access by Telnet, SSH, HTTP, SNMP, etc...)
- other packets directed to the switch that must be discarded by the CPU

If any one of these functions is overwhelmed, the CPU may be too busy to service other functions and switch performance will suffer. Even with very fast CPUs, there will always be ways to overwhelm the CPU by with packets requiring costly processing.

DoS Protection is designed to help prevent this degraded performance by attempting to characterize the problem and filter out the offending traffic so that other functions can continue. When a flood of packets is received from the switch, DoS Protection will count these packets. When the packet count nears the alert threshold, packets headers will be saved. If the threshold is reached, then these headers are analyzed, and a hardware access control list (ACL) is created to limit the flow of these packets to the CPU. This ACL will remain in place to provide relief to the CPU. Periodically, the ACL will expire, and if the attack is still occurring, it will be re-enabled. With the ACL in place, the CPU will have the cycles to process legitimate traffic and continue other services.

Configuring Denial of Service Protection

To configure denial of service protection, use the following command:

```
config cpu-dos-protect [alert-threshold <packets per second>] [notice-threshold
<packets per second>] [timeout <seconds>] [messages [on | off]] [filter-precedence
<number>] [filter-type-allowed {destination | source | destination source} {protocol}]
```

The default values for the parameters are as follows:

- alert-threshold—4000 packets per second
- notice-threshold—4000 packets per second
- timeout—15 seconds
- messages—on (messages are sent to syslog)
- filter-precedence—10
- filter-type-allowed—destination

If you wish to set all the parameters back to their default values, use the following command:

```
unconfig cpu-dos-protect
```

NOTE

If you set the filter-precedence to 0, the ACLs created by DoS protection will be overwritten by the default VLAN QoS profile.

Enabling Denial of Service Protection

Enable denial of service protection using the following command:

```
enable cpu-dos-protect
```

Once enabled, denial of service protection creates an access list for packets when the receive packet on a port is greater than the alert level. For example, if `cpu-dos-protect` is enabled on a Summit7i switch and the threshold alert level is set to 3000 packets per second, an access list is created if one of the ports on the switch receives 3000 or more packets per second. The precedence is set at 10 for the duration of the timeout.

For example, if you set the timeout to 15 seconds , the ACL is created for 15 seconds. The switch continues to create access lists for the duration of the timeout until the packet rate declines to less than the configured threshold alert level.

Disabling Denial of Service Protection

To disable denial of service protection, use the following command:

```
disable cpu-dos-protect
```

Displaying Denial of Service Settings

To display denial of service settings and the status of the access list, use the following command:

```
show cpu-dos-protect
```

How to Deploy DoS Protection

The conservative way to deploy DoS Protection is to use the simulated mode first. In simulated mode, DoS Protection is enabled, but no ACLs are generated. To enable the simulated mode, use the command:

```
enable cpu-dos-protect simulated
```

Next, configure the notice threshold. This will help determine the actual traffic received by the CPU by logging when the traffic exceeds the threshold. This can help understand the types of traffic encountered, and evaluate whether legitimate traffic may be accidentally blocked. Some examples of heavy legitimate traffic to the cpu include:

- route loss—during this period, the switch may receive lots of routing updates that cause heavy traffic processing loads on the CPU.
- configuration or image upload / download

To configure the notice threshold, use the following command:

```
config cpu-dos-protect notice-threshold <packets per second>
```

Next, configure the alert threshold. If the alert threshold is reached, a simulated ACL is put in place. Although packets will not be dropped, this provides good information about the heavy traffic, which might be legitimate or might be an attack. The Ethernet address of the source and the type of traffic can be characterized by the type of ACL put in place. This is another way to judge if legitimate traffic would have been cut off. To configure the alert threshold, use the following command:

```
config cpu-dos-protect alert-threshold <packets per second>
```

After normal traffic is characterized, steps should be taken to set:

- the appropriate notice level if some warning is desired
- the appropriate alert level at which an ACL is put in place
- trusted ports from which traffic won't be blocked

In some cases, traffic from a switch port or group of ports will never cause an attack. These ports can be configured as trusted port and will never be considered for traffic that will generate an ACL. This can prevent innocent hosts from being blocked, or ensure that when an innocent host responds to an attack that the flood of response packets is not mistaken for the attack. To configure a trusted port, use the following command:

```
config cpu-dos-protect trusted-ports add <port list>
```

The last step is to enable DoS Protection. At this point, only attack traffic should be blocked and legitimate traffic should pass through. To enable the creation of ACLs for DoS Protection, use the following command:

```
enable cpu-dos-protect
```

Management Access Security

Management access security features control access to the management functions available on the switch. These features help insure that any configuration changes to the switch can only be done by authorized users. In this category are the following features:

- Authenticating Users Using RADIUS or TACACS+
- Secure Shell 2 (SSH2)

Authenticating Users Using RADIUS or TACACS+

ExtremeWare provides two methods to authenticate users who login to the switch:

- RADIUS client
- TACACS+

RADIUS Client

Remote Authentication Dial In User Service (RADIUS, RFC 2138) is a mechanism for authenticating and centrally administrating access to network nodes. The ExtremeWare RADIUS client implementation allows authentication for Telnet, Vista, or console access to the switch.

NOTE

You cannot configure RADIUS and TACACS+ at the same time.

You can define a primary and secondary RADIUS server for the switch to contact. When a user attempts to login using Telnet, http, or the console, the request is relayed to the primary RADIUS server, and then to the secondary RADIUS server, if the primary does not respond. If the RADIUS client is enabled, but access to the RADIUS primary and secondary server fails, the switch uses its local database for authentication.

The privileges assigned to the user (admin versus nonadmin) at the RADIUS server take precedence over the configuration in the local switch database.

To configure the RADIUS servers, use the following command:

```
config radius server [primary | secondary] <ipadress> <UDP_port> client-ip <ipaddress>
```

To configure the timeout if a server fails to respond, use the following command:

```
config radius timeout <seconds>
```

Configuring the Shared Secret Password

In addition to specifying the RADIUS server IP information, RADIUS also contains a means to verify communication between network devices and the server. The *shared secret* is a password configured on the network device and RADIUS server, used by each to verify communication.

To configure the shared secret for RADIUS servers, use the following command:

```
config radius [primary | secondary] shared-secret {encrypted} <string>
```

Enabling and Disabling RADIUS

After server information is entered, you can start and stop RADIUS authentication as many times as necessary without needing to reconfigure server information.

To enable RADIUS authentication, use the following command:

```
enable radius
```

To disable RADIUS authentication, use the following command:

```
disable radius
```

Configuring RADIUS Accounting

Extreme switches are capable of sending RADIUS accounting information. As with RADIUS authentication, you can specify two servers for receipt of accounting information. You can configure RADIUS accounting servers to be the same as the authentication servers, but this is not required.

To specify RADIUS accounting servers, use the following command:

```
config radius-accounting [primary | secondary] server [<ipaddress> | <hostname>]
{<udp_port>} client-ip <ipaddress>
```

To configure the timeout if a server fails to respond, use the following command:

```
config radius-accounting timeout <seconds>
```

RADIUS accounting also makes use of the shared secret password mechanism to validate communication between network access devices and RADIUS accounting servers.

To specify shared secret passwords for RADIUS accounting servers, use the following command:

```
config radius [primary | secondary] shared-secret {encrypted} <string>
```

After you configure RADIUS accounting server information, you must enable accounting before the switch begins transmitting the information. You must enable RADIUS authentication for accounting information to be generated. You can enable and disable accounting without affecting the current state of RADIUS authentication.

To enable RADIUS accounting, use the following command:

```
enable radius-accounting
```

To disable RADIUS accounting, use the following command:

```
disable radius-accounting
```

Per-Command Authentication Using RADIUS

The RADIUS implementation can be used to perform per-command authentication. Per-command authentication allows you to define several levels of user capabilities by controlling the permitted command sets based on the RADIUS username and password. You do not need to configure any additional switch parameters to take advantage of this capability. The RADIUS server implementation automatically negotiates the per-command authentication capability with the switch. For examples on per-command RADIUS configurations, see the next section.

Configuring RADIUS Client

You can define primary and secondary server communication information, and for each RADIUS server, the RADIUS port number to use when talking to the RADIUS server. The default port value is 1645. The client IP address is the IP address used by the RADIUS server for communicating back to the switch.

RADIUS RFC 2138 Attributes

The RADIUS RFC 2138 optional attributes supported are as follows:

- User-Name
- User-Password
- Service-Type
- Login-IP-Host

Using RADIUS Servers with Extreme Switches

Extreme Networks switches have two levels of user privilege:

- Read-only
- Read-write

Because there are no CLI commands available to modify the privilege level, access rights are determined when you log in. For a RADIUS server to identify the administrative privileges of a user, Extreme switches expect a RADIUS server to transmit the Service-Type attribute in the Access-Accept packet, after successfully authenticating the user.

Extreme switches grant a RADIUS-authenticated user read-write privilege if a Service-Type value of 6 is transmitted as part of the Access-Accept message from the Radius server. Other Service-Type values, or no value, result in the switch granting read-only access to the user. Different implementations of RADIUS handle attribute transmission differently. You should consult the documentation for your specific implementation of RADIUS when you configure users for read-write access.

Cistron RADIUS

Cistron RADIUS is a popular server, distributed under GPL. Cistron RADIUS can be found at:

http://www.miquels.cistron.nl/radius/

When you configure the Cistron server for use with Extreme switches, you must pay close attention to the users file setup. The Cistron RADIUS dictionary associates the word Administrative-User with Service-Type value 6, and expects the Service-Type entry to appear alone on one line with a leading tab character.

The following is a user file example for read-write access:

```
adminuser   Auth-Type = System
            Service-Type = Administrative-User,
            Filter-Id = “unlim”
```

Livingston (Lucent) RADIUS

Livingston RADIUS is produced by Lucent Technologies primarily for use with their portmaster products. Version 2.1 is released under a BSD license agreement and can be found at ftp://ftp.livingston.com/pub/le/radius/radius21.tar.Z. As with Cistron RADIUS, the Livingston server default dictionary associates Administrative-User with Service-Type value 6. The administrative users file entry example for Cistron RADIUS also works with Livingston RADIUS.

RSA Ace

For users of their SecureID product, RSA offers RADIUS capability as part of their ACE server software. With some versions of ACE, the RADIUS shared-secret is incorrectly sent to the switch resulting in an inability to authenticate. As a work around, do *not* configure a shared-secret for RADIUS accounting and authentication servers on the switch.

Limiting Max-Concurrent Sessions with Funk Software's Steel Belted Radius

For users who have Funk Software's Steel Belted Radius (SBR) server, it is possible to limit the number of concurrent login sessions using the same user account. This feature allows the use of shared user accounts, but limits the number of simultaneous logins to a defined value. Using this feature requires Funk Software Steel-Belted-Radius for Radius Authentication & Accounting.

Complete the following two steps to limit the maximum concurrent login sessions under the same user account:

1. Configure Radius and Radius-Accounting on the switch

   The Radius and Radius-Accounting servers used for this feature must reside on the same physical Radius server. Standard Radius and Radius-Accounting configuration is required as described earlier in this chapter.

2. Modifiy the Funk SBR 'vendor.ini' file and user accounts

   To configure the Funk SBR server, the file '***vendor.ini***' must be modified to change the Extreme Networks configuration value of '***ignore-ports***' to yes as shown in the example below:

   ```
   vendor-product       = Extreme Networks
   dictionary           = Extreme
   ignore-ports         = yes
   port-number-usage    = per-port-type
   help-id              = 2000
   ```

   After modifying the 'vendor.ini' file, the desired user accounts must be configured for the Max-Concurrent connections. Using the SBR Administrator application, enable the check box for 'Max-Concurrent connections' and fill in the desired number of maximum sessions.

Extreme RADIUS

Extreme Networks provides its users, free of charge, a radius server based on Merit RADIUS. Extreme RADIUS provides per-command authentication capabilities in addition to the standard set of radius features. Source code for Extreme RADIUS can be obtained from the Extreme Networks Technical Assistance Center and has been tested on Red Hat Linux and Solaris.

When Extreme RADIUS is up and running, the two most commonly changed files will be users and profiles. The users file contains entries specifying login names and the profiles used for per-command authentication after they have logged in. Sending a HUP signal to the RADIUS process is sufficient to get changes in the users file to take place. Extreme RADIUS uses the file named profiles to specify command lists that are either permitted or denied to a user based on their login identity. Changes to the profiles file require the RADIUS server to be shutdown and restarted. Sending a HUP signal to the RADIUS process is not enough to force changes to the profiles file to take effect.

When you create command profiles, you can use an asterisk to indicate any possible ending to any particular command. The asterisk cannot be used as the beginning of a command. Reserved words for commands are matched exactly to those in the profiles file. Due to the exact match, it is not enough to simply enter "sh" for "show" in the profiles file, the complete word must be used. Commands can still be entered in the switch in partial format.

When you use per-command authentication, you must ensure that communication between the switch(es) and radius server(s) is not lost. If the RADIUS server crashes while users are logged in, they will have full administrative access to the switch until they log out. Using two RADIUS servers and enabling idle timeouts on all switches will greatly reduce the chance of a user gaining elevated access due to RADIUS server problems.

RADIUS Server Configuration Example (Merit)

Many implementations of RADIUS server use the publicly available Merit© AAA server application, available on the World Wide Web at:

http://www.merit.edu/aaa

Included below are excerpts from relevant portions of a sample Merit RADIUS server implementation. The example shows excerpts from the client and user configuration files. The client configuration file (`ClientCfg.txt`) defines the authorized source machine, source name, and access level. The user configuration file (`users`) defines username, password, and service type information.

`ClientCfg.txt`

```
#Client Name        Key             [type]          [version]   [prefix]
#----------------   ---------------  --------------  ---------   --------
#10.1.2.3:256       test             type = nas      v2          pfx
#pm1                %^$%#*(&!(*&)+   type=nas                    pm1.
#pm2                :-):-(;^):-}!    type nas                    pm2.
#merit.edu/homeless hmoemreilte.ses
#homeless           testing          type proxy      v1
#xyz.merit.edu      moretesting      type=Ascend:NAS v1
#anyoldthing:1234   whoknows?        type=NAS+RAD_RFC+ACCT_RFC
10.202.1.3          andrew-linux     type=nas
10.203.1.41         eric             type=nas
10.203.1.42         eric             type=nas
10.0.52.14          samf             type=nas
```

`users`

```
user    Password = ""
     Filter-Id = "unlim"
admin   Password = "", Service-Type = Administrative
     Filter-Id = "unlim"

eric    Password = "", Service-Type = Administrative
     Filter-Id = "unlim"

albert     Password = "password", Service-Type = Administrative
     Filter-Id = "unlim"

samuel  Password = "password", Service-Type = Administrative
      Filter-Id = "unlim"
```

RADIUS Per-Command Configuration Example

Building on this example configuration, you can use RADIUS to perform per-command authentication to differentiate user capabilities. To do so, use the Extreme-modified RADIUS Merit software that is available from the Extreme Networks web server at:

http://www.extremenetworks.com/extreme/support/otherapps.htm

or by contacting Extreme Networks technical support. The software is available in compiled format for Solaris™ or Linux™ operating systems, as well as in source code format. For all clients that use RADIUS per-command authentication, you must add the following type to the client file:

```
type:extreme:nas + RAD_RFC + ACCT_RFC
```

Within the users configuration file, additional keywords are available for Profile-Name and Extreme-CLI-Authorization. To use per-command authentication, enable the CLI authorization function and indicate a profile name for that user. If authorization is enabled without specifying a valid profile, the user is unable to perform any commands.

Next, define the desired profiles in an ASCII configuration file called profiles. This file contains named profiles of exact or partial strings of CLI commands. A named profile is linked with a user through the users file. A profile with the permit on keywords allows use of only the listed commands. A profile with the deny keyword allows use of all commands *except* the listed commands.

CLI commands can be defined easily in a hierarchal manner by using an asterisk (*) to indicate any possible subsequent entry. The parser performs exact string matches on other text to validate commands. Commands are separated by a comma (,) or newline.

Looking at the following example content in profiles for the profile named PROFILE1, which uses the deny keyword, the following attributes are associated with the user of this profile:

- Cannot use any command starting with enable.
- Cannot issue the disable ipforwarding command.
- Cannot issue a show switch command.
- Can perform all other commands.

We know from the users file that this applies to the users albert and lulu. We also know that eric is able to log in, but is unable to perform any commands, because he has no valid profile assigned.

In PROFILE2, a user associated with this profile can use any enable command, the clear counter command and the show management command, but can perform no other functions on the switch. We also know from the users file that gerald has these capabilities.

The following lists the contents of the file users with support for per-command authentication:

```
user    Password = ""
        Filter-Id = "unlim"

admin   Password = "", Service-Type = Administrative
        Filter-Id = "unlim"

eric    Password = "", Service-Type = Administrative, Profile-Name = ""
        Filter-Id = "unlim"
        Extreme:Extreme-CLI-Authorization = Enabled

albert  Password = "", Service-Type = Administrative, Profile-Name =
"Profile1"
          Filter-Id = "unlim"
          Extreme:Extreme-CLI-Authorization = Enabled

lulu    Password = "", Service-Type = Administrative, Profile-Name =
"Profile1"
          Filter-Id = "unlim"
          Extreme:Extreme-CLI-Authorization = Enabled

gerald    Password = "", Service-Type = Administrative, Profile-Name "Profile2"
          Filter-Id = "unlim"
          Extreme:Extreme-CLI-Authorization = Enabled
```

Contents of the file "profiles":

```
PROFILE1 deny
{
enable  *, disable ipforwarding
show switch
}

PROFILE2
{
enable *, clear counters
show   management
}

PROFILE3 deny
{
create vlan *, configure iproute *, disable *, show fdb
delete *, configure rip add
}
```

Configuring TACACS+

Terminal Access Controller Access Control System Plus (TACACS+) is a mechanism for providing authentication, authorization, and accounting on a centralized server, similar in function to the RADIUS client. The ExtremeWare version of TACACS+ is used to authenticate prospective users who are attempting to administer the switch. TACACS+ is used to communicate between the switch and an authentication database.

NOTE

You cannot use RADIUS and TACACS+ at the same time.

You can configure two TACACS+ servers, specifying the primary server address, secondary server address, and UDP port number to be used for TACACS+ sessions.

Secure Shell 2 (SSH2)

Secure Shell 2 (SSH2) is a feature of ExtremeWare that allows you to encrypt Telnet session data between a network administrator using SSH2 client software and the switch, or to send encrypted data from the switch to an SSH2 client on a remote system. Image and configuration files may also be transferred to the switch using the Secure Copy Protocol 2 (SCP2). The ExtremeWare CLI provides a command that enable the switch to function as an SSH2 client, sending commands to a remote system via an SSH2 session. It also provides commands to copy image and configuration files to the switch using the SCP2.

The ExtremeWare SSH2 switch application is based on the Data Fellows™ SSH2 server implementation. It is highly recommended that you use the F-Secure® SSH client products from Data Fellows corporation. These applications are available for most operating systems. For more information, see the Data Fellows website at:

http://www.datafellows.com.

NOTE

SSH2 is compatible with the Data Fellows SSH2 client version 2.0.12 or above. SSH2 is not compatible with SSH1.

The ExtremeWare SSH2 switch application also works with SSH2 client and server (version 2.x or later) from SSH Communication Security, and the free SSH2 and SCP2 implementation (version 2.5 or later) from OpenSSH. The SFTP file transfer protocol is required for file transfer using SCP2.

Enabling SSH2 for Inbound Switch Access

Because SSH2 is currently under U.S. export restrictions, you must first obtain a security-enabled version of the ExtremeWare software from Extreme Networks before you can enable SSH2. The procedure for obtaining a security-enabled version of the ExtremeWare software is described in Chapter 1.

You must enable SSH2 on the switch before you can connect to it using an external SSH2 client. Enabling SSH2 involves two steps:

- Enabling SSH2 access, which may include specifying a list of clients that can access the switch, and specifying a TCP port to be used for communication.

  By default, if you have a security license, SSH2 is enabled using TCP port 22, with no restrictions on client access.
- Generating or specifying an authentication key for the SSH2 session.

To enable SSH2, use the following command:

```
enable ssh2 {access-profile [<access_profile> | none] {port <tcp_port_number>}}
```

You can specify a list of predefined clients that are allowed SSH2 access to the switch. To do this, you must create an access profile that contains a list of allowed IP addresses.

You can also specify a TCP port number to be used for SSH2 communication. By default the TCP port number is 22.

The supported cipher is 3DES-CBC. The supported key exchange is DSA.

An authentication key must be generated before the switch can accept incoming SSH2 sessions. This can be done automatically by the switch, or you can enter a previously generated key. To have the key generated by the switch, use the following command:

```
config ssh2 key
```

You are prompted to enter information to be used in generating the key. The key generation process takes approximately ten minutes. Once the key has been generated, you should save your configuration to preserve the key.

To use a key that has been previously created, use the following command:

```
config ssh2 key pregenerated
```

You are prompted to enter the pregenerated key.

The key generation process generates the SSH2 private host key. The SSH2 public host key is derived from the private host key, and is automatically transmitted to the SSH2 client at the beginning of an SSH2 session.

Before you initiate a session from an SSH2 client, ensure that the client is configured for any nondefault access list or TCP port information that you have configured on the switch. Once these tasks are accomplished, you may establish an SSH2-encrypted session with the switch. Clients must have a valid user name and password on the switch in order to log into the switch after the SSH2 session has been established.

For additional information on the SSH protocol refer to [FIPS-186] Federal Information Processing Standards Publication (FIPSPUB) 186, Digital Signature Standard, 18 May 1994. This can be download from: ftp://ftp.cs.hut.fi/pub/ssh. General technical information is also available from:

http://www.ssh.fi

Using SCP2 from an External SSH2 Client

In ExtremeWare version 6.2.1 or later, the SCP2 protocol is supported for transferring image and configuration files to the switch from the SSH2 client, and for copying the switch configuration from the switch to an SSH2 client.

CAUTION

You can download a configuration to an Extreme Networks switch using SCP. If you do this, you cannot save this configuration. If you save this configuration and reboot the switch, the configuration will be corrupted.

The user must have administrator-level access to the switch. The switch can be specified by its switch name or IP address.

Configuration or image files stored on the system running the SSH2 client may be named as desired by the user. However, files on the switch have predefined names, as follows:

- `configuration.cfg`—The current configuration
- `incremental.cfg`—The current incremental configuration
- `primary.img`—The primary ExtremeWare image
- `secondary.img`—The secondary ExtremeWare image
- `bootrom.img`—The BootROM image

For example, to copy an image file saved as *image1.xtr* to switch with IP address 10.10.0.5 as the primary image using SCP2, you would enter the following command within your SSH2 session:

```
scp image1.xtr admin@10.20.0.5:primary.img
```

To copy the configuration from the switch and save it in file *config1.save* using SCP, you would enter the following command within your SSH2 session:

```
scp admin@10.10.0.5:configuration.cfg config1.save
```

SSH2 Client Functions on the Switch

In ExtremeWare version 6.2.1 or later, an Extreme Networks switch can function as an SSH2 client. This means you can connect from the switch to a remote device running an SSH2 server, and send commands to that device. You can also use SCP2 to transfer files to and from the remote device.

You do not need to enable SSH2 or generate an authentication key to use the SSH2 and SCP2 commands from the ExtremeWare CLI.

To send commands to a remote system using SSH2, use the following command:

```
ssh2 {cipher [3des | blowfish]} {port <portnum>} {compression [on | off]} {user
<username>} {debug <debug_level>} {<username>@}
[<host> | <ipaddress>] <remote commands>
```

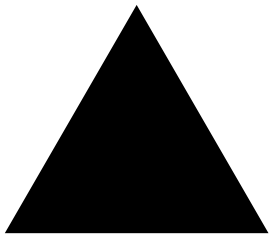
The remote commands can be any commands acceptable by the remote system. You can specify the login user name as a separate argument, or as part of the user@host specification. If the login user name for the remote system is the same as your user name on the switch, you can omit the username parameter entirely.

To initiate a file copy from a remote system to the switch using SCP2, use the following command:

```
scp2 {cipher [3des | blowfish]} {port <portnum>} {debug <debug_level>}
<user>@[<hostname> | <ipaddress>]:<remote_file> [configuration {incremental} | image
[primary | secondary] | bootrom]
```

To initiate a file copy to a remote system from the switch using SCP2, use the following command:

```
scp2 {cipher [3des | blowfish]} {port <portnum>} {debug <debug_level>} configuration
<user>@[<hostname> | <ipaddress>]:<remote_file>
```



Part 2

Using Switching and Routing Protocols

12 Ethernet Automatic Protection Switching

This chapter describes the use of the Ethernet Automatic Protection Switching (EAPS™) protocol, and includes information on the following topics:

- Overview of the EAPS Protocol on page 233
- Fault Detection and Recovery on page 235
- Multiple EAPS Domains Per Switch on page 237
- Configuring EAPS with EMISTP on page 245
- Configuring EAPS with STP 802.1D on page 247

Overview of the EAPS Protocol

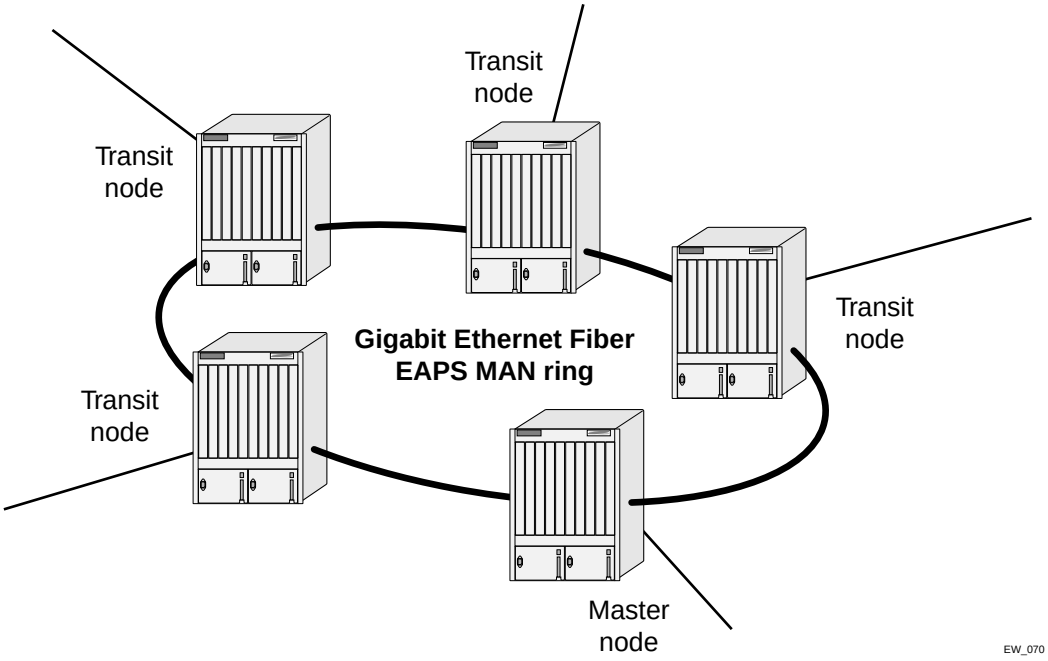
The EAPS protocol provides fast protection switching to layer 2 switches interconnected in an Ethernet ring topology, such as a Metropolitan Area Network (MAN) or large campuses (see Figure 34).

EAPS protection switching is similar to what can be achieved with the Spanning Tree Protocol (STP), but offers the advantage of converging in less than a second when a link in the ring breaks.

In order to use EAPS, you must enable EDP on the switch and EAPS ring ports. For more information on EDP, see Chapter 4.

EAPS operates by declaring an EAPS domain on a single ring. Any VLAN that warrants fault protection is configured on all ring ports in the ring, and is then assigned to an EAPS domain. On that ring domain, one switch, or node, is designated the *master* node (see Figure 35), while all other nodes are designated as *transit* nodes.

Figure 34: Gigabit Ethernet fiber EAPS MAN ring

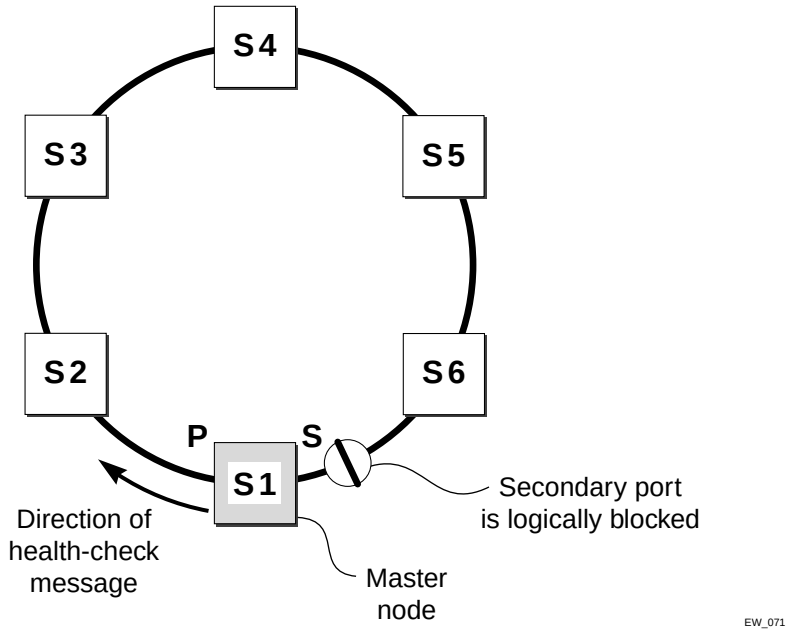


One port of the master node is designated the master node's *primary* port (P) to the ring; another port is designated as the master node's *secondary* port (S) to the ring. In normal operation, the master node blocks the secondary port for all non-control traffic belonging to this EAPS domain, thereby avoiding a loop in the ring, like STP. Layer 2 switching and learning mechanisms operate per existing standards on this ring.

NOTE

Like the master node, each transit node is also configured with a primary port and a secondary port on the ring, but the primary/secondary port distinction is ignored as long as the node is configured as a transit node.

Figure 35: EAPS operation



If the ring is complete, the master node logically blocks all data traffic in the transmit and receive directions on the secondary port to prevent a loop. If the master node detects a break in the ring, it unblocks its secondary port and allows data traffic to be transmitted and received through it.

Fault Detection and Recovery

EAPS fault detection on a ring is based on a single *control* VLAN per EAPS domain. This EAPS domain provides protection to one or more data-carrying VLANs called *protected* VLANs.

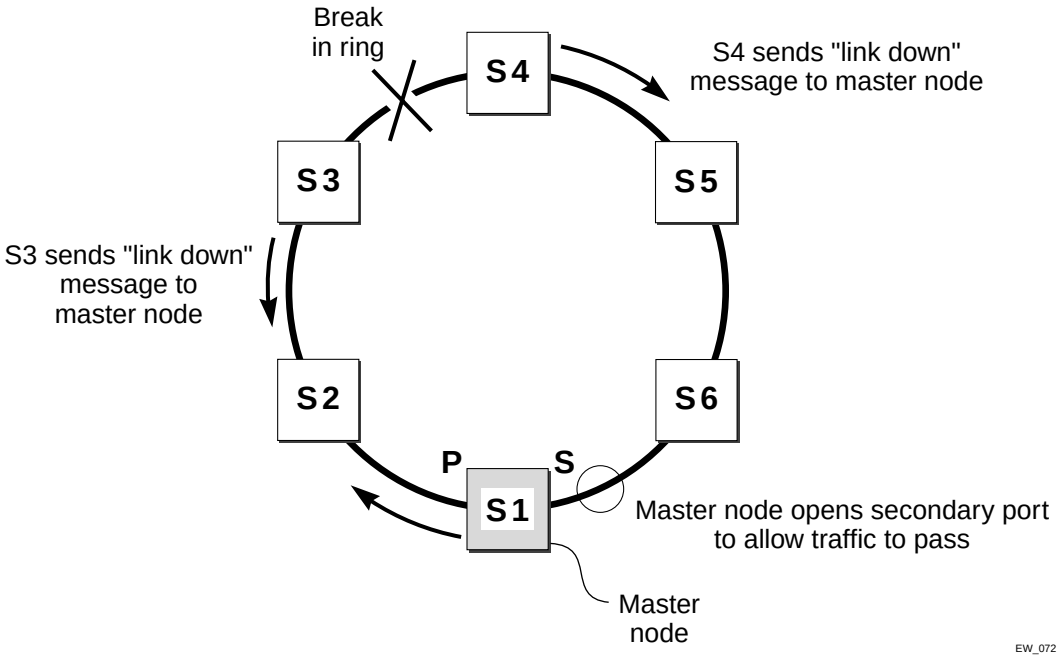
The control VLAN is used only to send and receive EAPS messages; the protected VLANs carry the actual data traffic. As long as the ring is complete, the EAPS master node blocks the protected VLANs from accessing its secondary port.

NOTE

The control VLAN is not blocked. Messages sent on the control VLAN must be allowed into the switch for the master node to determine whether the ring is complete.

To avoid loops in the network, the control VLAN must be NOT be configured with an IP address, and ONLY ring ports may be added to the VLAN.

Figure 36: EAPS fault detection and protection switching



A master node detects a ring fault in either of two ways:

- Polling response
- Trap message sent by a transit node

Polling

The master node transmits a health-check packet on the control VLAN at a user-configurable interval (see Figure 35). If the ring is complete, the master node will receive the health-check packet on its secondary port (the control VLAN is not blocked on the secondary port). When the master node receives the health-check packet, it resets its fail-period timer and continues normal operation.

If the master node does not receive the health-check packet before the fail-period timer expires, it declares a “failed” state and opens its logically blocked secondary port on all the protected VLANs. Now, traffic can flow through the master’s secondary port. The master node also flushes its forwarding database (FDB) and sends a message on the control VLAN to all of its associated transit nodes to flush their forwarding databases as well, so that all of the switches can learn the new paths to layer 2 end stations on the reconfigured ring topology.

Trap Message Sent by a Transit Node

When any transit node detects a loss of link connectivity on any of its ring ports, it immediately sends a “link down” message on the control VLAN using its good link to the master node.

When the master node receives the “link down” message (see Figure 36), it immediately declares a “failed” state and performs the same steps described above: it unblocks its secondary port for access by the protected VLANs, flushes its FDB, and sends a “flush FDB” message to its associated transit nodes.

Restoration Operations

The master node continues sending health-check packets out its primary port even when the master node is operating in the failed state. As long as there is a break in the ring, the fail-period timer of the master node will continue to expire and the master node will remain in the failed state.

When the broken link is restored, the master will receive its health-check packet back on its secondary port, and will once again declare the ring to be complete. It will logically block the protected VLANs on its secondary port, flush its FDB, and send a “flush FDB” message to its associated transit nodes.

During the time between when the transit node detects that the link is operable again and when the master node detects that the ring is complete, the secondary port on the master node is still open and data could start traversing the transit node port that just came up. To prevent the possibility of a such a temporary loop, when the transit node detects that its failed link is up again, it will perform these steps:

1. For the port that just came up, put all the protected VLANs traversing that port into a temporary blocked state.
2. Remember which port has been temporarily blocked.
3. Set the state to Preforwarding.

When the master node receives its health-check packet back on its secondary port, and detects that the ring is once again complete, it sends a message to all its associated transit nodes to flush their forwarding databases.

When the transit nodes receive the message to flush their forwarding databases, they perform these steps:

1. Flush their forwarding databases on the protected VLANs.
2. If the port state is set to Preforwarding, unblock all the previously blocked protected VLANs for the port.

Multiple EAPS Domains Per Switch

To take advantage of the Spatial Reuse technology and broaden the use of the ring’s bandwidth, EAPS supports multiple EAPS domains running on the ring at the same time.

So, a single ring might have two EAPS domains running on it. Each EAPS domain would have a different EAPS master node. Each EAPS domain will protect its own set of protected VLANS.

Figure 37: EAPS data VLAN spanning two rings interconnected by one switch

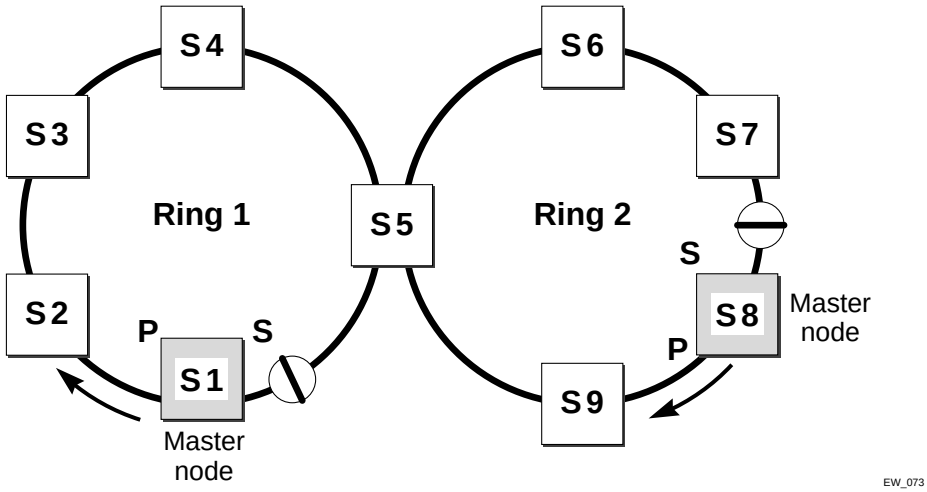


Figure 37 shows how a data VLAN could span two rings interconnected by a common switch—a "figure eight" topology. In this example, there is an EAPS domain with its own control VLAN running on ring 1 and another EAPS domain with its own control VLAN running on ring 2. A data VLAN that spans both rings will be added as a protected VLAN to both EAPS domains. In Figure 37, switch S5 will have two instances of EAPS domains running on it: one for each ring.

Creating and Deleting an EAPS Domain

Each EAPS domain is identified by a unique domain name.

To create an EAPS domain, use the following command:

```
create eaps <eaps domain>
```

The `name` parameter is a character string of up to 32 characters that identifies the EAPS domain to be created. EAPS domain names and VLAN names must be unique: Do not use the same name string to identify both an EAPS domain and a VLAN.

The following command example creates EAPS domain eaps_1 on the BlackDiamond switch:

```
create eaps eaps_1
```

To delete an EAPS domain, use the following command:

```
delete eaps <eaps domain>
```

The following command example deletes the EAPS domain eaps_1:

```
delete eaps eaps_1
```

Defining the EAPS Mode of the Switch

To configure the EAPS node type of the switch, use the following command:

```
config eaps <name> mode [master | transit]
```

One node on the ring must be configured as the master node for the specified domain; all other nodes on the ring are configured as transit nodes for the same domain.

The following command example identifies this switch as the master node for the domain named eaps_1.

```
config eaps eaps_1 mode master
```

The following command example identifies this switch as a transit node for the domain named eaps_1.

```
config eaps eaps_1 mode transit
```

Configuring EAPS Polling Timers

To set the values of the polling timers the master node uses for the EAPS health-check packet that is circulated around the ring for an EAPS domain, use the following command:

```
config eaps <eaps domain> [hellotime <seconds> | failtime <seconds>]
```

NOTE

This command applies only to the master node. If you configure the polling timers for a transit node, they will be ignored. If you later reconfigure that transit node as the master node, the polling timer values will be used as the current values.

Use the `hellotime` keyword and its associated `seconds` parameter to specify the amount of time the master node waits between transmissions of health-check packets on the control VLAN. `seconds` must be greater than 0 when you are configuring a master node. The default value is one second.

NOTE

Increasing the `hellotime` *value keeps the processor from sending and processing too many health-check packets. Increasing the* `hellotime` *value should not affect the network convergence time, because transit nodes are already sending "link down" notifications.*

Use the `failtime` keyword and its associated `seconds` parameter to specify the amount of time the master node waits before declaring a failed state and opens the logically blocked VLANs on the secondary port. `seconds` must be greater than the configured value for `hellotime`. The default value is three seconds.

NOTE

Increasing the `failtime` *value provides more protection against frequent "flapping" between the complete state and the failed state by waiting long enough to receive a health-check packet when the network is congested.*

NOTE

When the master node declares a failed state, it also flushes its forwarding database (FDB) and sends a "flush FDB" message to all the transit switches on the ring by way of the control VLAN. The reason for flushing the FDB is so that the switches can relearn the new directions to reach Layer 2 end stations via the reconfigured topology.

The following command examples configure the hellotime value for the EAPS domain "eaps_1" to 2 seconds and the failtime value to 10 seconds.

```
config eaps eaps_1 hellotime 2
config eaps eaps_1 failtime 10
```

Configuring the Primary and Secondary Ports

Each node on the ring connects to the ring through two ring ports. As part of the protection switching scheme, one port must be configured as the *primary* port; the other must be configured as the *secondary* port.

If the ring is complete, the master node prevents a loop by logically blocking all data traffic in the transmit and receive directions on its secondary port. If the master node subsequently detects a break in the ring, it unblocks its secondary port and allows data traffic to be transmitted and received through it.

To configure a node port as primary or secondary, use the following command:

```
config eaps <eaps domain> [primary | secondary] port <port number>
```

The following command example adds port 1 of the module installed in slot 8 of the BlackDiamond switch to the EAPS domain *eaps_1* as the primary port.

```
config eaps eaps_1 primary port 8:1
```

Configuring the EAPS Control VLAN

You must configure one *control* VLAN for each EAPS domain. The control VLAN is used only to send and receive EAPS messages.

NOTE

A control VLAN cannot belong to more than one EAPS domain. If the domain is active, you cannot delete the domain or modify the configuration of the control VLAN.

To configure the EAPS control VLAN for the domain, use the following command:

```
config eaps <eaps domain> add control vlan <vlan name>
```

NOTE

The control VLAN must NOT be configured with an IP address. In addition, only ring ports may be added to this control VLAN. No other ports can be members of this VLAN. Failure to observe these restrictions can result in a loop in the network.

NOTE

When you configure the VLAN that will act as the control VLAN, that VLAN must be assigned a QoS profile of Qp8, and the ring ports of the control VLAN must be tagged.

By assigning the control VLAN a QoS profile of Qp8 (with the QoS profile `HighHi` priority setting), you ensure that EAPS control VLAN traffic is serviced before any other traffic and that control VLAN messages reach their intended destinations. For example, if the control VLAN is not assigned the highest priority and a broadcast storm occurs in the network, the control VLAN messages might be dropped at intermediate points. Assigning the control VLAN the highest priority prevents dropped control VLAN messages.

Because the QoS profile `HighHi` priority setting by itself should ensure that the control VLAN traffic gets through a congested port first, you should not need to set the QoS profile minimum bandwidth (`minbw`) or maximum bandwidth (`maxbw`) settings. However, if you plan to use QoS (profile priority and bandwidth settings) for other traffic, you might need to set a `minbw` value on Qp8 for control VLAN traffic. Whether you need to do this depends entirely on your configuration.

The following command example adds the control VLAN “keys” to the EAPS domain *eaps_1*.

```
config eaps eaps_1 add control vlan keys
```

Configuring the EAPS Protected VLANs

You must configure one or more *protected* VLANs for each EAPS domain. The protected VLANs are the data-carrying VLANs.

NOTE

When you configure the VLAN that will act as a protected VLAN, the ring ports of the protected VLAN must be tagged (except in the case of the default VLAN).

To configure an EAPS protected VLAN, use the following command:

```
config eaps <eaps domaine> add protect vlan <vlan name>
```

NOTE

As long as the ring is complete, the master node blocks the protected VLANs on its secondary port.

The following command example adds the protected VLAN “orchid” to the EAPS domain “eaps_1.”

```
config eaps eaps_1 add protect vlan orchid
```

NOTE

The configuration of the Superbridge, SubBridge, and IP range control VLANs cannot be modified.

Enabling and Disabling an EAPS Domain

To enable a specific EAPS domain, use the following command:

```
enable eaps <eaps domain>
```

To disable a specific EAPS domain, use the following command:

```
disable eaps <eaps domain>
```

Enabling and Disabling EAPS

To enable the EAPS function for the entire switch, use the following command:

```
enable eaps
```

To disable the EAPS function for the entire switch, use the following command:

```
disable eaps
```

Unconfiguring an EAPS Ring Port

Unconfiguring an EAPS port sets its internal configuration state to INVALID, which causes the port to appear in the Idle state with a port status of Unknown when you use the `show eaps {<eaps domain>} detail` command to display the status information about the port.

To unconfigure an EAPS primary or secondary ring port for an EAPS domain, use the following command:

```
unconfig eaps <eaps domain> [primary | secondary] port
```

The following command example unconfigures this node's EAPS primary ring port on the domain eaps_1:

```
unconfig eaps eaps_1 primary port
```

Displaying EAPS Status Information

To display EAPS status information, use the following command:

```
show eaps {<eaps domain>} [detail]
```

If you enter the `show eaps` command without an argument or keyword, the command displays a summary of status information for all configured EAPS domains. You can use the `detail` keyword to display more detailed status information.

NOTE

The output displayed by this command depends on whether the node is a transit node or a master node. The display for a transit node contains information fields that are not shown for a master node. Also, some state values are different on a transit node than on a master node.

The following example of the `show eaps {<eaps domain>} detail` command displays detailed EAPS information for a transit node. Table 36 describes the fields and values in the display.

```
* Summit5iTx:39 # show eaps detail
EAPS Enabled: Yes
Number of EAPS instances: 1
EAPSD-Bridge links: 2

  Name: “eaps1” (instance=0)
  State: Links-Up          [Running: Yes]
  Enabled: Yes    Mode: Transit
  Primary port: 13          Port status: Up        Tag status: Tagged
  Secondary port: 14        Port status: Up        Tag status: Tagged
  Hello Timer interval: 1 sec     Fail Timer interval: 3 sec
  Preforwarding Timer interval: 3 sec
  Last update: From Master Id 00:E0:2B:81:20:00, Sat Mar 17 17:03:37 2001
  Eaps Domain has following Controller Vlan:
    Vlan Name            VID
    “rhsc”               0020
  EAPS Domain has following Protected Vlan(s):
    Vlan Name            VID
    “traffic”            1001
  Number of Protected Vlans: 1
```

The following example of the `show eaps {<eaps domain>} detail` command displays detailed EAPS information for a single EAPS domain named “eaps2” on the master node. Table 36 describes significant fields and values in the display.

```
* Baker15:4 # show eaps2 detail
  Name: “eaps2” (instance=0)
  State: Complete        [Running: Yes]
  Enabled: Yes    Mode: Master
  Primary port: 14          Port status: Up        Tag status: Tagged
  Secondary port: 13        Port status: Blocked   Tag status: Tagged
  Hello Timer interval: 1 sec     Fail Timer interval: 3 sec
  Eaps Domain has following Controller Vlan:
    Vlan Name            VID
    “rhsc”               0020
  EAPS Domain has following Protected Vlan(s):
    Vlan Name            VID
    “blue”               1003
    “traffic”            1001
  Number of Protected Vlans: 2
```

Table 36: show eaps Display Fields

Field	Description
EAPS Enabled:	Current state of EAPS on this switch: • Yes—EAPS is enabled on the switch. • no—EAPS is not enabled.
Number of EAPS instances:	Number of EAPS domains created. The maximum number of EAPS domains per switch is 64.
EAPSD-Bridge links:	The total number of EAPS bridge links in the system. The maximum count is 4096. Each time a VLAN is added to EAPS, this count increments by 1.

Table 36: show eaps Display Fields (continued)

Field	Description
Name:	The configured name for this EAPS domain.
(Instance=)	The instance number is created internally by the system.
State:	On a transit node, the command displays one of the following states: • Idle—The EAPS domain has been enabled, but the configuration is not complete. • Links-Up—This EAPS domain is running, and both its ports are up and in the FORWARDING state. • Links-Down—This EAPS domain is running, but one or both of its ports are down. • Preforwarding—This EAPS domain is running, and both of its ports are up, but one of them is in a temporary BLOCKED state. On a master node, the command displays one of the following states: • Idle—The EAPS domain has been enabled, but the configuration is not complete. • Complete—The ring is in the COMPLETE state for this EAPS domain. • Failed—There is a break in the ring for this EAPS domain.
[Running: …]	• Yes—This EAPS domain is running. • No—This EAPS domain is not running.
Enabled:	Indicates whether EAPS is enabled on this domain. • Yes—EAPS is enabled on this domain. • no—EAPS is not enabled.
Mode:	The configured EAPS mode for this switch: transit or master.
Primary/Secondary port:	The port numbers assigned as the EAPS primary and secondary ports. On the master node, the port distinction indicates which port is blocked to avoid a loop.
Port status:	• Unknown—This EAPS domain is not running, so the port status has not yet been determined. • Up—The port is up and is forwarding data. • Down—The port is down. • Blocked—The port is up, but data is blocked from being forwarded.
Tag status:	Tagged status of the control VLAN: • Tagged—The control VLAN has this port assigned to it, and the port is tagged in the VLAN. • Untagged—The control VLAN has this port assigned to it, but the port is untagged in the control VLAN. • Undetermined—Either a VLAN has not been added as the control VLAN to this EAPS domain or this port has not been added to the control VLAN.
Hello Timer interval:	The configured value of the timer in seconds, specifying the time that the master node waits between transmissions of health-check packets.
Fail Timer interval:	The configured value of the timer in seconds, specifying the time that the master node waits before declaring a failed state.
Preforwarding Timer interval:[1]	The configured value of the timer. This value is set internally by the EAPS software.

Table 36: show eaps Display Fields (continued)

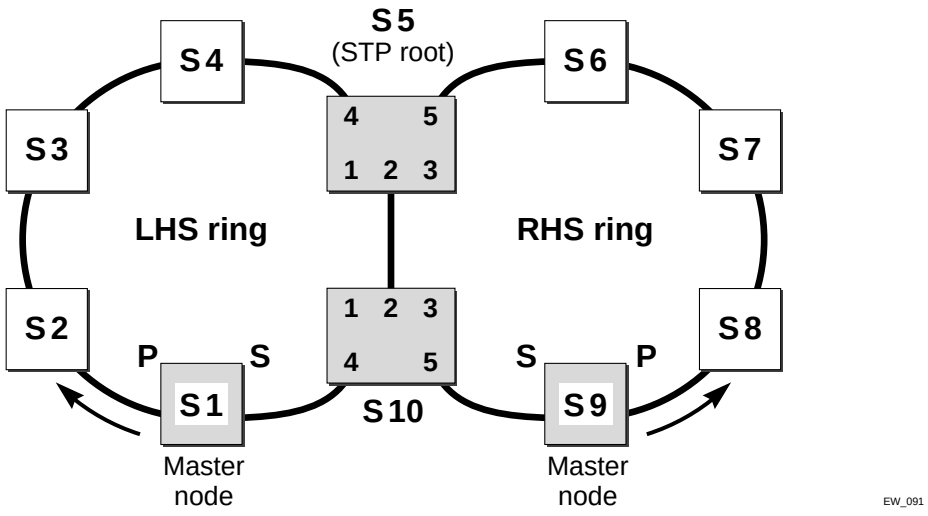
Field	Description
Last update:[1]	Displayed only for transit nodes; indicates the last time the transit node received a hello packet from the master node (identified by its MAC address).
EAPS Domain has ... Controller Vlans:	Lists the assigned name and ID of the control VLAN.
EAPS Domain has ... Protected Vlans:[2]	Lists the assigned names and VLAN IDs of all the protected VLANs configured on this EAPS domain.
Number of Protected Vlans:	The count of protected VLANs configured on this EAPS domain.

1. These fields apply only to transit nodes; they are not displayed for a master node.
2. This list is displayed when you use the `detail` keyword in the `show eaps` command.

Configuring EAPS with EMISTP

If the link between switches S5 and S10 breaks, we will have a superloop between the 2 rings. To prevent that, we have to run STP on the 2 common switches S5 and S10, as shown in Figure 38.

Figure 38: Superloop



Configuring an STP Carrier VLAN on all switches

To configure an STP Carrier VLAN on all switches, follow these steps:

1. Create an "STP Carrier" VLAN to carry Spanning Tree BPDU's using the following command:
   `create vlan <carrier vlan name>`
2. Tag this "STP Carrier" VLAN using the following command:
   `config vlan <carrier vlan name> tag <tag Id>`
3. Configure the "STP Carrier" VLAN to use qosprofile 8 using the following command:

```
configure <carrier vlan name> qosprofile qp8
```

4 Add the EAPS ring ports to "STP Carrier" VLAN using the following command:

```
configure <carrier vlan name> add ports <port number> tagged
```

5 Add the "STP Carrier" VLAN you created to the EAPS Domain as a protected VLAN using the following command:

```
configure eaps <eaps domain> add protect vlan <carrier vlan name>
```

Configuring EAPS VLANs for Switches Running STP

To configure EAPS VLANs for switches running STP, follow these steps:

1 Create a Spanning Tree Domain (in EMISTP mode, we do not want to use the default "s0" STP domain) using the following command:

```
create stpd <spanning tree name>
```

2 Configure the Spanning Tree Forward Delay to 4 seconds using the following command:

```
configure <spanning tree name>  forwarddelay  4
```

3 Configure the Spanning Tree MaxAge Time to 11 seconds using the following command:

```
configure <spanning tree name>  maxage  11
```

4 Add the "STP Carrier" VLAN you created to the STP Domain using the following command:

```
configure <spanning tree name> add <carrier vlan name>
```

5 Configure the "STP Carrier" VLAN's Tag on Spanning Tree Domain using the following command:

```
configure <spanning tree name> tag <STP Carrier Vlan's Tag Id>
```

6 Configure the Spanning Tree Domain and add all protected VLAN's to STPD using the following command:

```
configure <spanning tree name> add <vlan name>
```

7 Enable Spanning Tree using the following command:

```
enable <spanning tree name>
```

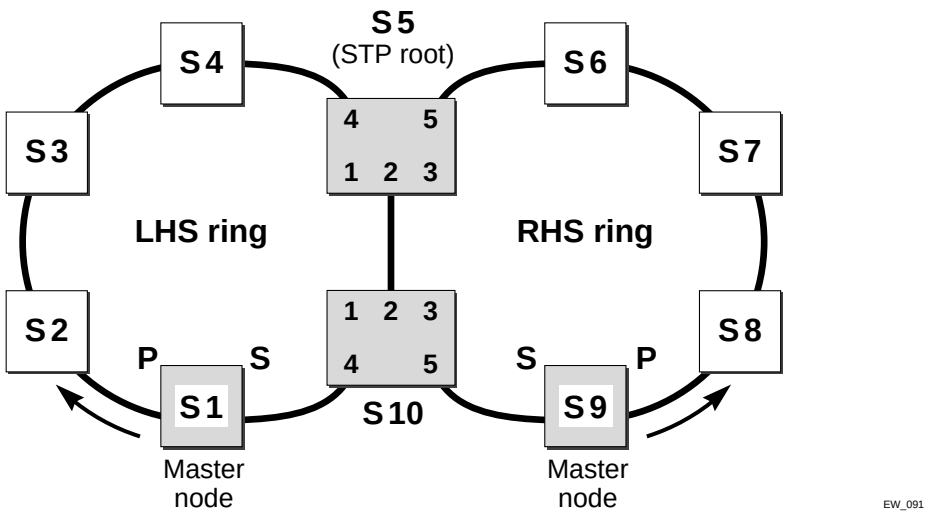
NOTE

EAPS Master should only be configured on a switch not running Spanning Tree.

Configuring EAPS with STP 802.1D

If the link between switches S5 and S10 breaks, we will have a superloop between the 2 rings. To prevent that, we have to run STP on the 2 common switches S5 and S10, as shown in Figure 39.

Figure 39: Superloop



Configuring EAPS VLANs for Switches Running STP

To configure EAPS VLANs for switches running STP, follow these steps:

1. Configure Spanning Tree Forward Delay to 4 seconds using the following command:

   ```
   configure <spanning tree name>  forwarddelay  4
   ```

2. Configure Spanning Tree MaxAge Time to 11 seconds using the following command:

   ```
   configure <spanning tree name>  maxage  11
   ```

3. Configure Spanning Tree Domain and add all protected VLANs to STPD using the following command:

   ```
   configure <spanning tree name> add <vlan name>
   ```

4. Enable Spanning Tree using the following command:

   ```
   enable <spanning tree name>
   ```

Configuring EAPS VLANs for Switches not Running STP

To configure EAPS VLANs for switches not running STP, follow these steps:

1. Create a "STP Carrier" VLAN to carry Spanning Tree BPDU's using the following command:

   `create vlan <carrier vlan name>`

   Do not tag this VLAN.

2. Configure the "STP Carrier" VLAN to use qosprofile 8 using the following command:

   `configure <carrier vlan name> qosprofile qp8`

3. Delete all ports from the default VLAN using the following command:

   `configure default delete ports all`

4. Add the EAPS ring ports untagged to the "STP Carrier" VLAN using the following command:

   `configure <carrier vlan name> add ports <port number>`

5. Add the "STP Carrier" VLAN you created to the EAPS Domain as a protected VLAN using the following command:

   `configure eaps <eaps domain> add protect vlan <carrier vlan name>`

   You will receive the following warning message when adding this VLAN to EAPS. This occurs because the ports you assigned to the VLAN are unprotected. This message can be ignored in this case. In the example below the EAPS primary port was configured as 14, and the EAPS secondary port was configured as 13.

CAUTION

The primary port 14 needs to be tagged in vlan <vlan name>, and the secondary port 13 needs to be tagged in vlan <vlan name>.

NOTE

The EAPS Master should only be configured on a switch not running Spanning Tree.

13 Spanning Tree Protocol (STP)

This chapter covers the following topics:

- Overview of the Spanning Tree Protocol on page 249
- Spanning Tree Domains on page 250
- STP Configurations on page 251
- Per-VLAN Spanning Tree on page 257
- STP Rules and Restrictions on page 257
- Configuring Basic STP on the Switch on page 258
- Displaying STP Settings on page 260

Using the Spanning Tree Protocol (STP) functionality of the switch makes your network more fault tolerant. The following sections explain more about STP and the STP features supported by ExtremeWare.

NOTE

STP is a part of the 802.1D bridge specification defined by the IEEE Computer Society. To explain STP in terms used by the 802.1D specification, the switch will be referred to as a bridge.

Overview of the Spanning Tree Protocol

STP is a bridge-based mechanism for providing fault tolerance on networks. STP allows you to implement parallel paths for network traffic, and ensure that:

- Redundant paths are disabled when the main paths are operational.
- Redundant paths are enabled if the main path fails.

NOTE

STP is not supported in conjunction with ESRP.

Spanning Tree Domains

The switch can be partitioned into multiple virtual bridges. Each virtual bridge can run an independent Spanning Tree instance. Each Spanning Tree instance is called a *Spanning Tree Domain* (STPD). Each STPD has its own root bridge and active path. After an STPD is created, one or more VLANs can be assigned to it.

A port can belong to multiple STPDs. In addition, a VLAN can span multiple STPDs.

The key points to remember when configuring VLANs and STP are:

- Each VLAN forms an independent broadcast domain.
- STP blocks paths to create a loop-free environment.
- When STP blocks a path, no data can be transmitted or received on the blocked port.
- Within any given STPD, all VLANs belonging to it use the same spanning tree.

If you delete a STPD, the VLANs that were members of that STPD are also deleted. You must remove all VLANs associated with the STP before deleting the STPD.

Defaults

The default device configuration contains a single STPD called *s0*. The default VLAN is a member of STPD s0.

All STP parameters default to the IEEE 802.1D values, as appropriate.

Port Modes

An STP port has three modes of operation:

- 802.1D mode

  This mode is used for backward compatibility with previous STP versions and for compatibility with third-party switches using IEEE standard 802.1D. BPDUs are sent untagged in 1D mode. Because of this, on any given physical interface there can be only *one* STPD running in 1D mode.

- Extreme Multiple Instance Spanning Tree Protocol (EMISTP) mode

  EMISTP mode is an extension of STP that allows a physical port to belong to multiple STPDs by assigning the port to multiple VLANs. EMISTP adds significant flexibility to STP network design. BPDUs are sent with an 802.1Q tag having an STPD instance Identifier (StpdID) in the VLANid field.

- PVST+ mode

  This mode implements PVST+ in compatibility with third-party switches running this version of STP. The STPDs running in this mode have a one-to-one relationship with VLANs, and send and process packets in PVST+ format.

These port modes are for STP ports, not for physical ports. When a physical port belongs to multiple STPDs, it is associated with multiple STP ports. It is possible for the physical port to run in different modes for different domains to which it belongs.

STPD Identifier

An StpdID is used to identify each STP domain. You assign the StpdID when configuring the domain, and that VLAN cannot belong to and other STPD.

An StpdID must be identical to the VLANid of one of the member VLANs in that STP domain.

NOTE

If an STPD contains at least one port not in 1D mode, the STPD must be configured with an StpdID.

STPD BPDU Tunneling

You can configure ExtremeWare to allow a BDPU to traverse a VLAN without being processed by STP, even if STP is enabled on the port. This is known as BPDU *tunneling.*

To enable and disable BPDU tunneling on a VLAN, use the following command:

```
[enable | disable] ignore-bpdu vlan <vlan name>
```

If you have a known topology and have switches outside of your network within your STPD, use this feature to keep the root bridge within your network.

Rapid Root Failover

ExtremeWare supports rapid root failover for faster STP failover recovery times. If the active root port link goes down ExtremeWare recalculates STP and elects a new root port. Rapid root failover allows the new root port to immediately begin forwarding, skipping the standard listening and learning phases. Rapid root failover occurs only when the link goes down, and not when there is any other root port failure, such as missing BPDUs.

The default setting is disabled. To enable rapid root failover, use the following command:

```
enable stpd <stpd_name> rapid-root-failover
```

To display the configuration, use the following command:

```
show stpd <stpd>
```

STP Configurations

When you assign VLANs to an STPD, pay careful attention to the STP configuration and its effect on the forwarding of VLAN traffic.

This section describes three types of STP configurations:

- Basic STP
- Multiple STPDs on a single port (EMISTP)
- A VLAN that spans multiple STPDs

Basic STP Configuration

This section describes a basic, 802.1d STP configuration. Figure 40 illustrates a network that uses VLAN tagging for trunk connections. The following four VLANs have been defined:

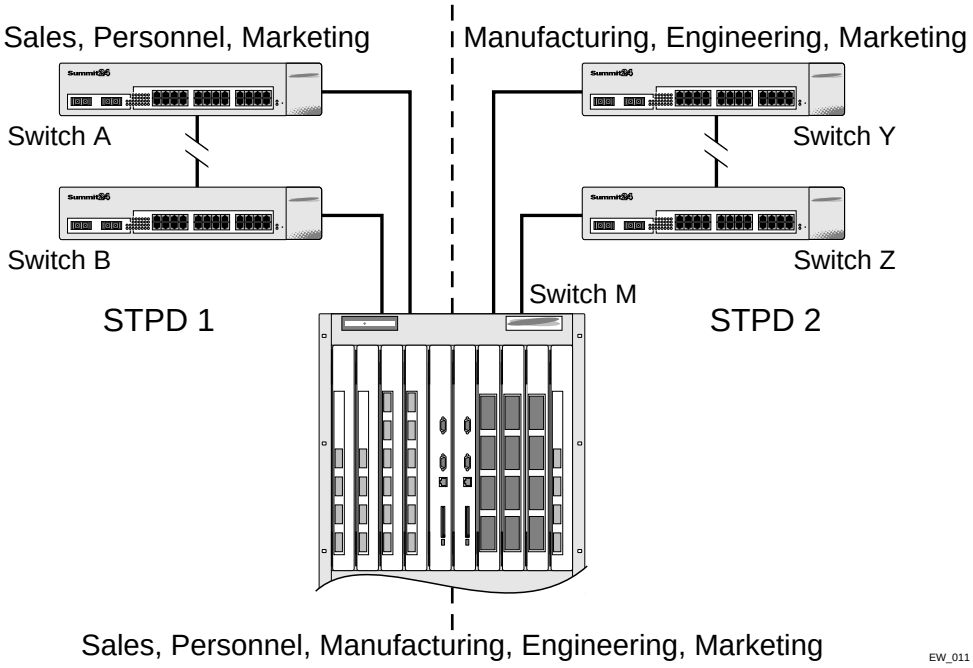
- *Sales* is defined on switch A, switch B, and switch M.
- *Personnel* is defined on switch A, switch B, and switch M.
- *Manufacturing* is defined on switch Y, switch Z, and switch M.
- *Engineering* is defined on switch Y, switch Z, and switch M.
- *Marketing* is defined on all switches (switch A, switch B, switch Y, switch Z, and switch M).

Two STPDs are defined:

- STPD1 contains VLANs *Sales* and *Personnel.*
- STPD2 contains VLANs *Manufacturing* and *Engineering.*

The VLAN *Marketing* is a member of both STPD1 and STPD2.

Figure 40: Multiple Spanning Tree Domains



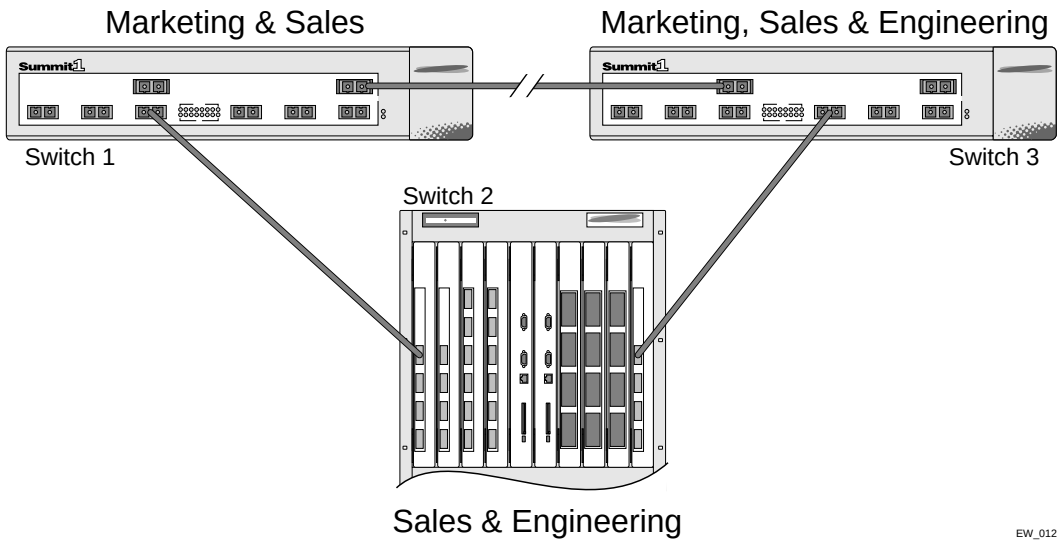
When the switches in this configuration start up, STP configures each STPD such that there are no active loops in the topology. STP could configure the topology in a number of ways to make it loop-free.

In Figure 40, the connection between switch A and switch B is put into blocking state, and the connection between switch Y and switch Z is put into blocking state. After STP converges, all the VLANs can communicate, and all bridging loops are prevented.

The VLAN *Marketing*, which has been assigned to both STPD1 and STPD2, communicates using all five switches. The topology has no loops, because STP has already blocked the port connection between switch A and switch B, and between switch Y and switch Z.

Within a single STPD, you must be extra careful when configuring your VLANs. Figure 41 illustrates a network that has been incorrectly set up using a single STPD so that the STP configuration disables the ability of the switches to forward VLAN traffic.

Figure 41: Tag-based STP configuration



The tag-based network in Figure 41 has the following configuration:

- Switch 1 contains VLAN *Marketing* and VLAN *Sales.*
- Switch 2 contains VLAN *Engineering* and VLAN *Sales.*
- Switch 3 contains VLAN *Marketing*, VLAN *Engineering*, and VLAN *Sales.*
- The tagged trunk connections for three switches form a triangular loop that is not permitted in an STP topology.
- All VLANs in each switch are members of the same STPD.

STP can block traffic between switch 1 and switch 3 by disabling the trunk ports for that connection on each switch.

Switch 2 has no ports assigned to VLAN marketing. Therefore, if the trunk for VLAN marketing on switches 1 and 3 is blocked, the traffic for VLAN marketing will not be able to traverse the switches.

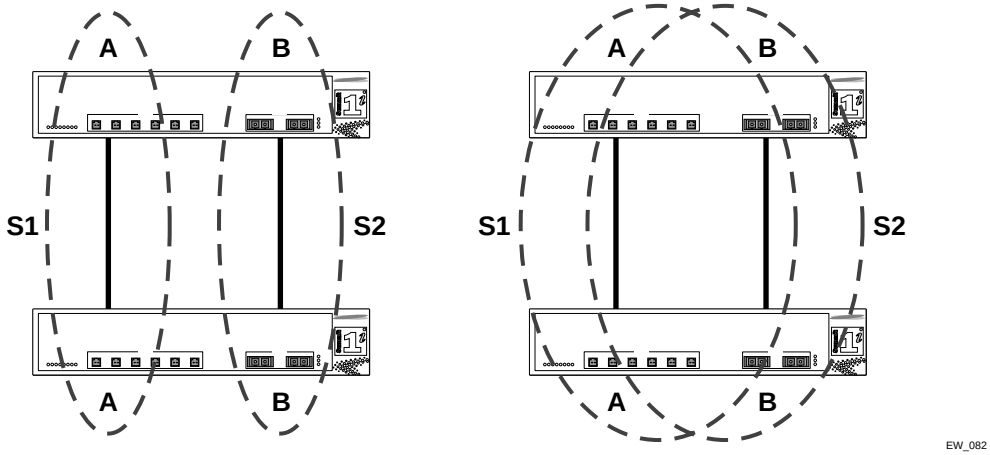
NOTE

If an STPD contains multiple VLANs, all VLANs must be configured on all ports in that domain, except for ports that connect to hosts (edge ports).

Multiple STPDs on a Port

Traditional 802.1d STP has some inherent limitations when addressing networks that have multiple VLANs and multiple STPDs. For example, consider the simple depicted in Figure 42.

Figure 42: Limitations of Traditional STPD



The two switches are connected by a pair of parallel links. Both switches run two VLANs, A and B. To achieve load-balancing between the two links using the traditional approach, you would have to associate A and B with two different STPDs, called S1 and S2, respectively, and make the left link carry VLAN A traffic while the right link carry VLAN B traffic (or vice versa). If the right link fails, S2 is broken and VLAN B traffic is disrupted.

To optimize the solution, you can use the Extreme Multiple Instance Spanning (EMISTP) mode, which allows a port to belong to multiple STPDs. EMISTP adds significant flexibility to STP network design. Referring to Figure 42, using EMISTP, you can configure all four ports to belong to both VLANs.

Assuming that S1 and S2 still correspond to VLANs A and B, respectively, you can fine-tune STP parameters to make the left link active in S1 and blocking in S2, while the right link is active in S2 and blocking in S1. Once again, if the right link fails, the left link is elected active by the STP algorithm for S2, without affecting normal switching of data traffic.

Using EMISTP, an STPD becomes more of an abstract concept. It does not necessarily correspond to a physical domain. It is better regarded as a vehicle to carry VLANs that have STP instances. Because VLANs can overlap, so do STPDs. However, even if the different STPDs share the entire topology or part of the redundant topology, the STPDs react to topology change events in an independent fashion.

VLAN Spanning Multiple STPDs

Traditionally, the mapping from VLANs to STP instances have been one-to-one, or many-to-one. In both cases, a VLAN is wholly contained in a single instance. In practical deployment there are cases in which a one-to-many mapping is desirable. In a typical large enterprise network, for example, VLANs span multiple sites and/or buildings. Each site represents a redundant looped area. However, between any two sites the topology is usually very simple.

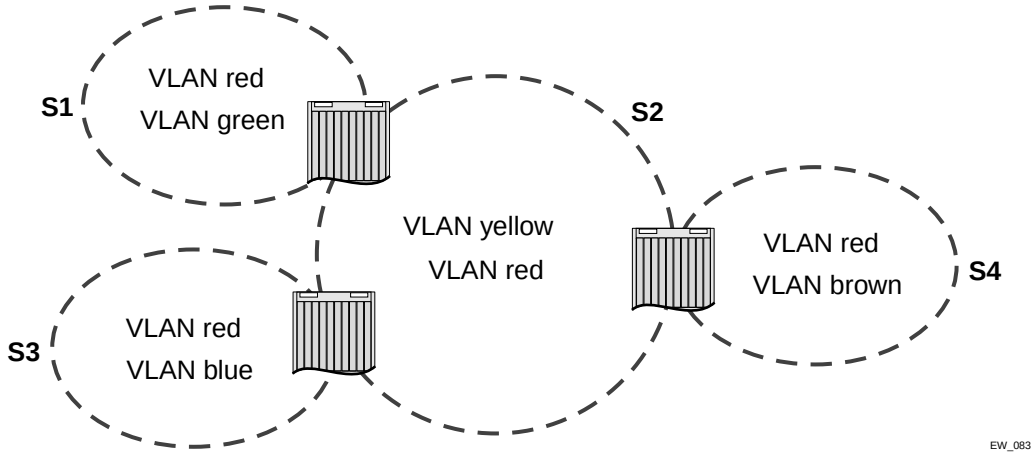
Alternatively, the same VLAN may span multiple large geographical areas (because they belong to the same enterprise) and may traverse a great many nodes. In this case, it is desirable to have multiple STP domains operating in a single VLAN, one for each looped area. The justifications include the following:

- The complexity of the STP algorithm increases, and performance drops, with the size and complexity of the network. The 802.1d standard specifies a maximum network diameter of 7 hops. By segregating a big VLAN into multiple STPDs, you reduce complexity and enhance performance.

- Local to each site, there may be other smaller VLANs that share the same redundant looped area with the large VLAN. Some STPDs must be created to protect those VLAN. The ability to partition VLANs allows the large VLAN to be “piggybacked” in those STPDs in a site-specific fashion.

Figure 43 has five domains. VLANs green, blue, brown, and yellow are local to each domain. VLAN red spans all of the four domains. Using a VLAN that spans multiple STPDS, you do not have to create a separate domain for VLAN red. Instead, VLAN red is “piggybacked” onto those domains local to other VLANs.

Figure 43: VLAN Spanning Multiple STPDs



In addition, the configuration in Figure 43 has these features:

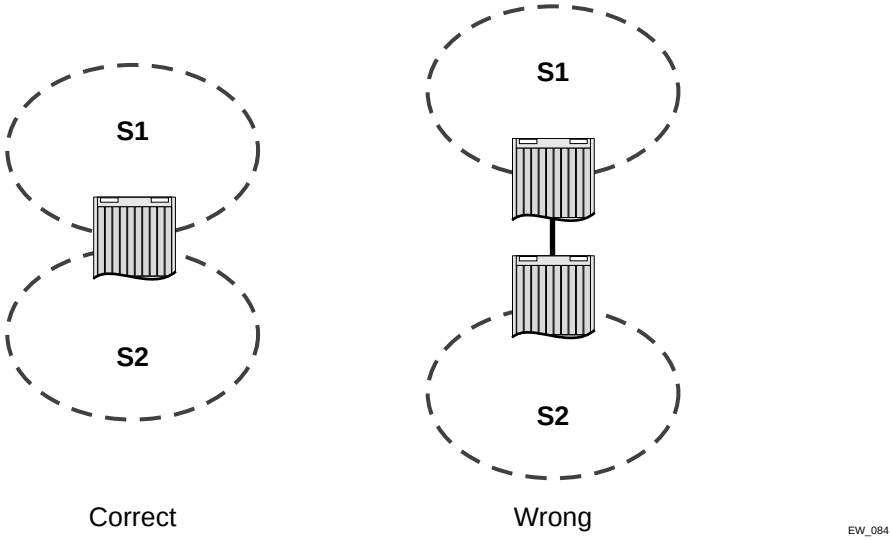
- Each site can be administered by a different organization or department within the enterprise. Having a site-specific STP implementation makes the administration more flexible and convenient.
- Between the sites the connection usually traverse distribution switches in ways that are known beforehand to be “safe” with STP. In other words, the looped areas are already well-defined.

EMISTP Deployment Constraints

While EMISTP greatly enhances STP capability, these features must deployed with care. This section discusses configuration issues that, if not followed, could lead to an improper deployment of EMISTP. This section also provides the restrictive principles to abide by in network design.

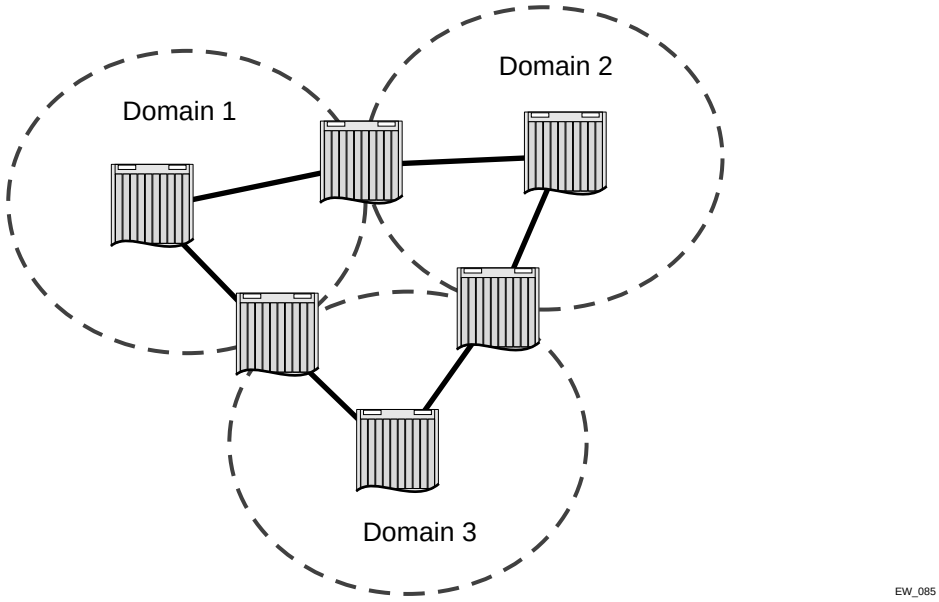
- While a physical port can belong to multiple STPDs, any VLAN on that port can be in only one domain. Put another way, a VLAN can not belong to two domains on the same physical port.
- While a VLAN can span multiple domains, any LAN segment in that VLAN must be in the same STPD. VLANs traverse domains only inside switches, not across links. On a single switch, however, bridge ports for the same VLAN can be assigned to different STPDs. This scenario is illustrated in Figure 44.

Figure 44: VLANs traverse domains inside switches



- The VLAN partition feature is deployed under the premise that the overall inter-domain topology for that VLAN is loop-free. Consider the case in Figure 45, VLAN red (the only VLAN in the figure) spans domains 1, 2, and 3. Inside each domain, STP produces a loop-free topology. However, VLAN red is still looped, because the three domains form a ring among themselves.

Figure 45: Looped VLAN topology



A necessary (but not sufficient) condition for a loop-free inter-domain topology is that every two domains only meet at a single crossing point.

NOTE

Newly created EMISTP VLANs are not associated with STPD s0 by default.

Per-VLAN Spanning Tree

Switching products that implement Per-VLAN Spanning Tree (PVST) have been in existence for many years and are widely deployed. To support STP configurations that use PVST, ExtremeWare has an operational mode called PVST+.

NOTE

In this document, PVST and PVST+ are used interchangeably. PVST+ is an enhanced version of PVST that is interoperable with 802.1Q STP. The following discussions are in regard to PVST+, if not specifically mentioned.

STPD VLAN Mapping

Each VLAN participating in PVST+ must be in a separate STPD and the VLAN number must be the same as the STPD identifier (StpdID).As a result, PVST+ VLANs can not be partitioned.

This fact does not exclude other non-PVST+ VLANs from being grouped into the same STPD. A PVST+ VLAN can be joined by multiple non-PVST+ VLANs to be in the same STP domain.

Native VLAN

In PVST+, the native VLAN must be peered with default VLAN on Extreme devices, as both are the only VLAN allowed to send and receive untagged packets on the physical port.

Third-party PVST+ devices send VLAN 1 packets in a special manner. ExtremeWare does not support PVST+ for VLAN 1. Therefore, when the switch receives a packet for VLAN 1, the packet is dropped.

When a PVST+ instance is disabled, the fact that PVST+ uses a different packet format raises an issue. If the STPD also contains ports not in PVST+ mode, the flooded packet has an in incompatible format with those ports. The packet is not recognized by the devices connected to those ports. Therefore, ExtremeWare has the following limitation:

- If an STPD contains both PVST+ and non-PVST+ ports, the STPD must not be disabled. Otherwise, the BPDUs are flooded in the format of the incoming STP port.

STP Rules and Restrictions

This section summarizes the rules and restrictions for configuring STP.

- The StpdID must be the VLANid of one of its member VLANs, and that VLAN can not be partitioned.

- A default VLAN can not be partitioned. If a VLAN traverses multiple STP domains, the VLAN must be tagged.
- An STPD can carry, at most, one VLAN running in PVST+ mode, and its StpdID must be identical with that VLANid. In addition, the PVST+ VLAN can not be partitioned.
- The default VLAN of a PVST+ port must be identical with the native VLAN on the PVST+ device connected to that port.
- If a port supports 802.1s-STPD, then the port must be configured with a default VLAN. If not, the BPDUs for that STPD are not flooded when the STPD is disabled.
- If an STPD contains both PVST+ and non-PVST+ ports, it must be enabled. If it is disable, the BPDUs are flooded in the format of the incoming STP port, which may be incompatible with those of the connected devices.

Configuring Basic STP on the Switch

To configure basic STP, follow these steps:

1 Create one or more STP domains using the following command:

```
create stpd <stpd_name>
```

NOTE

STPD, VLAN, and QoS profile names must all be unique. For example, a name used to identify a VLAN cannot be used when you create an STPD or a QoS profile.

2 Add one or more VLANs to the STPD using the following command:

```
config stpd <stpd_name> add vlan <vlan name>
```

3 Enable STP for one or more STP domains using the following command:

```
enable stpd {<stpd_name>}
```

After you have created the STPD, you can optionally configure STP parameters for the STPD.

NOTE

You should not configure any STP parameters unless you have considerable knowledge and experience with STP. The default STP parameters are adequate for most networks.

The following parameters can be configured on each STPD:

- Hello time
- Forward delay
- Max age
- Bridge priority
- StpdID

The following parameters can be configured on each port:

- Path cost
- Port priority
- Port mode

NOTE

The device supports the RFC 1493 Bridge MIB. Parameters of only the s0 default STPD are accessible through this MIB.

NOTE

If an STPD contains at least one port not in dot1D mode, the STPD must be configured with an StpdID.

STP Configuration Examples

This section provides two configuration examples:

- Basic 802.1d STP
- EMISTP

Basic 802.1d Configuration Example

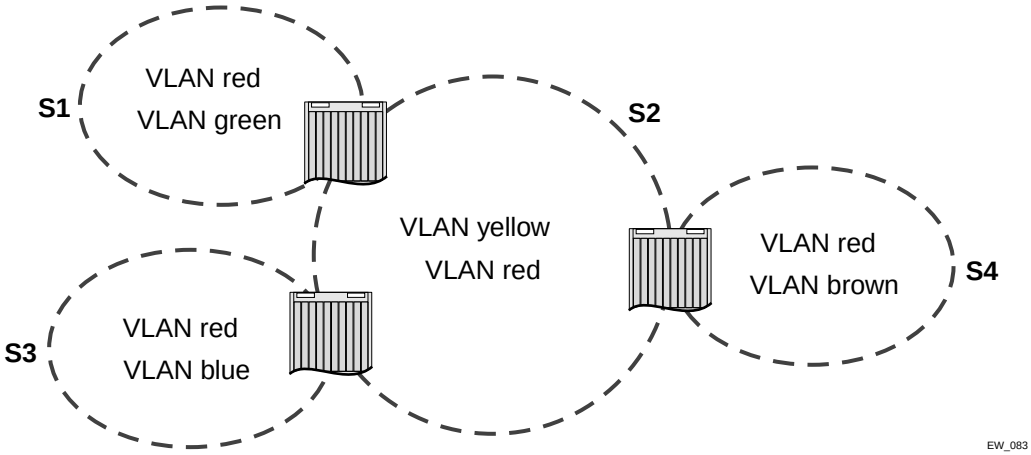
The following modular switch example creates and enables an STPD named *Backbone_st*. It assigns the *Manufacturing* VLAN to the STPD. It disables STP on slot 2, ports 1 through 7, and slot 3 port 12.

```
create stpd backbone_st
config stpd backbone_st add vlan manufacturing
enable stpd backbone_st
disable stpd backbone_st port 2:1-2:7,3:12
```

EMISTP Configuration Example

Figure 46 is an example of EMISTP.

Figure 46: EMISTP configuration example



The following commands configure the switch located between S1 and S2:

```
create vlan red
config red tag 100
config red add ports 1-4 tagged

create vlan green
config green tag 200
config green add ports 1-2 tagged

create vlan yellow
config yellow tag 300
config yellow add ports 3-4 tagged

create stpd s1
config stpd s1 add green
config stpd s1 tag 200
config stpd s1 add red ports 1-2 emistp

create stpd s2
config stpd s2 add yellow
config stpd s2 tag 300
config stpd s2 add red ports 3-4 emistp
```

Displaying STP Settings

To display STP settings, use the following command:

```
show stpd {detail}
```

This command displays the following information:

- STPD name
- Tag
- Flags

- Bridge ID
- STPD configuration information

To display the STP state of a port, use the following command:

```
show stpd <stpd_name> ports {detail}
```

This command displays the following information:

- STPD port configuration
- STPD state (root bridge, and so on)
- STPD port state (forwarding, blocking, and so on)

14 Extreme Standby Router Protocol

This chapter covers the following topics:

- Overview on page 263
- ESRP Basics on page 264
- Determining the ESRP Master on page 265
- Grouping Blocks of 10/100 Ports on page 271
- ESRP Options on page 273
- ESRP and VLAN Aggregation on page 277
- Displaying ESRP Information on page 280

Overview

ESRP is a feature of ExtremeWare that allows multiple switches to provide redundant routing services to users. From the workstation's perspective, there is only one default router (that has one IP address and one MAC address), so ARP cache entries in client workstations do not need to be refreshed or aged-out.

In addition to providing layer 3 routing redundancy for IP and IPX, ESRP also provides for layer 2 redundancy. These "layered" redundancy features can be used in combination or independently. You do not have to configure the switch for routing to make valuable use of ESRP. The layer 2 redundancy features of ESRP offer fast failure recovery and provide for dual-homed system design. In some instances, depending on network system design, ESRP can provide better resiliency than using the Spanning Tree Protocol (STP).

It is highly recommended all switches participating in ESRP run the same version of ExtremeWare. Not all ESRP features are available in all ExtremeWare software releases.

ESRP-Aware Switches

Extreme switches that are not running ESRP, but are connected on a network that has other Extreme switches running ESRP are ESRP-*aware*. When ESRP-aware switches are attached to ESRP-enabled switches, the ESRP-aware switches reliably perform fail-over and fail-back scenarios in the prescribed recovery times. No configuration of this feature is necessary.

If Extreme switches running ESRP are connected to layer 2 switches that are not manufactured by Extreme Networks (or Extreme switches that are not running ExtremeWare 4.0 or above), the fail-over times seen for traffic local to the segment may appear longer, depending on the application involved and the FDB timer used by the other vendor's layer 2 switch. As such, ESRP can be used with layer 2 switches from other vendors, but the recovery times vary.

The VLANs associated with the ports connecting an ESRP-aware switch to an ESRP-enabled switch must be configured using an 802.1Q tag on the connecting port, or, if only a single VLAN is involved, as untagged using the protocol filter any. ESRP will not function correctly if the ESRP-aware switch interconnection port is configured for a protocol-sensitive VLAN using untagged traffic.

To display ESRP-aware information, use the following command:

```
show esrp-aware vlan <vlan name>
```

The display includes the group number, MAC address for the master of the group, and age of the information.

ESRP Basics

ESRP is configured on a per-VLAN basis on each switch. A maximum of four switches can participate in providing redundant layer 3 or layer 2 services to a single VLAN. The switches exchange keep-alive packets for each VLAN independently. Only one switch can actively provide layer 3 routing and/or layer 2 switching for each VLAN. The switch performing the forwarding for a particular VLAN is considered the "master" for that VLAN. Other participating switches for the VLAN are in standby mode.

For a VLAN with ESRP enabled, each participating switch uses the same MAC address and must be configured with the same IP address or IPX NetID. It is possible for one switch to be master for one or more VLANs while being in standby for others, thus allowing the load to be split across participating switches.

NOTE

If you configure OSPF and ESRP, you must manually configure an OSPF router identifier (ID). Be sure that you configure a unique OSPF router ID on each switch running ESRP. For more information on configuring OSPF, see Chapter 17.

To have two or more switches participate in ESRP, the following must be true:

- For each VLAN to be made redundant, the switches must have the ability to exchange packets on the same layer 2 broadcast domain for that VLAN. Multiple paths of exchange can be used, and typically exist in most network system designs that take advantage of ESRP.
- For a VLAN to be recognized as participating in ESRP, the assigned IP address or the IPX NETid for the separate switches must be *identical*. Other aspects of the VLAN, including its name, are ignored.
- ESRP must be enabled on the desired VLANs for each switch.

NOTE

ESRP can not be enabled on the VLAN default.

- Extreme Discovery Protocol (EDP) must be enabled on the ports that are members of the ESRP VLANs (The default setting is enabled.).

  To verify EDP status, use the following command:

  ```
  show ports <portlist> info {detail}
  ```

NOTE

If you configure a super-VLAN for ESRP, the super-VLAN must contain all ports belonging to the sub-VLANs in order to operate properly as an ESRP VLAN.

Determining the ESRP Master

The ESRP master switch (providing layer 3 routing and/or layer 2 switching services for a VLAN) is determined by the following factors:

- **Active ports**—The switch that has the greatest number of active ports takes highest precedence.
- **Tracking information**—Various types of tracking are used to determine if the switch performing the master ESRP function has connectivity to the outside world. ExtremeWare supports the following types of tracking:
  - VLAN – Tracks any active port connectivity to one or more designated VLANs
  - IP route table entry – Tracks specific learned routes from the IP route table
  - Ping – Tracks ICMP ping connectivity to specified devices

  If any of the configured tracking mechanisms fail, the master ESRP switch relinquishes status as master, and remains in standby mode for as long as the tracking mechanism continues to fail.
- **ESRP priority**—This is a user-defined field. The range of the priority value is 0 to 254; a higher number has higher priority. The default priority setting is 0. A priority setting of 255 loses the election and remains in standby mode.
- **System MAC address**—The switch with the higher MAC address has priority.

ESRP Tracking

Tracking information is used to track various forms of connectivity from the ESRP switch to the outside world. This section describes the following ESRP tracking options:

- ESRP Environment and Diagnostic Tracking on page 265
- ESRP VLAN Tracking on page 266
- ESRP Route Table Tracking on page 266

ESRP Environment and Diagnostic Tracking

You can configure ESRP to track hardware status. If a power supply or fan fails, if the chassis is overheating, if a non-fully loaded power supply is detected, or if the diagnostics fail, the priority for the ESRP VLAN will change to the failover settings.

To configure the failover priority for ESRP VLAN, follow these steps:

1 Assign a priority to each ESRP VLAN, using the following command:

```
config vlan <vlan name> esrp priority
```

The range of the priority value is 0 to 254; a higher number has a higher priority. The default priority setting is 0.

NOTE

If you set the priority to 255, the ESRP VLAN will remain in standby mode even if the master ESRP VLAN fails.

You will typically configure both ESRP VLANs with the same priority.

2 Assign the priority flag precedence over the active ports count, using the following command:

```
config vlan <vlan name> esrp esrp-election priority-ports-track-mac
```

Because the priority of both ESRP VLANs are set to the same value, ESRP will use the active ports count to determine the master ESRP VLAN.

3 Set the failover priority, using the following command:

```
config vlan <vlan name> add [track-diagnostic | track-environment | track-rip |
track-bgp | track-ospf] failover <priority>
```

Where:

— `track-bgp` tracks for any available BGP route.

— `track-diagnostic` tracks for any diagnostics failure.

— `track-environment` tracks for any environmental failure.

— `track-ospf` tracks for any available OSPF route.

— `track-rip` tracks for any available RIP route.

The range of the priority value is 0 to 254; a higher number has a higher priority. The default priority setting is 0.

Typically you will set the failover priority lower than the configured priority. Then, if one of the ESRP VLANs experiences a hardware or diagnostics failure, it will become the standby VLAN.

ESRP VLAN Tracking

You can configure ESRP to track port connectivity to one or more specified VLANs as criteria for failover. The maximum is four routes per VLAN. The number of VLAN active ports are tracked. If no active ports remain on the specified VLANs, the switch automatically relinquishes master status and remains in standby mode.

To add or delete a tracked VLAN, use the following command:

```
config vlan <vlan name> [add | delete] track-vlan <vlan_tracked>
```

ESRP Route Table Tracking

You can configure ESRP to track specified routes in the route table as criteria for failover. If all of the configured routes are not available within the route table, the switch automatically relinquishes master status and remains in standby mode.

To participate in ESRP route table tracking, all ESRP switches must run ExtremeWare version 6.0 or above.

To add or delete a tracked route, use the following command:

```
config vlan <vlan name> [add | delete] track-route <ipaddress/mask_length>
```

ESRP Ping Tracking

You can configure ESRP to track connectivity using a simple ping to any outside responder. The responder may represent the default route of the switch, or any device meaningful to network connectivity of the master ESRP switch. The switch automatically relinquishes master status and remains in standby mode if a ping keepalive fails.

NOTE

The ESRP ping tracking option cannot be configured to ping an IP address within an ESRP VLAN subnet. It should be configured on some other normal VLAN across the router boundary.

To participate in ESRP ping tracking, all ESRP switches must run ExtremeWare version 6.0 or above.

To view the status of tracked devices, use the following command:

```
show esrp
```

ESRP Multiple Ping Tracking

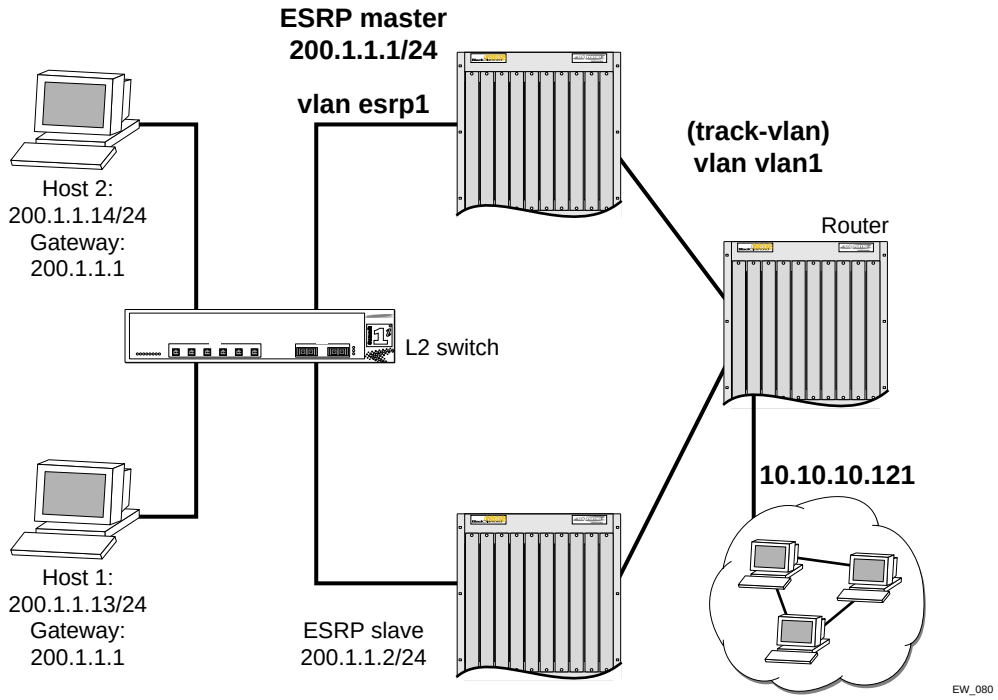
You can configure ESRP to track connectivity to up to four outside responders using a simple `ping`. To configure ping tracking, use the following command:

```
config vlan <vlan name> add track-ping <ip address> frequency <seconds> miss <number>
```

ESRP Tracking Example

Figure 47 is an example of ESRP tracking.

Figure 47: ESRP tracking



To configure VLAN tracking, use the following command:

```
Configure vlan esrp1 add track-vlan vlan1
```

Using the tracking mechanism, if VLAN1 fails, the ESRP master realizes that there is no path to the upstream router via the Master switch and implements a failsover to the slave.

To configure route table tracking, use the following command:

```
Config vlan esrp1 add track-iproute 10.10.10.0/24
```

The route specified in this command must exist in the IP routing table. When the route is no longer available, the switch implements a failover to the slave.

To configure ping tracking, use the following command:

```
Config vlan esrp1 add track-ping 10.10.10.121 2 2
```

The specified IP address is tracked. If the fail rate is exceeded the switch implements a failover to the slave.

To configure RIP tracking, use the following command:

```
Config vlan esrp1 add track-rip failover 20
```

The switch tracks RIP routes in its IP routing table. If no RIP routes are available, the switch implements a failover to failover priority 20.

To configure OSPF tracking, use the following command:

```
Config vlan esrp1 add track-ospf failover 20
```

The switch tracks OSPF routes in its IP routing table. If no OSPF routes are available, the switch implements a failover to failover priority 20.

To configure BGP tracking, use the following command:

```
Config vlan esrp1 add track-bgp failover 20
```

The switch tracks BGP routes in its IP routing table. If no BGP routes are available, the switch implements a failover to failover priority 20.

ESRP Election Algorithms

You configure the switch to use one of seven different election algorithms to select the ESRP master. Each algorithm considers the election factors in a different order of precedence, as follows:

- `ports-track-priority-mac`—Active ports, tracking information, ESRP priority, MAC address (Default)
- `ports-track-priority`—Active ports, tracking information, ESRP priority
- `track-ports-priority-mac`—Tracking information, active ports, ESRP priority, MAC address
- `track-ports-priority`—Tracking information, active ports, ESRP priority
- `priority-ports-track-mac`—ESRP priority, active ports, tracking information, MAC address
- `priority-track-ports-mac`—ESRP priority, tracking information, active ports, MAC address
- `priority-mac-only`—ESRP priority, MAC address

CAUTION

All switches in the ESRP network must use the same election algorithm, otherwise loss of connectivity, broadcast storms, or other unpredictable behavior may occur.

NOTE

Only the `ports-track-priority-mac` *election algorithm is compatible with ExtremeWare releases prior to version 6.0.*

Master Switch Behavior

If a switch is master, it actively provides layer 3 routing services to other VLANs, and layer 2 switching between all the ports of that VLAN. Additionally, the switch exchanges ESRP packets with other switches that are in standby mode.

Standby Switch Behavior

If a switch is in standby mode, it exchanges ESRP packets with other switches on that same VLAN. When a switch is in standby, it does not perform layer 3 routing or layer 2 switching services for the VLAN. From a layer 3 routing protocol perspective (for example, RIP or OSPF), when in standby for the

VLAN, the switch marks the router interface associated with the VLAN as down. From a layer 2 switching perspective, no forwarding occurs between the member ports of the VLAN; this prevents loops and maintains redundancy.

Electing the Master Switch

A new master can be elected in one of the following ways:

- A communicated parameter change
- Loss of communication between master and slave(s)

If a parameter that determines the master changes (for example, link loss or priority change), the election of the new master typically occurs within one timer cycle (2 seconds by default). If a switch in standby mode loses its connection with the master, a new election (using the same precedence order indicated previously) occurs. The new election typically takes place in three times the defined timer cycle (6 seconds by default).

When the master transitions to a slave, it enters a temporary neutral state. While in the neutral state the VLAN does not send ESRP PDUs until the neutral state timeout expires. When the timeout expires, the slave VLAN operates normally. Traffic is unaffected by the neutral state because the master continues to operate normally. The neutral state avoids the possibility of having simultaneous masters.

You can configure the neutral state timeout using the following command:

```
config <vlan> esrp esrp-neutral-timeout <neutral-timer (0-512, 0 restores dflt)>
```

CAUTION

Configure the neutral state timeout only with guidance from Extreme Networks personnel. Misconfiguration can severely degrade the performance of ESRP and your switch.

Failover Time

Failover time is largely determined by the following factors:

- The ESRP timer setting.
- The routing protocol being used for inter-router connectivity if layer 3 redundancy is used. OSPF fail-over time is faster than RIP fail-over time.

The failover time associated with the ESRP protocol is dependent on the timer setting and the nature of the failure. The default timer setting is 2 seconds; the range is 1 to 255 seconds.

If routing is configured, the failover of the particular routing protocol (such as RIP V1, RIP V2, or OSPF) is added to the failover time associated with ESRP.

Grouping Blocks of 10/100 Ports

Restrictions on port groupings apply only to switches that do not use the "*i*" chipset.

If you enable ESRP on a VLAN that contains 10/100 ports, a specific block of neighboring ports must also be participating in a VLAN running ESRP, or must not be used. The blocks of ports are physically adjacent, regardless of the switch module. For example, the blocks on a BlackDiamond F32T module consist of the following:

- Ports 1-4 and 17-20
- Ports 5-8 and 21-24
- Ports 9-12 and 25-28
- Ports 13-16 and 29-32

Figure 48 through Figure 52 illustrate the port blocks for each switch.

Figure 48: F32T and F32F ESRP port blocks

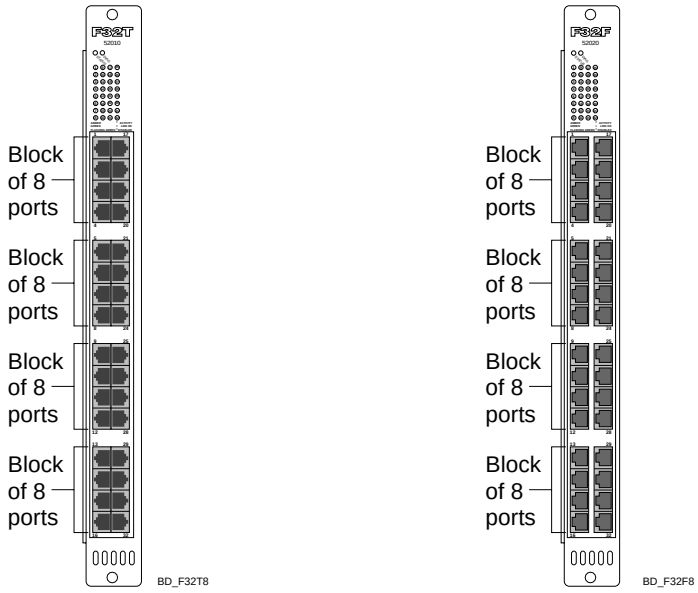


Figure 49: Summit24 switch ESRP port blocks

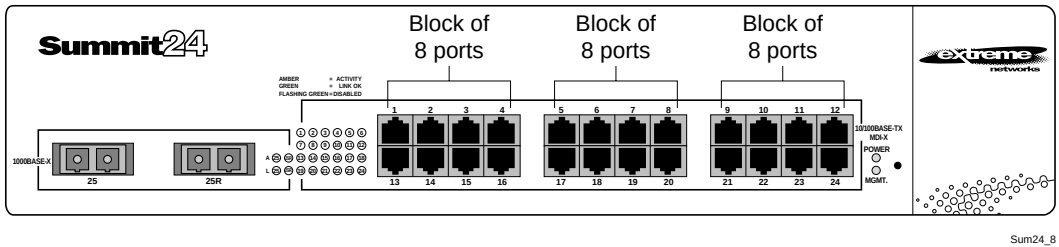


Figure 50: Summit4 switch ESRP port blocks

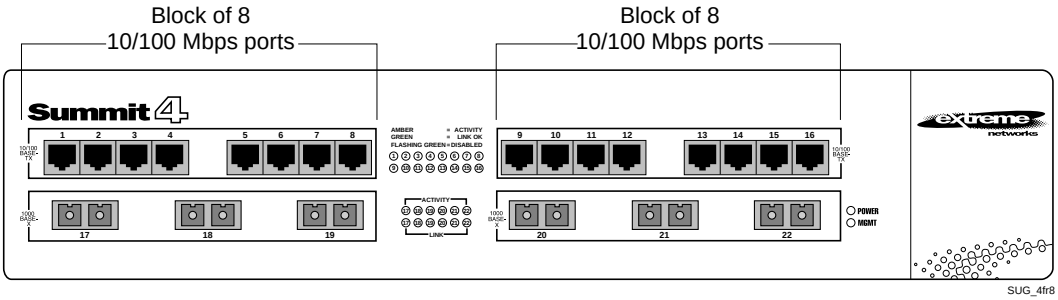


Figure 51: Summit4/FX switch ESRP port blocks

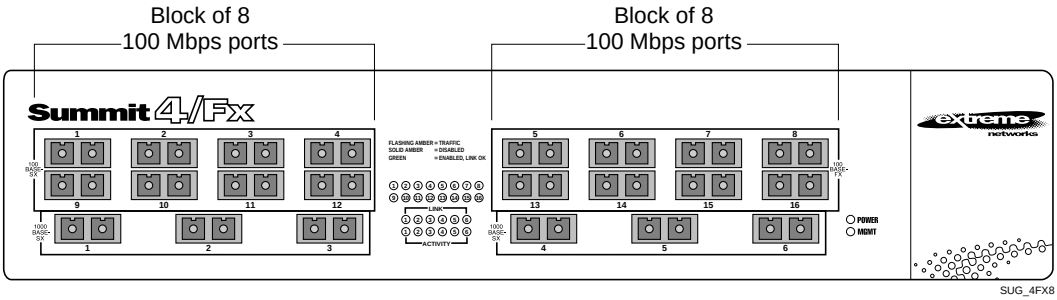
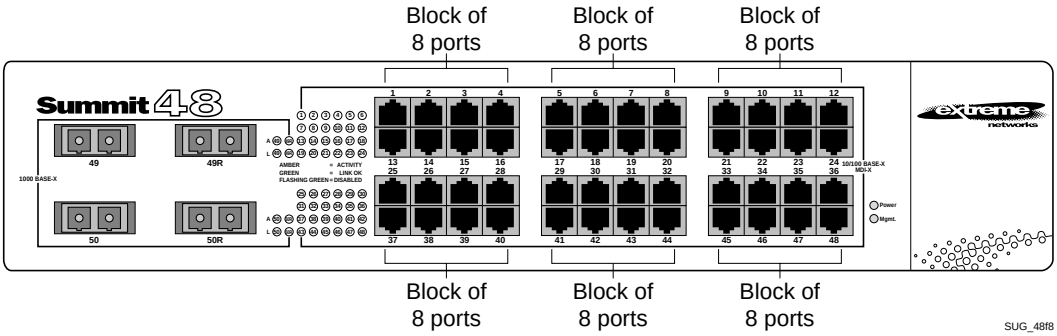


Figure 52: Summit48 switch ESRP port blocks



NOTE

For switches that do not use the "i" chipset, all VLANs using a port or port block must enable ESRP. This requirement does not apply to switches that use the "i" chipset.

ESRP Options

This section discusses the following ESRP options:

- ESRP Host Attach
- ESRP Domains
- ESRP Groups
- Linking ESRP Switches
- Configuring ESRP and Multinetting
- ESRP and Spanning Tree
- ESRP Multiple ping Tracking
- ESRP Port Restart

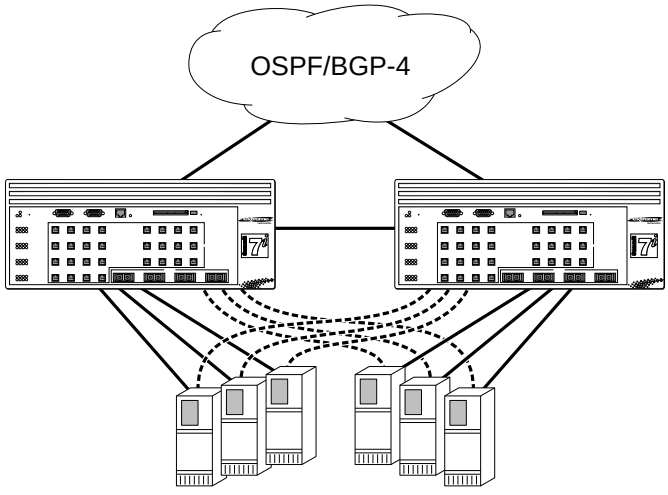
ESRP Host Attach

ESRP host attach (HA) is an optional ESRP configuration that allows you to connect active hosts directly to an ESRP master or standby switch. Normally, the Layer 2 redundancy and loop prevention capabilities of ESRP do not allow packet forwarding from the standby ESRP switch. ESRP HA allows configured ports that do not represent loops to the network to continue layer 2 operation independent of their ESRP status.

ESRP HA is designed for redundancy for dual-homed server connections. HA allows the network to continue Layer 2 forwarding regardless of the ESRP status. Do not use ESRP HA to interconnect devices on the slave ESRP switch instead of connecting directly to the ESRP master switch.

The ESRP HA option is useful if you are using dual-homed network interface cards (NICs) for server farms, and in conjunction with high availability server load-balancing (SLB) configurations, as shown in Figure 53.

Figure 53: ESRP host attach



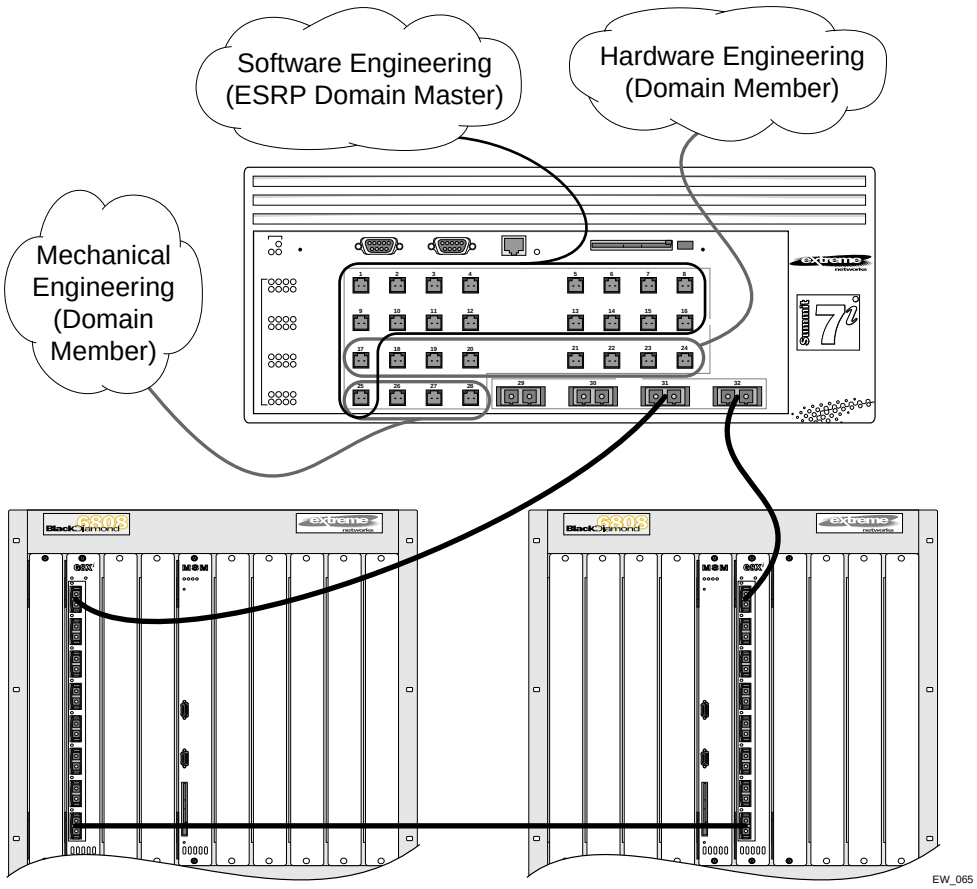
ESRP VLANs that share ESRP HA ports must be members of different ESRP groups.

Other applications allow lower cost redundant routing configurations, because hosts can be directly attached to the switch involved with ESRP. The ESRP HA feature is used only on switches and I/O modules that have the "*i*" series chipset. It also requires at least one link between the master and standby ESRP switch for carrying traffic and to exchange ESRP hello packets.

ESRP Domains

ESRP domains is an optional ESRP configuration that allows you to configure multiple VLANs under the control of a single instance of the ESRP protocol. By grouping multiple VLANs under one ESRP domain, the ESRP protocol can scale to provide protection to large numbers of VLANs. All VLANs within an ESRP domain simultaneously share the same active and standby router and failover, providing one port of each member VLAN belongs to the domain master, as shown in Figure 54.

Figure 54: ESRP domains



When a port in a member VLAN belongs to the domain master, the member VLAN ports are considered when determining the ESRP master.

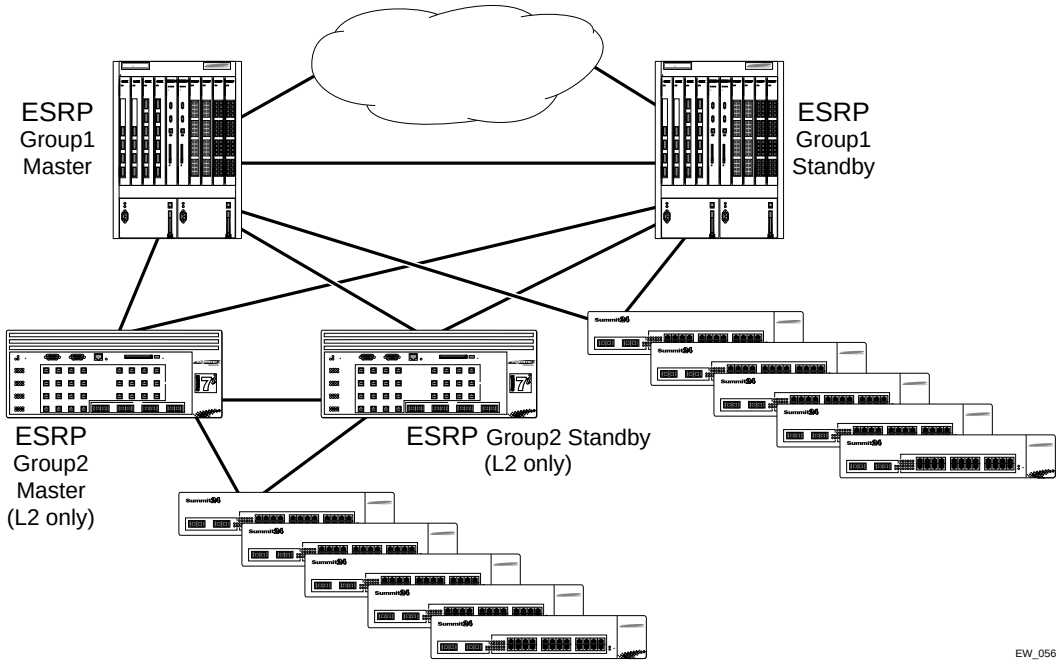
ESRP Groups

ExtremeWare supports running multiple instances of ESRP within the same VLAN or broadcast domain. This functionality is called an ESRP group. Though other uses exist, the most typical application for multiple ESRP groups is when two or more sets of ESRP switches are providing

fast-failover protection within a subnet. A maximum of four distinct ESRP groups can be supported within the same networked broadcast domain.

For example, two ESRP switches provide L2/L3 connectivity and redundancy for the subnet, while another two ESRP switches provide L2 connectivity and redundancy for a portion of the same subnet. Figure 55 shows ESRP groups.

Figure 55: ESRP groups



NOTE

A switch cannot perform both master and slave functions on the same VLAN for separate instances of ESRP.

An additional user for ESRP groups is ESRP Host Attach (HA), described on page 273.

Linking ESRP Switches

When considering system design using ESRP, direct links between ESRP switches are useful under the following conditions:

- A direct link can provide a more direct routed path, if the ESRP switches are routing and supporting multiple VLANs where the master/standby configuration is split such that one switch is master for some VLANs and a second switch is master for other VLANs. The direct link can contain a unique router-to-router VLAN/subnet, so that the most direct routed path between two VLANs with different master switches uses a direct link, instead of forwarding through another set of connected routers.
- A direct link can be used as a highly reliable method to exchange ESRP hellos, so that the possibility of having multiple masters for the same VLAN is lessened, should all downstream layer 2 switches fail.

- A direct link is necessary when the ESRP HA option. The direct link is used to provide layer 2 forwarding services through an ESRP standby switch.

Direct links may contain a router-to-router VLAN, along with VLANs running ESRP. If multiple VLANs are used on the direct links, use 802.1Q tagging. The direct links may be aggregated into a load-shared group, if desired.

Configuring ESRP and Multinetting

When configuring ESRP and IP multinetting on the same switch, the parameters that affect the determination of the ESRP master must be configured identically for all the VLANs involved with IP multinetting. For example, the number of links in your configuration, the priority settings, and timer settings must be identical for all affected VLANs.

ESRP and Spanning Tree

A switch running ESRP should not simultaneously participate in the Spanning Tree Protocol (STP) for the same VLAN(s). Other switches in the VLAN being protected by ESRP may run STP and the switch running ESRP forwards, but does not filter, STP BPDUs. Therefore, you can combine ESRP and STP on a network and a VLAN, but you must do so on separate devices. You should be careful to maintain ESRP connectivity between ESRP master and standby switches when you design a network that uses ESRP and STP.

ESRP Port Restart

You can configure ESRP to restart ports in the ESRP master VLAN when the downstream switch is a non-Extreme switch. This restarts the ports when the state changes to slave. To configure port restart, use the following command:

```
config vlan <vlan name> add ports [<portlist> | all] restart
```

To disable port restart, use the following command:

```
config vlan <vlan name> add ports [<portlist> | all] no-restart
```

If a VLAN becomes a slave, ESRP disconnects member ports that have port restart enabled. The disconnection of these ports causes downstream devices to remove the ports from their FDB tables. This feature allows you to use ESRP in networks that include equipment from other vendors. After 3 seconds the ports re-establish connection with the ESRP switch.

To remove a port from the restart configuration, delete the port from the VLAN and re-add it.

NOTE

The port restart feature is also available for VRRP. For more information on VRRP, see Chapter 15.

ESRP and VLAN Aggregation

ESRP can be used to provide redundant default router protection to VLAN aggregation clients. ESRP is enabled on the super-VLAN *only* (not the sub-VLANs). The procedure is to add ports to the super-VLAN that is shared with the sub VLANs. To do so, the super-VLAN should be configured with an 802.1Q tag, and added as tagged with the sub-VLAN ports to avoid a protocol conflict. Lastly, enable ESRP on the super-VLAN.

NOTE

All ports must be tagged for the super-VLAN.

The following example combines ESRP and VLAN aggregation for the super-VLAN *vsuper* and two sub-VLANs, *v1sub* and *v2sub*, that have ports 1 and 2 as members, respectively.

1 Create the VLANs and set up the super to sub-VLAN relationship.

```
create vlan v1sub
create vlan v2sub
create vlan vsuper
config vsuper ipaddress 10.1.2.3/24
enable ipforwarding
enable ospf
config ospf add vsuper area 0.0.0.0
config v1sub add port 1
config v2sub add port 2
config vsuper add subvlan v1sub
config vsuper add subvlan v2sub
```

2 Turn on ESRP for the VLAN *vsuper*.

```
config vsuper tag 1234
config vsuper add port 1,2 tagged
enable esrp vlan vsuper
```

Use the following commands to verify the configuration:

- `show vlan {detail}`— Displays super- and sub-VLAN relationships, IP addresses, and port membership.
- `show esrp {detail}`—Verifies ESRP is enabled and operational.

ESRP Examples

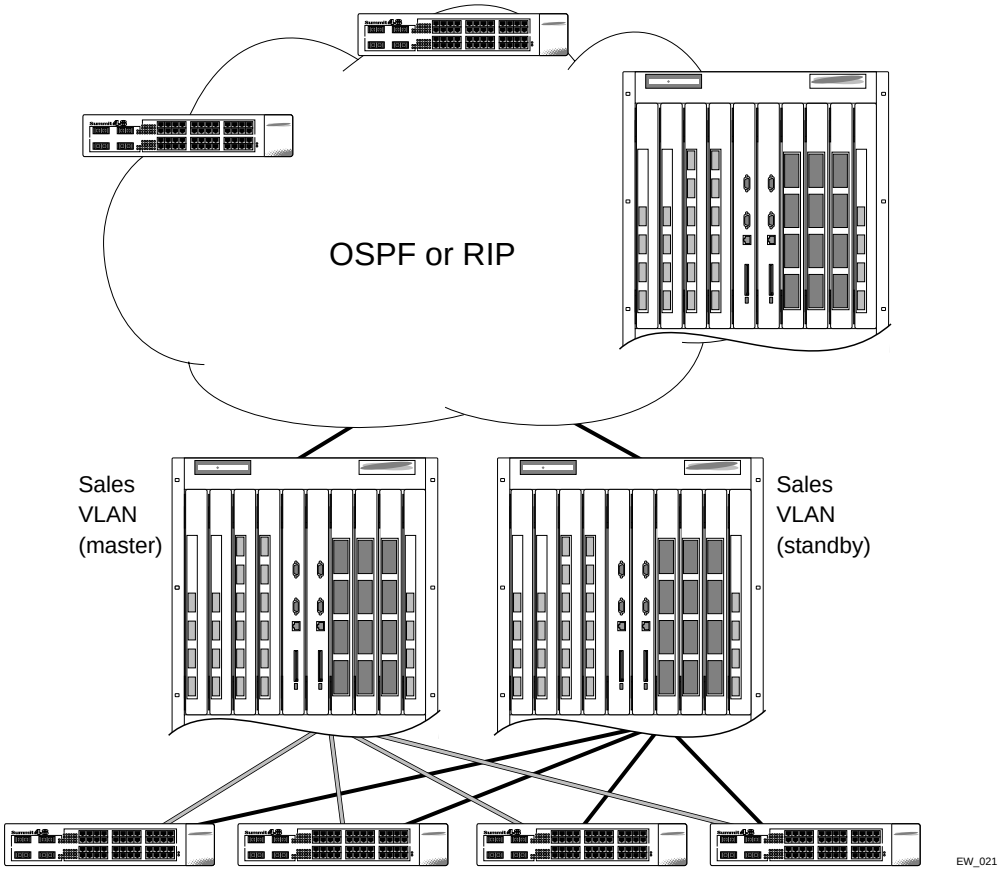
This section provides examples of ESRP configurations.

Single VLAN Using Layer 2 and Layer 3 Redundancy

This example, shown in Figure 56, uses a number of Summit switches that perform layer 2 switching for VLAN *Sales*. The Summit switches are dual-homed to the BlackDiamond switches. The BlackDiamond switches perform layer 2 switching between the Summit switches and layer 3 routing to the outside world. Each Summit switch is dual-homed using active ports to two BlackDiamond switches (as many as four could be used). ESRP is enabled on each BlackDiamond switch only for the VLAN that interconnects to the Summit switches. Each BlackDiamond switch has the VLAN *Sales* configured using

the identical IP address. The BlackDiamond switches then connect to the routed enterprise normally, using the desired routing protocol (for example RIP or OSPF).

Figure 56: ESRP example using layer 2 and layer 3 redundancy



The BlackDiamond switch, acting as master for VLAN *Sales*, performs both layer 2 switching and layer 3 routing services for VLAN *Sales*. The BlackDiamond switch in standby mode for VLAN *Sales* performs neither, thus preventing bridging loops in the VLAN. The BlackDiamond switch in standby mode does, however, exchange ESRP packets with the master BlackDiamond switch.

There are four paths between the BlackDiamond switches on VLAN *Sales*. All the paths are used to send ESRP packets, allowing for four redundant paths for ESRP communication. The Summit switches, being ESRP-aware, allow traffic within the VLAN to fail-over quickly, as they will sense when a master/slave transition occurs and flush FDB entries associated with the uplinks to the ESRP-enabled BlackDiamond switches.

The following commands are used to configure both BlackDiamond switches. The assumption is that the inter-router backbone is running OSPF, with other routed VLANs already properly configured. Similar commands would be used to configure a switch on a network running RIP. The primary requirement is that the IP address for the VLAN(s) running ESRP must be identical. In this scenario, the master is determined by the programmed MAC address of the switch, because the number of active links for the VLAN and the priority are identical to both switches.

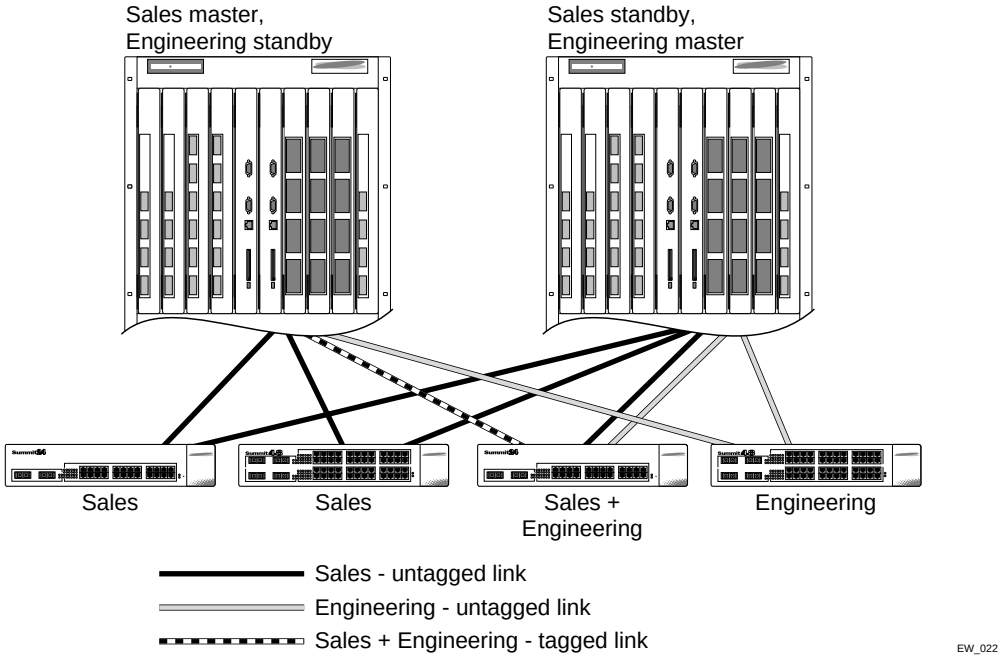
The commands used to configure the BlackDiamond switches are as follows:

```
create vlan sales
config sales add port 1:1-1:4
config sales ipaddr 10.1.2.3/24
enable ipforwarding
enable esrp sales
enable edp ports all
config ospf add vlan sales
enable ospf
```

Multiple VLANs Using Layer 2 Redundancy

The example shown in Figure 57 illustrates an ESRP configuration that has multiple VLANs using layer 2 redundancy.

Figure 57: ESRP example using layer 2 redundancy



This example builds on the previous example, but eliminates the requirement of layer 3 redundancy. It has the following features:

- An additional VLAN, *Engineering*, is added that uses layer 2 redundancy.
- The VLAN *Sales* uses three active links to each BlackDiamond switch.
- The VLAN *Engineering* has two active links to each BlackDiamond switch.
- The third Summit switch carries traffic for both VLANs.
- The link between the third Summit switch and the first BlackDiamond switch uses 802.1Q tagging to carry traffic from both VLANs traffic on one link. The BlackDiamond switch counts the link active for each VLAN.
- The second BlackDiamond switch has a separate physical port for each VLAN connected to the third Summit switch.

In this example, the BlackDiamond switches are configured for ESRP such that the VLAN *Sales* normally uses the first BlackDiamond switch and the VLAN *Engineering* normally uses the second BlackDiamond switch. This is accomplished by manipulating the ESRP priority setting for each VLAN for the particular BlackDiamond switch.

Configuration commands for the first BlackDiamond switch are as follows:

```
create vlan sales
config sales tag 10
config sales add port 1:1-1:2
config sales add port 1:3 tagged
config sales ipaddr 10.1.2.3/24
create vlan eng
config eng tag 20
config eng add port 1:4
config eng add port 1:3 tagged
config eng ipaddr 10.4.5.6/24
enable esrp sales
enable esrp eng
enable edp ports all
config sales esrp priority 5
```

Configuration commands for the second BlackDiamond switch are as follows:

```
create vlan sales
config sales add port 1:1-1:3
config sales ipaddr 10.1.2.3/24
create vlan eng
config eng add port 1:4, 2:1
config eng ipaddr 10.4.5.6/24
enable esrp sales
enable esrp eng
config eng esrp priority 5
```

Displaying ESRP Information

To verify the operational state of an ESRP VLAN and the state of its neighbor, use the following command:

```
show esrp
```

To view tracking information about a particular VLAN, including the VLANs tracked by it and a list of the VLANs tracking it, use the `show vlan` command.

To view ESRP configuration information and ESRP counters for a specific VLAN, use the following command:

```
show esrp vlan <vlan name> {counters}
```

15 Virtual Router Redundancy Protocol

This chapter covers the following topics:

- Overview on page 281
- Determining the VRRP Master on page 282
- Additional VRRP Highlights on page 285
- VRRP Operation on page 286
- VRRP Configuration Parameters on page 288
- VRRP Examples on page 289

This chapter assumes that you are already familiar with the Virtual Router Redundancy Protocol (VRRP). If not, refer to the following publications for additional information:

- RFC 2338—*Virtual Router Redundancy Protocol (VRRP)*
- RFC 2787—*Definitions of Managed Objects for the Virtual Router Redundancy Protocol*

Overview

Like ESRP, VRRP is a protocol that allows multiple switches to provide redundant routing services to users. VRRP is used to eliminate the single point of failure associated with manually configuring a default gateway address on each host in a network. Without using VRRP, if the configured default gateway fails, you must reconfigure each host on the network to use a different router as the default gateway. VRRP provides a redundant path for the hosts. If the default gateway fails, the backup router assumes forwarding responsibilities.

NOTE

IGMP snooping must be enabled for VRRP to operate correctly.

VRRP Terms

Table 37 describes terms associated with VRRP.

Table 37: VRRP Terms

Term	Description
virtual router	A VRRP router is a group of one or more physical devices that acts as the default gateway for hosts on the network. The virtual router is identified by a virtual router identifier (VRID) and an IP address.
VRRP router	Any router that is running VRRP. A VRRP router can participate in one or more virtual routers. A VRRP router can be a backup router for one more master routers.
IP address owner	A single VRRP router that has the IP address of the virtual router configured as its real interface address. The IP address owner responds to TCP/IP packets addressed to the virtual router IP address. The IP address owner is optional in a VRRP configuration.
master router	The physical device (router) in the virtual router that is responsible for forwarding packets sent to the virtual router, and responding to ARP requests. The master router sends out periodic advertisements that let backup routers on the network know that it is alive. If the IP address owner is identified, it always becomes the master.
backup router	Any VRRP router in the virtual router that is not elected as the master. The backup router is available to assume forwarding responsibility if the master becomes unavailable.
VRID	Virtual router identifier. Each virtual router is given a unique VRID. All of the VRRP routers that participate in the virtual router are assigned the same VRID.
virtual router MAC address	RFC 2338 assigns a static MAC address for the first 5 octets of the virtual router. These octets are set to 00-00-5E-00-01. When you configure the VRID, the last octet of the MAC address is dynamically assigned the VRID number.

Determining the VRRP Master

The VRRP master is determined by the following factors:

- **IP address**—If a router is configured with the IP address of the virtual IP address, it becomes the master.
- **VRRP priority**—This is a user-defined field. The range of the priority value is 1 to 254; a higher number has higher priority. The value of 255 is reserved for a router that is configured with the virtual router IP address. A value of 0 is reserved for the master router, to indicate it is releasing responsibility for the virtual router. The default value is 100.
- **Higher IP address**—If the routers have the same configured priority, the router with the higher IP address becomes the master.

VRRP Tracking

Tracking information is used to track various forms of connectivity from the VRRP router to the outside world. This section describes the following VRRP tracking options:

- VRRP VLAN tracking
- VRRP route table tracking
- VRRP ping tracking

VRRP VLAN Tracking

You can configure VRRP to track connectivity to one or more specified VLANs as criteria for failover. If no active ports remain on the specified VLANs, the router automatically relinquishes master status and remains in backup mode.

To add or delete a tracked VLAN, use the following command:

```
config vlan <vlan name> [add | delete] track-vlan <vlan name>
```

VRRP Route Table Tracking

You can configure VRRP to track specified routes in the route table as criteria for failover. If any of the configured routes are not available within the route table, the router automatically relinquishes master status and remains in backup mode.

To add or delete a tracked route, use the following command:

```
config vlan <vlan name> [add | delete] track-route <ipaddress/mask_length>
```

VRRP Ping Tracking

You can configure VRRP to track connectivity using a simple ping to any outside responder. The responder may represent the default route of the router, or any device meaningful to network connectivity of the master VRRP router. The router automatically relinquishes master status and remains in backup mode if a ping keepalive fails three consecutive times.

To add or delete a tracked route, use the following command:

```
config vlan <vlan name> [add | delete] track-ping <ipaddress> frequency <number> miss
<number>
```

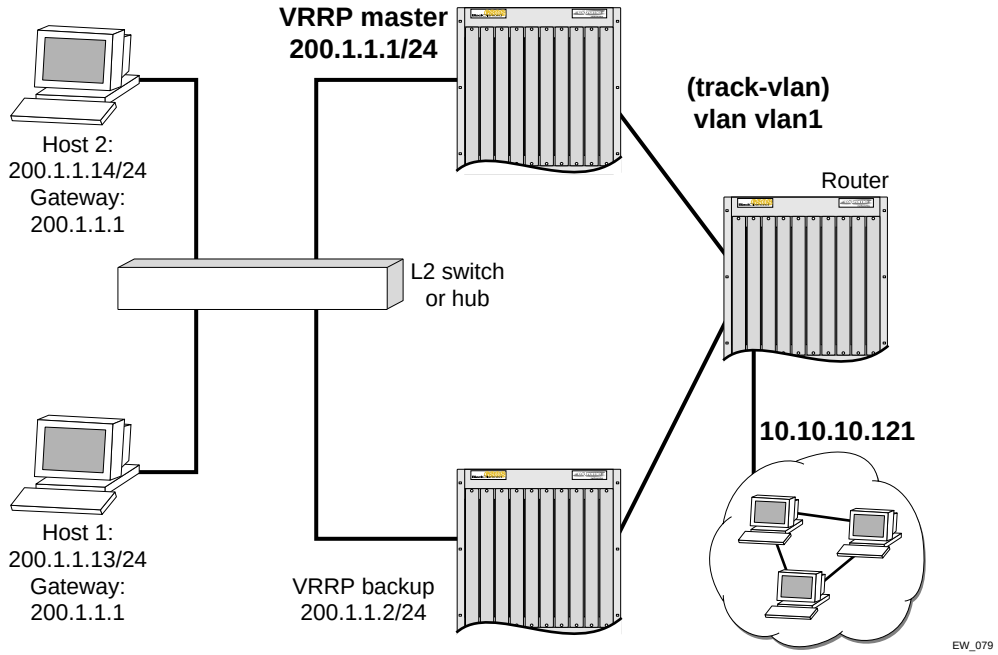
To view the status of tracked devices, use the following command:

```
show vrrp {vlan <vlan name>} {detail}
```

VRRP Tracking Example

Figure 58 is an example of VRRP tracking.

Figure 58: VRRP tracking



To configure VLAN tracking, as shown in Figure 58, use the following command:

```
Configure vlan vrrp1 add track-vlan vlan1
```

Using the tracking mechanism, if VLAN1 fails, the VRRP master realizes that there is no path to upstream router via the Master switch and implements a failover to the backup.

To configure route table tracking, as shown in Figure 58, use the following command:

```
Config vlan vrrp1 add track-iproute 10.10.10.0/24
```

The route specified in this command must exist in the IP routing table. When the route is no longer available, the switch implements a failover to the backup.

To configure ping tracking, as shown in Figure 58, use the following command:

```
Config vlan vrrp1 add track-ping 10.10.10.121 2 2
```

The specified IP address is tracked. If the fail rate is exceeded the switch implements a failover to the backup.

Electing the Master Router

VRRP uses an election algorithm to dynamically assign responsibility for the master router to one of the VRRP routers on the network. A VRRP router is elected master if one of the following is true:

- The router is the IP address owner.
- The router is configured with the highest priority (the range is 3 - 255).

If the master router becomes unavailable, the election process provides dynamic failover and the backup router that has the highest priority assumes the role of master.

A new master is elected when one of the following things happen:

- VRRP is disabled on the master router.
- Loss of communication between master and backup router(s).

When VRRP is disabled on the master interface, the master router sends an advertisement with the priority set to 0 to all backup routers. This signals the backup routers that they do not need to wait for the master down interval to expire, and the master election process for a new master can begin immediately.

The master down interval is set as follows:

3 * advertisement interval + skew time

Where:

- The advertisement interval is a user-configurable option.
- The skew time is (256-priority / 256).

Additional VRRP Highlights

The following additional points pertain to VRRP:

- VRRP packets are encapsulated IP packets.
- The VRRP multicast address is 224.0.0.18.
- The virtual router MAC address is `00 00 5E 00 01 <vrid>`
- Duplicate virtual router IDs are allowed on the router, but not on the same interface.
- The maximum number of supported VRIDs per interface is 4.
- An interconnect link between VRRP routers should not be used, except when VRRP routers have hosts directly attached.
- A maximum of 64 VRID instances are supported on the router.
- Up to 4 unique VRIDs can be configured on the router. VRIDs can be re-used, but not on the same interface.
- VRRP and Spanning Tree can be simultaneously enabled on the same switch.
- VRRP and ESRP cannot be simultaneously enabled on the same switch.

VRRP Port Restart

You can configure VRRP to restart ports if those ports are members of a VLAN that becomes a backup. To configure port restart, use the following command:

```
config vlan <vlan name> add ports [<portlist> | all] restart
```

To disable port restart, use the following command:

```
config vlan <vlan name> add ports [<portlist> | all] no-restart
```

If a VLAN becomes a backup, VRRP disconnects member ports that have port restart enabled. The disconnection of these ports causes downstream devices to remove the ports from their FDB tables. This feature allows you to use VRRP in networks that include equipment from other vendors. After 3 seconds the ports re-establish connection with the VRRP switch.

To remove a port from the restart configuration, delete the port from the VLAN and re-add it.

NOTE

The port restart feature is also available for ESRP. For more information on ESRP, see Chapter 14.

VRRP Operation

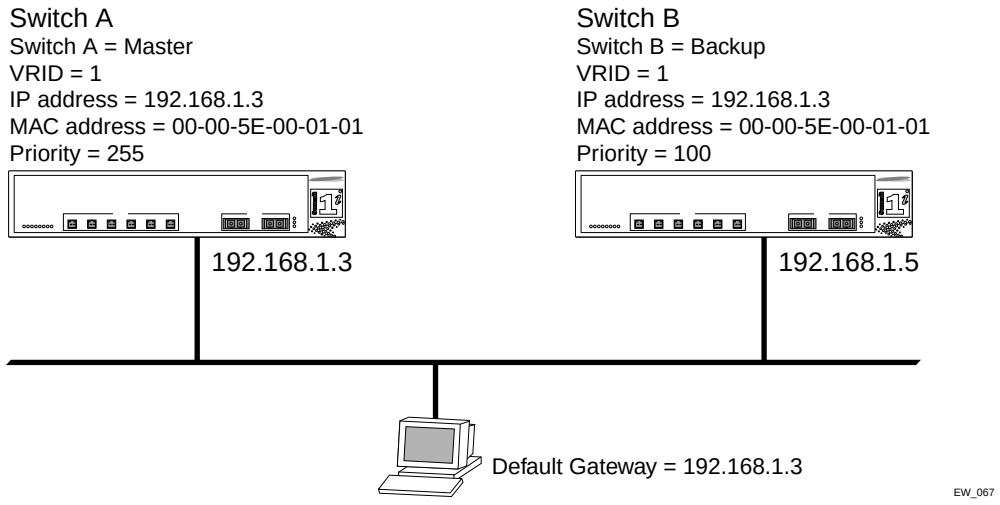
This section describes two VRRP network configuration:

- A simple VRRP network
- A fully-redundant VRRP network

Simple VRRP Network Configuration

Figure 59 shows a simple VRRP network.

Figure 59: Simple VRRP network



In Figure 59, a virtual router is configured on Switch A and Switch B using these parameters:

- VRID is 1.
- MAC address is 00-00-5E-00-01-01.
- IP address is 192.168.1.3.

Switch A is configured with a priority of 255. This priority indicates that it is the master router. Switch B is configured with a priority of 100. This indicates that it is a backup router.

The master router is responsible for forwarding packets sent to the virtual router. When the VRRP network becomes active, the master router broadcasts an ARP request that contains the virtual router MAC address (in this case, 00-00-5E-00-01-01) for each IP address associated with the virtual router. Hosts on the network use the virtual router MAC address when they send traffic to the default gateway.

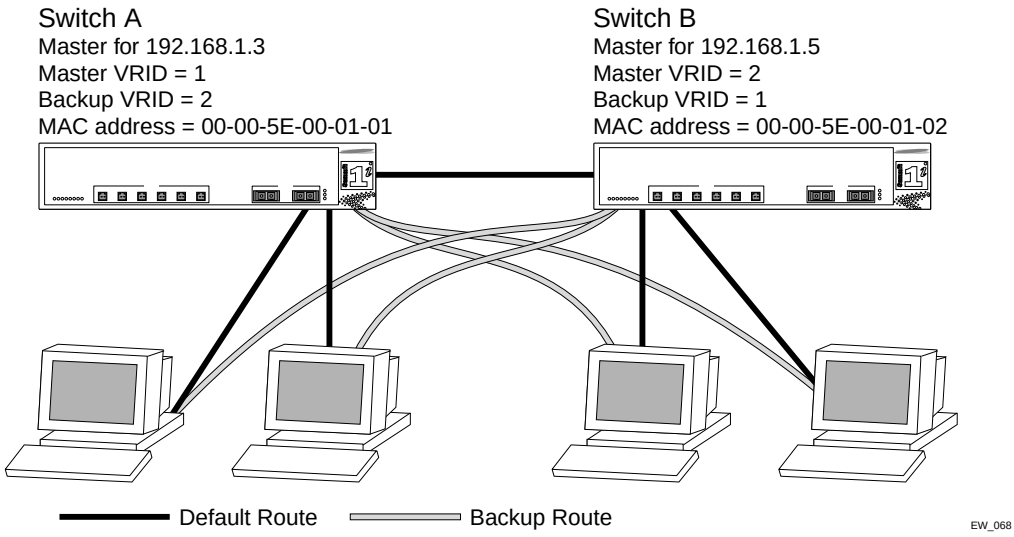
The virtual router IP address is configured to be the real interface address of the IP address owner. The IP address owner is usually the master router. The virtual router IP address is also configured on each backup router. However, in the case of the backup router, this IP address is not associated with a physical interface. Each physical interface on each backup router must have a unique IP address. The virtual router IP address is also used as the default gateway address for each host on the network.

If the master router fails, the backup router assumes forwarding responsibility for traffic addressed to the virtual router MAC address. However, because the IP address associated with the master router is not physically located on the backup router, the backup router cannot reply to TCP/IP messages (such as pings) sent to the virtual router.

Fully-Redundant VRRP Network

You can use two or more VRRP-enabled switches to provide a fully-redundant VRRP configuration on your network. Figure 60 shows a fully-redundant VRRP configuration.

Figure 60: Fully-redundant VRRP configuration



In Figure 60, switch A is configured as follows:

- IP address 192.168.1.3

- Master router for VRID 1
- Backup router for VRID 2
- MAC address 00-00-5E-00-01-01

Switch B is configured as follows:

- IP address 192.168.1.5
- Master router for VRID 2
- Backup router for VRID 1
- MAC address 00-00-5E-00-01-02

Both virtual routers are simultaneously operational. The traffic load from the four hosts is split between them. Host 1 and host 2 are configured to use VRID 1 on switch A as their default gateway. Host 3 and host 4 are configured to use VRID 2 on switch B as their default gateway. In the event that either switch fails, the backup router configured is standing by to resume normal operation.

VRRP Configuration Parameters

Table 38 lists the parameters that are configured on a VRRP router.

Table 38: VRRP Configuration Parameters

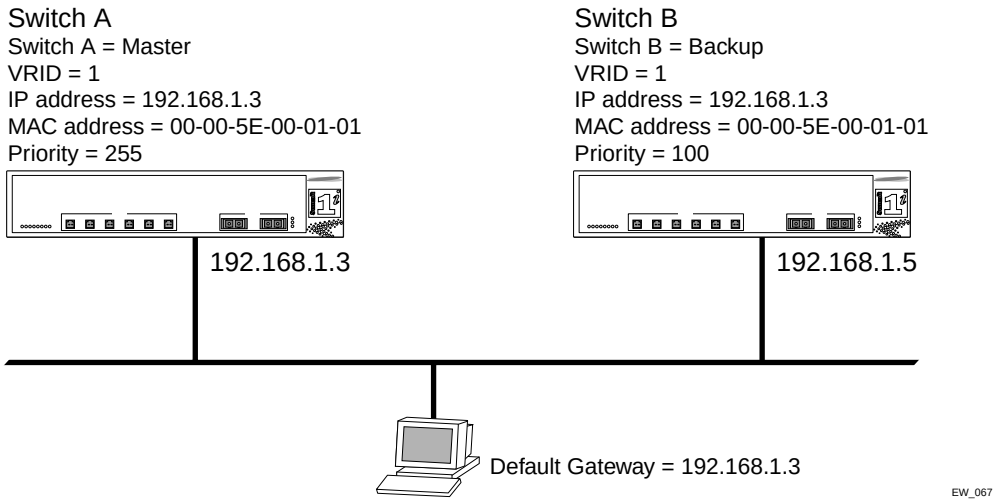
Parameter	Description
vrid	Virtual router identifier. Configured item in the range of 1- 255. This parameter has no default value.
priority	Priority value to be used by this VRRP router in the master election process. A value of 255 is reserved for a router that is configured with the virtual router IP address. A value of 0 is reserved for the master router to indicate it is releasing responsibility for the virtual router. The range is 1 - 254. The default value is 100.
ip_address	One or more IP addresses associated with this virtual router. This parameter has no default value.
advertisement_interval	Time interval between advertisements, in seconds. The range is 1 - 255. The default value is 1 second.
skew_time	Time to skew master_down_interval, in seconds. This value is calculated as ((256-priority)/256).
master_down_interval	Time interval for backup router to declare master down, in seconds. This value is calculated as ((3 * advertisement_interval) + skew_time).
preempt_mode	Controls whether a higher priority backup router preempts a lower priority master. A value of true allows preemption. A value of false prohibits preemption. The default setting is true. **NOTE** *The router that owns the virtual router IP address always preempts, independent of the setting of this parameter.*

VRRP Examples

This section provides the configuration syntax for the two VRRP networks discussed in this chapter.

Configuring the Simple VRRP Network

The following illustration shows the simple VRRP network described in Figure 59.



The configuration commands for switch A are as follows:

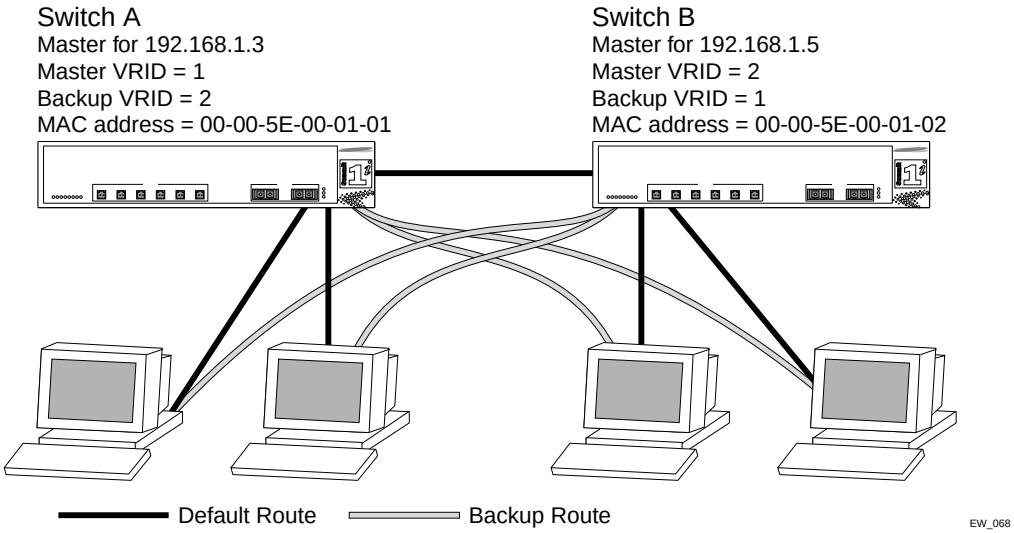
```
config vlan vlan1 ipaddress 192.168.1.3/24
config vrrp add vlan vlan2
config vrrp vlan vlan1 add master vrid 1 192.168.1.3
enable vrrp
```

The configuration commands for switch B are as follows:

```
config vlan vlan1 ipaddress 192.168.1.5/24
config vrrp add vlan vlan1
config vrrp vlan vlan1 add backup vrid 1 192.168.1.3
enable vrrp
```

Configuring the Fully-Redundant VRRP Network

The following illustration shows the fully-redundant VRRP network configuration described in Figure 60.



The configuration commands for switch A are as follows:

```
config vlan vlan1 ipaddress 192.168.1.3/24
config vrrp vlan vlan1 add master vrid 1 192.168.1.3
config vrrp vlan vlan1 add backup vrid 2 192.168.1.5
config vrrp add vlan vlan1
enable vrrp
```

The configuration commands for switch B are as follows:

```
config vlan vlan1 ipaddress 192.168.1.5/24
config vrrp vlan vlan1 add master vrid 2 192.168.1.5
config vrrp vlan vlan1 add backup vrid 1 192.168.1.3
config vrrp add vlan vlan1
enable vrrp
```

16 IP Unicast Routing

This chapter describes the following topics:

- Overview of IP Unicast Routing on page 291
- Proxy ARP on page 295
- Relative Route Priorities on page 296
- Configuring IP Unicast Routing on page 297
- Routing Configuration Example on page 297
- IP Multinetting on page 299
- Configuring DHCP/BOOTP Relay on page 302
- UDP-Forwarding on page 302
- VLAN Aggregation on page 304

This chapter assumes that you are already familiar with IP unicast routing. If not, refer to the following publications for additional information:

- RFC 1256—*ICMP Router Discovery Messages*
- RFC 1812—*Requirements for IP Version 4 Routers*

NOTE

For more information on interior gateway protocols, see Chapter 17. For information on exterior gateway protocols, see Chapter 18.

Overview of IP Unicast Routing

The switch provides full layer 3, IP unicast routing. It exchanges routing information with other routers on the network using either the Routing Information Protocol (RIP) or the Open Shortest Path First (OSPF) protocol. The switch dynamically builds and maintains a routing table, and determines the best path for each of its routes.

Each host using the IP unicast routing functionality of the switch must have a unique IP address assigned. In addition, the default gateway assigned to the host must be the IP address of the router interface.

Router Interfaces

The routing software and hardware routes IP traffic between router interfaces. A router interface is simply a VLAN that has an IP address assigned to it.

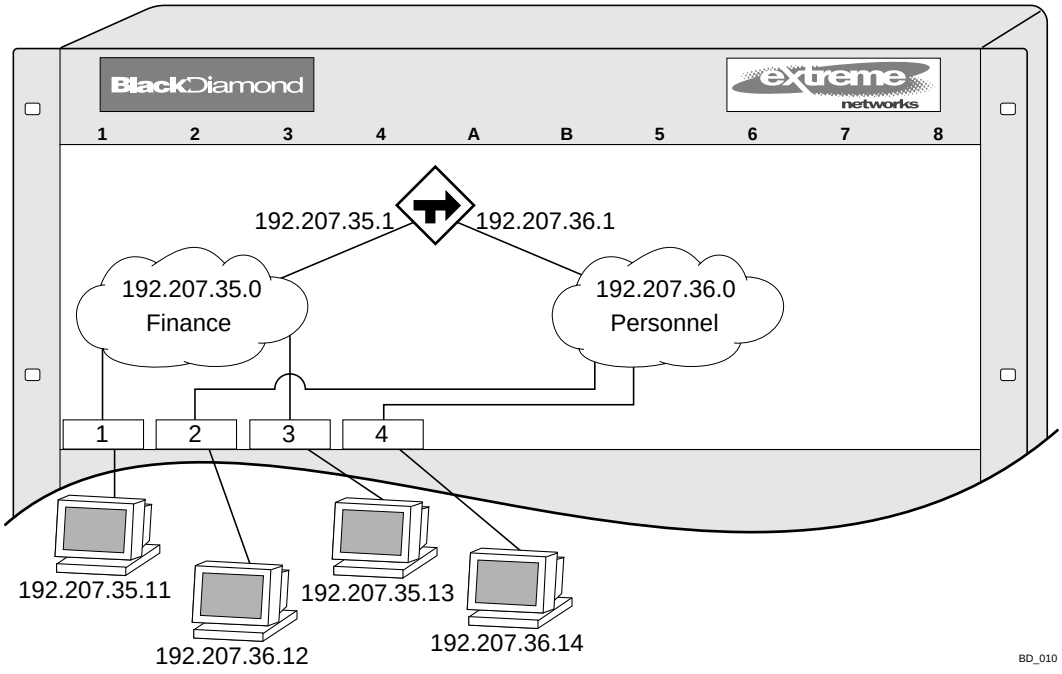
As you create VLANs with IP addresses belonging to different IP subnets, you can also choose to route between the VLANs. Both the VLAN switching and IP routing function occur within the switch.

NOTE

Each IP address and mask assigned to a VLAN must represent a unique IP subnet. You cannot configure the same IP address and subnet on different VLANs.

In Figure 61, a BlackDiamond switch is depicted with two VLANs defined; *Finance* and *Personnel*. All ports on slots 1 and 3 are assigned to *Finance*; all ports on slots 2 and 4 are assigned to *Personnel*. *Finance* belongs to the IP network 192.207.35.0; the router interface for *Finance* is assigned the IP address 192.206.35.1. *Personnel* belongs to the IP network 192.207.36.0; its router interface is assigned IP address 192.207.36.1. Traffic within each VLAN is switched using the Ethernet MAC addresses. Traffic between the two VLANs is routed using the IP addresses.

Figure 61: Routing between VLANs



Populating the Routing Table

The switch maintains an IP routing table for both network routes and host routes. The table is populated from the following sources:

- Dynamically, by way of routing protocol packets or by ICMP redirects exchanged with other routers
- Statically, by way of routes entered by the administrator
  - Default routes, configured by the administrator
  - Locally, by way of interface addresses assigned to the system
  - By other static routes, as configured by the administrator

NOTE

If you define a default route, and subsequently delete the VLAN on the subnet associated with the default route, the invalid default route entry remains. You must manually delete the configured default route.

Dynamic Routes

Dynamic routes are typically learned by way of RIP or OSPF. Routers that use RIP or OSPF exchange information in their routing tables in the form of advertisements. Using dynamic routes, the routing table contains only networks that are reachable.

Dynamic routes are aged out of the table when an update for the network is not received for a period of time, as determined by the routing protocol.

Static Routes

Static routes are manually entered into the routing table. Static routes are used to reach networks not advertised by routers.

Static routes can also be used for security reasons, to control which routes you want advertised by the router. You can decide if you want all static routes to be advertised, using one of the following commands:

```
[enable | disable] rip export static
[enable | disable] ospf export static
```

The default setting is disabled. Static routes are never aged out of the routing table.

A static route must be associated with a valid IP subnet. An IP subnet is associated with a single VLAN by its IP address and subnet mask. If the VLAN is subsequently deleted, the static route entries using that subnet must be deleted manually.

Multiple Routes

When there are multiple, conflicting choices of a route to a particular destination, the router picks the route with the longest matching network mask. If these are still equal, the router picks the route using the following criteria (in the order specified):

- Directly attached network interfaces
- ICMP redirects
- Static routes

- Directly attached network interfaces that are not active.

NOTE

If you define multiple default routes, the route that has the lowest metric is used. If multiple default routes have the same lowest metric, the system picks one of the routes.

You can also configure *blackhole* routes—traffic to these destinations is silently dropped.

IP Route Sharing

IP route sharing allows multiple equal-cost routes to be used concurrently. IP route sharing can be used with static routes or with OSPF routes. In OSPF, this capability is referred to as *equal cost multipath* (ECMP) routing. To use IP route sharing, use the following command:

```
enable iproute sharing
```

Next, configure static routes and/or OSPF as you would normally. ExtremeWare supports unlimited route sharing across static routes and up to 12 ECMP routes for OSPF.

Route sharing is useful only in instances where you are constrained for bandwidth. This is typically not the case using Extreme switches. Using route sharing makes router troubleshooting more difficult because of the complexity in predicting the path over which the traffic will travel.

Route Maps

Route maps for IP routing can be configured based on the route origin. When routes are added to the IP routing table from various source, the route map configured for the origin of the route is applied to the route. After matching on specified characteristics, the characteristics for the route can be modified using the route maps. The characteristics that can be matched and modified are dependent on the origin of the route. Route maps for IP routing can be dynamically changed. In the case of direct and static route origins, the changes are reflected immediately. In the case of routes that are sourced from other origin, the changes are reflected within 30 seconds.

To configure route maps for IP routing, use the following command:

```
config iproute route-map [bgp | direct | e-bgp | i-bgp | ospf | ospf-extern1 |
ospf-extern2 | ospf-inter | ospf-intra | rip | static] [<route map> | none]
```

To view the route maps for IP routing, use the following command:

```
show iproute route-map
```

Subnet-Directed Broadcast Forwarding

You can enable or disable the hardware forwarding of subnet-directed broadcast IP packets. This allows the switch to forward subnet-directed broadcast packets at wire-speed.

To enable or disable hardware forwarding, use the following command:

```
[enable | disable] ipforwarding fast-direct-broadcast [vlan <vlan_name>]
```

The entries are added to the IP forwarding table as standard entries and you can view them using the `show ipfdb` command.

You can also configure the VLAN router interface to either forward and process all subnet-directed broadcast packets, or to simply forward these packets after they have been added to the IP forwarding database. The latter option allows you to improve CPU forwarding performance by having upper layers, such as UDP and TCP, ignore broadcast packet processing (for example, if the packets have IP-options configured).

To enable or disable broadcast packet processing, use the following command:

```
[enable | disable] ipforwarding ignore-broadcast vlan <vlan_name>
```

Using these commands together, you can achieve a 30-50% reduction in system processing cycles in forwarding subnet-directed broadcast traffic on a BlackDiamond switch, and a 100% reduction on the Alpine and Summit switches.

NOTE

Although forwarding performance is improved in the BlackDiamond switch, the CPU continues to observe the subnet-directed broadcast packets and does not ignore such packets when traversing modules in a BlackDiamond switch. Only I/O modules containing the "i" series chipset support this command on the BlackDiamond switch.

Proxy ARP

Proxy Address Resolution Protocol (ARP) was first invented so that ARP-capable devices could respond to ARP Request packets on behalf of ARP-incapable devices. Proxy ARP can also be used to achieve router redundancy and simplify IP client configuration. The switch supports proxy ARP for this type of network configuration. The section describes some example of how to use proxy ARP with the switch.

ARP-Incapable Devices

To configure the switch to respond to ARP Requests on behalf of devices that are incapable of doing so, you must configure the IP address and MAC address of the ARP-incapable device using the use the following command:

```
config iparp add proxy <ipaddress> {<mask>} <mac_address> {always}
```

Once configured, the system responds to ARP Requests on behalf of the device as long as the following conditions are satisfied:

- The valid IP ARP Request is received on a router interface.
- The target IP address matches the IP address configured in the proxy ARP table.
- The proxy ARP table entry indicates that the system should always answer this ARP Request, regardless of the ingress VLAN (the `always` parameter must be applied).

Once all the proxy ARP conditions are met, the switch formulates an ARP Response using the configured MAC address in the packet.

Proxy ARP Between Subnets

In some networks, it is desirable to configure the IP host with a wider subnet than the actual subnet mask of the segment. Proxy ARP can be used so that the router answers ARP Requests for devices outside of the subnet. As a result, the host communicates as if all devices are local. In reality, communication with devices outside of the subnet are proxied by the router.

For example, an IP host is configured with a class B address of 100.101.102.103 and a mask of 255.255.0.0. The switch is configured with the IP address 100.101.102.1 and a mask of 255.255.255.0. The switch is also configured with a proxy ARP entry of IP address 100.101.0.0 and mask 255.255.0.0, *without* the `always` parameter.

When the IP host tries to communicate with the host at address 100.101.45.67, the IP hosts communicates as if the two hosts are on the same subnet, and sends out an IP ARP Request. The switch answers on behalf of the device at address 100.101.45.67, using its own MAC address. All subsequent data packets from 100.101.102.103 are sent to the switch, and the switch routes the packets to 100.101.45.67.

Relative Route Priorities

Table 39 lists the relative priorities assigned to routes depending upon the learned source of the route.

NOTE

Although these priorities can be changed, do not attempt any manipulation unless you are expertly familiar with the possible consequences.

Table 39: Relative Route Priorities

Route Origin	Priority
Direct	10
BlackHole	50
Static	1100
ICMP	1200
OSPFIntra	2200
OSPFInter	2300
RIP	2400
OSPFExtern1	3200
OSPFExtern2	3300
BOOTP	5000

To change the relative route priority, use the following command:

```
config iproute priority [rip | bootp | icmp | static | ospf-intra | ospf-inter |
ospf-as-external | ospf-extern1 | ospf-extern2] <priority>
```

Configuring IP Unicast Routing

This section describes the commands associated with configuring IP unicast routing on the switch. To configure routing, follow these steps:

1. Create and configure two or more VLANs.
2. Assign each VLAN that will be using routing an IP address using the following command:

   `config vlan <name> ipaddress <ipaddress> {<mask>}`

   Ensure that each VLAN has a unique IP address.
3. Configure a default route using the following command:

   `config iproute add default <gateway> {<metric>}`

   Default routes are used when the router has no other dynamic or static route to the requested destination.
4. Turn on IP routing for one or all VLANs using the following command:

   `enable ipforwarding {vlan <name>}`
5. Turn on RIP or OSPF using one of the following commands:

   `enable rip`

   enable ospf

Verifying the IP Unicast Routing Configuration

Use the `show iproute` command to display the current configuration of IP unicast routing for the switch, and for each VLAN. The `show iproute` command displays the currently configured routes, and includes how each route was learned.

Additional verification commands include:

- `show iparp`—Displays the IP ARP table of the system.
- `show ipfdb`—Displays the hosts that have been transmitting or receiving packets, and the port and VLAN for each host.
- `show ipconfig`—Displays configuration information for one or more VLANs.

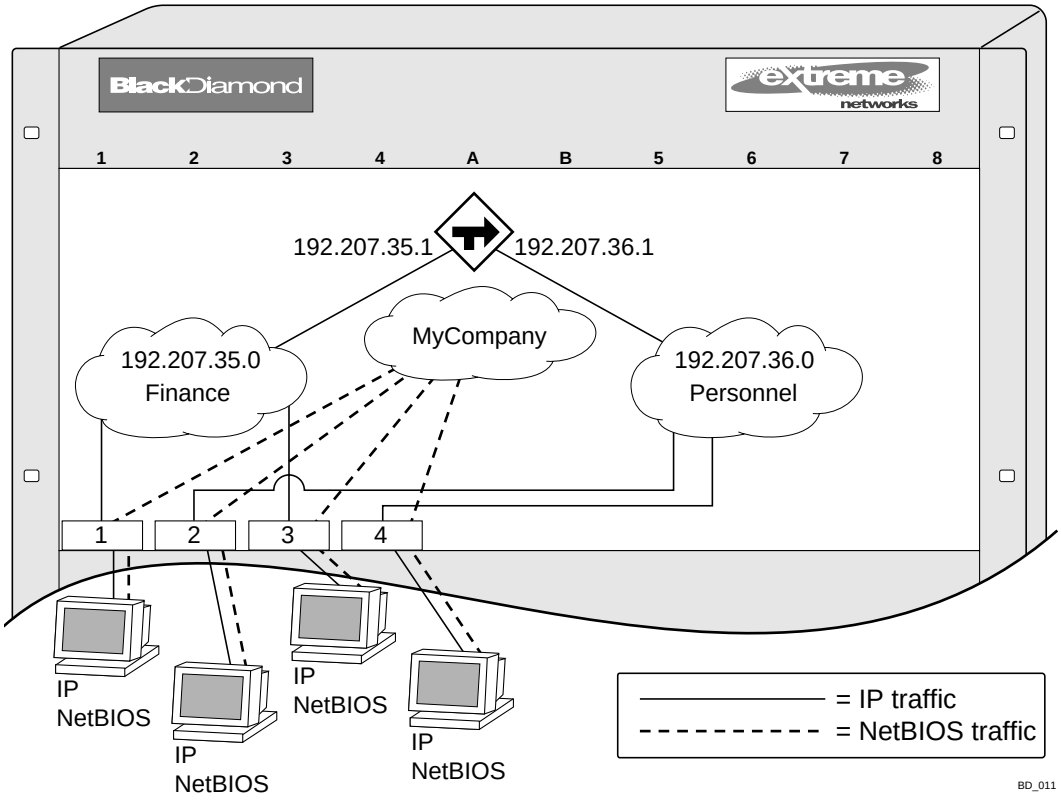
Routing Configuration Example

Figure 62 illustrates a BlackDiamond switch that has three VLANs defined as follows:

- *Finance*
  - Protocol-sensitive VLAN using the IP protocol.
  - All ports on slots 1 and 3 have been assigned.
  - IP address 192.207.35.1.
- *Personnel*
  - Protocol-sensitive VLAN using the IP protocol.
  - All ports on slots 2 and 4 have been assigned.
  - IP address 192.207.36.1.

- *MyCompany*
  - Port-based VLAN.
  - All ports on slots 1 through 4 have been assigned.

Figure 62: Unicast routing configuration example



The stations connected to the system generate a combination of IP traffic and NetBIOS traffic. The IP traffic is filtered by the protocol-sensitive VLANs. All other traffic is directed to the VLAN *MyCompany*.

In this configuration, all IP traffic from stations connected to slots 1 and 3 have access to the router by way of the VLAN *Finance*. Ports on slots 2 and 4 reach the router by way of the VLAN *Personnel*. All other traffic (NetBIOS) is part of the VLAN *MyCompany*.

The example in Figure 62 is configured as follows:

```
create vlan Finance
create vlan Personnel
create vlan MyCompany

config Finance protocol ip
config Personnel protocol ip

config Finance add port 1:*,3:*
config Personnel add port 2:*,4:*
config MyCompany add port all

config Finance ipaddress 192.207.35.1
config Personnel ipaddress 192.207.36.1

config rip add vlan Finance
config rip add vlan Personnel

enable ipforwarding
enable rip
```

IP Multinetting

IP multinetting is used in many legacy IP networks when there is need to overlap multiple subnets onto the same physical segment. Though it can be a critical element in a transition strategy, due to the additional constraints introduced in troubleshooting and bandwidth, it is recommended that multinetting be used as a transitional tactic, and not as a long-term network design strategy.

On the switch, each subnet is represented by a different VLAN, and each of those VLANs has its own IP address. All of the VLANs share the same physical port(s). The switch routes IP traffic from one subnet to another, all within the same physical port(s).

The following rules and comments apply when you are configuring IP multinetting:

- Multiple VLANs share the same physical ports; each of the VLANs is configured with an IP address.
- A maximum of four subnets (or VLANs) on multinetted ports is recommended.
- All VLANs used in the multinetting application must share the same port assignment.
- One VLAN is configured to use an IP protocol filter. This is considered the "primary" VLAN interface for the multinetted group.
- The "secondary" multinetted VLANs can be exported using the `export direct` command.
- The FDB aging timer is automatically set to 3,000 seconds (50 minutes).
- If you are using a UDP or DHCP relay function, only the "primary" VLAN that is configured with the IP protocol filter is capable of servicing these requests.
- The VLAN *default* should not be used for multinetting.

IP Multinetting Operation

To use IP multinetting, follow these steps:

1 Select a slot (modular switches only) and port on which IP multinetting is to run.

For example, slot 1, port 2 on a modular switch, or port 2 on a stand-alone switch.

2 Remove the port from the default VLAN using the following command:

`config default delete port 1:2` (modular switch)

or

`config default delete port 2` (stand-alone switch)

3 Create a dummy protocol by using the following command:

```
create protocol mnet
```

4 Create the multinetted subnets using the following commands:

```
create vlan net21
create vlan net22
```

5 Assign IP addresses to the net VLANs using the following commands:

```
config net21 ipaddress 123.45.21.1 255.255.255.0
config net22 ipaddress 192.24.22.1 255.255.255.0
```

6 Assign one of the subnets to the IP protocol using the following command:

```
config net21 protocol ip
```

7 Assign the other subnets to the dummy protocol using the following command:

```
config net22 protocol mnet
```

8 Assign the subnets to a physical port using the following commands:

```
config net21 add port 1:2
config net22 add port 1:2
```

9 Enable IP forwarding on the subnets using the following command:

```
enable ipforwarding
```

10 Enable IP multinetting using the following command:

```
enable multinetting
```

11 If you are using RIP, disable RIP on the dummy VLANs using the following command:

```
config rip delete net22
```

NOTE

Multinetted VLAN groups must contain identical port assignments.

IP Multinetting Examples

The following example configures a modular switch to have one multinetted segment (slot 5, port 5) that contains three subnets (192.67.34.0, 192.67.35.0, and 192.67.37.0).

```
config default delete port 5:5
create protocol mnet
create vlan net34
create vlan net35
create vlan net37
config net34 ipaddress 192.67.34.1
config net35 ipaddress 192.67.35.1
config net37 ipaddress 192.67.37.1
config net34 protocol ip
config net35 protocol mnet
config net37 protocol mnet
config net34 add port 5:5
config net35 add port 5:5
config net37 add port 5:5
enable ipforwarding
enable multinetting
```

The following example configures a modular switch to have one multinetted segment (slot 5: port 5) that contains three subnets (192.67.34.0, 192.67.35.0, and 192.67.37.0). It also configures a second multinetted segment consisting of two subnets (192.67.36.0 and 192.99.45.0). The second multinetted segment spans three ports (slot1:port 8, slot2:port 9, and slot3:port 10). RIP is enabled on both multinetted segments.

```
config default delete port 5:5
create protocol mnet
create vlan net34
create vlan net35
create vlan net37
config net34 ipaddress 192.67.34.1
config net35 ipaddress 192.67.35.1
config net37 ipaddress 192.67.37.1
config net34 protocol ip
config net35 protocol mnet
config net37 protocol mnet
config net34 add port 5:5
config net35 add port 5:5
config net37 add port 5:5
config default delete port 1:8, 2:9, 3:10
create vlan net36
create vlan net45
config net36 ipaddress 192.67.36.1
config net45 ipaddress 192.99.45.1
config net36 protocol ip
config net45 protocol mnet
config net36 add port 1:8, 2:9, 3:10
config net45 add port 1:8, 2:9, 3:10
config rip add vlan net34
config rip add vlan net36
enable rip
enable ipforwarding
enable multinetting
```

Configuring DHCP/BOOTP Relay

Once IP unicast routing is configured, you can configure the switch to forward Dynamic Host Configuration Protocol (DHCP) or BOOTP requests coming from clients on subnets being serviced by the switch and going to hosts on different subnets. This feature can be used in various applications, including DHCP services between Windows NT servers and clients running Windows 95. To configure the relay function, follow these steps:

1. Configure VLANs and IP unicast routing.
2. Enable the DHCP or BOOTP relay function, using the following command:

   ```
   enable bootprelay
   ```

3. Configure the addresses to which DHCP or BOOTP requests should be directed, using the following command:

   ```
   config bootprelay add <ipaddress>
   ```

To delete an entry, use the following command:

```
config bootprelay delete {<ipaddress> | all}
```

Verifying the DHCP/BOOTP Relay Configuration

To verify the DHCP/BOOTP relay configuration, use the following command:

```
show ipconfig
```

This command displays the configuration of the BOOTP relay service, and the addresses that are currently configured.

UDP-Forwarding

UDP-forwarding is a flexible and generalized routing utility for handling the directed forwarding of broadcast UDP packets. UDP-forwarding allows applications, such as multiple DHCP relay services from differing sets of VLANs, to be directed to different DHCP servers. The following rules apply to UDP broadcast packets handled by this feature:

- If the UDP profile includes BOOTP or DHCP, it is handled according to guidelines in RFC 1542.
- If the UDP profile includes other types of traffic, these packets have the IP destination address modified as configured, and changes are made to the IP and UDP checksums and decrements to the TTL field, as appropriate.

If the UDP-forwarding is used for BOOTP or DHCP forwarding purposes, do not configure or use the existing `bootprelay` function. However, if the previous `bootprelay` functions are adequate, you may continue to use them.

NOTE

UDP-forwarding only works across a layer 3 boundary.

Configuring UDP-Forwarding

To configure UDP-forwarding, the first thing you must do is create a UDP-forward destination profile. The profile describes the types of UDP packets (by port number) that are used, and where they are to be forwarded. You must give the profile a unique name, in the same manner as a VLAN, protocol filter, or Spanning Tree Domain.

Next, configure a VLAN to make use of the UDP-forwarding profile. As a result, all incoming traffic from the VLAN that matches the UDP profile is handled as specified in the UDP-forwarding profile.

A maximum of ten UDP-forwarding profiles can be defined. Each named profile may contain a maximum of eight "rules" defining the UDP port, and destination IP address or VLAN. A VLAN can make use of a single UDP-forwarding profile. UDP packets directed toward a VLAN use an all-ones broadcast on that VLAN.

UDP-Forwarding Example

In this example, the VLAN *Marketing* and the VLAN *Operations* are pointed toward a specific backbone DHCP server (with IP address 10.1.1.1) and a backup server (with IP address 10.1.1.2). Additionally, the VLAN *LabUser* is configured to use any responding DHCP server on a separate VLAN called *LabSvrs.*

The commands for this configuration are as follows:

```
create udp-profile backbonedhcp
create udp-profile labdhcp
config backbonedhcp add 67 ipaddress 10.1.1.1
config backbonedhcp add 67 ipaddress 10.1.1.2
config labdhcp add 67 vlan labsvrs
config marketing udp-profile backbonedhcp
config operations udp-profile backbonedhcp
config labuser udp-profile labdhcp
```

ICMP Packet Processing

As ICMP packets are routed or generated, you can take various actions to control distribution. For ICMP packets typically generated or observed as part of the routing function, you can assert control on a per-type, per-VLAN basis. You would alter the default settings for security reasons: to restrict the success of tools that can be used to find an important application, host, or topology information. The controls include the disabling of transmitting ICMP messages associated with unreachables, port-unreachables, time-exceeded, parameter-problems, redirects, time-stamp, and address-mask requests.

For ICMP packets that are typically routed, you can apply access lists to restrict forwarding behavior. Access lists are described in Chapter 11.

UDP Echo Server

You can use UDP Echo packets to measure the transit time for data between the transmitting and receiving end.

To enable UDP echo server support, use the following command:

```
enable udp-echo-server
```

To disable UDP echo server support, use the following command:

```
disable udp-echo-server
```

VLAN Aggregation

VLAN aggregation is an ExtremeWare feature aimed primarily at service providers. The purpose of VLAN aggregation is to increase the efficiency of IP address space usage. It does this by allowing clients within the same IP subnet to use different broadcast domains while still using the same default router.

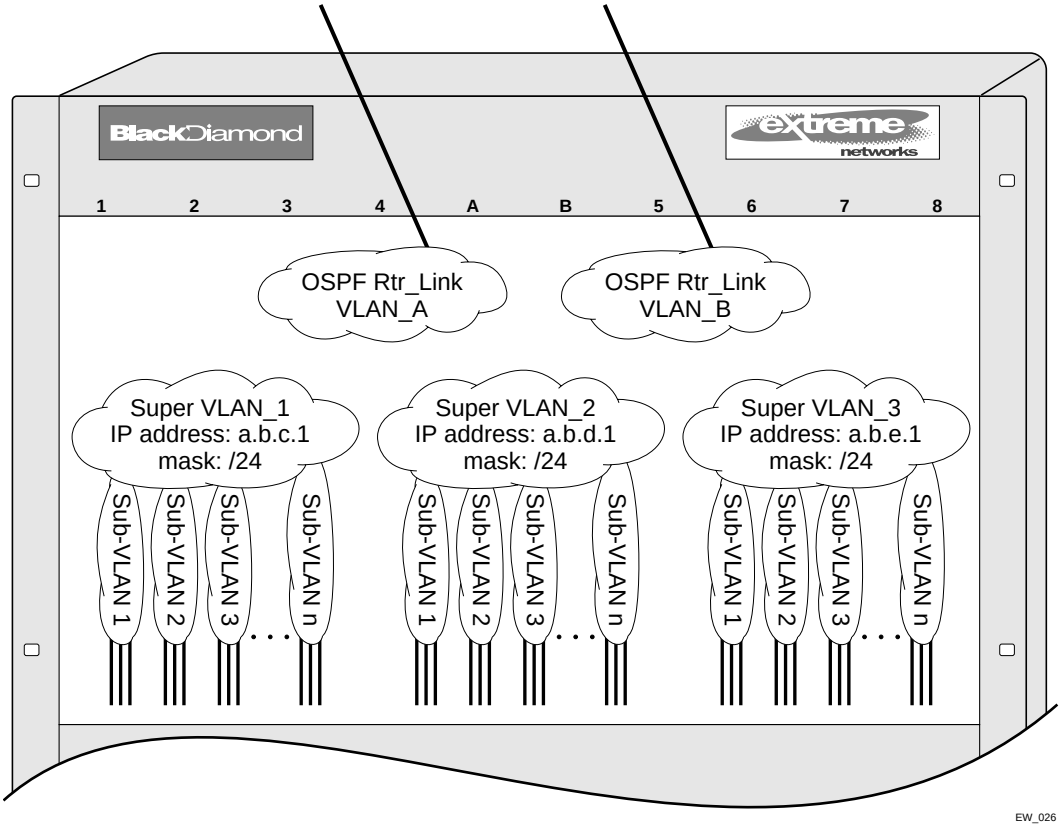
Using VLAN aggregation, a *super-VLAN* is defined with the desired IP address, but without any member ports (unless it is running ESRP). The sub-VLANs use the IP address of the super-VLAN as the default router address. Groups of clients are then assigned to sub-VLANs that have no IP address, but are members of the super-VLAN. In addition, clients can be informally allocated any valid IP addresses within the subnet. Optionally, you can prevent communication between sub-VLANs for isolation purposes. As a result, sub-VLANs can be quite small, but allow for growth without re-defining subnet boundaries.

Without using VLAN aggregation, each VLAN has a default router address, and you need to use large subnet masks. The result of this is more unused IP address space.

Multiple secondary IP addresses can be assigned to the super-VLAN. These IP addresses are *only* used to respond to ICMP ping packets to verify connectivity.

Figure 63 illustrates VLAN aggregation.

Figure 63: VLAN aggregation



In Figure 63, all stations are configured to use the address 10.3.2.1 for the default router.

VLAN Aggregation Properties

VLAN aggregation is a very specific application, and the following properties apply to its operation:

- All broadcast and unknown traffic remains local to the sub-VLAN and does not cross the sub-VLAN boundary. All traffic within the sub-VLAN is switched by the sub-VLAN, allowing traffic separation between sub-VLANs (while using the same default router address among the sub-VLANs).
- Hosts are located on the sub-VLAN. Each host can assume any IP address within the address range of the super-VLAN router interface. Hosts on the sub-VLAN are expected to have the same network mask as the super-VLAN and have their default router set to the IP address or the super-VLAN.
- All traffic (IP unicast and IP multicast) between sub-VLANs is routed through the super-VLAN. For example, no ICMP redirects are generated for traffic between sub-VLANs, because the super-VLAN is responsible for sub-VLAN routing. Unicast IP traffic across the sub-VLANs is facilitated by the automatic addition of an ARP entry (similar to a proxy ARP entry) when a sub-VLAN is added to a super-VLAN. This feature can be disabled for security purposes.
- IP multicast traffic between sub-VLANs is routed when an IP multicast routing protocol is enabled on the super-VLAN.

VLAN Aggregation Limitations

The following limitations apply to VLAN aggregation:

- No additional routers may be located in a sub-VLAN. This feature is only applicable for “leaves” of a network.
- A sub-VLAN cannot be a super-VLAN, and vice-versa.
- Sub-VLANs are not assigned an IP address.
- Typically, a super-VLAN has no ports associated with it, except in the case of running ESRP.
- If a client is moved from one sub-VLAN to another, you must clear the IP ARP cache at the client and the switch to resume communication.

VLAN Aggregation SubVLAN Address Range Checking

You can configure subVLAN address ranges on each subVLAN to prohibit the entry of IP addresses from hosts outside of the configured range.

To configure a subVLAN range, use the following command:

```
config vlan <name> subvlan-address-range <ip_address> - <ip_address>
```

To remove a subVLAN address range, use the following command:

```
config vlan <name> subvlan-address-range 0.0.0.0 – 0.0.0.0
```

To view the subVLAN address range, use the following command:

```
show vlan <vlan_name>
```

There is no error checking to prevent the configuration of overlapping subVLAN address ranges between multiple subVLANs. Doing so can result in unexpected behavior of ARP within the superVLAN and associated subVLANs.

Isolation Option for Communication Between Sub-VLANs

To facilitate communication between sub-VLANs, by default, an entry is made in the IP ARP table of the super-VLAN that performs a proxy ARP function. This allows clients on one sub-VLAN to communicate with clients on another sub-VLAN. In certain circumstances, intra-sub-VLAN communication may not be desired for isolation reasons.

To prevent normal communication between sub-VLANs, disable the automatic addition of the IP ARP entries on the super-VLAN using the following command:

```
disable subvlan-proxy-arp vlan <super-vlan name>
```

NOTE

The isolation option works for normal, dynamic, ARP-based client communication.

VLAN Aggregation Example

The follow example illustrates how to configure VLAN aggregation. The VLAN *vsuper* is created as a super-VLAN, and sub-VLANs, *vsub1*, *vsub2*, and *vsub3* are added to it.

1. Create and assign an IP address to a VLAN designated as the super-VLAN. This VLAN should have no member ports. Be sure to enable IP forwarding, and any desired routing protocol, on the switch.

   ```
   create vlan vsuper
   config vsuper ipaddress 192.201.3.1/24
   enable ipforwarding
   enable ospf
   config ospf add vsuper
   ```

2. Create and add ports to the sub-VLANs.

   ```
   create vlan vsub1
   con vsub1 add port 10-12
   create vlan vsub2
   config vsub2 add po 13-15
   create vlan vsub3
   config vsub3 add po 16-18
   ```

3. Configure the super-VLAN by adding the sub-VLANs.

   ```
   config vsuper add subvlan vsub1
   config vsuper add subvlan vsub2
   config vsuper add subvlan vsub3
   ```

4. Optionally, disable communication among sub-VLANs.

   ```
   disable subvlan-proxy-arp <super-VLAN name>
   ```

Verifying the VLAN Aggregation Configuration

The following commands can be used to verify proper VLAN aggregation configuration.

- `show vlan`—Indicates the membership of a sub-VLANs in a super-VLAN.
- `show iparp`—Indicates an ARP entry that contains sub-VLAN information. Communication with a client on a sub-VLAN must have occurred in order for an entry to be made in the ARP table.

17 Interior Gateway Protocols

This chapter describes the following topics:

- Overview on page 310
- Overview of RIP on page 311
- Overview of OSPF on page 312
- Route Re-Distribution on page 317
- RIP Configuration Example on page 320
- Configuring OSPF on page 322
- OSPF Configuration Example on page 323
- Displaying OSPF Settings on page 325
- Overview of IS-IS on page 326
- Implementing IS-IS Routing on page 327

This chapter assumes that you are already familiar with IP unicast routing. If not, refer to the following publications for additional information:

- RFC 1058—*Routing Information Protocol (RIP)*
- RFC 1195—*Use of OSI IS-IS for Routing in TCP/IP and Dual Environments*
- ISO 10589—*OSI IS-IS Intra-Domain Routing Protocol* (also available as RFC 1142)
- RFC 1723—*RIP Version 2*
- RFC 2178—*OSPF Version 2*
- *Interconnections: Bridges and Routers*
  by Radia Perlman
  ISBN 0-201-56332-0
  Published by Addison-Wesley Publishing Company

Overview

The switch supports the use of three interior gateway protocols (IGPs); the Routing Information Protocol (RIP), the Open Shortest Path First (OSPF) protocol, and the Integrated Intermediate System-to-Intermediate System (IS-IS) dynamic routing protocol for IP unicast routing.

RIP is a distance-vector protocol, based on the Bellman-Ford (or distance-vector) algorithm. The distance-vector algorithm has been in use for many years, and is widely deployed and understood.

OSPF is a link-state protocol, based on the Dijkstra link-state algorithm. OSPF is a newer Interior Gateway Protocol (IGP), and solves a number of problems associated with using RIP on today's complex networks.

The IS-IS routing protocol is very similar to OSPF. OSPF was derived from the IS-IS protocol. IS-IS also is a link-state protocol, based on the Dijkstra link-state algorithm. As originally implemented, IS-IS can support both IP and ISO routing in mixed environments. ExtremeWare Integrated IS-IS supports IP-only routing.

NOTE

RIP, OSPF, and IS-IS can be enabled on a single VLAN.

RIP Versus Either OSPF or IS-IS

The distinction between RIP and OSPF or IS-IS lies in the fundamental differences between distance-vector protocols and link-state protocols. Using a distance-vector protocol, each router creates a unique routing table from summarized information obtained from neighboring routers. Using a link-state protocol, every router maintains an identical routing table created from information obtained from all routers in the autonomous system. Each router builds a shortest path tree, using itself as the root. The link-state protocol ensures that updates sent to neighboring routers are acknowledged by the neighbors, verifying that all routers have a consistent network map.

The biggest advantage of using RIP is that it is relatively simple to understand and implement, and it has been the *de facto* routing standard for many years.

RIP has a number of limitations that can cause problems in large networks, including:

- A limit of 15 hops between the source and destination networks.
- A large amount of bandwidth taken up by periodic broadcasts of the entire routing table.
- Slow convergence.
- Routing decisions based on hop count; no concept of link costs or delay.
- Flat networks; no concept of areas or boundaries.

OSPFand IS-IS offers many advantages over RIP, including:

- No limitation on hop count.
- Route updates multicast only when changes occur.
- Faster convergence.
- Support for load balancing to multiple routers based on the actual cost of the link.
- Support for hierarchical topologies where the network is divided into areas.

The details of RIP, OSPF, and IS-IS are explained later in this chapter.

Overview of RIP

RIP is an Interior Gateway Protocol (IGP) first used in computer routing in the Advanced Research Projects Agency Network (ARPAnet) as early as 1969. It is primarily intended for use in homogeneous networks of moderate size.

To determine the best path to a distant network, a router using RIP always selects the path that has the least number of hops. Each router that data must traverse is considered to be one hop.

Routing Table

The routing table in a router using RIP contains an entry for every known destination network. Each routing table entry contains the following information:

- IP address of the destination network
- Metric (hop count) to the destination network
- IP address of the next router
- Timer that tracks the amount of time since the entry was last updated

The router exchanges an update message with each neighbor every 30 seconds (default value), or if there is a change to the overall routed topology (also called *triggered updates*). If a router does not receive an update message from its neighbor within the route timeout period (180 seconds by default), the router assumes the connection between it and its neighbor is no longer available.

Split Horizon

Split horizon is a scheme for avoiding problems caused by including routes in updates sent to the router from which the route was learned. Split horizon omits routes learned from a neighbor in updates sent to that neighbor.

Poison Reverse

Like split horizon, poison reverse is a scheme for eliminating the possibility of loops in the routed topology. In this case, a router advertises a route over the same interface that supplied the route, but the route uses a hop count of 16, defining it as unreachable.

Triggered Updates

Triggered updates occur whenever a router changes the metric for a route, and it is required to send an update message immediately, even if it is not yet time for a regular update message to be sent. This will generally result in faster convergence, but may also result in more RIP-related traffic.

Route Advertisement of VLANs

VLANs that are configured with an IP address, but are configured to not route IP or are not configured to run RIP, do not have their subnets advertised by RIP. Only those VLANs that are configured with an IP address and are configured to route IP and run RIP have their subnets advertised.

RIP Version 1 Versus RIP Version 2

A new version of RIP, called RIP version 2, expands the functionality of RIP version 1 to include:

- Variable-Length Subnet Masks (VLSMs).
- Support for next-hop addresses, which allows for optimization of routes in certain environments.
- Multicasting.

  RIP version 2 packets can be multicast instead of being broadcast, reducing the load on hosts that do not support routing protocols.

NOTE

If you are using RIP with supernetting/Classless Inter-Domain Routing (CIDR), you must use RIPv2 only. In addition, RIP route aggregation must be turned off.

Overview of OSPF

OSPF is a link-state protocol that distributes routing information between routers belonging to a single IP domain, also known as an *autonomous system* (AS). In a link-state routing protocol, each router maintains a database describing the topology of the autonomous system. Each participating router has an identical database maintained from the perspective of that router.

From the link-state database (LSDB), each router constructs a tree of shortest paths, using itself as the root. The shortest path tree provides the route to each destination in the autonomous system. When several equal-cost routes to a destination exist, traffic can be distributed among them. The cost of a route is described by a single metric.

Link-State Database

Upon initialization, each router transmits a link-state advertisement (LSA) on each of its interfaces. LSAs are collected by each router and entered into the LSDB of each router. Once all LSAs are received, the router uses the LSDB to calculate the best routes for use in the IP routing table. OSPF uses flooding to distribute LSAs between routers. Any change in routing information is sent to all of the routers in the network. All routers within an area have the exact same LSDB. Table 40 describes LSA type numbers.

Table 40: LSA Type Numbers

Type Number	Description
1	Router LSA
2	Network LSA
3	Summary LSA
4	AS summary LSA

Table 40: LSA Type Numbers (continued)

Type Number	Description
5	AS external LSA
7	NSSA external LSA
9	Link local—Opaque
10	Area scoping—Opaque
11	AS scoping—Opaque

Database Overflow

The OSPF database overflow feature allows you to limit the size of the LSDB and to maintain a consistent LSDB across all the routers in the domain, which ensures that all routers have a consistent view of the network.

Consistency is achieved by:

- Limiting the number of external LSAs in the database of each router.
- Ensuring that all routers have identical LSAs.

To configure OSPF database overflow, use the following command:

```
config ospf ase-limit <number> {timeout <seconds>}
```

where:

- `<number>`—Specifies the number of external LSAs that the system supports before it goes into overflow state. A limit value of zero disables the functionality.

  When the LSDB size limit is reached, OSPF database overflow flushes LSAs from the LSDB. OSPF database overflow flushes the same LSAs from all the routers, which maintains consistency.
- `timeout`—Specifies the timeout, in seconds, after which the system ceases to be in overflow state. A timeout value of zero leaves the system in overflow state until OSPF is disabled and re-enabled.

Opaque LSAs

Opaque LSAs are a generic OSPF mechanism used to carry auxiliary information in the OSPF database. Opaque LSAs are most commonly used to support OSPF traffic engineering.

Normally, support for opaque LSAs is auto-negotiated between OSPF neighbors. In the event that you experience interoperability problems, you can disable opaque LSAs across the entire system using the following command:

```
disable ospf capability opaque-lsa
```

To re-enable opaque LSAs across the entire system, use the following command:

```
enable ospf capability opaque-lsa
```

If your network uses opaque LSAs, we recommend that all routers on your OSPF network support opaque LSAs. Routers that do not support opaque LSAs do not store or flood them. At minimum a well-interconnected subsection of your OSPF network needs to support opaque LSAs to maintain reliability of their transmission.

On an OSPF broadcast network, the designated router (DR) must support opaque LSAs or none of the other routers on that broadcast network will reliably receive them. You can use the OSPF priority feature to give preference to an opaque-capable router, so that it becomes the elected DR.

For transmission to continue reliably across the network, the backup designated router (BDR) must also support opaque LSAs.

NOTE

Opaque LSAs are supported in ExtremeWare version 6.2 and above.

Areas

OSPF allows parts of a network to be grouped together into *areas*. The topology within an area is hidden from the rest of the autonomous system. Hiding this information enables a significant reduction in LSA traffic, and reduces the computations needed to maintain the LSDB. Routing within the area is determined only by the topology of the area.

The three types of routers defined by OSPF are as follows:

- **Internal Router (IR)**—An internal router has all of its interfaces within the same area.
- **Area Border Router (ABR)**—An ABR has interfaces in multiple areas. It is responsible for exchanging summary advertisements with other ABRs. You can create a maximum of 7 non-zero areas.
- **Autonomous System Border Router (ASBR)**—An ASBR acts as a gateway between OSPF and other routing protocols, or other autonomous systems.

Backbone Area (Area 0.0.0.0)

Any OSPF network that contains more than one area is required to have an area configured as area 0.0.0.0, also called the *backbone*. All areas in an autonomous system must be connected to the backbone. When designing networks, you should start with area 0.0.0.0, and then expand into other areas.

NOTE

Area 0.0.0.0 exists by default and cannot be deleted or changed.

The backbone allows summary information to be exchanged between ABRs. Every ABR hears the area summaries from all other ABRs. The ABR then forms a picture of the distance to all networks outside of its area by examining the collected advertisements, and adding in the backbone distance to each advertising router.

When a VLAN is configured to run OSPF, you must configure the area for the VLAN. If you want to configure the VLAN to be part of a different OSPF area, use the following command:

```
config ospf vlan <vlan name> area <area identifier>
```

If this is the first instance of the OSPF area being used, you must create the area first using the following command:

```
create ospf area <area identifier>
```

Stub Areas

OSPF allows certain areas to be configured as *stub areas*. A stub area is connected to only one other area. The area that connects to a stub area can be the backbone area. External route information is not distributed into stub areas. Stub areas are used to reduce memory consumption and computation requirements on OSPF routers. Use the following command to configure an OSPF area as a stub area:

```
config ospf area <area identifier> stub [summary | nosummary] stub-default-cost <cost>
```

Not-So-Stubby-Areas (NSSA)

NSSAs are similar to the existing OSPF stub area configuration option, but have the following two additional capabilities:

- External routes originating from an ASBR connected to the NSSA can be advertised within the NSSA.
- External routes originating from the NSSA can be propagated to other areas, including the backbone area.

The CLI command to control the NSSA function is similar to the command used for configuring a stub area, as follows:

```
config ospf area <area identifier> nssa [summary | nosummary] stub-default-cost <cost>
{translate}
```

The `translate` option determines whether type 7 LSAs are translated into type 5 LSAs. When configuring an OSPF area as an NSSA, the `translate` should only be used on NSSA border routers, where translation is to be enforced. If `translate` is not used on any NSSA border router in a NSSA, one of the ABRs for that NSSA is elected to perform translation (as indicated in the NSSA specification). The option should not be used on NSSA internal routers. Doing so inhibits correct operation of the election algorithm.

Normal Area

A normal area is an area that is not:

- Area 0.
- Stub area.
- NSSA.

Virtual links can be configured through normal areas. External routes can be distributed into normal areas.

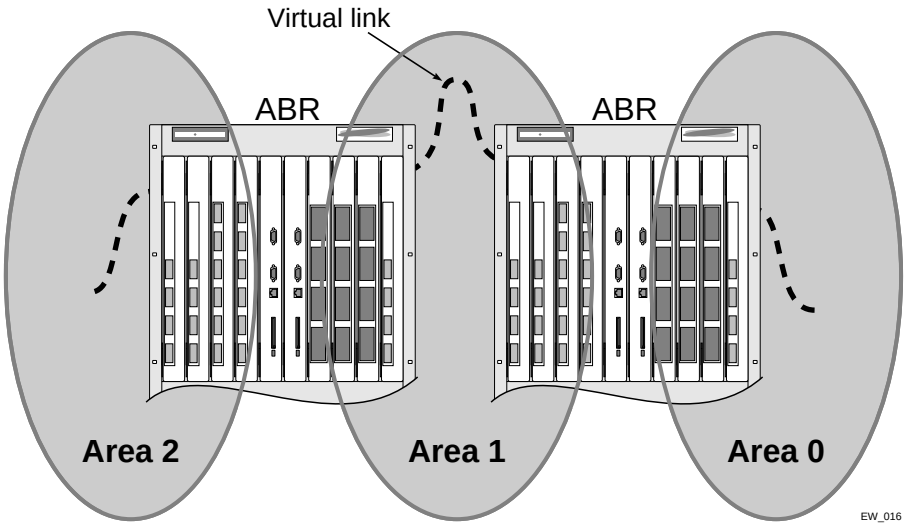
Virtual Links

In the situation when a new area is introduced that does not have a direct physical attachment to the backbone, a *virtual link* is used. A virtual link provides a logical path between the ABR of the disconnected area and the ABR of the normal area that connects to the backbone. A virtual link must be established between two ABRs that have a common area, with one ABR connected to the backbone. Figure 64 illustrates a virtual link.

NOTE

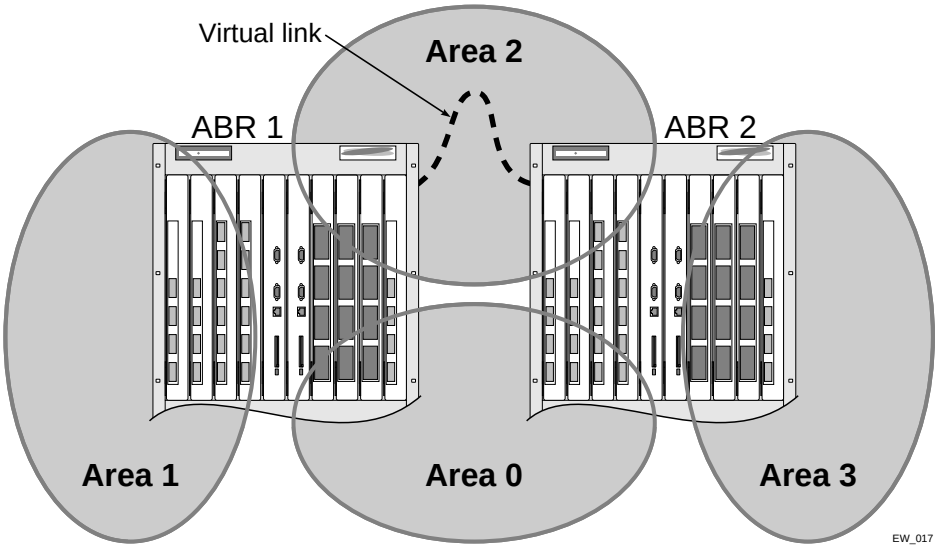
Virtual links can not be configured through a stub or NSSA area.

Figure 64: Virtual link using Area 1 as a transit area



Virtual links are also used to repair a discontiguous backbone area. For example, in , if the connection between ABR1 and the backbone fails, the connection using ABR2 provides redundancy so that the discontiguous area can continue to communicate with the backbone using the virtual link.

Figure 65: Virtual link providing redundancy



Point-to-Point Support

You can manually configure the OSPF link type for a VLAN. Table 41 describes the link types.

Table 41: OSPF Link Types

Link Type	Number of Routers	Description
Auto	Varies	ExtremeWare automatically determines the OSPF link type based on the interface type. This is the default setting.
Broadcast	Any	Routers must elect a designated router (DR) and a backup designated router (BDR) during synchronization. Ethernet is an example of a broadcast link.
Point-to-point	Up to 2	Synchronizes faster than a broadcast link because routers do not elect a DR or BDR. Does not operate with more than two routers on the same VLAN. PPP is an example of a point-to-point link. An OSPF point-to-point link supports only zero to two OSPF routers and does not elect a DR or BDR. If you have three or more routers on the VLAN, OSPF will fail to synchronize if the neighbor is not configured.
Passive		A passive link does not send or receive OSPF packets.

NOTE

The number of routers in an OSPF point-to-point link is determined per-VLAN, not per-link.

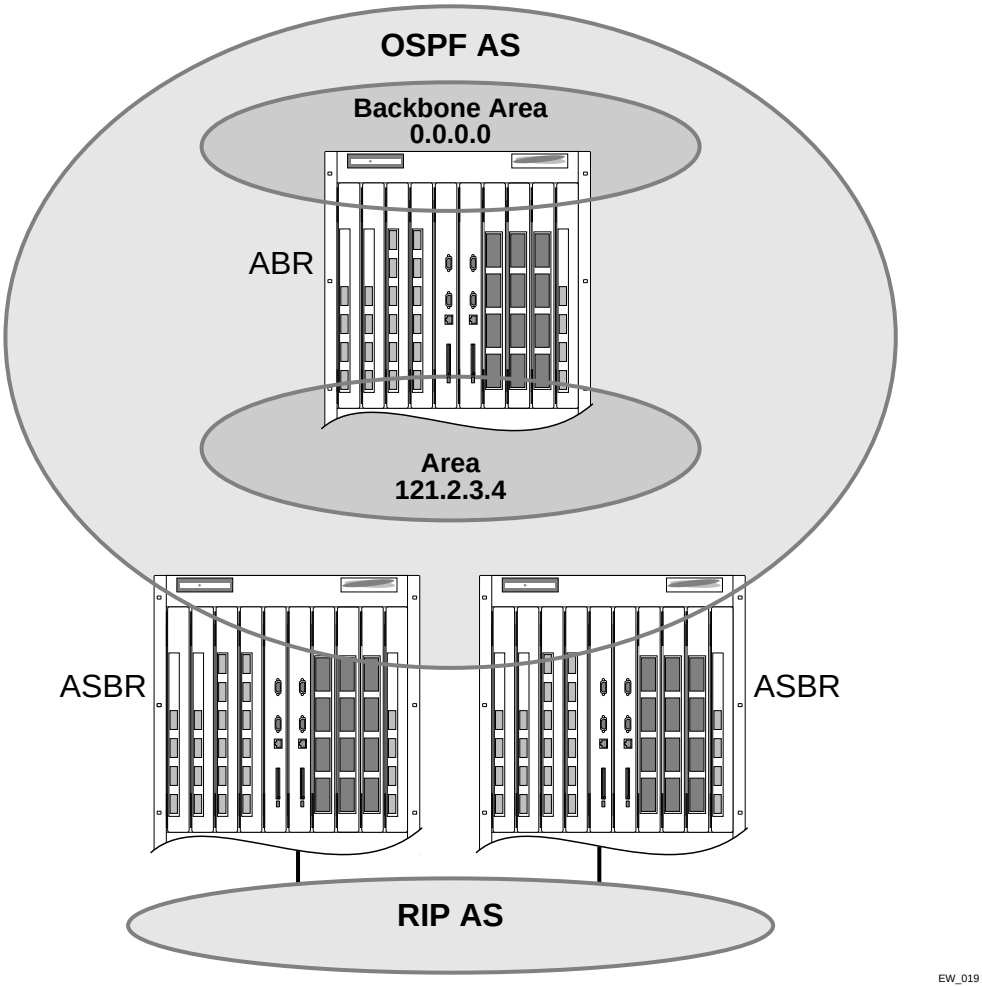
NOTE

All routers in the VLAN must have the same OSPF link type. If there is a mismatch, OSPF attempts to operate, but may not be reliable.

Route Re-Distribution

RIP, OSPF and IS-IS can be enabled simultaneously on the switch. Route re-distribution allows the switch to exchange routes, including static routes, between the three routing protocols. Figure 66 is an example of route re-distribution between an OSPF autonomous system and a RIP autonomous system.

Figure 66: Route re-distribution



Configuring Route Re-Distribution

Exporting routes from one protocol to another, and from that protocol to the first one, are discreet configuration functions. For example, to run OSPF and RIP simultaneously, you must first configure both protocols and then verify the independent operation of each. Then you can configure the routes to export from OSPF to RIP and the routes to export from RIP to OSPF. Likewise, for any other combinations of protocols, you must separately configure each to export routes to the other.

Re-Distributing Routes into OSPF

Enable or disable the exporting of RIP, static, and direct (interface) routes to OSPF using the following commands:

```
enable ospf export [bgp |direct | e-bgp | i-bgp | rip | static | vip] [cost <number>
[ase-type-1 | ase-type-2] {tag <number>} | <route map>]

disable ospf export [bgp |direct | e-bgp | i-bgp | rip | static | vip] [cost <number>
[ase-type-1 | ase-type-2] {tag <number>} | <route map>]
```

These commands enable or disable the exporting of RIP, static, and direct routes by way of LSA to other OSPF routers as AS-external type 1 or type 2 routes. The default setting is disabled.

The cost metric is inserted for all RIP-learned, static, and direct routes injected into OSPF. If the cost metric is set to 0, the cost is inserted from the route. The tag value is used only by special routing applications. Use 0 if you do not have specific requirements for using a tag. The tag value in this instance has no relationship with 802.1Q VLAN tagging.

The same cost, cost-type, and tag values can be inserted for all the export routes, or route maps can be used for selective insertion. When a route map is associated with the export command, the route map is applied on every exported route. The exported routes can also be filtered using route maps. Routes filtered with a route map will be exported as ase-type-1.

Enable or disable the export of virtual IP addresses to other OSPF routers using the following commands:

```
enable ospf export vip [cost <number> [ase-type-1 | ase-type-2] {tag <number>} |
<route map>]

disable ospf export vip
```

Verify the configuration using the command:

```
show ospf {area | ase-summary | interfaces | lsdb | neighbor | virtual-link}
```

Previous Release Issues with OSPF Re-Distribution

In versions of ExtremeWare prior to release 6.0, direct routes corresponding to the interfaces on which RIP was enabled were exported into OSPF as part of RIP routes, using the command `enable ospf export rip`. Using ExtremeWare 6.0 and above, you must configure ExtremeWare to export these direct routes to OSPF. You can use an access profile to filter unnecessary direct routes, using the command:

```
config ospf direct-filter [<access-profile> | none]
```

Re-Distributing Routes into RIP

Enable or disable the exporting of static, direct, and OSPF-learned routes into the RIP domain using the following commands:

```
enable rip export [direct | ospf | ospf-extern1 | ospf-extern2 | ospf-inter |
ospf-intra | static | vip] cost <number> tag <number>

disable rip export [direct | ospf | ospf-extern1 | ospf-extern2 | ospf-inter |
ospf-intra | static | vip]
```

These commands enable or disable the exporting of static, direct, and OSPF-learned routes into the RIP domain. You can choose which types of OSPF routes are injected, or you can simply choose `ospf`, which will inject all learned OSPF routes regardless of type. The default setting is disabled.

OSPF Timers and Authentication

Configuring OSPF timers and authentication on a per-area basis is a shorthand for applying the timers and authentication to each VLAN in the area at the time of configuration. If you add more VLANs to the area, you must configure the timers and authentication for the new VLANs explicitly. Use the command:

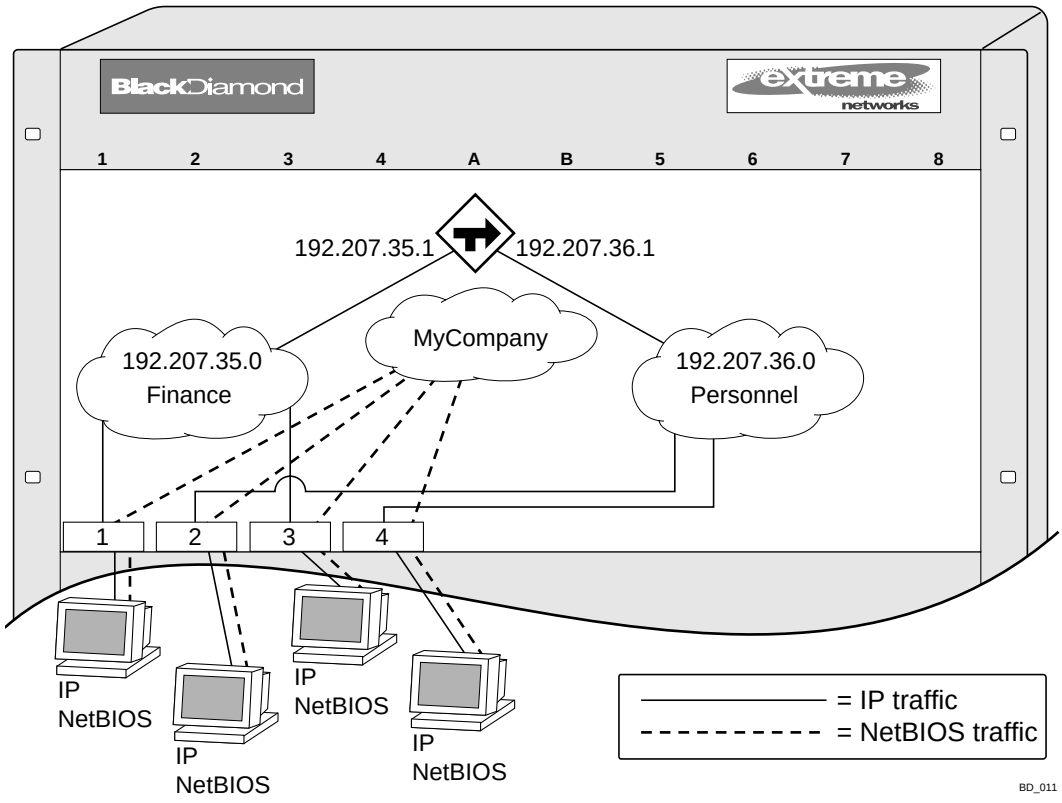
```
config ospf [vlan <vlan name> | area <area identifier> | virtual-link
<routerid> <area identifier>] timer <retransmit interval> <transit delay>
<hello interval> <dead interval> {<wait timer interval>}
```

RIP Configuration Example

Figure 67 illustrates a BlackDiamond switch that has three VLANs defined as follows:

- *Finance*
  - Protocol-sensitive VLAN using the IP protocol.
  - All ports on slots 1 and 3 have been assigned.
  - IP address 192.207.35.1.
- *Personnel*
  - Protocol-sensitive VLAN using the IP protocol.
  - All ports on slots 2 and 4 have been assigned.
  - IP address 192.207.36.1.
- *MyCompany*
  - Port-based VLAN.
  - All ports on slots 1 through 4 have been assigned.

Figure 67: RIP configuration example



The stations connected to the system generate a combination of IP traffic and NetBIOS traffic. The IP traffic is filtered by the protocol-sensitive VLANs. All other traffic is directed to the VLAN *MyCompany.*

In this configuration, all IP traffic from stations connected to slots 1 and 3 have access to the router by way of the VLAN *Finance*. Ports on slots 2 and 4 reach the router by way of the VLAN *Personnel*. All other traffic (NetBIOS) is part of the VLAN *MyCompany.*

The example in Figure 67 is configured as follows:

```
create vlan Finance
create vlan Personnel
create vlan MyCompany

config Finance protocol ip
config Personnel protocol ip

config Finance add port 1:*,3:*
config Personnel add port 2:*,4:*
config MyCompany add port all

config Finance ipaddress 192.207.35.1
config Personnel ipaddress 192.207.36.1

enable ipforwarding
config rip add vlan all
enable rip
```

Configuring OSPF

Each switch that is configured to run OSPF must have a unique router ID. It is recommended that you manually set the router ID of the switches participating in OSPF, instead of having the switch automatically choose its router ID based on the highest interface IP address. Not performing this configuration in larger, dynamic environments could result in an older link state database remaining in use.

Configuring OSPF Wait Interval

ExtremeWare allows you to configure the OSPF wait interval, rather than using the router dead interval.

CAUTION

Do not configure OSPF timers unless you are comfortable exceeding OSPF specifications. Non-standard settings might not be reliable under all circumstances.

To specify the timer intervals, use the following command:

```
config ospf vlan <vlan name> timer <retransmit interval> <transmit delay> <hello
interval> [1-655191] <dead interval> [<wait timer interval>]
```

You can configure the following parameters:

- **Retransmit interval**—The length of time that the router waits before retransmitting an LSA that is not acknowledged. If you set an interval that is too short, unnecessary retransmissions will result. The default value is 5 seconds.
- **Transmit delay**—The length of time it takes to transmit an LSA packet over the interface. The transit delay must be greater than 0.
- **Hello interval**—The interval at which routers send hello packets. Smaller times allow routers to discover each other more quickly, but also increase network traffic. The default value is 10 seconds.
- **Dead router wait interval (Dead Interval)**—The interval after which a neighboring router is declared down due to the fact that hello packets are no longer received from the neighbor. This interval should be a multiple of the hello interval. The default value is 40 seconds.
- **Router wait interval (Wait Timer Interval)**—The interval between the interface coming up and the election of the DR and BDR. This interval should be greater than the hello interval. If it is close to the hello interval, the network synchronizes very quickly, but might not elect the correct DR or BDR. The default value is equal to the dead router wait interval.

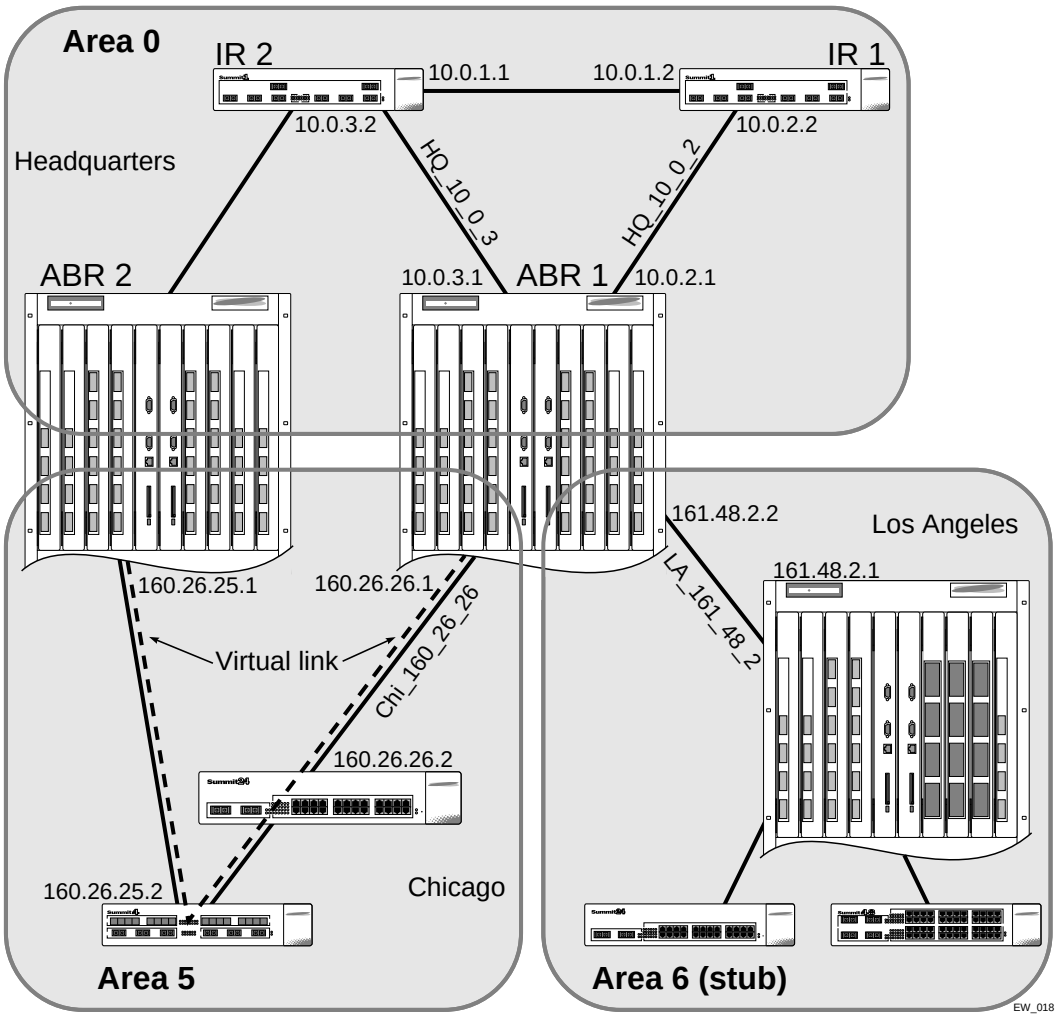
NOTE

The OSPF standard specifies that wait times are equal to the dead router wait interval.

OSPF Configuration Example

Figure 68 is an example of an autonomous system using OSPF routers. The details of this network follow.

Figure 68: OSPF configuration example



Area 0 is the backbone area. It is located at the headquarters and has the following characteristics:

- Two internal routers (IR1 and IR2)
- Two area border routers (ABR1 and ABR2)
- Network number 10.0.x.x
- Two identified VLANs (HQ_10_0_2 and HQ_10_0_3)

Area 5 is connected to the backbone area by way of ABR1 and ABR2. It is located in Chicago and has the following characteristics:

- Network number 160.26.x.x

- One identified VLAN (Chi_160_26_26)
- Two internal routers

Area 6 is a stub area connected to the backbone by way of ABR1. It is located in Los Angeles and has the following characteristics:

- Network number 161.48.x.x
- One identified VLAN (LA_161_48_2)
- Three internal routers
- Uses default routes for inter-area routing

Two router configurations for the example in Figure 68 are provided in the following section.

Configuration for ABR1

The router labeled ABR1 has the following configuration:

```
create vlan HQ_10_0_2
create vlan HQ_10_0_3
create vlan LA_161_48_2
create vlan Chi_160_26_26

config vlan HQ_10_0_2 ipaddress 10.0.2.1 255.255.255.0
config vlan HQ_10_0_3 ipaddress 10.0.3.1 255.255.255.0
config vlan LA_161_48_26 ipaddress 161.48.2.26 255.255.255.0
config vlan Chi_160_26_26 ipaddress 160.26.2.1 255.255.255.0

create ospf area 0.0.0.5
create ospf area 0.0.0.6

enable ipforwarding

config ospf area 0.0.0.6 stub nosummary stub-default-cost 10
config ospf add vlan LA_161_48_2 area 0.0.0.6
config ospf add vlan Chi_160_26_26 area 0.0.0.5
config ospf add vlan all area 0.0.0.0

enable ospf
```

Configuration for IR1

The router labeled IR1 has the following configuration:

```
config vlan HQ_10_0_1 ipaddress 10.0.1.2 255.255.255.0
config vlan HQ_10_0_2 ipaddress 10.0.2.2 255.255.255.0
enable ipforwarding
config ospf add vlan all area 0.0.0.0
enable ospf
```

Displaying OSPF Settings

There are a number of commands you can use to display settings for OSPF. To show global OSPF information, use the `show ospf` command with no options.

To display information about one or all OSPF areas, use the following command:

```
show ospf area {<area identifier> | detail}
```

The `detail` option displays information about all OSPF areas in a detail format.

To display information about OSPF interfaces for an area, a VLAN, or for all interfaces, use the following command:

```
show ospf interfaces {vlan <vlan name> | area <area identifier> | detail}
```

The `detail` option displays information about all OSPF interfaces in a detail format.

OSPF LSDB Display

ExtremeWare provides several filtering criteria for the `show ospf lsdb` command. You can specify multiple search criteria and only results matching all of the criteria are displayed. This allows you to control the displayed entries in large routing tables.

To display the current link-state database, use the following command:

```
show ospf lsdb area [all | <area identifier>[/<len>]][detail | interface] [lsid
<id>[/<len>]] lstype [all | as-external | external-type7 | network | router |
summary-asb | summary-net] [routerid <id>[/<len>]] [stats | summary | vlan]
```

The `detail` option displays all fields of matching LSAs in a multi-line format. The `summary` option displays several important fields of matching LSAs, one line per LSA. The `stats` option displays the number of matching LSAs, but not any of their contents. If not specified, the default is to display in the summary format.

A common use of this command is to omit all optional parameters, resulting in the following shortened form:

```
show ospf lsdb
```

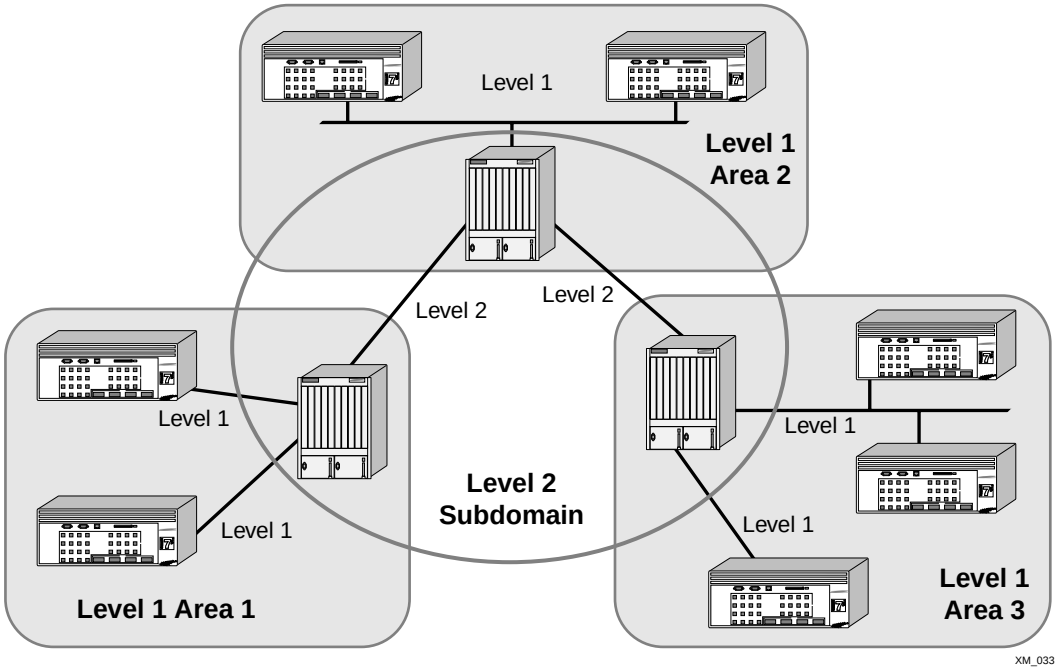
The shortened form displays all areas and all types in a summary format.

Overview of IS-IS

The IS-IS routing protocol provides transport-independent routing. IS-IS partitions the network into "routing domains." Routing domain boundaries are defined by interior and exterior links. Interior links are part of the IS-IS routing domain; exterior links are not. No IS-IS routing messages are sent on exterior links.

A routing domain is partitioned into areas, as shown in Figure 69. IS-IS routing uses two levels of hierarchical routing: level 1 and level 2.

Figure 69: Basic IS-IS network



Level 1 routers know the topology in their area, including all routers and end systems. Level 1 routers do not know the identity of routers or end systems outside of their area. Level 1 routers forward all traffic for destinations outside of their area to a level 2 router in their area.

Level 2 routers know the level 2 topology in their area, and know which addresses are reachable via each level 2 router. However, level 2 routers do not know the level 1 topology within any area, except to the extent that level 2 routers might also be level 1 routers within an area. Level 2 routers that are also level 1 routers are also called level 1/2 routers.

Overview of Integrated IS-IS

Integrated IS-IS allows a single routing protocol to route both IP and OSI packets. The protocol allows for mixing of IP-only, OSI-only, and dual (IP and OSI) routers.

- **IP-only**—An IP-only IS-IS router is a router that uses IS-IS as the routing protocol for IP and does not support OSI protocols. The ExtremeWare integrated IS-IS implementation is IP-only.
- **OSI-only**—An OSI-only router is a router that uses IS-IS as the routing protocol for OSI.

- **Dual**—A dual IS-IS router is a router that uses IS-IS as a single integrated routing protocol for both IP and OSI.

The IS-IS protocol uses the existing IS-IS packets and adds IP-specific fields containing the following:

- Authentication information
- The protocols supported by each router, as well as each router's IP addresses (specified in IS-IS Hello and Link State Packets (LSPs))
- Internally and externally reachable IP addresses (specified in all Link State Packets)

The same two-level hierarchy is used for both IP and OSI routing. Each area is specified as IP-only, OSI-only, or dual. The protocol does not allow for partial overlap of OSI and IP areas.

Within an area, level 1 routers exchange link state packets, which identify the IP addresses reachable by each router. Specifically, zero or more combinations of IP address, subnet mask, and metric can be included in each link state packet. Each level 1 router is manually configured with the combinations that are reachable on each interface. A level 1 router routes as follows:

1. If a specified destination address matches a combination reachable within the area, the packet is routed via level 1 routing.
2. If a specified destination address does not match any combination listed as reachable within the area, the packet is routed towards the nearest level 2 router by ISO routing or the packet is routed by the originate default route.

Flexible use of the limited IP address space is important in order to cope with the anticipated growth of IP environments. Thus an area (and by implication a routing domain) can simultaneously use a variety of different address masks for different subnets in the area (or domain). Generally, if a specified destination address matches more than one IP address and subnet mask pair, the more specific address (the one with more "1" bits in the mask, known as "best match" routing) is the one routed towards.

Level 2 routers include in their level 2 LSPs a complete list of combinations specifying all IP addresses reachable in their area. In addition, both level 1 and level 2 routers can report external reachability information, corresponding to addresses that can be reached via routers in other routing domains.

Typically, small IS-IS networks are a single area that includes all the routers in the network. As the network grows, that single area is usually reorganized into a backbone area made up of the connected set of all level 2 routers from all areas, which in turn connect to local areas.

Implementing IS-IS Routing

To implement integrated IS-IS routing, perform these basic steps:

1. Create IS-IS areas using the following command:

   ```
   create isis area
   ```

2. Add area addresses to level 1 using the following command:

   ```
   config isis area add
   ```

3. Add interfaces to level 1 using the following command:

   ```
   config isis add vlan level-1 area
   ```

4. Add area addresses to level 2 using the following command:

   ```
   config isis level-2 add
   ```

5 Add interfaces to level 2 using the following command:

```
config isis add vlan level-2-only
```

6 Enable ISIS using the following command:

```
enable isis
```

ExtremeWare 6.1.8 IS-IS supports integrated IS-IS as specified in ISO/IEC 10589 and RFC 1195. The IS-IS implementation allows the switches to act as an IP-only IS-IS router. No OSI routes are calculated, as there is no support for network layer forwarding of OSI traffic in Extreme switches. ExtremeWare IS-IS does not support OSI.

Integrated IS-IS is supported over VLANs containing Ethernet and PoS interfaces. VLANs containing Ethernet interfaces or a mixture of Ethernet and PoS interfaces are treated as broadcast subnetworks. VLANs containing PoS interfaces are treated as either broadcast or point-to-point subnetworks based on the PPP mode enabled on the PoS interfaces.

Currently, you can create one level 1 area. A level 2 subdomain is the domain that contains all of the level 2 routers. A level 2 subdomain is always present in every system. When you enable IS-IS on an interface, you configure the type of the interface. Depending on the type, the interface is part of a level 1 area, level 2 subdomain, or both. The presence of an interface in a level 1 area or level 2 subdomain determines the type of the router.

The IP routes that are generated as a result of running shortest-path-first (SPF) calculations on the information received from all the routers in the subdomain or area is installed in the IP routing table as IS-IS Level 1 Internal, IS-IS Level 1 External, IS-IS Level 2 Internal, and IS-IS Level 2 External routes.

Basic IS-IS includes the following features:

- Authentication
- Summarizing level 1 routing information
- Filtering level 1 routing information
- External route redistribution
- Originating default route
- Overload bit
- Metric size

Authentication

Authentication is supported at two different levels: interface, and domain or area.

- **Interface authentication**—prevents unauthorized routers from forming adjacency. This is achieved by inserting authentication information in the Hello PDUs and validating them on the received Hello PDUs. You can configure authentication separately for level 1 and level 2.
- **Domain or area authentication**—prevents intruders from injecting invalid routing information into this router. Similar to interface authentication, this is achieved by inserting the authentication information using LSP, CSNP, and PSNP PDUs and validating them on receipt. You can configure authentication separately for level 1 and level 2.

At each of the above levels two different authentication methods are supported: simple password as specified in ISO/IEC 10589, and HMAC-MD5 as specified in draft-ietf-isis-hmac-00.txt.

Summarizing Level 1 IP Routing Information

Level 2 routers include in their level 2 LSPs a list of all combinations (IP address, subnet mask, and metric) reachable in the level 1 area attached to them. This information is gathered from the level 1 LSPs from all routers in the area. By default the combinations from all the level 1 routers are included in the level 2 LSPs. Summarization of the level 1 combinations reduces the amount of information stored on the level 2 router and helps in scaling to a large routing domain.

You can configure the level 1 areas with one or more combinations for announcement in their level 2 LSPs. The level 1 IP routing information is matched against the summary addresses configured on the level 1 area. Matches are included in the level 2 LSP.

You can also configure the level 2 router to disregard the summary information. This effectively acts as a filter, preventing reachability information from being included in the level 2 LSP.

Filtering Level 1 IP Routing Information

Level 2 routers include in their level 2 LSPs a list of all combinations (IP address, subnet mask, and metric) reachable in the level 1 area attached to them. This information is gathered from the level 1 LSPs from all routers in the area. By default the combinations from all the level 1 routers are included in the level 2 LSPs. Filtering the level 1 combinations prevents the advertisement of the information to other parts of the domain. This creates a network that is reachable only from routers within the area.

You can configure the level 1 areas in the router with an IP access profile. The level 1 IP routing information in the level 2 LSP is matched against the access profile, and if the result is a deny, the information is not included in the level 2 LSP.

External Route Redistribution

This feature injects routing information learned from other IP routing protocols into an IS-IS domain, thereby advertising their reachability in the IS-IS domain. These are included as combinations (IP address, subnet mask, and metric) in the locally originated LSPs.

Redistribution of the routes into the level 1 areas or level 2 subdomain can be controlled based on the protocol originating the routing information. The metric and the type of the metric are also configured. You can also associate a route map, which can selectively assign metric, metric type, and filter routes.

You can also configure an Access Profile to filter out unwanted external routes.

Originating Default Route

This feature injects IP routing information for the default route in the LSP originated by the router, thereby advertising the router as the default gateway.

Injection of the default route into the level 2 subdomain and level 1 area can be controlled individually. You can configure the metric and metric type associated with the default route. You can also configure the default to be automatically generated based on the presence of a default route in the kernel routing table.

Overload Bit

This feature forces the router to set the overload bit (also known as the hippity bit) in its non-pseudo node link-state packets. Normally the setting of the overload bit is allowed only when a router runs into

problems. For example, when a router has a memory shortage, it might be that the Link State database is not complete, resulting in an incomplete or inaccurate routing table. By setting the overload bit in its LSPs, other routers can ignore the unreliable router in their SPF calculations until the router has recovered from its problems.

Set the overload bit when you want to prevent traffic flow.

Metric Size

Normally, IS-IS metrics can have values up to 63. IS-IS generates two type, length, and value (TLV) codings, one for an IS-IS adjacency (code, length, and value (CLV) 2) and the second for an IP prefix (CLV 128 and CLV 130). During SPF, if the total cost of the path to a destination exceeds 1023, then according to ISO/IEC 10587, the path is ignored.

To overcome these restrictions, a second pair of TLVs is available, one for IP prefixes (CLV 135) and the second for IS-IS adjacency (CLV 22). With these TLVs, IS-IS metrics can have values up 16,777,215 and the maximum path metric allowed is 4,261,412,864. This allows more flexibility while designing a domain. These metrics are “wide” metrics.

You can configure a router to originate LSPs with regular metrics, wide metrics, or both.

Default Routes to Nearest Level 1/2 Switch for Level 1 Only Switches

When one router is a level 1 switch, the route to the nearest level 1/2 switch which attaches to a level 2 backbone network may be installed in the kernel routing table of the level 1 switch.

There are three kinds of level 1 only switches:

- a switch that does not attach to any level 1/2 switch; it is part of a level 1 only network
- a switch that attaches to at least one level 1/2 switch, but none of the level 1/2 switches are attached to a level 2 backbone network. Here the level 1 non-pseudo node LSP of the level 1/2 switches should set the attach bit to 0. A level 1 only switch will not install the default routes based on the unattached level 1/2 switch’s LSP information.
- a switch that attaches to at least one level 1/2 switch, and at least one of the level 1/2 switches is attached to the level 2 backbone network. Here the level 1 non-pseudo node LSP of the level 1/2 switch should set the attach bit to 1. A level 1 only switch will install the default routes based on the attached level 1/2 switch’s LSP information.

The level 1/2 switch that is attached to the level 2 backbone network when at least one of area addresses of level 2 LSP received from other level 2 or level 1/2 switches is not in the list of the level 1 union area address set.

When IS-IS installs default routes based on the attached bit, the routes should have a lower priority than originated default routes. Default routes based on the attached bit can only be installed when an originated default route does not exist. The metric installed should be 2047(e1) for the regular metric and 4,261,412,864 (i1) for the wide metric. A maximum of eight equal default routes is supported.

This feature is enabled by default. The level 1 router installs default routes based on the attach bit. To disable this feature, the attach bit must be ignored. The following command disables this feature by configuring the router to ignore the attach bit:

```
enable isis ignore-attached-bit
```

To enable this feature use the following command:

```
disable isis ignore-attached-bit
```

18 Exterior Gateway Routing Protocols

This chapter covers the following topics:

- Overview on page 333
- BGP Attributes on page 334
- BGP Communities on page 334
- BGP Features on page 334

This chapter describes how to configure the Border Gateway Protocol (BGP), an exterior routing protocol available on the switch.

For more information on BGP, refer to the following documents:

- RFC 1771—*Border Gateway Protocol version 4 (BGP-4)*
- RFC 1965—*Autonomous System Confederations for BGP*
- RFC 1966—*BGP Route Reflection*
- RFC 1997—*BGP Communities Attribute*
- RFC 1745—*BGP/OSPF Interaction*
- RFC 2439—*BGP Route Flap Damping*

NOTE

ExtremeWare supports BGP version 4 only.

Overview

BGP is an exterior routing protocol that was developed for use in TCP/IP networks. The primary function of BGP is to allow different autonomous systems (ASs) to exchange network reachability information.

An autonomous system is a set of routers that are under a single technical administration. This set of routers uses a different routing protocol (such as OSPF) for intra-AS routing. One or more routers in the AS are configured to be border routers, exchanging information with other border routers (in different autonomous systems) on behalf of all of the intra-AS routers.

BGP can be used as an exterior gateway protocol (E-BGP), or it can be used within an AS as an interior gateway protocol (I-BGP).

BGP Attributes

The following well-known BGP attributes are supported by the switch:

- Origin – Defines the origin of the route. Possible values are IGP, EGP, and incomplete.
- AS_Path – The list of ASs that are traversed for this route.
- Next_hop – The IP address of the next hop BGP router to reach the destination listed in the NLRI field.
- Multi_Exist_Discriminator – Used to select a particular border router in another AS when multiple border routers exist.
- Local_Preference – Used to advertise this router's degree of preference to other routers within the AS.
- Atomic_aggregate – Indicates that the sending border router has used a route aggregate prefix in the route update.
- Aggregator – Identifies the BGP router AS number and IP address that performed route aggregation.
- Community – Identifies a group of destinations that share one or more common attributes.
- Cluster_ID – Specifies a 4-byte field used by a route reflector to recognize updates from other route reflectors in the same cluster.
- Originator_ID – Specifies the router ID of the originator of the route in the local AS.

BGP Communities

A BGP community is a group of BGP destinations that require common handling. ExtremeWare supports the following well-known BGP community attributes:

- no-export
- no-advertise
- internet

BGP Features

This section describes the following BGP features supported by ExtremeWare:

- Route Reflectors on page 335
- Route Confederations on page 335
- Route Aggregation on page 338
- IGP Synchronization on page 339
- Using the Loopback Interface on page 339
- BGP Peer Groups on page 339

- BGP Route Flap Dampening on page 340

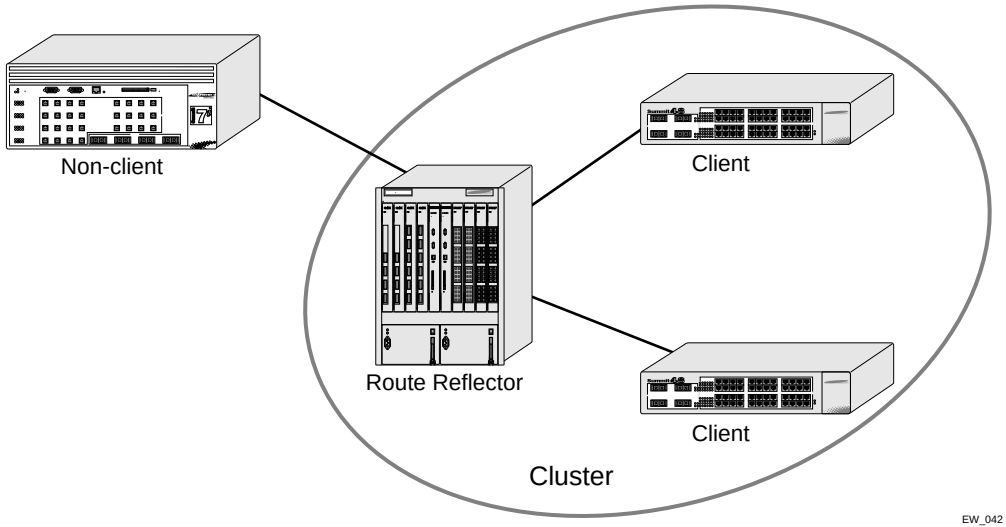
Route Reflectors

Another way to overcome the difficulties of creating a fully-meshed AS is to use *route reflectors*. Route reflectors allow a single router to serve as a central routing point for the AS or sub-AS.

A *cluster* is formed by the route reflector and its client routers. Peer routers that are not part of the cluster must be fully meshed according to the rules of BGP.

A BGP cluster, including the route reflector and its clients, is shown in Figure 70.

Figure 70: Route reflectors



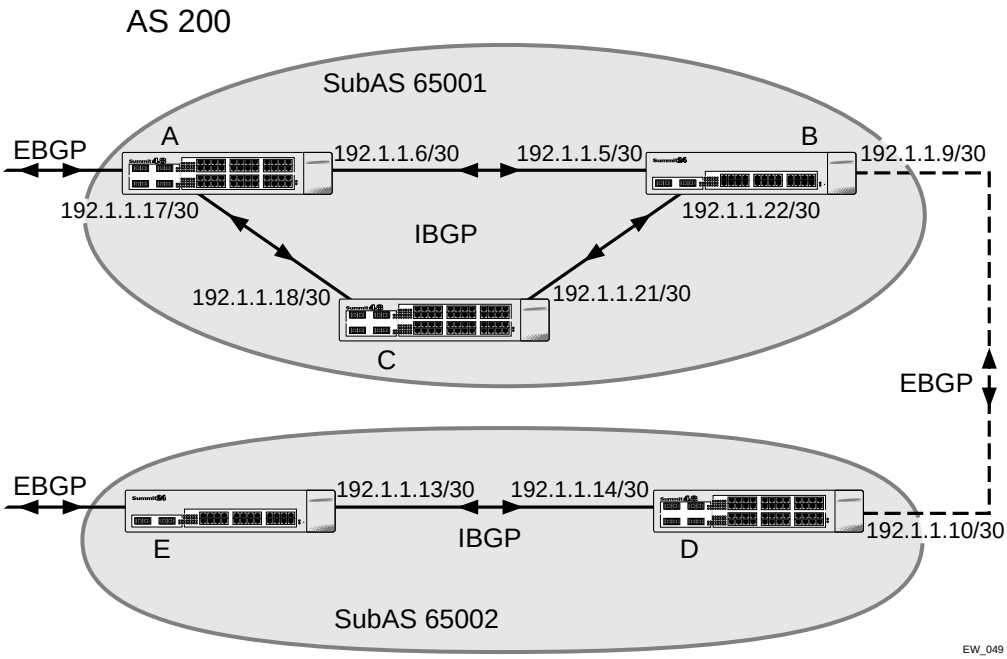
Route Confederations

BGP requires networks to use a fully-meshed router configuration. This requirement does not scale well, especially when BGP is used as an interior gateway protocol. One way to reduce the size of a fully-meshed AS is to divide the AS into multiple sub-autonomous systems and group them into a *routing confederation*. Within the confederation, each sub-AS must be fully-meshed. The confederation is advertised to other networks as a single AS.

Route Confederation Example

Figure 71 shows an example of a confederation.

Figure 71: Routing confederation



In this example, AS 200 has five BGP speakers. Without a confederation, BGP would require that the routes in AS 200 be fully meshed. Using the confederation, AS 200 is split into two sub-ASs: AS65001 and AS65002. Each sub-AS is fully meshed, and IBGP is running among its members. EBGP is used between sub-AS 65001 and sub-AS 65002. Router B and router D are EBGP peers. EBGP is also used between the confederation and outside ASs.

To configure router A, use the following commands:

```
create vlan ab
config vlan ab add port 1
config vlan ab ipaddress 192.1.1.6/30
enable ipforwarding vlan ab
config ospf add vlan ab area 0.0.0.0

create vlan ac
config vlan ac add port 2
config vlan ac ipaddress 192.1.1.17/30
enable ipforwarding vlan ac
config ospf add vlan ac area 0.0.0.0

disable bgp
config bgp as-number 65001
config bgp routerid 192.1.1.17
config bgp confederation-id 200
enable bgp
```

```
create bgp neighbor 192.1.1.5 as-number remote-AS-number 65001
create bgp neighbor 192.1.1.18 as-number remote-AS-number 65001
enable bgp neighbor all
```

To configure router B, use the following commands:

```
create vlan ba
config vlan ba add port 1
config vlan ba ipaddress 192.1.1.5/30
enable ipforwarding vlan ba
config ospf add vlan ba area 0.0.0.0

create vlan bc
config vlan bc add port 2
config vlan bc ipaddress 192.1.1.22/30
enable ipforwarding vlan bc
config ospf add vlan bc area 0.0.0.0

create vlan bd
config vlan bd add port  3
config vlan bd ipaddress 192.1.1.9/30
enable ipforwarding vlan bd
config ospf add vlan bd area 0.0.0.0

disable bgp
config bgp as-number 65001
config bgp routerid 192.1.1.22
config bgp confederation-id 200
enable bgp

create bgp neighbor 192.1.1.6 as-number remote-AS-number 65001
create bgp neighbor 192.1.1.21 as-number remote-AS-number 65001
create bgp neighbor 192.1.1.10 as-number remote-AS-number 65002
enable bgp neighbor all
config bgp add confederation-peer sub-AS-number 65002
```

To configure router C, use the following commands:

```
create vlan  ca
config vlan ca add port 1
config vlan ca ipaddress 192.1.1.18/30
enable ipforwarding vlan ca
config ospf add vlan ca area 0.0.0.0

create vlan cb
config vlan cb add port 2
config vlan cb ipaddress 192.1.1.21/30
enable ipforwarding vlan cb
config ospf add vlan cb area 0.0.0.0

disable bgp
config bgp as-number 65001
config bgp routerid 192.1.1.21
config bgp confederation-id 200
enable bgp

create bgp neighbor 192.1.1.22 as-number remote-AS-number 65001
```

```
create bgp neighbor 192.1.1.17 as-number remote-AS-number 65001
enable bgp neighbor all
```

To configure router D, use the following commands:

```
create vlan db
config vlan db add port 1
config vlan db ipaddress 192.1.1.10/30
enable ipforwarding vlan db
config ospf add vlan db area 0.0.0.0

create vlan de
config vlan de add port 2
config vlan de ipaddress 192.1.1.14/30
enable ipforwarding vlan de
config ospf add vlan de area 0.0.0.0

disable bgp
config bgp as-number 65002
config bgp routerid 192.1.1.14
config bgp confederation-id 200
enable bgp

create bgp neighbor 192.1.1.9 as-number remote-AS-number 65001
create bgp neighbor 192.1.1.13 as-number remote-AS-number 65002
enable bgp neighbor all
config bgp add confederation-peer sub-AS-number 65001
```

To configure router E, use the following commands:

```
create vlan ed
config vlan ed add port  1
config vlan ed ipaddress 192.1.1.13/30
enable ipforwarding vlan ed
config ospf add vlan ed area 0.0.0.0

disable bgp
config bgp as-number 65002
config bgp routerid 192.1.1.13
config bgp confederation-id 200
enable bgp

create bgp neighbor 192.1.1.14 as-number remote-AS-number 65002
enable bgp neighbor 192.1.1.14
```

Route Aggregation

Route aggregation is the process of combining the characteristics of several routes so that they are advertised as a single route. Aggregation reduces the amount of information that a BGP speaker must store and exchange with other BGP speakers. Reducing the information that is stored and exchanged also reduces the size of the routing table.

Using Route Aggregation

To use BGP route aggregation, follow these steps:

1. Enable aggregation using the following command:

   ```
   enable bgp aggregation
   ```

2. Create an aggregate route using the following commands:

   ```
   config bgp add aggregate-address <ip address>/<net mask> {advertise-route-map
   <route-map> | as-match | as-set | attribute-route-map <route-map> | summary-only}
   ```

IGP Synchronization

You can configure an AS to be a transit AS, so that it can pass traffic through from one AS to a third AS. When you configure a transit AS, it is important that the routes advertised by BGP are consistent with the routes that are available within the AS using its interior gateway protocol. To ensure consistency, BGP should be synchronized with the IGP used within the AS. This will ensure that the routes advertised by BGP are, in fact, reachable within the AS. IGP synchronization is enabled by default.

Using the Loopback Interface

If you are using BGP as your interior gateway protocol, you may decide to advertise the interface as available, regardless of the status of any particular interface. The loopback interface can also be used for EBGP multihop. Using the loopback interface eliminates multiple, unnecessary route changes.

BGP Peer Groups

You can use BGP peer groups to group together up to 128 BGP neighbors. All neighbors within the peer group inherit the parameters of the BGP peer group. The following mandatory parameters are shared by all neighbors in a peer group:

- remote AS
- source-interface
- out-nlri-filter
- out-aspath-filter
- out-route-map
- send-community
- next-hop-self

Each BGP peer group is assigned a unique name when it is created. To create or delete peer groups, use the following command:

```
[create | delete] bgp peer-group <name>
```

Changes made to the parameters of a peer group are applied to all neighbors in the peer group. Modifying the following parameters will automatically disable and enable the neighbors before changes take effect:

- remote-as
- timer
- source-interface

- soft-in-reset
- password

Adding Neighbors to a BGP Peer Group

To create a new neighbor and add it to a BGP peer group, use the following command:

```
create bgp neighbor <ip address> peer-group <peer group> {multi-hop}
```

The new neighbor is created as part of the peer group and inherits all of the existing parameters of the peer group. The peer group must have remote AS configured.

To add an existing neighbor to a peer group, use the following command:

```
config bgp neighbor [<ip address> | all] peer-group <peer group> {acquire-all}
```

If you do not specify acquire-all, only the mandatory parameters are inherited from the peer group. If you specify acquire-all, all of the parameters of the peer group are inherited. This command disables the neighbor before adding it to the peer group.

BGP Route Flap Dampening

Route flap dampening is a BGP feature designed to minimize the propagation of flapping routes across an internetwork. A route is considered to be flapping when it is repeatedly available, then unavailable, then available, then unavailable, and so on. When a route becomes unavailable, a Withdrawal message is sent to other connected routers, which in turn propagate the Withdrawal message to other routers. As the route becomes available again, an Advertisement message is sent and propagated throughout the network. As a route repeatedly changes from available to unavailable, large numbers of messages propagate throughout the network. This is a problem in an internetwork connected to the Internet because a route flap in the Internet backbone usually involves many routes.

Minimizing the Route Flap

The route flap dampening feature minimizes the flapping problem as follows. Suppose that the route to network 172.25.0.0 flaps. The router (in which route dampening is enabled) assigns network 172.25.0.0 a penalty of 1000 and moves it to a “history” state in which the penalty value is monitored. The router continues to advertise the status of the route to neighbors. The penalties are cumulative. When the route flaps so often that the penalty exceeds a configurable suppress limit, the router stops advertising the route to network 172.25.0.0, regardless of how many times it flaps. Thus, the route is dampened.

The penalty placed on network 172.25.0.0 is decayed until the reuse limit is reached, upon which the route is once again advertised. At half of the reuse limit, the dampening information for the route to network 172.25.0.0 is removed.

The penalty is decayed by reducing the penalty value by one-half at the end of a configurable time period, called the half-life. Routes that flap many times may reach a maximum penalty level, or ceiling, after which no additional penalty is added. The ceiling value is not directly configureable, but the configuration parameter used in practice is the maximum route suppression time. No matter how often a route has flapped, once it stops flapping, it will again be advertised after the maximum route suppression time.

Configuring Route Flap Dampening

BGP route flap dampening can be enabled on a per BGP peer session basis, for a BGP peer group, or for a set of routes, using a route map.

Use the following command to enable route flap dampening over BGP peer sessions:

```
config bgp neighbor [<ipaddress> | all] dampening {{<half-life> {<reuse> <suppress>
<max-suppress>}} | {route-map <route-map>}}
```

Use the following command to enable route flap dampening for a BGP peer group:

```
config bgp peer-group [<ipaddress> | all] dampening {{<half-life> {<reuse> <suppress>
<max-suppress>}} | {route-map <route-map>}}
```

You can supply the dampening parameters through the route map or directly in the CLI command, but not both (these are mutually exclusive).

For route maps there is a set operation to configure dampening parameters. Use the following command to add a set statement to a route map for dampening :

```
config route-map <route-map> <sequence number> add set dampening <half-life>
<reuse-limit> <suppress-limit> <max-suppress>
```

Disabling Route Flap Dampening

Use the following command to disable route flap dampening for a BGP neighbor (disabling the dampening will also delete all the configured dampening parameters):

```
config bgp neighbor [<ipaddress> | all] no-dampening
```

Use the following command to disable route flap dampening for a BGP peer group:

```
config  bgp  peer-group <peer group> no-dampening
```

Viewing the Route Flap Dampening Configuration

Use the following command to view the configured values of the route flap dampening parameters for a BGP neighbor:

```
show bgp neighbor <ipaddress>
```

Use the following command to view the configured values of the route flap dampening parameters for a BGP peer group:

```
show bgp peer-group <peer group>
```

Viewing Route Flap Statistics

Use the following command to view the flap statistics of a particular route from BGP neighbor:

```
show bgp neighbor  <ip address> flap-statistics net <ip address>/<mask> {exact}
```

Use the following command to view the flap statistics of all the routes from a particular BGP neighbor:

```
show bgp neighbor <ip address> flap-statistics {detail} all
```

Use the following command to view the flap statistics of all the routes which matches a route map filter from a particular BGP neighbor:

```
show bgp neighbor <ip address> flap-statistics {detail} route-map <route map>
```

Use the following command to view the flap statistics of all the routes which matches a community criteria from a particular BGP neighbor:

```
show bgp neighbor <ip address> flap-statistics {detail} [community [access-profile
<access-profile> | <autonomous-system-id>:<bgp-community> | number <community_number>
| no-advertise | no-export | no-export-subconfed]
```

Use the following command to view the flap statistics of all the routes which matches a AS-PATH criteria from a particular BGP neighbor:

```
show bgp neighbor <ip address> flap-statistics {detail} as-path [access-profile
<access-profile> | <path-expression]
```

Clearing Route Flap Statistics

Use the following command to delete the flap statistics of a particular route from BGP neighbor:

```
clear bgp neighbor  <ip address> flap-statistics net <ip address>/<mask> {exact}
```

Use the following command to delete the flap statistics of all the routes from a particular BGP neighbor:

```
clear bgp neighbor <ip address> flap-statistics all
```

Use the following command to delete the flap statistics of all the routes which matches a route map filter from a particular BGP neighbor:

```
clear bgp neighbor <ip address> flap-statistics route-map <route map>
```

Use the following command to delete the flap statistics of all the routes which matches a community criteria from a particular BGP neighbor:

```
clear bgp neighbor <ip address> flap-statistics [community [access-profile
<access-profile> | <autonomous-system-id>:<bgp-community> | number <community_number>
| no-advertise | no-export | no-export-subconfed]
```

Use the following command to delete the flap statistics of all the routes which matches a AS-PATH criteria from a particular BGP neighbor

```
clear bgp neighbor <ip address> flap-statistics {detail} as-path [access-profile
<access-profile> | <path-expression]
```

Viewing Suppressed Routes

Use the following command to view a particular suppressed route from BGP neighbor

```
show bgp neighbor  <ip address> suppressed-routes net <ip address>/<mask> {exact}
```

Use the following command to view all the suppressed routes from a particular BGP neighbor

```
show bgp neighbor  <ip address> suppressed-routes {detail} all
```

Use the following command to view all the suppressed routes which matches a route-map filter from a particular BGP neighbor

```
show bgp neighbor  <ip address> suppressed-routes {detail} route-map <route-map>
```

Use the following command to view all the suppressed routes which matches a community criteria from a particular BGP neighbor

```
show bgp neighbor <ip address> suppressed-routes {detail} [community [access-profile
<access-profile> | <autonomous-system-id>:<bgp-community> | number <community_number>
| no-advertise | no-export | no-export-subconfed]
```

Use the following command to view all the suppressed routes which matches a AS-PATH criteria from a particular BGP neighbor

```
show bgp neighbor <ip address> suppressed-routes {detail} as-path [access-profile
<access-profile> | <path-expression]
```

BGP Route Selection

BGP will select routes based on the following precedence (from highest to lowest):

- weight
- local preference
- shortest length (shortest AS path)
- lowest origin code
- lowest MED
- route from external peer
- lowest cost to Next Hop
- lowest routerID

Stripping Out Private AS Numbers from Route Updates

Private AS numbers are AS numbers in the range 64512 through 65534. You can remove private AS numbers from the AS path attribute in updates that are sent to external BGP (EBGP) neighbors. Possible reasons for using private AS numbers include:

- The remote AS does not have officially allocated AS numbers.
- You want to conserve AS numbers if you are multi-homed to the local AS.

Private AS numbers should not be advertised on the Internet. Private AS numbers can only be used locally within an administrative domain. Therefore, when routes are advertised out to the Internet, the routes can be stripped out from the AS Paths of the advertised routes using this feature.

To configure private AS numbers to be removed from updates, use the following command:

```
enable bgp neighbor [<ipaddress> | all] {remove-private-as-numbers | soft-in-reset}
```

To disable this feature, use the following command:

```
disable bgp neighbor [<ipaddress> | all] {remove-private-as-numbers | soft-in-reset}
```

Route Re-Distribution

BGP, OSPF, and RIP can be enabled simultaneously on the switch. Route re-distribution allows the switch to exchange routes, including static, direct, and VIP routes, between any two routing protocols.

Exporting routes from OSPF to BGP, and from BGP to OSPF, are discreet configuration functions. To run OSPF and BGP simultaneously, you must first configure both protocols and then verify the independent operation of each. Then you can configure the routes to export from OSPF to BGP and the routes to export from BGP to OSPF.

Configuring Route Re-Distribution

Exporting routes between any two routing protocols are discreet configuration functions. For example, you must configure the switch to export routes from OSPF to BGP and, if desired, you must configure the switch to export routes from BGP to OSPF. You must first configure both protocols and then verify the independent operation of each. Then you can configure the routes to export from OSPF to BGP and the routes to export from BGP to OSPF.

You can use route maps to associate BGP attributes including Community, NextHop, MED, Origin, and Local Preference with the routes. Route maps can also be used to filter out exported routes.

To enable or disable the exporting of OSPF, RIP, static, direct (interface), and VIP routes to BGP, use the following commands:

```
enable bgp export [direct | ospf | ospf-extern1 | ospf-extern2 | ospf-inter |
ospf-intra | rip | static | vip] {<route map>}

disable bgp export [direct | ospf | ospf-extern1 | ospf-extern2 | ospf-inter |
ospf-intra | rip | static | vip]
```

Using the `export` command to redistribute routes complements the redistribution of routes using the `config bgp add network` command. The `config bgp add network` command adds the route to BGP only if the route is present in the routing table. The `enable bgp export` command redistributes an individual route from the routing table to BGP. If you use both commands to redistribute routes, the routes redistributed using the `network` command take precedence over routes redistributed using the `export` command.

19 IP Multicast Routing

This chapter covers the following topics:

- Overview on page 345
- Configuring IP Multicasting Routing on page 348
- Configuration Examples on page 349

For more information on IP multicasting, refer to the following publications:

- RFC 1112 – *Host Extension for IP Multicasting*
- RFC 2236 – *Internet Group Management Protocol, Version 2*
- DVMRP Version 3 – *draft_ietf_dvmrp_v3_07*
- PIM-DM Version 2 – *draft_ietf_pim_v2_dm_03*
- RFC 2362 – *Protocol Independent Multicast-Sparse Mode*

The following URLs point to the Web sites for the IETF Working Groups:

IETF DVMRP Working Group:

http://www.ietf.org/html.charters/idmr-charter.html

IEFT PIM Working Group:

http://www.ietf.org/html.charters/pim-charter.html

Overview

IP multicast routing is a function that allows a single IP host to send a packet to a group of IP hosts. This group of hosts can include devices that reside on the local network, within a private network, or outside of the local network.

IP multicast routing consists of the following functions:

- A router that can forward IP multicast packets.
- A router-to-router multicast routing protocol (for example, Distance Vector Multicast Routing Protocol (DVMRP) or Protocol Independent Multicast (PIM)).

- A method for the IP host to communicate its multicast group membership to a router (for example, Internet Group Management Protocol (IGMP)).

NOTE

You should configure IP unicast routing before you configure IP multicast routing.

DVMRP Overview

DVMRP is a distance vector protocol that is used to exchange routing and multicast information between routers. Like RIP, DVMRP periodically sends the entire routing table to its neighbors.

DVMRP has a mechanism that allows it to prune and graft multicast trees to reduce the bandwidth consumed by IP multicast traffic.

PIM Overview

The switch supports both dense mode and sparse mode operation. You can configure dense mode or sparse mode on a per-interface basis. Once enabled, some interfaces can run dense mode, while others run sparse mode.

PIM Dense Mode

Protocol Independent Multicast-Dense Mode (PIM-DM) is a multicast routing protocol that is similar to DVMRP. PIM-DM routers perform reverse path multicasting (RPM). However, instead of exchanging its own unicast route tables for the RPM algorithm, PIM-DM uses the existing unicast route table for the reverse path. As a result, PIM-DM requires less system memory.

PIM-DM is a broadcast and prune protocol. Using PIM-DM, multicast routes are pruned and grafted in a way similar to DVMRP.

PIM Sparse Mode (PIM-SM)

Unlike PIM-DM, PIM-SM is an explicit join and prune protocol, and it supports shared trees as well as shortest path trees (SPTs). The routers must explicitly join the group(s) in which they are interested in becoming a member, which is beneficial for large networks that have group members who are sparsely distributed.

Using PIM-SM, the router sends a join message to the rendezvous point (RP). The RP is a central multicast router that is responsible for receiving and distributing multicast packets. By default, the RP is selected dynamically. You can also define a static RP in your network, using the following command:

```
config pim crp static <rp address> [none | <access profile> {<priority [0-254]>}]
```

When a router has a multicast packet to distribute, it encapsulates the packet in a unicast message and sends it to the RP. The RP decapsulates the multicast packet and distributes it among all member routers.

When a router determines that the multicast rate from a particular originating router (not the RP) has exceeded a configured threshold, that router can send an explicit join to the originating router. Once this occurs, the receiving router gets the multicast directly from the sending router, and bypasses the RP.

NOTE

You can run either PIM-DM or PIM-SM per VLAN.

PIM Mode Interoperation

An Extreme Networks switch can function as a PIM multicast border router (PMBR). A PMBR integrates PIM-SM and PIM-DM traffic.

When forwarding PIM-DM traffic into a PIM-SM network, the PMBR notifies the RP that the PIM-DM network exists. The PMBR forwards PIM-DM multicast packets to the RP, which, in turn, forwards the packets to those routers that have joined the multicast group.

The PMBR also forwards PIM-SM traffic to a PIM-DM network, based on the (*.*.RP) entry. The PMBR sends a join message to the RP and the PMBR forwards traffic from the RP into the PIM-DM network.

No commands are required to enable PIM mode interoperation. PIM mode interoperation is automatically enabled when a dense mode interface and a sparse mode interface are enabled on the same switch.

IGMP Overview

IGMP is a protocol used by an IP host to register its IP multicast group membership with a router. Periodically, the router queries the multicast group to see if the group is still in use. If the group is still active, a single IP host responds to the query, and group registration is maintained.

IGMP is enabled by default on the switch. However, the switch can be configured to disable the generation of periodic IGMP query packets. IGMP should be enabled when the switch is configured to perform IP unicast or IP multicast routing.

IGMP Snooping

IGMP snooping is a layer 2 function of the switch. It does not require multicast routing to be enabled. IGMP snooping optimizes the usage of network bandwidth, and prevents multicast traffic from being flooded to parts of the local network that do not need it. The switch does not reduce any IP multicast traffic in the local multicast domain (224.0.0.x).

IGMP snooping is enabled by default on the switch. If IGMP snooping is disabled, all IGMP and IP multicast traffic floods within a given VLAN. IGMP snooping expects at least one device in the network to periodically generate IGMP query messages. An optional optimization for IGMP snooping is the strict recognition of multicast routers only if the remote devices have joined the DVMRP (224.0.0.4) or PIM (244.0.0.13) multicast groups.

When a port sends an IGMP leave message, the switch removes the IGMP snooping entry after 10 seconds. The switch sends a query to determine which ports want to remain in the multicast group. If other members of the VLAN want to remain in the multicast group, the router ignores the leave message, but the port that requests removal is removed from the IGMP snooping table.

If the last port within a VLAN sends an IGMP leave message, the router does not receive any responses to the query, and the router immediately removes the VLAN from the multicast group.

Performance Enhancements for the BlackDiamond Switch

The BlackDiamond switch can optimize multicast data forwarding performance for modules that use the “i” series chipset. To increase the performance of multicast applications, you can disable I/O modules in the system that do not use the “i” series chipset.

In addition, you can modify the backplane load-sharing policy for more robust support of multicast streams.

NOTE

The round-robin algorithm is not supported on non-“i” series I/O modules. The default backplane loadsharing policy is “port-based”.

To configure the switch backplane load-sharing policy, use this command:

```
config backplane-ls-policy [address-based | port-based | round-robin]
```

NOTE

For more information on load sharing, see Chapter 4.

Configuring IP Multicasting Routing

To configure IP multicast routing, you must do the following:

1. Configure the system for IP unicast routing.
2. Enable multicast routing on the interface using the following command:

   ```
   enable ipmcforwarding {vlan <vlan name>}
   ```
3. Enable DVMRP or PIM on all IP multicast routing interfaces using one of the following commands:

   ```
   config dvmrp add vlan [<vlan name> | all]
   config pim add vlan [<vlan name> | all] {dense | sparse}
   ```
4. Enable DVMRP or PIM on the router using one of the following commands:

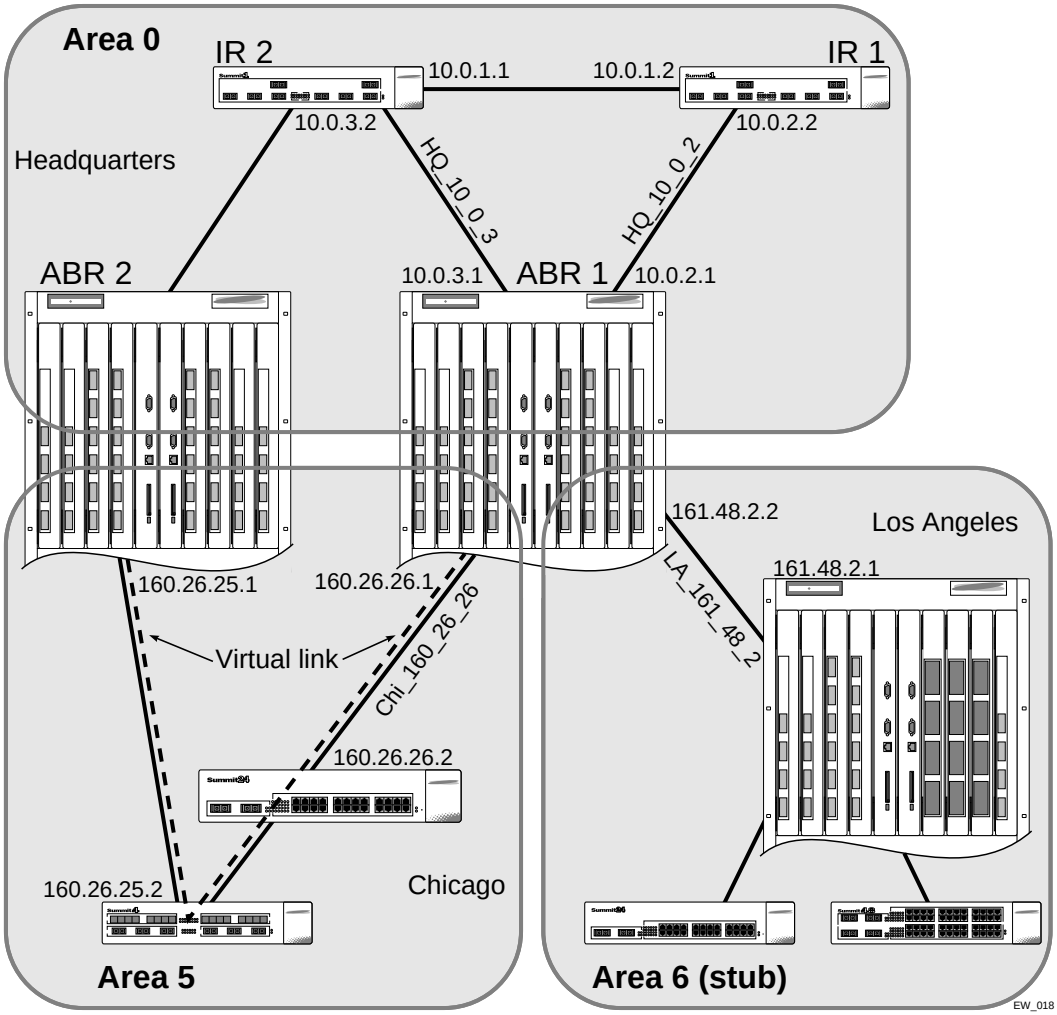
   ```
   enable dvmrp [rxmode | txmode]
   enable pim
   ```

Configuration Examples

Figure 72 andFigure 73 are used in Chapter 17 to describe the OSPF configuration on a switch. Refer to Chapter 17 for more information about configuring OSPF. In the first example, the system labeled IR1 is configured for IP multicast routing, using PIM-DM. In the second example, the system labeled ABR1 is configured for IP multicast routing using PIM-SM.

PIM-DM Configuration Example

Figure 72: IP multicast routing using PIM-DM configuration example



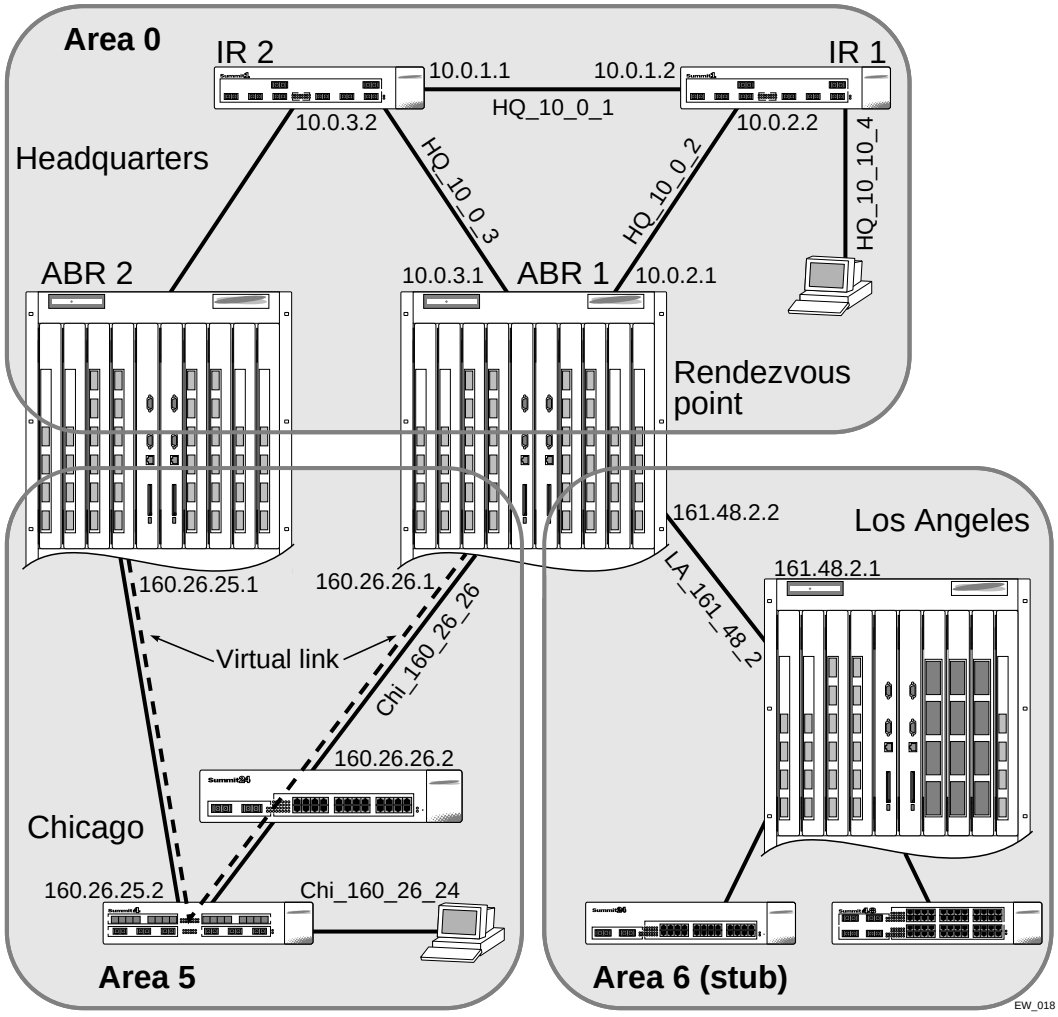
Configuration for IR1

The router labeled IR1 has the following configuration:

```
config vlan HQ_10_0_1 ipaddress 10.0.1.2 255.255.255.0
config vlan HQ_10_0_2 ipaddress 10.0.2.2 255.255.255.0
config ospf add vlan all
enable ipforwarding
enable ospf
enable ipmcforwarding
config pim add vlan all dense
config pim spt-threshold 16 8
enable pim
```

The following example configures PIM-SM.

Figure 73: IP multicast routing using PIM-SM configuration example



Configuration for ABR1

The router labeled ABR1 has the following configuration:

```
config vlan HQ_10_0_2 ipaddress 10.0.2.1 255.255.255.0
config vlan HQ_10_0_3 ipaddress 10.0.3.1 255.255.255.0
config vlan LA_161_48_2 ipaddress 161.48.2.2 255.255.255.0
config vlan CHI_160_26_26 ipaddress 160.26.26.1 255.255.255.0
config ospf add vlan all
enable ipforwarding
enable ipmcforwarding
config pim add vlan all sparse
create access-profile rp-list ipaddress
config rp-list add ipaddress 224.0.0.0 240.0.0.0
enable loopback HQ_10_0_3
config pim crp HQ_10_0_3 rp-list 30
config pim csbr HQ_10_0_3 30

config pim spt-threshold 16 8
```

20 IPX Routing

This chapter describes the following topics:

- Overview of IPX on page 353
- IPX/RIP Routing on page 356
- Configuring IPX on page 357
- IPX Configuration Example on page 359

This chapter assumes that you are already familiar with IPX. If not, refer to your Novell™ documentation.

Overview of IPX

The switch provides support for the IPX, IPX/RIP, and IPX/SAP protocols. The switch dynamically builds and maintains an IPX routing table and an IPX service table.

Router Interfaces

The routing software and hardware routes IPX traffic between IPX router interfaces. A router interface is simply a VLAN that has an IPX network identifier (NetID) and IPX encapsulation type assigned to it.

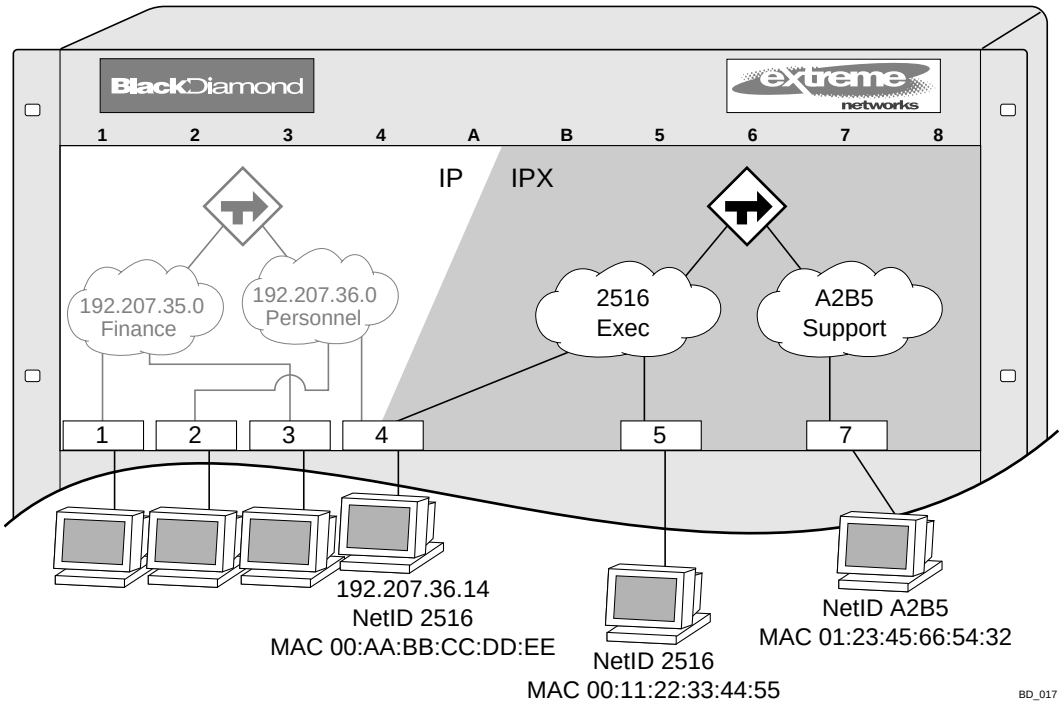
As you create VLANs with different IPX NetIDs the switch automatically routes between them. Both the VLAN switching and IPX routing function occur within the switch.

Extreme switches support these IPX routing features:

- Separate routing interfaces for IP and IPX traffic on the same VLAN
- Load sharing of IPX routed traffic
- 802.1Q tagged packets on a routed IPX VLAN

Figure 74 shows the same BlackDiamond switch discussed in earlier chapters. In Figure 74, IPX routing has been added to the BlackDiamond switch, and two additional VLANs have been defined; *Exec* and *Support*. Both VLANs have been configured as protocol-specific VLANs, using IPX.

Figure 74: IPX VLAN configuration



Exec has been assigned the IPX NetID 2516. *Support* has been assigned the IPX NetID A2B5. All ports on slot 5 are assigned to *Exec*; all ports on slot 7 are assigned to *Support*. In addition, all ports on slot 4 have been assigned to *Exec*. Thus, the ports on slot 4 belong to both the *Personnel* VLAN (running IP) and the *Exec* VLAN (running IPX).

Traffic within each VLAN is switched using the Ethernet MAC address. Traffic between *Exec* and *Support* is routed using the IPX NetID. Traffic cannot be sent between the IP VLANs (*Finance* and *Personnel*) and the IPX VLANs (*Exec* and *Support*).

IPX Routing Performance

Extreme switches are capable of performing IPX routing at wire-speed.

IPX Load Sharing

ExtremeWare supports IPX load sharing on all products that use the “i” chipset. No additional configuration is required to support this function, simply configure load sharing as you would normally.

NOTE

For more information on load sharing, see Chapter 4.

IPX Encapsulation Types

Novell NetWare™ supports four types of frame encapsulation. The ExtremeWare term for each type is described in Table 42.

Table 42: IPX Encapsulation Types

Name	Description
ENET_II	The frame uses the standard Ethernet 2 header.
ENET_8023	The frame includes the IEEE 802.3 length field, but does not include the IEEE 802.2 Logical Link Control (LLC) header. This encapsulation is used by NetWare version 2.x and the original 3.x version.
ENET_8022	The frame uses the standard IEEE format and includes the IEEE 802.2 LLC header. This encapsulation is used by NetWare version 3.12 and 4.x.
ENET_SNAP	The frame adds a Subnetwork Access Protocol (SNAP) header to the IEEE 802.2 LLC header.

To configure a VLAN to use a particular encapsulation type, use the following command:

```
config vlan <vlan name> xnetid <netid> [enet_ii | enet_8023 | enet_8022 | enet_snap]
```

Tagged IPX VLANs

ExtremeWare supports tagged 802.1Q traffic on an IPX VLAN that is performing routing. Tagging is most commonly used to create VLANs that span multiple switches. Using VLAN tags, multiple VLANs can span multiple switches using one or more trunks. In a port-based VLAN, each VLAN requires its own pair of trunk ports.

Another benefit of tagged VLANs is the ability to have a port be a member of multiple VLANs. This is particularly useful if you have a device (such as a server) that must belong to multiple VLANs. A single port can be a member of only one port-based VLAN. All additional VLAN memberships for that port must be configured with tags.

To configure a tagged IPX VLAN, assign a tag to the VLAN using the following command:

```
config vlan <vlan name> tag <vlanid>
```

The valid range is from 1 to 4095.

To assign tagged ports to the VLAN, use the following command:

```
config vlan <vlan name> add port <portlist> {tagged | untagged} {nobroadcast}
```

To display your VLAN settings, use the following command:

```
show vlan {<vlan name>} {detail}
```

Populating the Routing Table

The switch builds and maintains an IPX routing table. As in the case of IP, the table is populated using dynamic and static entries.

Dynamic Routes

Dynamic routes are typically learned by way of IPX/RIP. Routers that use IPX/RIP exchange information in their routing tables in the form of advertisements. Using dynamic routes, the routing table contains only networks that are reachable.

Dynamic routes are aged out of the table when an update for the network is not received for a period of time, as determined by the routing protocol.

Static Routes

Static routes are manually entered into the routing table. Static routes are used to reach networks not advertised by routers. You can configure up to 64 static IPX routes on the switch. Static routes are never aged out of the routing table. Static routes are advertised to the network using IPX/RIP.

IPX/RIP Routing

The switch supports the use of IPX/RIP for unicast routing. IPX/RIP is different from IP/RIP. However, many of the concepts are the same. ExtremeWare supports the following IPX/RIP features:

- Split horizon
- Poison reverse
- Triggered Updates

Route information is entered into the IPX route table in one of the following two ways:

- Dynamically, by way of RIP
- Statically, using the command:

  ```
  config ipxroute add [<dest_netid> | default] next_hop_netid next_hop_node_addr
  <hops> <ticks>
  ```

IPX/RIP is automatically enabled when a NetID is assigned to the VLAN. To remove the advertisement of an IPX VLAN, use the command:

```
config ipxrip delete {vlan <vlan name> | all}
```

GNS Support

ExtremeWare supports the Get Nearest Server (GNS) reply function. When a NetID is assigned to the switch, the GNS reply service is automatically enabled. When a station requests a particular service on the network (for example, locating a print server), the station sends a GNS request and the switch responds to the request. If GNS-reply is disabled, the switch drops the request.

To disable GNS-reply, use the following command:

```
disable ipxsap gns-reply {vlan <vlan name>}
```

Routing SAP Advertisements

The switch contains an IPX Service Table, and propagates SAP advertisements to other IPX routers on the network. Each SAP advertisement contains the following:

- Service type
- Server name
- Server NetID
- Server node address

The service information is entered into the IPX Service Table in one of the following two ways:

- Dynamically, by way of SAP
- Statically, using the following command:

  ```
  config ipxservice add <service_type> <service_name> <netid> <mac_address> <socket> <hops>
  ```

Configuring IPX

This section describes the commands associated with configuring IPX, IPX/RIP, and IPX/SAP on the switch. To configure IPX routing, follow these steps:

1. Create at least two VLANs.
2. If you are combining an IPX VLAN with another VLAN on the same port(s), you must use a protocol filter on one of the VLANs, or use 802.1Q tagging.
3. Assign each VLAN a NetID and encapsulation type using the following command:

   ```
   config vlan <vlan name> xnetid <netid> [enet_ii | enet_8023 | enet_8022 | enet_snap]
   ```

   Ensure that each VLAN has a unique IPX NetID and that the encapsulation type matches the VLAN protocol.

Once you configure the IPX VLAN information, IPX forwarding automatically begins to function. Specifically, configuring the IPX VLAN automatically enables the IPX/RIP, IPX/SAP, and SAP GNS services.

Verifying IPX Router Configuration

You can use the following commands to verify the IPX routing configuration:

- `show vlan`—In addition to other information, this command displays the IPX NetID setting and encapsulation type.
- `show ipxconfig`—This command is analogous to the `show ipconfig` command for the IP protocol. It displays summary global IPX configuration information followed by per-VLAN information. Information includes enable/disable status for IPX/RIP, IPX/SAP, IPX route sharing, IPX service sharing, and so on.
- `show ipxroute`—This command is analogous to the `show iproute` command for the IP protocol. It displays static and learned routes, along with information about the VLAN that uses the route, hop count, age of the route, and so on.
- `show ipxsap`—This command displays the enable status of IPX/SAP for the VLAN, and its operational and administrative status (including the GNS reply service). It also lists any identified IPX/SAP neighbors, SAP packet statistics, and several other timer settings.
- `show ipxrip`—This command displays the enable status of IPX/RIP for the VLAN, including operational and administrative status. It also lists any identified IPX/RIP neighbors, RIP packet statistics, and several other timer settings.
- `show ipxservice`—This command displays the contents of the IPX Service Table.

Protocol-Based VLANs for IPX

When combining IPX VLANs with other VLANs on the same physical port, it may be necessary to assign a protocol filter to the VLAN. This is especially true if it is not possible to use 802.1Q VLAN tagging. For convenience, IPX-specific protocol filters have been defined and named in the default configuration of the switch. Each filter is associated with a protocol encapsulation type. The IPX-specific protocol filters and the associated encapsulation type of each are described in Table 43.

Table 43: IPX Protocol Filters and Encapsulation Types

Protocol Name	Protocol Filter	Used for Filtering IPX Encapsulation Type
IPX	eypte 0x8137	enet_ii
IPX_8022	llc 0xe0e0	enet_802_2
IPX_snap	SNAP 0x8137	enet_snap

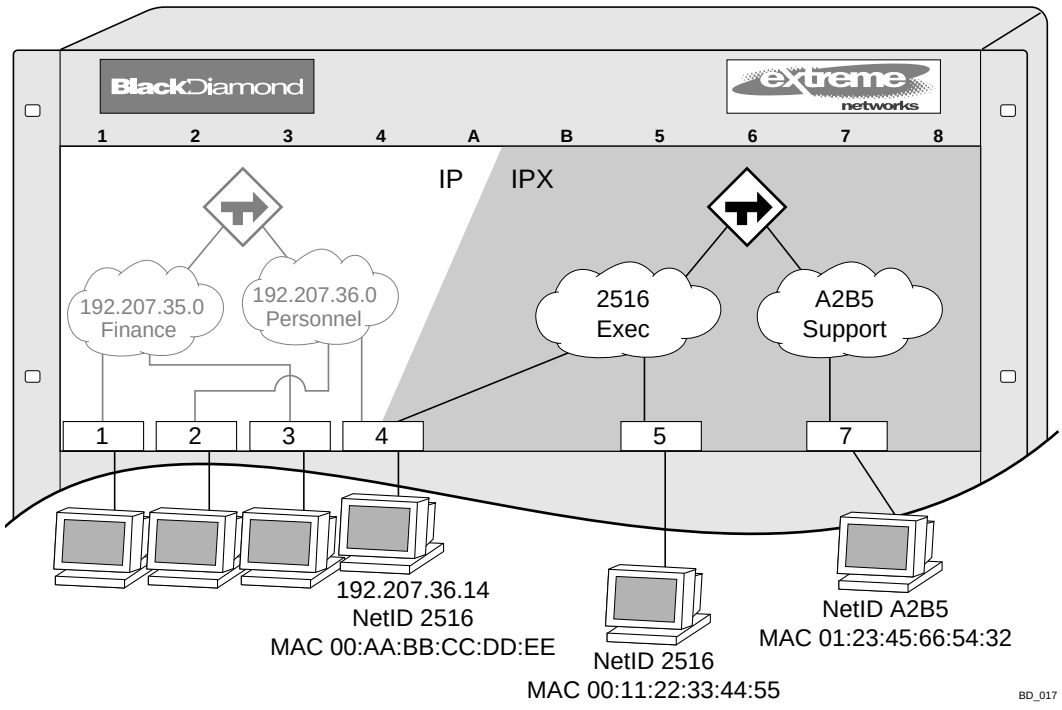
It is not possible to define a protocol-sensitive VLAN for filtering the IPX `enet_8023` encapsulation type. Instead, use a protocol-sensitive filter on the other VLANs that share the same ports, leaving the `enet_8023` encapsulation VLAN configured using the any protocol.

IPX Configuration Example

Figure 75 builds on the example showing the IP/RIP configuration that was used in earlier chapters. Now, in addition to having IP VLANs configured, this example illustrates a switch that has the following IPX VLANs defined:

- *Exec*
  - Protocol-sensitive VLAN using the IPX protocol with the filter IPX_8022.
  - All ports on slot 4 and slot 5 have been assigned to *Exec.*
  - *Exec* is configured for IPX NetID 2516 and IPX encapsulation type 802.2.
- *Support*
  - All ports on slot 7 have been assigned to *Support.*
  - *Support* is configured for IPX NetID A2B5 and IPX encapsulation type 802.2.

Figure 75: IPX routing configuration example



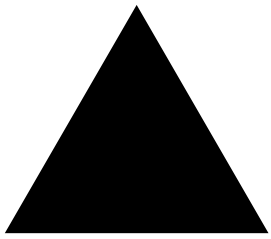
The stations connected to the system generate a combination of IP traffic and IPX traffic. The IP traffic is filtered by the IP VLANs. IPX traffic is filtered by the IPX VLANs.

In this configuration, all IP traffic from stations connected to slots 1 and 3 have access to the IP router by way of the VLAN *Finance.* IP traffic on ports on slots 2 and 4 reach the IP router by way of the VLAN *Personnel.*

Similarly, IPX traffic from stations connected to slots 4 and 5 have access to the IPX router by way of the VLAN *Exec*. IPX traffic on ports on slot 7 reach the IPX router by way of the VLAN *Support*. Both *Exec* and *Support* use enet_8022 as the encapsulation type.

The IPX configuration shown in example in Figure 75 is as follows:

```
create vlan Exec
create vlan Support

config Exec protocol ipx_8022

config Exec add port 4:*,5:*
config Support add port 7:*

config Exec xnetid 2516 enet_8022
config Support xnetid A2B5 enet_8022
```



Part 3
Configuring Modules

21 Accounting and Routing Module (ARM)

The Accounting and Routing Module (ARM) is a self-contained module for the BlackDiamond 6800 series chassis-based system. Unlike most other BlackDiamond modules, there are no external network interfaces on the ARM. Instead, the ARM provides advanced IP services for the other input/output (I/O) modules installed in the chassis. The ARM contains a powerful set of packet processing resources that operate in a one-armed fashion: receiving frames from the switch fabric, processing the frames, and transmitting the frames back into the switch fabric. More specifically, the accounting feature is used to track and record IP unicast packets. This enables you to create custom billing rates for your customers.

The ARM contains a powerful set of network processors specifically programmed to implement the IP routing and accounting function. The card has no external ports, but contains four full-duplex gigabit Ethernet internal ports to the BlackDiamond backplane switch fabric. Each internal processor provides media speed packet processing for two internal full-duplex gigabit Ethernet ports. The ARM operates in a one-armed fashion: receiving frames from the switch fabric, processing the frames, and transmitting the frames back into the switch fabric to the appropriate I/O module output port.

This chapter covers the following topics:

- Summary of Features on page 363
- Configuring the ARM on page 367
- ARM Configuration Examples on page 373
- Retrieving Accounting Statistics on page 383
- Diagnostics Commands on page 384
- Layer 2 and Layer 3 Switching Attributes on page 385
- Debug Trace Commands on page 385

Summary of Features

The ARM includes the following features:

- **Selective Longest Prefix Match—**IP unicast packets are routed in the ARM hardware using a longest prefix match (LPM) algorithm. This differs from the BlackDiamond switch fabric, which uses an exact match algorithm. The BlackDiamond switch fabric has great forwarding capacity, but the ARM module has better handling of large numbers (hundreds of thousands) of destination IP addresses to match each packet's destination IP address. To take advantage of the BlackDiamond switch fabric forwarding capacity and the ARM module's scalability, the ARM module can be configured to use

the BlackDiamond switch fabric for some routes and the ARM's LPM for others. This feature is called Selective Longest Prefix Match (Selective-LPM).

- **Destination-Sensitive Accounting—**Destination Sensitive Accounting gives you the flexibility to bill your customers at predetermined and different rates. The rates are based on the customers' IP unicast packet destinations.

  The accounting feature categorizes IP unicast packets using two parameters, input VLAN ID and accounting bin number. The VLAN ID is used to identify from which customer the packet is received. The accounting bin number is associated with the route used to forward the packet. External billing application servers can correlate the accounting bin number to a specific billing rate.

ARM Module Limitations

The following limitations apply to the ARM module:

- SLB is a mutually exclusive function with ARM
- Selective LPM is not supported when Accounting is enabled (all IP traffic is LPM routed)
- Flows are not redirected if the flow redirection rule destination matches a subnet that is LPM enabled
- IPX routing is not supported
- PoS/ATM bridging is not compatible with ARM when two MSMs are installed
- ARM and MPLS modules cannot be installed in the same switch
- Commands with port parameters are not directly applicable to the ARM

About IP Unicast Forwarding

IP unicast forwarding is performed on the ARM to facilitate implementation of accounting. When `lpm` or `accounting` is enabled, the ARM, rather than the switch fabric hardware, performs some or all of the layer-3 IP unicast forwarding. Layer-2 switching and layer-3 IP multicast forwarding are unaffected.

The ExtremeWare software distributes its IP unicast routing table, ARP table, and interface IP addresses to each ARM so that every ARM contains the same IP routing database.

Each ARM has sufficient capacity to support 239 K IP longest prefix match lookup route entries. Each route entry also supports up to four equal-cost paths, providing a maximum routing database capacity of 958 K routes. IP forwarding is configurable per VLAN.

Each ARM IP routing database provides an aggregate IP forwarding throughput of up to 4 Gbps. The total forwarding throughput for a single BlackDiamond chassis can be scaled up to 16 Gbps by adding up to three ARMs. ARMs interface to the BlackDiamond switch fabric via four 1 Gbps internal links. IP unicast traffic is internally forwarded from the BlackDiamond I/O modules using one of three backplane load sharing policies: port-based, address-based, or round-robin. The default backplane load-sharing policy is port-based. The round-robin load sharing backplane is not recommended because packet ordering is not guaranteed.

About Selective Longest Prefix Match

Selective Longest Prefix Match (SLPM) provides control over the method by which IP unicast packets are routed. The routing method can be specified for individual VLANs and routes. Packets may either be routed using the Longest Prefix Match (LPM) algorithm, or they may be routed using an IP address-caching method. To configure SLPM on a per VLAN basis, the ExtremeWare `enable`

`ipforwarding lpm-routing` and `disable ipforwarding lpm-routing` commands are used. To configure SLPM on a per route basis, the ExtremeWare `route-map` command is used.

The LPM algorithm is supported in two ways on the BlackDiamond. The first method is implemented by the ExtremeWare software and runs on the MSM's CPU. The second method is implemented in hardware on either the MPLS module or the ARM. When one or more MPLS modules or ARMs are installed and active, LPM processing is performed on those modules. Packets destined to VLANs or routes that are configured for LPM are forwarded to the MPLS modules or ARMs for processing when SLPM is enabled. The term for packets forwarded in this manner is "LPM routing."

The IP address-caching method is implemented in hardware on both the MSM and many of the I/O modules. On Extreme Networks products, this IP address cache is called the IP Forwarding Database (IP FDB). Packets destined to VLANs or routes that are not configured for LPM routing will not be sent to the MPLS module or ARM for processing. The term for packets forwarded in this manner is "IP host routing." The default forwarding behavior for IP unicast packets is IP host routing.

Due to the nature of the IP FDB, the overall system performance can suffer under adverse conditions. Under heavy traffic loads with a large number of destination IP addresses, updating IP FDB entries can tax the system's CPU resources. Similarly, network topology changes can cause large numbers of IP FDB entries to be added or deleted, taxing the system's CPU. Enabling LPM routing can allow forwarding decisions for one or more traffic flows to bypass the IP FDB and reduce the load on the CPU.

SLPM, when enabled, also augments the performance of "slow path" forwarding. Under normal circumstances, if an IP packet received by the system has a destination IP address that cannot be found in the IP FDB, the CPU must forward that packet. Inserting an MPLS module or ARM, and enabling SLPM allows slow path processing to be performed by the module's hardware at a greatly accelerated rate.

The choice of when to configure LPM routing versus IP host routing depends on two criteria:

- The ratio of destination IP addresses to IP routes.
- Bandwidth requirements for IP traffic flows.

When the ratio of destination IP addresses to IP routes is extremely high, as is usually the case for a switch connected to the Internet, LPM routing should be considered. Typically, LPM routing would be enabled for any VLAN containing ports that connect to the Internet. However, LPM routing can be beneficial in any circumstance where the number of IP addresses in a destination network greatly exceeds the number of routes being advertised by that network. For example, LPM routing could be enabled for a network consisting mainly of end-user computers or one consisting of dial-up customers.

The amount of bandwidth required by specific IP traffic flows needs to considered as well. LPM routing is performed by hardware on the MPLS modules or ARMs installed in the system. Each module is capable of processing 4 Gbps of traffic at maximum, and a maximum of four modules can be installed. This places an upper limit of 16 Gbps of throughput for traffic being LPM routed. If the aggregate bandwidth for a set of IP traffic flows exceeds the LPM routing bandwidth, then IP host routing should be used. An example where IP host routing is beneficial is a core router connecting multiple campus networks to each other.

A special set of commands is used to configure the SLPM function. Table XX describes the commands added to the ExtremeWare software for configuring SLPM.

Table 44: SLMP Commands

Command	Description of Change
config iproute route-map [ospf-intra | ospf-inter | ospf-extern1 | ospf-extern2 | ospf | rip | static | e-bgp | i-bgp | bgp | direct] <route-map> | none	Configures how the specified route map is to be applied to IP routing tables. If none is selected, it disassociates the route map from the routing protocol.
config route-map <route-map> <sequence_number> [add | delete] set iphost-routing	Configures IP host routing for the specified route map entry.
config route-map <route-map> <sequence_number> [add | delete] set lpm-routing	Configures LPM routing for the specified route map entry.
disable ipforwarding lpm-routing {{vlan} <vlan>}	Disable the LPM routing feature for the specified VLAN. If no VLAN is specified, LPM routing is disabled for all VLANs except the management VLAN.
disable lpm	Disables the SLPM function.
enable ipforwarding lpm-routing {{vlan} <vlan>}	Enables the LPM routing feature for the specified VLAN. If no VLAN is specified, LPM routing is enabled for all VLANs except the management VLAN.
enable lpm	Enables the SLPM function.
show lpm	Indicates if SLPM is currently enabled or disabled.

NOTE

SLB, Selective-LPM and DSA are mutually exclusive functions and cannot be simultaneously enabled.

About Destination-Sensitive Accounting

Destination-sensitive accounting (DSA) collects statistics that are maintained for forwarded IP traffic to support billing on a destination basis. To configure destination-sensitive accounting, a bin number can be assigned to one or more IP route entries using the ExtremeWare `route-map` command.

Bin numbers are integers that range from 0-7 and their only intrinsic meaning is to identify a particular set of accounting statistics. Each bin contains a 64-bit count of the number of packets that have been forwarded and a 64-bit count of the number of bytes that have been forwarded. When the MPLS/ARM module forwards an IP packet, the bin number from the forwarding database entry for the IP destination is used to identify the set of counters to be updated. Packets forwarded to the MSM CPU are not counted.

Eight unique bins are maintained for each of the possible 4096 VLAN IDs. Logically, the bins are organized as a two-dimensional array, with the row index being a VLAN ID and the column index being a bin number. Thus, when an IP frame is forwarded, the input VLAN ID selects the row and the bin number from the forwarding database entry selects the column. The use of input VLAN ID enables billing statistics to be maintained on a per customer basis where the VLAN ID identifies the customer.

DSA can run on either an MPLS or ARM module.

You use a special set of commands to configure the accounting function. Table 45 describes the commands added to the ExtremeWare software for configuring accounting.

Table 45: Accounting Commands

Command	Description of Change
clear accounting counters	Clears (zeroes out) all of the accounting statistics.
config iproute route-map [ospf-intra | ospf-inter | ospf-extern1 | ospf-extern2 | ospf | rip | static | e-bgp | i-bgp | bgp | direct] <route-map> | none	Configures how the specified route map is to be applied to IP routing tables. If none is selected, it disassociates the route map from the routing protocol.
config route-map <route-map> <sequence_number> [add | delete] set accounting-index 1 value <bin_number>	Configures the accounting bin number to be associated with the specified route map entry. The accounting-index value is always set to 1 for destination-sensitive accounting.
disable accounting	Disables the destination-sensitive accounting function.
enable accounting	Enables the destination-sensitive accounting function.
show accounting {<vlan>}	Displays accounting statistics for the specified VLAN. If no VLAN is specified, statistics for all VLANs are displayed.

NOTE

SLB, Selective-LPM and DSA are mutually exclusive functions and cannot be simultaneously enabled.

Configuring the ARM

This section describes the ExtremeWare commands that support the ARM. For hardware installation information on the BlackDiamond 6800 series switch, see the *Extreme Networks Consolidated Hardware Guide*.

NOTE

Documentation for Extreme Networks products is available on the World Wide Web at the Extreme Networks home page at http://www.extremenetworks.com.

This section includes information on the following topics:

- Basic Accounting Configuration Information on page 367
- Basic SLPM Configuration Information on page 369
- Using Route Maps on page 371

Basic Accounting Configuration Information

This section uses several typical usage and configuration schemes to provide a brief overview of the accounting configuration process as a general context for the detailed command description sections that follow.

In the most basic terms, to enable the accounting function, you must enable the accounting feature, create a customer VLAN ID, enable IP forwarding, and configure the accounting bin using the route map feature.

You use a special set of commands to configure the accounting function. Due to the redirection of all incoming IP unicast packets to the ARM, the accounting feature is incompatible with ExtremeWare Server Load Balancing, and Selective-LPM. These features cannot be enabled simultaneously.

The following sections describe how to create a customer VLAN ID, how to enable and disable IP forwarding, how to configure the accounting bin, and how to display destination-based accounting statistics.

Creating Customer VLAN IDs

A unique VLAN ID is used to identify each of your customers. You create a VLAN ID to identify each customer and retrieve the accounting bin count for that customer. To create a customer VLAN ID, use the following commands:

```
create vlan <vlan name>
config vlan <vlan name> tag <vlanid>
config vlan <vlan name> add ports <portlist> {tagged | untagged} {nobroadcast}
```

The `name` parameter is the name of the VLAN you created.

The `vlanid` parameter is the number assigned to the VLAN. The valid numerical range for a VLAN ID is from 1 to 4095.

The `portlist` parameter specifies one or more ports assigned to the VLAN.

The `tagged | untagged` keyword configures the ports as tagged or untagged.

The `nobroadcast` keyword prevents the switch from forwarding broadcast, multicast, and unknown unicast traffic.

The following command example creates a customer VLAN named `acme` with a VLAN ID of 100. Ports 1 and 2 in slot 6 are assigned to the VLAN.

```
create vlan acme
config vlan acme tag 100
config vlan acme add ports 6:1-2 tagged
```

See Chapter 5 for more information.

Enabling and Disabling IP Forwarding

ExtremeWare allows IP forwarding to be enabled on a per-VLAN basis. To enable IP forwarding on a specific VLAN, use the following command:

```
enable ipforwarding {vlan <vlan name>}
```

The `name` parameter is the name of the VLAN you created.

The following command example enables IP forwarding on a VLAN named `acme`:

```
enable ipforwarding acme
```

To disable IP forwarding on a specific VLAN, use the following command:

```
disable ipforwarding {vlan <vlan name>}
```

The following command example disables IP forwarding on a VLAN named acme:

```
disable ipforwarding acme
```

Configuring the Accounting Bin

Destination Sensitive Accounting collects statistics that are maintained for forwarded IP traffic to support billing on a destination basis. To configure Destination Sensitive Accounting, a bin number may be assigned to one or more IP route entries using the ExtremeWare `route-map` command.

Bin numbers are integers that range from 0-7 and their only intrinsic meaning is to identify a particular set of accounting statistics. Each bin contains a 64-bit count of the number of packets that have been forwarded and a 64-bit count of the number of bytes that have been forwarded. When the ARM forwards an IP packet, the bin number from the forwarding database entry for the IP destination is used to identify the set of counters to be updated.

Eight unique bins are maintained for each of the possible 4096 VLAN IDs. Logically, the bins are organized as a 2-dimensional array, with the row index being a VLAN ID and the column index being a bin number. Thus, when an IP frame is forwarded, the input VLAN ID selects the row and the bin number from the forwarding database entry selects the column. The use of input VLAN ID enables billing statistics to be maintained on a per customer basis where the VLAN ID identifies the customer.

Displaying Accounting Statistics

To display accounting statistics, use the following command:

```
show accounting {vlan <vlan name>}
```

If you specify the optional `vlan` parameter, traffic statistics for that VLAN are displayed. If you do not specify the `vlan` parameter, traffic statistics for all VLANS are displayed. The statistics include eight bins per VLAN, where each bin includes the number of packets and bytes forwarded and IP destinations associated with the bin.

Basic SLPM Configuration Information

This section provides a brief overview of the SLPM configuration process as a general context for the detailed command description sections that follow.

In the most basic terms, to enable the SLPM function, you must configure LPM and IP host routing for the configured VLANs, optionally configure LPM and IP host routing using route maps, and enable the SLPM feature.

You use a special set of commands to configure the SLPM function. Due to the selective redirection of incoming IP unicast packets to the MPLS module or ARM, the SLPM feature is incompatible with ExtremeWare Server Load Balancing, and Destination Sensitive Accounting. These features cannot be enabled simultaneously.

The following sections describe how to configure LPM and IP host routing for the configured VLANs, how to configure LPM and IP host routing using route maps, how to enable and disable SLPM, and how to display information about SLPM.

Configuring VLAN-Based LPM and IP Host Routing

Selecting a routing method for a VLAN will cause all packets forwarded to that VLAN to use the specified routing method. To configure LPM routing for a VLAN, use the following command:

```
enable ipforwarding lpm-routing {{vlan} <vlan>}
```

To configure IP host routing for a VLAN, use the following command:

```
disable ipforwarding lpm-routing {{vlan} <vlan>}
```

For both commands, if a VLAN is specified, the command applies only to that VLAN. If no VLAN is specified, then all VLANs except for the management VLAN are affected. This command only affects VLANs that exist at the time the command is issued.

If neither of these commands is issued, then the default selection is to use IP host routing for all VLANs.

The following command example enables LPM routing for the VLAN named customer1 and disables LPM routing (selecting IP host routing) for the VLAN named srvr-farm.

```
enable ipforwarding lpm-routing customer1
disable ipforwarding lpm-routing srvr-farm
```

Configuring Route-Based LPM and IP Host Routing

In some circumstances, a finer grain of control is required when selecting a routing method. To select LPM or IP host routing for one or more IP route entries, use the ExtremeWare route-map command.

When configuring LPM or IP host routing using route maps, be aware that the routing method specified in the route map entries overrides the routing method configured for a VLAN. This override only applies to IP route entries that match the route map criteria. This feature allows packets destined to a specific route to, for example, be IP host routed, while all other packets forwarded to the same VLAN are LPM routed.

Enabling and Disabling the SLPM Feature

Once LPM and IP host routing have been configured for both VLANs and IP route entries, the SLPM feature must be enabled. To enable SLPM, use the following command:

```
enable lpm
```

To disable SLPM, use the following command:

```
disable lpm
```

It is allowable to enable the SLPM feature even though LPM routing has not been configured for any VLAN or IP route entry. In this case, the MPLS module or ARM takes over "slow path" forwarding from the MSM CPU. Any packet received by the system whose destination IP address cannot be found in the IP FDB, is forwarded using the slow path. The MPLS module or ARM, when SLPM is enabled, augments the performance of the slow path, providing a greatly accelerated forwarding rate.

Displaying SLPM Information

To determine if the SLPM feature has been enabled, use the following command:

```
show lpm
```

This command will report if SLPM is enabled or disabled.

The ExtremeWare show vlan and show iproute commands have been modified to indicate which VLANs and IP route entries have been enabled for LPM routing. A VLAN for which LPM routing has been enabled will display an "I" (capital "i") in the flags field of the show vlan command output. An IP route entry for which LPM routing has been enabled will display a "P" in the flags field of the show iproute command.

Configuring Access Profiles

The ExtremeWare `route-map` command is used for configuring LPM routing and assigning accounting bin numbers to specific destinations. To configure route map access policies, it may be necessary to define an access profile.

For more information about access profiles, see Chapter 11.

Using Route Maps

Route maps are used to conditionally configure LPM routing and also to conditionally assign accounting bin numbers to route destinations. Route maps are used in conjunction with the match and set operations. A match operation specifies a criteria that must be matched. A set operation specifies a change that is made to the route when the match operation is successful.

Configuring the Accounting Bin Number for Route Map Entry

To configure an accounting bin number associated with a specified route map entry, use the following command:

```
config route-map <route-map> <sequence_number> [add | delete] set accounting-index 1
value <bin_number>
```

Where the following is true:

- The `route-map` parameter identifies a particular route map.
- The `sequence_number` parameter identifies a specific entry in that route map. The sequence number must be associated with a match statement.
- The `set accounting-index 1 value` keyword phrase indicates that the following parameter is an accounting bin number.
- The `bin_number` parameter is an integer between 0—7, and allows you to define the accounting bin number.

Configuring the Routing Method for Route Map Entry

To the configure the routing method associated with a specified route map entry, use the following commands:

```
config route-map <route-map> <sequence_number> [add | delete] set iphost-routing
config route-map <route-map> <sequence_number> [add | delete] set lpm-routing
```

Where the following is true:

- The route-map parameter identifies a particular route map.
- The sequence_number parameter identifies a specific entry in that route map. The sequence number must be associated with a match statement.
- The set iphost-routing keyword phrase indicates that IP host routing is to be used for IP route entries matching this route map entry's criteria.
- The set lpm-routing keyword phrase indicates that LPM routing is to be used for IP route entries matching this route map entry's criteria.

Applying the Route Map to the IP Routing Table

To configure how the specified route map is applied to IP routing table entries, use the following command:

```
config iproute route-map [ospf-intra | ospf-inter | ospf-extern1 | ospf-extern2 | ospf
| rip | static | e-gbp | i-bgp | bgp | direct] <route-map>
```

Where the following is true:

- The `ospf-intra` (intra-area), `ospf-inter` (inter-area), `ospf-extern1` (external type 1), `ospf-extern2` (external type 2), `ospf`, `rip`, `static`, `e-bgp` (exterior gateway protocol), `i-bgp` (interior gateway protocol), `bgp` (border gateway protcol), and `direct` (directly connected subnets) are keywords that identify route sources that are inserted into the IP routing table.

The configured route map is applied when routes of the specified source type are entered into the routing table. If there is a match between a route map entry and routing table entry, then the specified action is taken. For accounting, the configured bin number is associated with the matching routing table entry. If there is no match, the bin number 0 is assigned to the routing table entry. For SLPM, the configured routing method is selected for the matching routing table entry. If there is no match, the routing method selected will be based on the routing method for the VLAN associated with the routing table entry's next-hop.

Displaying the Configured Route Maps for the IP Route Table

To display the configured route maps for the IP route table, use the following command:

```
show iproute route-map
```

The following command displays the route map associated with each IP route protocol:

```
show iproute route-map
Route Origin  Route-Map
Direct        dsb1
Static        dsb1
OSPFIntra     dsb2
OSPFInter     dsb2
RIP           dsb1
OSPFExt1      dsb2
```

```
OSPFExt2      dsb2
EBGP          dsb2
IBGP          dsb2
```

If a route map is excluded from the IP routing table, the route origins for that specific route map are not displayed. For example, if you exclude `ospf` from the iproute configuration command `config iproute route-map ospf none`, OSPF information is not displayed in the `show iproute route-map` command:

```
show iproute route-map
Route Origin  Route-Map
Direct        dsb1
Static        dsb1
RIP           dsb1
EBGP          dsb2
IBGP          dsb2
```

ARM Configuration Examples

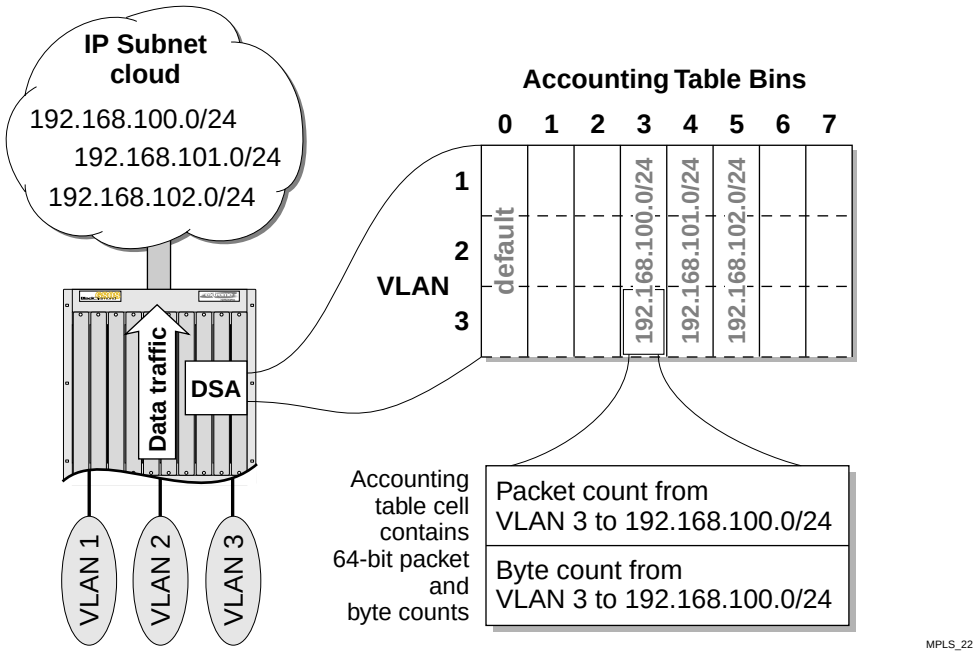
This section provides the following examples:

- Configuring Destination-Sensitive Accounting Based on Destination IP Subnets on page 373
- Configuring Destination-Sensitive Accounting Based on BGP Community Strings on page 377
- Configuring Routing Using SLPM on page 379

Configuring Destination-Sensitive Accounting Based on Destination IP Subnets

The following section gives an example of destination-sensitive accounting based on destination IP subnets, as shown in Figure 76. It depicts a core router in a network services provider environment. VLANs vlan1, vlan2, and vlan3 represent provider customers. The IP subnet cloud represents the provider's internal network where services are hosted. Three classes of service are defined, with each class residing on its own IP subnet.

Figure 76: Destination Sensitive Accounting Based on IP Subnets



In this example, all IP unicast traffic is forwarded by the BlackDiamond switch to one of three subnets. Each IP subnet is mapped to a different accounting bin.

Configure the accounting feature by following these steps:

1 Create VLANs for each attached IP subnet by using the following commands to configure the customer network interfaces as well as the provider's internal network interface. In this example, the provider is using OSPF to advertise network service IP subnets.

```
create vlan vlan1
configure vlan1 ipaddress 192.168.200.1/24
configure vlan1 add ports 8:1

create vlan vlan2
configure vlan2 ipaddress 192.168.201.1/24
configure vlan2 add ports 8:2

create vlan vlan3
configure vlan3 ipaddress 192.168.202.1/24
configure vlan3 add ports 8:3

create vlan backbone
configure backbone ipaddress 192.168.10.1/30
configure backbone add ports 7:1

enable ipforwarding

configure ospf add backbone area 0.0.0.0
enable ospf
```

2 Create access profiles for each destination subnet by using the following commands to create three different profiles: service1, service2, and service3. Each profile is defined to be type ipaddress. Each subnet is then assigned to one of the profiles.

```
create access-profile service1 type ipaddress
configure service1 add ipaddress 192.168.100.0/24

create access-profile service2 type ipaddress
configure service2 add ipaddress 192.168.101.0/24

create access-profile service3 type ipaddress
configure service3 add ipaddress 192.168.102.0/24
```

3 Create a route map named `service_example` by using the following commands:

```
create route-map service_example

configure service_example add 10 permit
configure service_example 10 add match nlri-list service1

configure service_example add 20 permit
configure service_example 20 add match nlri-list service2

configure service_example add 30 permit
configure service_example 30 add match nlri-list service3
```

4 Assign bin numbers to each route map entry by using the following commands:

```
configure service_example 10 add set accounting-index 1 value 3
configure service_example 20 add set accounting-index 1 value 4
configure service_example 30 add set accounting-index 1 value 5
```

5 Correlate the route map to OSPF intra-area routes by using the following command:

```
configure iproute route-map ospf-intra service_example
```

6. Enable the accounting feature by using the following command:

```
enable accounting
```

The `show iproute detail` command displays the bin number, if any, that is associated with a particular route. This command is useful for verifying that bin number configurations are correct.

Below is an excerpt from the output of the `show iproute detail` command for this example configuration

```
Destination: 192.168.100.0/24
Gateway: 192.168.10.2     Metric: 14          Origin: *OSPFIntra
Flags: UG-----umP-        Acct-1: 3           Duration: 0d:1h:07m:43s
Use: 0       M-Use: 0     VLAN: backbone

Destination: 192.168.101.0/24
Gateway: 192.168.10.2     Metric: 14          Origin: *OSPFIntra
Flags: UG-----umP-        Acct-1: 4           Duration: 0d:1h:07m:43s
Use: 0       M-Use: 0     VLAN: backbone

Destination: 192.168.102.0/24
Gateway: 192.168.10.2     Metric: 14          Origin: *OSPFIntra
Flags: UG-----umP-        Acct-1: 5           Duration: 0d:1h:07m:43s
Use: 0       M-Use: 0     VLAN: backbone
```

```
Origin(OR): (b) BlackHole, (be) EBGP, (bg) BGP, (bi) IBGP, (bo) BOOTP
            (ct) CBT, (d) Direct, (df) DownIF, (dv) DVMRP, (e1) ISISL1Ext
            (e2) ISISL2Ext, (h) Hardcoded, (i) ICMP, (i1) ISISL1
            (i2) ISISL2, (ma) MPLSIntra, (mr) MPLSInter, (mo) MOSPF
            (o) OSPF, (o1) OSPFExt1, (o2) OSPFExt2, (oa) OSPFIntra
            (oe) OSPFAsExt, (or) OSPFInter, (pd) PIM-DM, (ps) PIM-SM
            (r) RIP, (ra) RtAdvrt, (s) Static, (sv) SLB_VIP, (un) UnKnown
            (*) Preferred route

Flags: (B) BlackHole, (D) Dynamic, (G) Gateway, (H) Host Route
       (L) Direct LDP LSP, (l) Indirect LDP LSP, (m) Multicast
       (P) LPM-routing, (R) Modified, (S) Static, (T) Direct RSVP-TE LSP
       (t) Indirect RSVP-TE LSP, (u) Unicast, (U) Up

Mask distribution:
    1 routes at length  8          8 routes at length 24
    2 routes at length 30

Route origin distribution:
    6 routes from Direct           3 routes from OSPFIntra
    2 routes from EBGP

Total number of routes = 11.
```

The `show accounting` command lists the packet and octect counts for each bin number per VLAN. Bin 0 is always the default bin and is used to maintain traffic statistics for packets that do not match any of the route map profiles. Bins that have the same packet and octect counts are grouped together. All maintained statistics are 64-bit values.

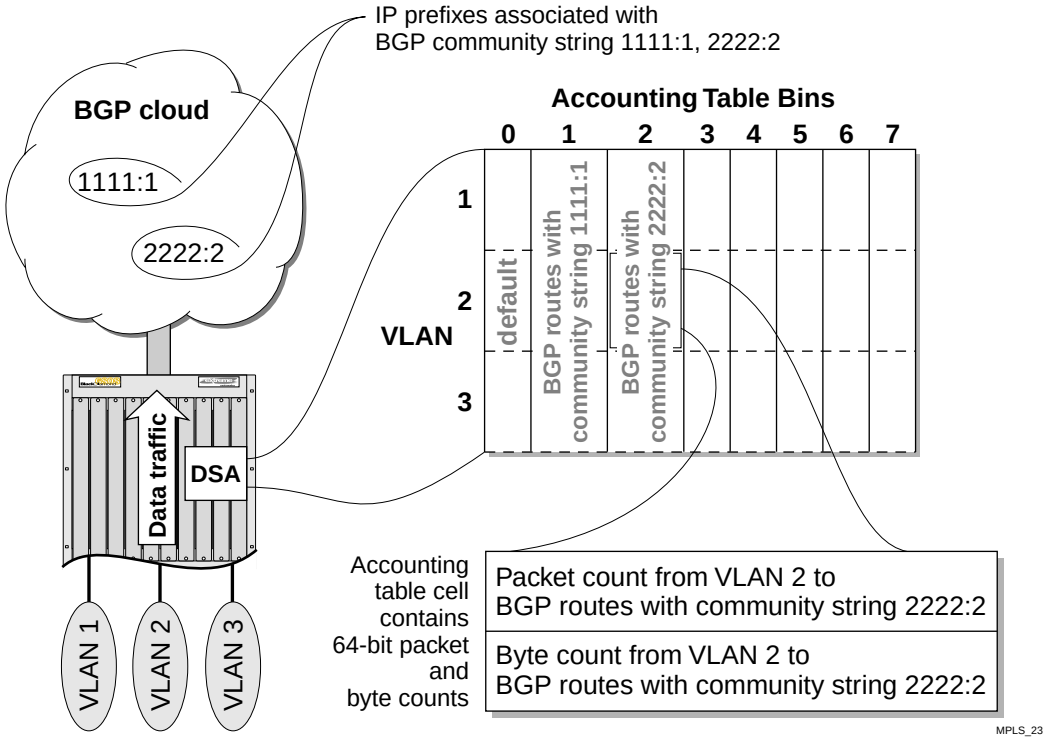
Below is an excerpt of the `show accounting` command. It is assumed that 1000 64-byte packets have been received for each service from each customer.

```
       VLAN Name(  ID)  Bins                  Packets                    Octets
---------------------  ----   ----------------------   ----------------------
         Default(   1)  0-7                         0                         0
 MacVlanDiscover(4095)  0-7                         0                         0
            Mgmt(4094)  0-7                         0                         0
          vlan1(4093)  0-2                         0                         0
                       3-5                      1000                     46000
                       6-7                         0                         0
          vlan2(4092)  0-2                         0                         0
                       3-5                      1000                     46000
                       6-7                         0                         0
          vlan3(4091)  0-2                         0                         0
                       3-5                      1000                     46000
                       6-7                         0                         0
        backbone(4090)  0-7                         0                         0
```

Configuring Destination-Sensitive Accounting Based on BGP Community Strings

The following section gives an example of destination-sensitive accounting based on BGP community strings, as shown in Figure 77. It depicts a core router in an internet service provider environment. VLANs vlan1, vlan2, and vlan3 represent provider customers. The BGP cloud represents the ISP's upstream network connections to the Internet. Two BGP communities are defined to represent two classes of bandwidth service.

Figure 77: Destination Sensitive Accounting Based on BGP



In this example, all IP unicast traffic forwarded by the BlackDiamond switch to one of two BGP communities is counted. Each IP subnet associated with the configured BGP community is mapped to a different accounting bin.

Configure the accounting feature by following these steps:

1 Create VLANs for each attached IP subnet by using the following commands to configure the customer network interfaces as well as the provider's Internet uplink:

```
create vlan vlan1
configure vlan1 ipaddress 192.168.200.1/24
configure vlan1 add ports 8:1

create vlan vlan2
configure vlan2 ipaddress 192.168.201.1/24
configure vlan2 add ports 8:2

create vlan vlan3
configure vlan3 ipaddress 192.168.202.1/24
```

```
configure vlan3 add ports 8:3

create vlan to-internet
configure to-internet ipaddress 192.168.20.1/30
configure to-internet add ports 7:2

enable ipforwarding

configure bgp routerid 192.168.20.1
configure bgp AS-number 65001
create bgp neighbor 192.168.20.2 remote-AS-number 65002
enable bgp neighbor all
enable bgp
```

2 Create the route map bgp_example, map the communities 1111:1 and 2222:2 to the newly created route map and assign a bin number to each BGP community by using the following commands:

```
create route-map bgp_example

configure bgp_example add 10 permit
configure bgp_example 10 add match community 1111:1
configure bgp_example 10 add set accounting-index 1 value 1

configure bgp_example add 20 permit
configure bgp_example 20 add match community 2222:2
configure bgp_example 20 add set accounting-index 1 value 2
```

3 Apply the route map to external BGP routes by using the following commands:

```
configure iproute route-map e-bgp bgp_example
```

4 Enable the accounting feature by using the following command:

```
enable accounting
```

Below is an excerpt from the output of the `show accounting` command for this example configuration:

```
Destination: 192.168.52.0/24
Gateway: 192.168.20.2     Metric: 1           Origin: *EBGP
Flags: UG-----umP-        Acct-1: 1           Duration: 0d:0h:43m:28s
Use: 0       M-Use: 0     VLAN: to-internet

Destination: 192.168.53.0/24
Gateway: 192.168.20.2     Metric: 1           Origin: *EBGP
Flags: UG-----umP-        Acct-1: 2           Duration: 0d:0h:43m:28s
Use: 0       M-Use: 0     VLAN: to-internet

Origin(OR): (b) BlackHole, (be) EBGP, (bg) BGP, (bi) IBGP, (bo) BOOTP
            (ct) CBT, (d) Direct, (df) DownIF, (dv) DVMRP, (e1) ISISL1Ext
            (e2) ISISL2Ext, (h) Hardcoded, (i) ICMP, (i1) ISISL1
            (i2) ISISL2, (ma) MPLSIntra, (mr) MPLSInter, (mo) MOSPF
            (o) OSPF, (o1) OSPFExt1, (o2) OSPFExt2, (oa) OSPFIntra
            (oe) OSPFAsExt, (or) OSPFInter, (pd) PIM-DM, (ps) PIM-SM
            (r) RIP, (ra) RtAdvrt, (s) Static, (sv) SLB_VIP, (un) UnKnown
            (*) Preferred route

Flags: (B) BlackHole, (D) Dynamic, (G) Gateway, (H) Host Route
       (L) Direct LDP LSP, (l) Indirect LDP LSP, (m) Multicast
       (P) LPM-routing, (R) Modified, (S) Static, (T) Direct RSVP-TE LSP
       (t) Indirect RSVP-TE LSP, (u) Unicast, (U) Up
```

```
Mask distribution:
    1 routes at length  8           8 routes at length 24
    2 routes at length 30

Route origin distribution:
    6 routes from Direct            3 routes from OSPFIntra
    2 routes from EBGP

Total number of routes = 11.
```

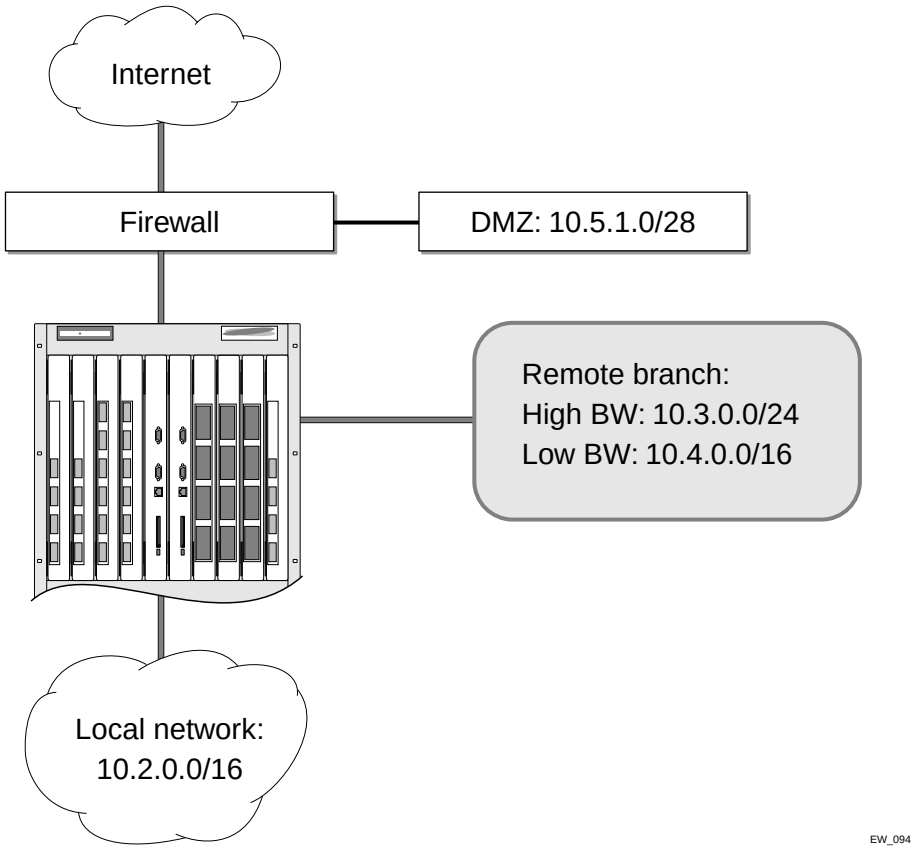
Below is an excerpt of `show accounting` command. It is assumed that 1000 64-byte packets have been received for each service from each customer.

```
       VLAN Name(  ID)  Bins                  Packets                    Octets
----------------------  ----   ----------------------   ----------------------
         Default(   1)  0-7                         0                         0
 MacVlanDiscover(4095)  0-7                         0                         0
            Mgmt(4094)  0-7                         0                         0
           vlan1(4093)  0                           0                         0
                        1-2                      1000                     46000
                        3-7                         0                         0
           vlan2(4092)  0                           0                         0
                        1-2                      1000                     46000
                        3-7                         0                         0
           vlan3(4091)  0                           0                         0
                        1-2                      1000                     46000
                        3-7                         0                         0
     to-internet(4090)  0-7                         0                         0
```

Configuring Routing Using SLPM

The following section gives an example of routing using SLPM on a core router in an enterprise environment, as shown in Figure 78. The switch has three principal network connections. The first connects to a local branch or campus network, the second connects to a remote branch or campus network, and the third connects to a firewall that is linked to the Internet. In addition to the Internet connection, the firewall also connects to a demilitarized zone (DMZ) where publicly-accessible web servers reside. A high-bandwidth forwarding path is desired between the branch networks and the DMZ. A high-bandwidth forwarding path is also desired between the branch networks, however, the remote branch network has an IP subnet containing a large number of low-bandwidth IP hosts.

Figure 78: SLPM Routing in an Enterprise



In this example, IP unicast traffic between the local and remote branches is forwarded using the BlackDiamond's switch fabric. However, IP subnet 10.4.0.0/16 does not require a high-bandwidth switching path. To conserve IP FDB entries, packets destined for this subnet is routed using LPM. IP unicast traffic between either branch network and the Internet is routed using LPM. However, IP packets destined for IP subnet 10.5.1.0/28 are forwarded using the BlackDiamond's switch fabric.

Configure the SLPM feature by following these steps:

1 Create VLANs for each attached IP network by using the following commands:

```
create vlan local_branch
configure local_branch ipaddress 10.2.0.1/16
configure local_branch add ports 7:1

create vlan remote_branch
configure remote_branch ipaddress 10.3.0.1/24
configure remote_branch add ports 7:2

create vlan to_internet
configure to_internet ipaddress 10.1.0.1/30
configure to_internet add ports 7:3

enable ipforwarding
```

2 Configure routing for the destination IP subnets by using the following commands:

```
configure iproute add 10.4.0.0/16 10.3.0.2
configure iproute add 10.5.1.0/28 10.1.0.2

configure bgp routerid 10.1.0.1
configure bgp AS-number 65001
create bgp neighbor 10.1.0.2 remote-AS-number 65002
enable bgp neighbor all
enable bgp
```

3 Enable LPM routing of IP packets for the to_internet VLAN by using the following commands. Though the LPM routing feature is disabled by default, the commands to disable it on the local_branch and remote_branch VLANs are included here.

```
enable ipforwarding lpm-routing to_internet
disable ipforwarding lpm-routing local_branch
disable ipforwarding lpm-routing remote_branch
```

4 Create access profiles for the DMZ and the remote branch's low-bandwidth IP subnet by using the following commands to create two different access profiles, dmz and remote_hosts. Each profile is defined to be type ipaddress. Each subnet is then assigned to one of the profiles.

```
create access-profile dmz type ipaddress
configure dmz add ipaddress 10.5.1.0/28

create access-profile remote_hosts type ipaddress
configure remote_hosts add ipaddress 10.4.0.0/16
```

5 Create a route map named lpm_example, and configure the LPM and IP host routing features for each of the subnets in the newly created route map by using the following commands:

```
create route-map lpm_example

configure lpm_example add 10 permit
configure lpm_example 10 add match nlri-list dmz
configure lpm_example 10 add set iphost-routing

configure lpm_example add 20 permit
configure lpm_example 20 add match nlri-list remote_hosts
configure lpm_example 20 add set lpm-routing
```

6 Apply the route map to static routes by using the following command:

```
configure iproute route-map static lpm_example
```

7 Enable the SLPM feature by using the following command:

```
enable lpm
```

The show vlan command has been enhanced to indicate which VLANs have the LPM routing feature enabled. The LPM routing feature is indicated by an “I” in the flags column of the show vlan command output.

Below is the output of the show vlan command for this example:

```
Name              VID  Protocol Addr        Flags        Proto  Super  Ports  STP
Default           1    0.0.0.0       /BP -----f------- ANY            0/0   0
MacVlanDiscover   4095 ----------------- -----         ANY            0/0   0
Mgmt              4094 ----------------- -----         ANY            1/1   0
local_branch      4093 10.2.0.1       /16 -----f------- ANY            1/1   0
remote_branch     4092 10.3.0.1       /24 -----f------- ANY            1/1   0
```

```
to_internet        4091 10.1.0.1       /30 -----f-I----- ANY            1/1   0

Flags: (C) Domain-masterVlan, (c) Domain-memberVlan, (d) DVMRP Enabled
       (E) ESRP Slave, (f) IP Forwarding Enabled, (G) GVRP Enabled
       (i) ISIS Enabled, (I) IP Forwarding lpm-routing Enabled
       (L) Loopback Enabled, (M) ESRP Master, (m) IPmc Forwarding Enabled
       (N) GNS Reply Enabled, (o) OSPF Enabled, (P) IPX SAP Enabled
       (p) PIM Enabled, (R) SubVLAN IP Range Configured, (r) RIP Enabled
       (S) SuperVlan, (s) SubVlan, (v) VRRP Enabled, (X) IPX RIP Enabled
       (2) IPX Type 20 Forwarding Enabled

Total number of Vlan(s) : 6
```

The show iproute command has been enhanced to indicate which routes have the LPM routing feature enabled. The LPM routing feature is indicated by a “P” in the flags column of the show iproute command output.

Below is the output of the show iproute command for this example:

```
Ori Destination        Gateway         Mtr Flags       VLAN        Duration
*d  10.1.0.0/30        10.1.0.1        1   U------u-P- to_inter    0d:0h:11m:34s
*s  10.5.1.0/28        10.1.0.2        1   UG---S-um-- to_inter    0d:0h:00m:21s
*d  10.3.0.0/24        10.3.0.1        1   U------u--- remote_b    0d:0h:11m:46s
*d  10.2.0.0/16        10.2.0.1        1   U------u--- local_br    0d:0h:11m:56s
*s  10.4.0.0/16        10.3.0.2        1   UG---S-umP- remote_b    0d:0h:00m:02s
*d  127.0.0.1/8        127.0.0.1       0   U-H----um-- Default     0d:0h:19m:34s

Origin(OR): (b) BlackHole, (be) EBGP, (bg) BGP, (bi) IBGP, (bo) BOOTP
            (ct) CBT, (d) Direct, (df) DownIF, (dv) DVMRP, (e1) ISISL1Ext
            (e2) ISISL2Ext, (h) Hardcoded, (i) ICMP, (i1) ISISL1
            (i2) ISISL2, (ma) MPLSIntra, (mr) MPLSInter, (mo) MOSPF
            (o) OSPF, (o1) OSPFExt1, (o2) OSPFExt2, (oa) OSPFIntra
            (oe) OSPFAsExt, (or) OSPFInter, (pd) PIM-DM, (ps) PIM-SM
            (r) RIP, (ra) RtAdvrt, (s) Static, (sv) SLB_VIP, (un) UnKnown
            (*) Preferred route

Flags: (B) BlackHole, (D) Dynamic, (G) Gateway, (H) Host Route
       (L) Direct LDP LSP, (l) Indirect LDP LSP, (m) Multicast
       (P) LPM-routing, (R) Modified, (S) Static, (T) Direct RSVP-TE LSP
       (t) Indirect RSVP-TE LSP, (u) Unicast, (U) Up

Mask distribution:
    1 routes at length  8          2 routes at length 16
    1 routes at length 24          1 routes at length 28
    1 routes at length 30

Route origin distribution:
    4 routes from Direct           2 routes from Static

Total number of routes = 6.
```

Retrieving Accounting Statistics

Accounting statistics are used to bill your customers. Destination Sensitive Accounting gives you the flexibility to bill your customers at predetermined and different rates. For a given set of counts, the source VLAN ID identifies the customer and the accounting bin number corresponds to a billing rate. You need to retrieve the destination sensitive accounting 64-bit counts of the number of packets and the number of bytes forwarded to the accounting bin. The following sections describe how to retrieve the accounting statistics using the Command Line Interface (CLI) or Simple Network Management Protocol (SNMP).

Using the CLI to Retrieve Accounting Statistics

You can display the accounting statistics for a single VLAN or all VLANs by issuing the `show accounting <vlan name>` command. The `show accounting <vlan name>` command lists the packet and octet counts for each bin number per VLAN. Omitting the VLAN name displays the accounting statistics for all the VLANs.

In the following command example, traffic originates from VLANs six1, six2, six3, seven1, seven2, seven3, and seven4. All traffic received is sent to destinations mapped to accounting bin 0.

```
VLAN Name(  ID) Bins               Packets                 Octets
---------------------- ---- --------------------- ---------------------
         Default(   1) 0-7                     0                     0
 MacVlanDiscover(4095) 0-7                     0                     0
         vlan100(4093) 0-7                     0                     0
            six1(4085) 0                840438040           38660149840
                       1-7                     0                     0
            six2(4084) 0                838650339           38577915594
                       1-7                     0                     0
            six3(4083) 0                839173438           38601978148
                       1-7                     0                     0
            six4(4082) 0-7                     0                     0
          seven1(4081) 0                871702314           40098306444
                       1-7                     0                     0
          seven2(4080) 0                871281308           40078940168
                       1-7                     0                     0
          seven3(4079) 0                870416088           40039140048
                       1-7                     0                     0
          seven4(4078) 0                870447512           40040585552
                       1-7                     0                     0
```

Using SNMP to Retrieve Accounting Statistics

Any network manager running SNMP can retrieve accounting statistics provided the Management Information Base (MIB) is installed correctly on the management station. Each network manager provides its own user interface to the management facilities. With support for the CISCO-BGP-POLICY-ACCOUNTING-MIB, you can retrieve accounting statistics using SNMP.

For information about the CISCO-BGP-POLICY-ACCOUNTING-MIB:

1. Go to http://www.cisco.com/public/mibs.
2. Select `SNMP v2 MIBs`.

3 Select `CISCO-BGP-POLICY-ACCOUNTING-MIB.my` for information about the MIB.

In this MIB, the accounting statistics are indexed using the following commands:

- interface index (`ifIndex`)
- traffic index (`cbpAcctTrafficIndex`)

To map a VLAN ID to an interface index, use the interface index of the router interface on the VLAN. The accounting bin number corresponds directly to the traffic index.

Refer to your SNMP Manager documentation for information on how to load MIBs for use within the network manager.

Diagnostics Commands

The `show diag slot <slot> iproute` command displays the ARM IP routing table. The ARM IP routing table is similar to the IP routing table maintained on the MSM module, but differs in the following ways:

- A maximum of four equal cost routes are stored.
- Directly attached hosts are inserted into the ARM IP routing table as host routes (OR=ho).

The following commands display the ARM IP routing table:

```
show diag slot <slot> iproute [origin | summary | <ipaddress>]

show diag slot <slot> iproute origin [bgp | blackhole | direct | e-bgp | best-route |
i-bgp | ospf-extern1 | ospf-extern2 | ospf-inter | ospf-intra | rip | static]
```

Below is an example of `show diagnostics slot <slot number> iproute` command:

```
                                                GWay                VLAN
 OR Destination        Gateway         Gateway MAC   Flags VLAN     Acct Flags
 d  192.168.20.0/30    192.168.20.1    000130032000  mf_L  to-internet    0 _____
 d  192.168.10.0/30    192.168.10.1    000130032000  mf_L  backbone    0 _____
 d  192.168.200.0/24   192.168.200.1   000130032000  mf_L  vlan1       0 _____
 d  192.168.201.0/24   192.168.201.1   000130032000  mf_L  vlan2       0 _____
 d  192.168.202.0/24   192.168.202.1   000130032000  mf_L  vlan3       0 _____
 ho 192.168.10.2/32    192.168.10.2    00a2f1000001  mf__  backbone    0 f_urt
 ho 192.168.20.2/32    192.168.20.2    00a2f2000001  mf__  to-internet    0 f_urt
 be 192.168.52.0/24    192.168.20.2    00a2f2000001  mf__  to-internet    1 f_urt
 be 192.168.53.0/24    192.168.20.2    00a2f2000001  mf__  to-internet    2 f_urt
 oa 192.168.100.0/24   192.168.10.2    00a2f1000001  mf__  backbone    3 f_urt
 oa 192.168.101.0/24   192.168.10.2    00a2f1000001  mf__  backbone    4 f_urt
 oa 192.168.102.0/24   192.168.10.2    00a2f1000001  mf__  backbone    5 f_urt

Origin(OR): b - BlackHole, bg - BGP, be - EBGP, bi - IBGP, bo - BOOTP, ct - CBT
            d - Direct, df - DownIF, dv - DVMRP, h - Hardcoded, ho - Host
            i - ICMP, mo - MOSPF, o - OSPF, oa - OSPFIntra, or - OSPFInter
            oe - OSPFAsExt, o1 - OSPFExt1, o2 - OSPFExt2, pd - PIM-DM
            ps - PIM-SM, r - RIP, ra - RtAdvrt, s - Static, sv - SLB_VIP
            mp - MPLS, un - UnKnown.
```

```
Flags: d - Discard, f - IP Forwarding, m - MAC Address Valid, L - Local Route

Vlan Flags: f - IP Forwarding, I - IP Forwarding lpm-routing, r - Redirect,
            t - Send Time Exceeded, u - Unreachable

Total number of routes = 12.

Mask distribution:
    8 routes at length 24           2 routes at length 30
    2 routes at length 32

Route origin distribution:
     5 routes from Direct            3 routes from OSPFIntra
     2 routes from EBGP              2 routes from Host
```

Layer 2 and Layer 3 Switching Attributes

NOTE

The ARM relies on the MSM switch fabric to support the layer 2 switching functions.

If Destination Sensitive Accounting is enabled, the switch fabric hardware does not perform layer 3 switching for any protocols. The ARM performs layer 3 forwarding the IP.

All of the IP routing protocols are supported: RIP, OSPF, BGP, DVMRP, PIM.

IPX routing is not supported when Destination Sensitive Accounting is enabled.

Jumbo Ethernet frames are supported by the ARM.

Server Load Balancing (SLB) feature is not supported by the ARM.

Debug Trace Commands

System-level debug tracing is provided for the accounting subsystem. To enable this support, use the following command:

```
config debug-trace accounting <level>
```

System-level debug tracing is provided for the Network Processor card (npcard) subsystem. To enable this support, use the following command:

```
config debug-trace npcard <level>
```

NOTE

The debug commands should be used only under the guidance of Extreme Networks technical personnel.

In general, the “level” maps the severity of the log message. Table 46 displays the definitions for the npcard subsystem.

Table 46: NPCard Debug Log Messages

Debug Level	Debug Level Definition
0—Error	Indicates that a severe event has occurred that most likely will result in the termination or improper operation of the ARM.
1—Warning	Indicates that a major event has occurred. It may represent a negative operation. It should be reviewed to ensure proper continuation of ARM operation.
2—Informational	Indicates a minor event has occurred.
3—Debug	Provides additional information to support engineers for the purpose of diagnosing network problems.

22 Asynchronous Transfer Mode (ATM) Module

The Asynchronous Transfer Mode (ATM) module is an I/O module for the BlackDiamond 6800 series chassis-based system. The ATM module connects a BlackDiamond 6800 series switch to the ATM infrastructure used by service providers or enterprise customers.

This chapter includes information on the following topics:

- About the ATM Module on page 387
- Configuring the ATM Module on page 390

About the ATM Module

Key applications for the ATM module are: interconnecting metropolitan area networks across an ATM network infrastructure, interconnecting server co-location network sites directly using ATM links, and providing connectivity between a legacy Enterprise ATM network and an Ethernet backbone.

In the first application, the metropolitan area network service provider can build service network sites in various cities, then use ATM modules in a BlackDiamond 6800 series switch to connect those cities to a carrier's ATM infrastructure.

In the second application, operators of server co-location networks can use ATM modules in BlackDiamond 6800 series switches to create an ATM-based connection between server co-location sites. The result is that their network is simpler to manage, and problems can be isolated and resolved more expediently.

In the third application, a service provider can provide Ethernet-based services by using ATM modules in a BlackDiamond 6800 series switch to connect their Enterprise ATM network to an Ethernet backbone.

Extreme Networks offers the ATM module in the following configuration:

- A3cSi: four OC-3c/STM-1 single-mode, intermediate-reach optical interfaces
- A3cMi: four OC-3 multimode, short-reach optical interfaces

Feature Summary

The ATM module supports the following key networking functions:

- Synchronous Optical Network (SONET) and Synchronous Digital Hierarchy (SDH) modes of operation
- IP routing via the Logical Link Control (LLC) Encapsulation for Routed Protocols compatible with RFC 2684/RFC 1483
- Transparent LAN Services (TLS) over Asynchronous Transfer Mode (ATM) via the LLC Encapsulation Bridged Protocols compatible with RFC 2684/RFC 1483
- Permanent Virtual Circuits (PVCs) may be associated with one or more VLANs
- Routed and bridged encapsulations on the same PVC
- Jumbo frames
- Quality of Service (QoS) and Differentiated Services (DiffServ) features, including support for:
  - Eight ingress queues and eight egress queues per interface
  - Ingress and egress rate shaping and limiting
  - IEEE 802.1p VLAN priorities
  - Weighted RED (WRED) congestion avoidance algorithm
  - Assured Forwarding and Expedited Forwarding RFCs
- Service provider specific features, such as:
  - Flexible remapping of DiffServ codepoints
  - Flexible remapping of IEEE 802.1Q VLAN IDs
  - VLAN tunneling via nested 802.1Q tags

Function Summary

The following sections provide brief descriptions of the key functions provided by the ATM module. Each of these sections is expanded into greater detail in “Configuring the ATM Module” on page 390.

Asynchronous Transfer Mode (ATM)

ATM is a connection-oriented packet transmission technique that is widely used in existing telecommunications networks to transport voice, video, and data. ATM uses fixed size data packets called “cells” which are 53-bytes long and have a header that includes a connection identifier. The connection identifier makes it possible to support more than one point-to-point connection on a single physical ATM connection. The switches in an ATM network use the connection identifier in each cell to forward the cell to the next hop.

Synchronous Optical Network (SONET) and Synchronous Digital Hierarchy (SDH)

SONET and SDH are the two terms used to identify a time division multiplexing technology that is optimized for transporting voice traffic across a digital optical network, but that is also capable of providing high-speed capacity for transporting data.

The term SONET is used to identify the technology used within the North American digital network. Its standards are published by Bellcore and the American National Standards Institute (ANSI). The term SDH is used to identify the equivalent standard approved by the International Telecommunication

Union (ITU) for use in Europe and elsewhere in the global digital network. Because SDH evolved out of SONET, the two standards are closely related and have been widely accepted as a dominant choice for implementations requiring high transport capacity and resistance to failure. The term SONET is used through out this guide. In instances where there are differences between SONET and SDH, the differences are explicitly called out.

Jumbo Frames

The ATM module ports provide jumbo frame support that is similar to that provided by Ethernet ports on a BlackDiamond 6800 series switch.

Jumbo frames are Ethernet frames that are larger than 1522 bytes, including four bytes used for the cyclic redundancy check (CRC). Extreme products support switching and routing of jumbo frames at wire-speed on all ports.

Jumbo frames are used between endstations that support larger frame sizes for more efficient transfers of bulk data. Both endstations involved in the transfer must be capable of supporting jumbo frames.

QoS and Differentiated Services

The ATM module supports eight ingress queues and eight egress queues per port. The scheduling parameters for these queues (minimum bandwidth, maximum bandwidth, priority level, etc.) are controlled by QoS profiles that you can customize for individual ingress or egress queues on a specific ATM port.

You can assign frames to queues based on IEEE 802.1p priorities, Differentiated Services Code Points (DSCPs), or by configuring a QoS profile for the port or VLAN. You can tailor the DSCP-to-queue mapping on a per-port basis. Most of the existing ingress classification functions, along with the DiffServ replacement functions, are also supported for ATM ports.

The supported DiffServ functions maximize user flexibility while providing all of the features needed to support the standard per-hop behaviors (PHBs), including:

- Default
- Class Selector
- Assured Forwarding
- Expedited Forwarding

The ATM module also provides flexible support for the well-known Weighted RED (WRED) congestion avoidance algorithm.

Service Provider Features

The ATM module provides the following features for service provider environments:

- DSCP mapping
- VLAN ID (VID) tag mapping
- VLAN ID (VID) tag nesting
- VLAN to PVC mapping

DSCP Mapping. You can use the `diffserv dscp-mapping` command to configure a mapped relationship between an input DSCP and an associated output DSCP. Each ATM port supports three DSCP mapping tables: one of the tables is used in the ingress direction; two are used for egress flows (onto the ATM link). The two egress tables are for the congested and noncongested states, as determined by the RED algorithm. If RED is not enabled on the ATM port, the egress congested-state mapping table is not used.

In the ingress direction, the input DSCP of a packet received from the ATM link is replaced by an output DSCP before the packet is forwarded. In the egress direction, the operation is similar, except that the DSCP mapping occurs before the packet is transmitted onto the ATM link.

One potential use of the DSCP mapping capability is to reconcile varying DiffServ policies at the boundary between autonomous systems, such as at the boundary between two ISPs. The availability of different tables for the congested and noncongested states is useful in marking operations that increase the probability of packets being dropped during times of congestion, as discussed in the DiffServ Assured Forwarding RFC (RFC 2597).

VLAN ID (VID) Tag Mapping. An analogous feature has been added for the managing of 802.1Q tags. The `dot1q tagmapping` command provides support for VLAN ID (VID) mapping tables. Each ATM port supports two VID tables: one table is used in the ingress direction; the other is used in the egress direction. Each of the tables enables an input VID to be mapped to an output VID. This feature is useful in reconciling policy differences at the boundary between the customer and the service provider.

VLAN ID (VID) Tag Nesting. Another related enhancement provides support for nested 802.1Q tags by allowing a *tag push* or *tag pop* attribute to be associated with a VID. The *push* attribute indicates that a new tag is to be added to the frame, while the *pop* attribute indicates that the top-level tag is to be removed from the frame. This capability is augmented by an option that allows the 802.1p priority of the frame to be either preserved or set to a user-configurable value when a new tag is pushed. These functions make it possible for service providers to tunnel customer-specific VLANs across a common ATM backbone in a very simple manner.

VLAN to PVC Mapping. VLAN to PVC mapping can be used by service providers to isolate and provision a customer's traffic using different VLANs and PVCs for each customer. Thus, a service provider can securely transport a customer's Ethernet traffic across an ATM backbone or vice-versa.

Configuring the ATM Module

This section describes the ExtremeWare commands that support the ATM module. For hardware installation information on the BlackDiamond 6800 series switch, see the *Extreme Networks Consolidated Hardware Guide*.

NOTE

Documentation for Extreme Networks products is available on the World Wide Web at the Extreme Networks home page at http://www.extremenetworks.com/.

Basic ATM Module Configuration Information

This section uses several typical usage and configuration schemes to provide a brief overview of the ATM module configuration process as a general context for the detailed command description sections that follow.

ATM Module Characteristics

ATM is a packet transmission technique that uses fixed size data frames called “cells”. Each cell is 53-bytes long and includes a 5-byte ATM header and 48-byte payload. The ATM header includes a Virtual Path Identifier (VPI) and a Virtual Circuit Identifier (VCI). The VPI/VCI pair uniquely identifies a Virtual Circuit (VC) which is a logical connection configured on a physical ATM link. Each VC is a separate point-to-point connection and the ATM network uses the VPI/VCI in each ATM cell to determine how to forward the cell. Intermediate ATM switches in the network may change the VPI/VCI values for a VC so the same VC may be identified by a different VPI/VCI at the termination point. Multiple VCs can be configured on a single physical ATM link. The ATM module supports Permanent Virtual Circuits PVCs which are VCs that have been pre-provisioned by the ATM service provider. To connect to a service provider’s ATM network using a PVC, the VPI and VCI values must be obtained from the ATM service provider. The ATM module does not support Switched Virtual Connections (SVCs) which are VCs that are dynamically established using a signalling protocol.

The ATM module segments each outbound packet into ATM cells before transmitting and conversely re-assembles received cells into packets. Before segmenting a packet, the ATM module encapsulates the packet in an ATM Adaption Layer (AAL-5) format as defined in IETF RFC 2684/1483. The ATM module supports two types of encapsulations as defined in IETF RFC 2684/1483: LLC Encapsulation for Routed Protocols and LLC Encapsulation for Bridged Protocols. After the packets are segmented into ATM cells, the cells are transported inside a SONET payload.

The contents of ATM cells can be scrambled to randomize the pattern of 1s and 0s carried in the cells. Randomizing the bits can prevent long strings of all 1s and 0s. Transitions between 1s and 0s are used by the physical layer to maintain clocking and achieve signal synchronization which can improve the performance of delineating received ATM cells. The ATM module supports cell scrambling.

The ATM module responds to Operations, Administrations and Maintenance (OAM) F5 loopback cells but does not generate them. Loopback can be used to detect if the remote device is still active.

NOTE

The ATM module can support one PVC per VLAN for each port. The BlackDiamond 6800 series switch can support 3000 VLANs.

Default ATM Module Configurations

When the BlackDiamond 6800 series switch is powered on, the ExtremeWare software determines which slots are occupied by I/O modules, determines whether it has a configuration for each module, and generates a default configuration for each slot that is occupied by an I/O module that has not yet been configured. The default configuration is the minimal set of configuration parameter settings that will allow the I/O module and its ports to function.

By default, only ports 1 and 3 on the ATM module are assigned to the default VLAN, while ports 2 and 4 are not assigned to a VLAN. By default, ATM scrambling is enabled for all ATM ports. Before any data can be forwarded across an ATM port, PVCs must be configured on the port and mapped to a VLAN. Use the `config atm add pvc` command to configure PVCs on the port and map PVCs to a VLAN. See “Configuring PVCs” on page 395 for more details.

Bridging and Routing Over ATM Ports

The ATM module supports bridging and routing across ATM PVCs. Frames can be forwarded across ATM PVCs using either bridged or routed protocol encapsulations as defined in IETF RFC 2648/1483. When using the bridged protocol encapsulation, the ATM module forwards the entire Ethernet frame

(except the Frame Check Sequence) across an ATM PVC. The ATM PVC looks like an Ethernet segment to the rest of the switch. The Ethernet frame can carry any protocol including IP, IPX, and MPLS, and it can also include 802.1Q and 802.1p tags. The ATM module can also use the routed protocol encapsulation for sending IP packets across an ATM PVC. When using the routed protocol encapsulation, the ATM module strips the Ethernet header and only forwards the IP datagram across the ATM PVC, resulting in improved throughput for IP packets.

Before packets can be forwarded over ATM ports, at least one PVC must be configured on the port and mapped to a VLAN using the `config atm add pvc` command. Each PVC must be mapped to one or more VLANs and each mapping must be designated to use the bridged protocol encapsulation (using the `encap l2` keywords in the `config atm add pvc` command) or the routed protocol encapsulation (using the `encap ip` keywords in the `config atm add pvc` command). Both encapsulations can be simultaneously used on a PVC as long as they are associated with different VLANs. ExtremeWare supports up to 500 routed VLANs and 4000 total VLANs in the BlackDiamond switch. When a routed VLAN is configured, the total number of VLANs supported in the BlackDiamond switch is 1500.

Each ATM port can support the previously described VLAN limits, and the following rules govern the association of PVCs with VLANs:

- Each PVC configured on a given ATM port must be associated with one or more VLANs.
- The same VLAN cannot be associated with multiple PVCs on the same ATM port.
- Ports 1 and 2 on the same ATM module may not be bridged together; similarly, ports 3 and 4 on the same ATM module may not be bridged together. Ports 1 and 2 or ports 3 and 4 may not be members of the same VLAN.
- Ports 1 and 2 on the same ATM module may not use the same VPI/VCI for a PVC; similarly, ports 3 and 4 on the same ATM module may not use the same VPI/VCI for a PVC.
- Both encapsulation types may be carried on the same PVC as long as they are associated with different VLANs.
- Multiple tagged VLANs may be configured to use the L2 encapsulation on the same PVC.
- Only one VLAN may be configured to use the IP encapsulation on a given PVC.
- Only one untagged VLAN may use the L2 encapsulation on a given PVC.
- When the IP encapsulation is configured, the ATM port must be the only member of the associated VLAN, and the IP address of the peer router must be configured using the `peer-ipaddress <ipaddress>` parameter in the `config atm add pvc` command.

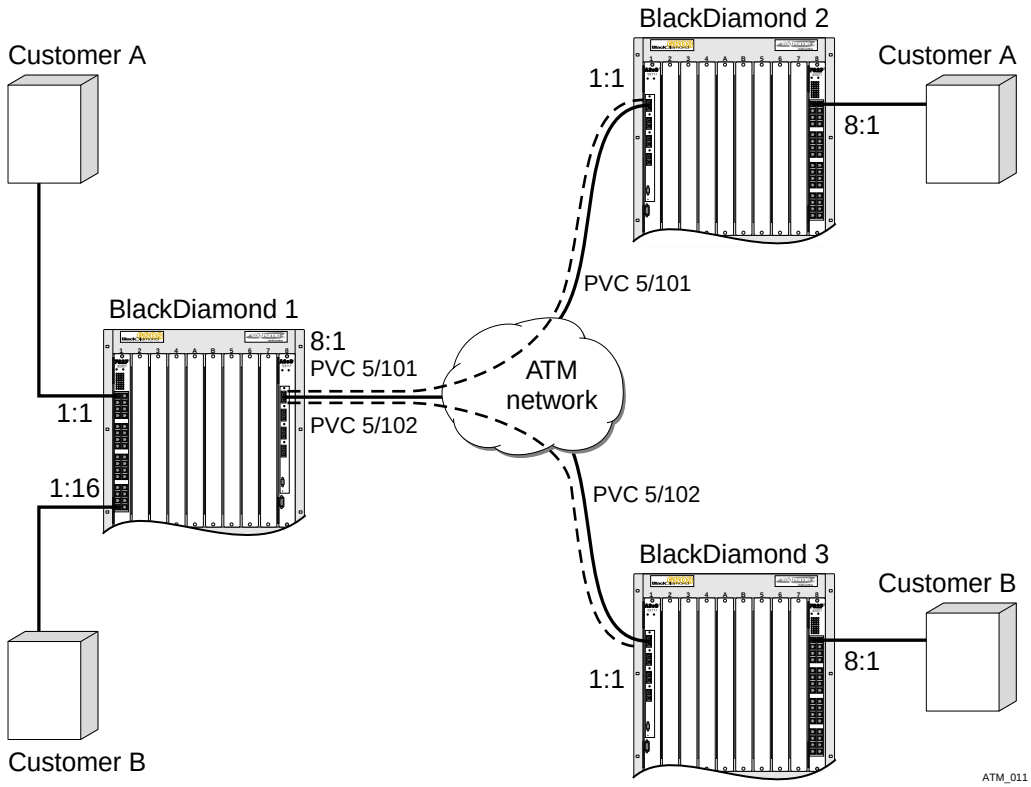
Frames received on an ATM port for VLANs that the ATM port is not a member of are discarded. Additionally, frames received from a PVC that contain a VLAN ID which does not match the VLAN ID associated with any of the VLANs configured for that PVC are discarded. Similarly, a frame received from the switch backplane is only forwarded on a PVC when the VLAN ID in the frame matches the VLAN ID associated with one of the VLANs configured for that PVC.

The ATM module supports all of the Spanning Tree Protocol (STP) commands. STP Bridge Protocol Data Units (BPDUs) are sent on a PVC when an L2 encapsulated VLAN associated with the PVC has been added to an STP domain. STP BPDUs are always transmitted as untagged frames on ATM PVCs. The `enable ignore-stp vlan` command can be used to indicate that the spanning tree forwarding state should be ignored for a particular VLAN.

Bridging Over ATM ports. Figure 79 displays multiple BlackDiamonds being used by an Ethernet Service Provider to provide point-to-point connectivity between their customer's Ethernet networks using ATM PVCs. In this example, CustomerA has an Ethernet network in two different locations, one connected to BlackDiamond switch 1 via port 1:1 and the other connected to BlackDiamond switch 2 via

port 8:1. Similarly, CustomerB is connected to BlackDiamond switch 1 via port 1:16 and BlackDiamond switch 3 via port 8:1. On BlackDiamond switch 1, the service provider has configured PVC 5/101 on ATM port 8:1 to connect to BlackDiamond switch 2 and PVC 5/102 on ATM port 8:1 to connect to BlackDiamond switch 3. The following configuration commands describe the basic steps necessary to configure the network displayed in Figure 79.

Figure 79: Bridging over ATM ports



Commands for configuring BlackDiamond switch 1:

```
create vlan customerA
config vlan customerA tag 101
config vlan customerA add ports 1:1, 8:1 tagged
config atm add pvc 5/101 encap l2 vlan customerA port 8:1

create vlan customerB
config vlan customerB tag 102
config vlan customerB add ports 1:16, 8:1 tagged
config atm add pvc 5/102 encap l2 vlan customerB port 8:1
```

Commands for configuring BlackDiamond switch 2:

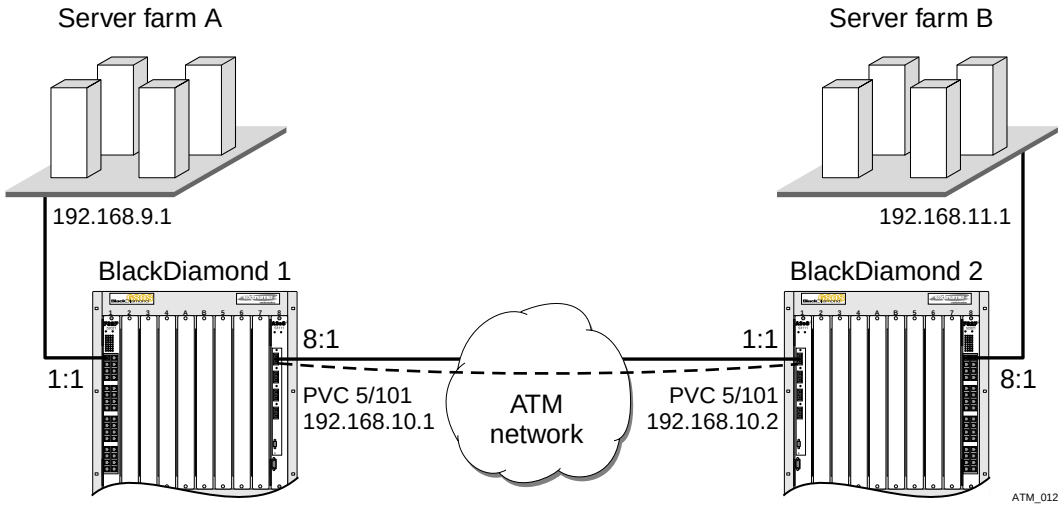
```
create vlan customerA
config vlan customerA tag 101
config vlan customerA add ports 1:1, 8:1 tagged
config atm add pvc 5/101 encap l2 vlan customerA port 1:1
```

Commands for configuring BlackDiamond switch 3:

```
create vlan customerB
config vlan customerB tag 102
config vlan customerB add ports 1:1, 8:1 tagged
config atm add pvc 5/102 encap l2 vlan customerB port 1:1
```

Routing Over ATM Ports. Figure 80 displays multiple BlackDiamonds being used to inter-connect server co-location sites using an ATM PVC. In this example, the customer has leased an ATM PVC between the different server co-location sites. The following configuration commands describe the basic steps necessary to configure the network displayed in Figure 80.

Figure 80: Routing over ATM ports



Commands for configuring BlackDiamond switch 1:

```
create vlan Serverfarma
config vlan Serverfarma add ports 1:1
config vlan Serverfarma ipaddress 192.168.9.1/24

create vlan wanLink
config vlan wanLink add ports 8:1
config vlan wanLink ipaddress 192.168.10.1/24
config atm add pvc 5/101 encap ip peer-ipaddress 192.168.10.2 vlan wanLink port 8:1
enable ipforwarding
```

Commands for configuring BlackDiamond switch 2:

```
create vlan Serverfarmb
config vlan Serverfarmb add ports 8:1
config vlan Serverfarmb ipaddress 192.168.11.1/24

create vlan wanLink
config vlan wanLink add ports 1:1
config vlan wanLink ipaddress 192.168.10.2/24
config atm add pvc 5/101 encap ip peer-ipaddress 192.168.10.1 vlan wanLink port 1:1
enable ipforwarding
```

Configuring and Monitoring ATM Ports

This section describes the commands used to configure ATM ports and provides information on the following topics:

- Configuring PVCs on page 395
- Deleting PVCs on page 395
- Displaying ATM Port Status Information on page 396
- Displaying PVC Status Information on page 397
- Configuring ATM Scrambling on page 397

Configuring PVCs

This section describes how to configure a PVC on an ATM port.

The following command is used to define a PVC on an ATM port:

```
config atm add pvc <vpi/vci> encap [l2 | ip peer-ipaddress <ipaddress>] vlan <vlan
name> ports <portlist>
```

Where the following is true:

- The PVC is identified by the specified `vpi` and `vci` parameters. The `vpi` parameter is an integer in the range of 0 through 15. The `vci` parameter is an integer in the range of 17 through 4095.
- The `encap` parameter indicates the type of encapsulation that is to be used on the PVC for traffic from the associated VLAN. The `l2` keyword is an abbreviation for Layer-2 and indicates the LLC Encapsulation for Bridged Protocols (defined in RFC 2684). The `ip` keyword indicates that the VLAN will carry only routed IP traffic and that the LLC Encapsulation for Routed Protocols (defined in RFC 2684) should be used.

Deleting PVCs

The following command is used to delete a PVC configuration on an ATM port:

```
config atm delete pvc [<vpi / vci> | all] {vlan <vlan name>} ports <portlist>
```

This command deletes the specified PVC configuration on the specified ATM port(s). The optional `vlan` parameter may be used to limit the scope of the command to the specified VLAN. The PVC may still exist following command execution if multiple VLANs have been configured to use the PVC. If the `vlan` parameter is omitted, the PVC configuration is deleted for all VLANs on the specified ATM port(s).

The command can be used to delete configuration information for the PVC identified via the `vpi` and `vci` parameters for all PVCs defined for the specified VLAN(s) or port(s). The all keyword may also be used as the portlist parameter to indicate that the command should be applied to all ATM ports. A PVC is completely deleted when there are no longer any VLANs configured for the PVC on a given ATM port.

NOTE

All associated PVCs must be deleted before an ATM port can be removed from a VLAN.

Displaying ATM Port Status Information

To display status information for the ATM ports, use the following command:

```
show atm {<portlist>}
```

You can use the optional `portlist` parameter to narrow the range of status information the command displays; otherwise, the command displays the status information for all ports.

By default, the command displays a summary of status information for the specified ports.

The summary of status information includes the following information for each port:

- Values of all port configuration parameters
- Port state
- ATM statistics

The detailed status information includes the summary information plus any ATM statistics. Table 47 describes the ATM receive statistics, and Table 48 describes the ATM transmit statistics.

Table 47: Summary of ATM Receive Statistics

Receive Statistics	Description
Cells Received	Number of cells received.
Cells OAM	Number of Operations, Administration, and Maintenance (OAM) cells received.
Cells Dropped (Congestion)	Number of cells dropped due to insufficient buffers.
Cells Dropped (Invalid VCC)	Number of cells dropped due to invalid VPI/VCI or AAL-5 header.
Cells Dropped (HEC)	Number of cells dropped with Header Error Control (HEC) errors. HEC is an 8 bit cyclic redundancy check (CRC) computed on all fields in an ATM header and capable of detecting bit errors. HEC is used for cell delineation.
PDUs Received	Number of PDUs received.
PDUs Dropped (CRC)	Number of PDUs discarded due to CRC-32 errors.
PDUs Dropped (Oversized)	Number of PDUs discarded because they were too large. See “Jumbo Frame Support” on page 419 for more details.
PDUs Dropped (Other)	PDUs dropped due to an invalid VLAN ID, Spanning Tree Protocol (STP) state, or invalid encapsulation.

Table 48 describes the ATM transmit statistics.

Table 48: Summary of ATM Transmit Statistics

Receive Statistics	Description
Cells Transmitted	Number of cells transmitted.
Cells Dropped (Congestion)	Number of cells dropped due to insufficient buffers.
PDUs Transmitted	Number of PDUs transmitted.

Displaying PVC Status Information

To display status information for a PVC, use the following command:

```
show atm pvc [<vpi / vci> | all] {vlan <vlan name>} {<portlist>}
```

You can specify a particular PVC to display information for, or you can specify that information for all PVCs be displayed.

You can use the optional `vlan` parameter to narrow the range of status information the command displays; otherwise, the command displays status information for all VLANs.

You can use the optional `portlist` parameter to narrow the range of status information the command displays; otherwise, the command displays the status information for all PVCs associated with all ATM ports.

By default, the command displays a summary of status information for the specified PVC.

The summary of status information includes the following information for each PVC:

- Port number
- VPI/VCI
- VLAN IDs on this PVC
- Type of PVC (L2 or IP)
- Peer IP address (for IP PVCs)
- Received octets
- Received packets
- Transmitted octets
- Transmitted packets

The following command example displays all of the PVC status information for a PVC configured on an ATM port in a BlackDiamond switch:

```
show atm pvc 5/101 port 1:1
```

Configuring ATM Scrambling

To enable or disable payload data scrambling on the specified port, use the following command:

```
config atm scrambling [on | off] ports <portlist>
```

Choose either `on` or `off`. Scrambling is enabled by default.

Scrambling is used to improve signal synchronization and the performance of the ATM cell delineation process.

The following command example turns off the scrambling function for port 1 of the ATM module installed in slot 8 of the BlackDiamond switch.

```
config atm scrambling off ports 8:1
```

Configuring and Monitoring SONET

This section describes the commands used to configure and monitor SONET-specific attributes on ATM ports and provides information on the following topics:

- SONET Parameters and Values on page 398
- Configuring SONET Framing on page 399
- Configuring SONET Clocking on page 399
- Configuring the Signal Fail Threshold on page 399
- Configuring the Signal Degrade Threshold on page 400
- Configuring the Section Trace Identifier on page 400
- Configuring the Path Trace Identifier on page 401
- Configuring the Signal Label on page 401
- Resetting SONET Configuration Parameter Values on page 402
- Displaying SONET Status Information on ATM ports on page 402
- SONET Events on ATM Ports on page 403

SONET Parameters and Values

Table 49 describes the SONET parameters and values.

Table 49: SONET Parameters and Values

Parameter	Possible Values	Default Value
Framing	SONET or SDH	SONET
Clock source	internal or line	internal
Signal Failure threshold[1]	10^{-3} through 10^{-5}	10^{-5}
Signal Degrade threshold[2]	10^{-5} through 10^{-9}	10^{-6}
J0 Section Trace byte[3]	0 through 255	1
J0 Section Trace string[4]	Maximum of 15 characters	15 NULL characters
J1 Path Trace identifier string[5]	Maximum of 62 characters	NULL characters
C2 Signal Label[6]	0 through xFF	auto

1. B2 bit error rate (BER) threshold; a Signal Failure (SF) event is generated if the BER exceeds the specified threshold.
2. B2 bit error rate (BER) threshold; a Signal Degrade (SD) event is generated if the BER exceeds the specified threshold.
3. The default value of 1 is per ANSI T1.105-1995. This parameter applies only when SONET framing is configured on the port.
4. This parameter applies only when SDH framing is configured on the port.
5. When SDH framing is configured on the port, only the first 15 characters of the string are applied.
6. Set automatically based on synchronous payload envelope (SPE) payload type.

Configuring SONET Framing

You can configure each port for framing that complies with either the SONET standard or the SDH standard. SONET is primarily an American standard; SDH is the international version. The default is SONET.

To configure the framing for the specified SONET feature on an ATM port, use the following command:

```
config sonet framing [sonet | sdh] ports <portlist>
```

The following command example selects SDH framing for port 1 of the ATM module installed in slot 8 of the BlackDiamond switch.

```
config sonet framing sdh ports 8:1
```

Configuring SONET Clocking

You can configure each port on the ATM module to use either line clocking, where the clock source is recovered from the received bit stream, or internal clocking, where the clock source is based on an internal clock. The default is internal.

To configure the clocking source for the specified ATM port, use the following command:

```
config sonet clocking [line | internal] ports <portlist>
```

The following command example selects line clocking for port 1 of the ATM module installed in slot 8 of the BlackDiamond switch.

```
config sonet clocking line ports 8:1
```

Configuring the Signal Fail Threshold

A Signal Failure (SF) event is generated if the bit error rate (BER) for the SONET line exceeds the configured threshold. An SF event brings the port down.

To configure the Signal Fail threshold for the specified ATM port, use the following command:

```
config sonet threshold signal fail <error_rate> ports <portlist>
```

The `error_rate` parameter is an integer in the range from 3 to 5, where the SF BER is 10^{-error_rate}. The default value of the `error_rate` parameter is 5, which equates to an SF bit error rate of 10^{-5}, or 1 per hundred thousand.

The following command example sets the Signal Fail threshold value to 3 for port 1 of the ATM module installed in slot 8 of the BlackDiamond switch.

```
config sonet threshold signal fail 3 ports 8:1
```

NOTE

You can set the signal fail threshold to a value different than the default value of 5 if your particular application has a very low tolerance for errors. In general, you should not change the default setting unless you are an expert and have a specific reason for the change.

Configuring the Signal Degrade Threshold

A Signal Degrade (SD) event is generated if the BER for the SONET line exceeds the configured Signal Degrade threshold.

To configure the Signal Degrade threshold for the specified ATM port, use the following command:

```
config sonet threshold signal degrade <error_rate> ports <portlist>
```

The `error_rate` parameter is an integer in the range from 5 to 9, where the SD bit error rate is 10^{-error_rate}. The default value of the `error_rate` parameter is 6, which equates to an SD bit error rate of 10^{-6}, or 1 per million.

The following command example sets the Signal Degrade threshold value to 8 for port 1 of the ATM module installed in slot 8 of the BlackDiamond switch.

```
config sonet threshold signal degrade 8 ports 8:1
```

NOTE

You can set the signal degrade threshold to a different value than the default value of 6 depending on your particular application's tolerance for errors. In general, you should not change the default setting unless you are an expert and have a specific reason for the change.

Configuring the Section Trace Identifier

Section trace is a maintenance feature of SONET. One byte of the Section Overhead associated with each SONET frame is used to carry information identifying the transmitting equipment.

To configure the Section Trace identifier for the specified ATM port, use the following command:

```
config sonet trace section [<id_byte> | string <id_string>] ports <portlist>
```

In this command, the Section Trace identifier can take one of two forms: an ID byte (`id_byte`) or an ID string (`id_string`).

The `id_byte` parameter is an integer in the range from 1 to 255, with a default value of 1. This parameter applies only when SONET framing is configured, in which case, the configured `id_byte` value is transmitted in each SONET frame.

The `id_string` parameter is a string of up to 15 characters. By default, the <id_string> parameter contains 15 NULL characters. This parameter applies only when SDH framing is configured, in which case the SDH framing cycles repetitively through a 15-character string, sending one character per frame. If the configured string contains fewer than 15 characters, it is padded to full length by NULL characters.

The following command example sets the Section Trace identifier to the string “1800wombat” for port 1 of the ATM module installed in slot 8 of the BlackDiamond switch:

```
config sonet trace section string 1800wombat ports 8:1
```

Configuring the Path Trace Identifier

Path trace is a maintenance feature of SONET. One byte of the Path Overhead associated with each SONET frame is used to carry information identifying the originating Path Terminating Equipment (PTE).

To configure the Path Trace identifier for the specified ATM port, use the following command:

```
config sonet trace path <id_string> ports <portlist>
```

The `id_string` parameter defaults to a string of 62 NULL characters.

When SONET framing is configured, a 62-character string is transmitted repetitively, one character per frame. If the configured string consists of fewer than 62 characters, it is padded to its full length with NULL characters.

When SDH framing is configured, the maximum length of the `id_string` parameter is 15 characters. If the configured string consists of more than 15 characters, it is truncated to 15 characters.

The following command example sets the Path Trace identifier to the string “parador” for port 1 of the ATM module installed in slot 8 of the BlackDiamond switch.

```
config sonet trace path parador ports 8:1
```

Configuring the Signal Label

The Signal Label field occupies one byte (C2) of the Path Overhead associated with each SONET frame. It is used to indicate the type of contents carried in the Synchronous Payload Envelope (SPE). For example, 0x13 indicates that the SONET SPE contains ATM cells.

To configure the C2 Signal Label value for the specified ATM port, use the following command:

```
config sonet signal label [auto | <hex_octet>] ports <portlist>
```

The `hex_octet` parameter is specified as a hexadecimal integer in the range from 00 to FF. It may be necessary to specify a particular Signal Label value in order to interoperate with implementations that do not follow the standard conventions for the Signal Label field.

To determine whether you need to specify a particular Signal Label value, perform the following tasks:

1. Use the `show sonet` command to display SONET status information on ATM ports.
2. Look for a Path Payload Label Mismatch (PLM-P) event indicating that the received payload type does not match the expected payload.
3. Compare the contents of the received C2 field (Signal Label value) with the contents of the transmitted C2 field.

If no Signal Label value is specified, the command defaults to `auto`, which causes the value of the Signal Label field to be set automatically based on standard conventions for the given payload type.

The following command example sets the Signal Label to the hexadecimal value CF for port 1 of the ATM module installed in slot 8 of the BlackDiamond switch:

```
config sonet signal label CF ports 8:1
```

Resetting SONET Configuration Parameter Values

To reset the SONET configuration parameters for the specified ATM ports to their default values, use the following command:

```
unconfig sonet ports <portlist>
```

Displaying SONET Status Information on ATM ports

To display SONET status information for the ATM ports, use the following command:

```
show sonet {<portlist>} {detail}
```

You can use the optional `portlist` parameter to narrow the range of status information the command displays; otherwise, the command displays the status information for all ports.

By default, the command displays a summary of status information for the specified ports. You can use the optional `detail` keyword to display detailed status information for the specified ports.

The summary of status information includes the following information for each port:

- Values of all port configuration parameters
- Port state
- Any active events

The detailed status information includes the summary information plus any SONET statistics (listed and described in Table 50).

Table 50: Summary of SONET Statistics

Statistic	Description
Section parity errors	Number of B1 parity errors detected
Line parity errors	Number of B2 parity errors detected
Path parity errors	Number of B3 parity errors detected
REI-L event counter	Number of B2 parity errors detected by peer LTE
REI-P event counter	Number of B3 parity errors detected by peer PTE
LOS event counter	Number of LOS events
LOF event counter	Number of LOF events
LOP event counter	Number of LOP events
AIS-L event counter	Number of AIS-L events
AIS-P event counter	Number of AIS-P events
RDI-L event counter	Number of RDI-L events
RDI-P event counter	Number of RDI-P events
PLM-P event counter	Number of PLM-P events
SF BER event counter	Number of SF BER events

Table 50: Summary of SONET Statistics (continued)

Statistic	Description
SD BER event counter	Number of SD BER events

SONET Events on ATM Ports

The ATM module can detect and report a variety of error and alarm conditions, some of which also trigger actions on the SONET link. Table 51 describes these events and their associated actions. Syslog messages are output for these events. For more information about Syslog, see Chapter 10.

Table 51: SONET Events

Event	Description
Loss of Signal (LOS)	Loss of Signal is detected by the Section Terminating Equipment (STE) when an all-zeroes pattern on the incoming SONET signal lasts 100 microseconds or longer. This condition can be caused by loss of light on the fiber.
	SONET Action: Send RDI-L upon LOS detection.
Loss of Frame (LOF)	Loss of Frame is detected by the STE when a Severely Errored Framing (SEF) defect on the incoming signal persists for 3 milliseconds.
	Related SONET Overhead: A1, A2 (framing pattern).
	SONET Action: Send RDI-L upon LOF detection.
Loss of Pointer (LOP)	The Path Loss Of Pointer event is detected as a result of excess New Data Flags (NDFs) or invalid pointers in the H1/H2 fields of the received signal.
	Related SONET Overhead: H1,H2 contain NDF and pointer.
	SONET Action: Send RDI-P upon LOP detection.
Alarm Indication Signal—Line (AIS-L)	The Line Alarm Indication Signal is sent by the upstream STE to inform the LTE that a LOS or LOF defect has been detected. Extreme's SONET module never sends AIS-L. AIS-L was formerly known as Line Far End Receive Failure (FERF).
	Related SONET Overhead: K2 carries AIS-L.
	SONET Action: Send RDI-L upon reception of AIS-L.
Alarm Indication Signal—Path (AIS-P)	The Path Alarm Indication Signal is sent by the upstream LTE to inform the PTE that a LOS, LOF, AIS-L, or LOP defect has been detected. Extreme's SONET module never sends AIS-P. AIS-P was formerly known as Path Far End Receive Failure (FERF).
	Related SONET Overhead: H1,H2,H3 = 0 when indicating AIS-P.
	SONET Action: Send RDI-P upon receiving AIS-P.
Remote Defect Indicator—Line (RDI-L)	The Line Remote Defect Indication is sent by the downstream LTE when a LOS, LOF, or AIS-L defect is detected.
	Related SONET Overhead: K2 carries RDI-L.
Remote Defect Indicator—Path (RDI-P)	The Path Remote Defect Indication is sent by the downstream PTE when a LOP or AIS-P defect is detected.
	Related SONET Overhead: G1 carries RDI-P.
Remote Error Indicator—Line (REI-L)	The Line Remote Error Indicator conveys a count of detected B2 parity errors from the peer LTE.
	Related SONET Overhead: M1 carries REI-L.

Table 51: SONET Events (continued)

Event	Description
Remote Error Indicator—Path (REI-P)	The Path Remote Error Indicator conveys a count of detected B3 parity errors from the peer PTE.
	Related SONET Overhead: G1 carries REI-P.
Path Payload Label Mismatch (PLM-P)	The Path Payload Label Mismatch event occurs when the received payload type does not match the expected payload. This event is commonly caused by a Signal Label or scrambling mode mismatch configuration error.
	Related SONET Overhead: C2 carries the Signal Label.
Signal Failure Bit Error Rate (SF BER)	The Signal Failure BER event occurs when the B2 bit error rate exceeds the configured SF threshold.
	Related SONET Overhead: B2 carries line parity.
	SONET Action: Send RDI-L upon detecting SF BER event.
Signal Degrade Bit Error Rate (SD BER)	The Signal Degrade BER event occurs when the B2 bit error rate exceeds the configured SD threshold. This event is used for APS switching.
	Related SONET Overhead: B2 carries line parity.

Configuring VLAN-Related Attributes

The ExtremeWare software and the Extreme Networks switch architecture provide a range of Virtual Local Area Network (VLAN) features. This section describes how these features are supported on the ATM module.

NOTE

This section assumes some familiarity with the Extreme Networks implementation of VLAN features. For more information about VLAN-related features supported by ExtremeWare, see Chapter 5, "Virtual LANs (VLANs)" on page 83.

This section provides information on the following topics:

- Configuring Tagged VLAN 802.1p and 802.1Q Functions on page 405
- Generic VLAN Registration Protocol Functions on page 407

ATM module ports do not support protocol-based VLANs or MAC address VLANs. Thus, there are restrictions on the use of the following commands:

- `config vlan <vlan name> [add | delete] ports <portlist> {tagged | untagged} {nobroadcast}`
- `config vlan <vlan name> protocol [<protocol_name> | any]`
- `enable mac-vlan mac-group [any | group_number] ports <portlist>`

The restrictions are as follows:

- An ATM port cannot be added to a VLAN if the VLAN is a protocol-based VLAN.
- A VLAN cannot be configured to be a protocol-based VLAN if the VLAN contains an ATM port.
- A MAC address VLAN cannot be enabled on an ATM port.

The `config vlan <vlan name> protocol any` command is supported, because it can be used to configure the default VLAN for ATM ports.

In the `config vlan <vlan name> [add | delete] ports <portlist> {tagged | untagged} {nobroadcast}` command, ATM ports support the optional `tagged` and `untagged` keywords when LLC encapsulation for bridged protocols is enabled, and ignore them when LLC encapsulation for routed protocols is enabled.

Configuring Tagged VLAN 802.1p and 802.1Q Functions

NOTE

The dot1q tag mapping and tag nesting commands are supported only by ATM ports and apply only when LLC encapsulation for bridged protocols is enabled on the ATM port.

The following ExtremeWare commands are supported for the ATM module:

- `config dot1q ethertype <ethertype>`
- `config dot1p type dot1p_priority <priority> qosprofile <qosprofile>`

NOTE

If an ATM port receives a frame with a priority value "n" that is not mapped to a profile in the range from qp1 through qp8, the frame is assigned to QoS profile qp_{n+1}.

The following commands provide ATM module support for managing 802.1Q tags:

- `config dot1q tagmapping`
- `config dot1q tagnesting`

Configuring VLAN Tag Mapping Tables

The `config dot1q tagmapping` command provides support for VLAN ID (VID) mapping tables. Each ATM port supports two VID tables: one table is used in the ingress direction; the other is used in the egress direction. These tables make it possible to map an input VID to an output VID, which can be useful in reconciling policy differences at the boundary between the customer and the service provider. The tables also allow the option of preserving the 802.1p priority or overwriting the priority with a configured value.

To configure the VLAN tag mapping tables for an ATM port, use the following command:

```
config dot1q tagmapping <input_vlanid/output_vlanid> ports <portlist>
   {egress {priority <priority>} | ingress {priority <priority>}}
```

The input_vlanid and output_vlanid parameters are both integers in the range from 1 to 4095 and must be separated by a slash character.

The priority parameter is an integer in the range from 0 to 7.

Use the egress keyword to apply the mapping of the input VLAN ID to the output VLAN ID to frames received from the switch backplane prior to transmitting them onto the ATM link. Use the ingress keyword to apply the mapping to input frames received from the ATM link. The mappings are applied after they are classified to a QoS profile. Frames containing the VLAN ID specified in input_vlanid are changed so that the VLAN ID is set to the value specified in output_vlanid before the frame is forwarded.

If you omit both the egress and the ingress keywords, the command automatically applies the specified mapping to the egress direction, and also applies a symmetrical mapping (with the input_vlanid and output_vlanid values reversed) to the ingress direction.

These tables also give you the option of preserving the 802.1p priority or overwriting the priority with a user-configured value. Using the priority keyword in the command indicates that the 802.1p priority field is to be set to the value specified in priority. To preserve the 802.1p priority, do not enter the priority keyword and value when using this command.

The default behavior is that the tables are initialized such that VLAN IDs are not altered by the mapping operations, and frame priority is preserved. For example, an input VLAN ID of *n* is always mapped to an output VLAN ID of *n*, and the 802.1p priority field is not changed.

Configuring VLAN Tag Nesting Attributes

The config dot1q tagnesting command provides support for 802.1Q tags by allowing a tag *push* or *pop* attribute to be associated with a VLAN ID. The push attribute indicates that a new tag is to be added to the frame, while the pop attribute indicates that the top-level tag is to be removed from the frame. The command also gives you the option to preserve the 802.1p priority of the frame or set it to a configured value when a new tag is added (pushed) to the frame. VLAN ID (VID) mapping occurs before a new tag is pushed, and after a nested tag is popped.

To configure the VLAN tag nesting attributes for an ATM port, use the following command:

```
config dot1q tagnesting {<vlanid> | <vlanid_range>} [off | pop |
push <new_vlanid> {priority <priority>}] ports <portlist> {egress | ingress}
```

The vlanid parameter is an integer in the range from 1 to 4095. The vlanid_range parameter is specified in the form start_vlanid-end_vlanid, where the start and end values are both integers in the range from 1 to 4095 and must be separated by a hyphen.

The push keyword indicates that a new tag is to be added to frames containing the VID specified in vlanid or to one of the VIDs in the range specified in vlanid_range. The new tag added to frames contains the value specified in new_vlanid.

The pop keyword indicates that the top-level tag is to be removed from frames when that tag contains either the VID specified in vlanid or any one of the VIDs in the range specified in vlanid_range.

If you do not specify a VID or a range of VIDs, the command settings are applied to all VIDs.

Tag operations can be performed in either the egress direction (to the ATM link) or the ingress direction (from the ATM link). If you do not specify a direction, the default behavior is that tag operations are performed in the egress direction. If you do not use either the egress or ingress keyword and tag pushing is configured, a corresponding tag pop operation is automatically configured for the ingress

direction. If you do not use either the egress or ingress keyword and tag nesting is disabled using the `off` keyword, tag nesting is disabled in both directions.

The optional `priority` keyword provides a way to overwrite the 802.1p priority with a user-configured value when a new tag is pushed. Using the `priority` keyword in the command indicates that the 802.1p priority field is to be set to the value specified in `priority`, which is an integer in the range from 0 to 7. To preserve the 802.1p priority, do not enter the `priority` keyword and value when using this command.

Default behavior is that tag nesting is disabled (off) for all VLAN IDs.

Tag push operations apply to egress frames only when the port is configured to transmit tagged frames for the associated VLAN. Tag nesting operations apply only to ingress frames that contain a VLAN tag. Tag nesting operations are applied after classification to a QoS profile.

NOTE

The DiffServ and RED functions are not performed by ATM ports when frames contain nested tags (more than one tag).

Generic VLAN Registration Protocol Functions

The Generic VLAN Registration Protocol (GVRP) is not supported on ATM module ports, so the following command will not work if you specify an ATM port:

```
config gvrp {listen | send | both | none] ports <portlist>
```

Configuring Forwarding Database Attributes

ATM ports support all of the existing ExtremeWare forwarding database (FDB) commands. For more information on these commands, see Chapter 6.

Configuring Spanning Tree Attributes

ATM ports support all of the existing ExtremeWare Spanning Tree (STP) commands except EMISTP and PVSTP. For more information on STP commands, see Chapter 13.

Configuring QoS Functions

The ExtremeWare software and the Extreme Networks switch architecture provide a number of Quality of Service (QoS) functions, which are described in detail in Chapter 7. This section describes how these QoS functions, such as Differentiated Services (DiffServ) and Random Early Detection (RED) are supported on the ATM module.

NOTE

This section assumes some familiarity with the Extreme Networks implementation of QoS and DiffServ features. For more information about QoS and DiffServ features supported by ExtremeWare, see Chapter 7.

This section contains information on the following topics:

- Configuring a QoS Profile on page 408
- Classification and Replacement Policies on page 409
- Configuring DiffServ on page 410
- Enhanced RED Support on page 412

Configuring a QoS Profile

The ATM module supports eight ingress queues and eight egress queues per port. The scheduling parameters (minimum bandwidth, maximum bandwidth and priority level) for these queues are controlled by QoS profiles qp1 through qp8, which are defined using the existing ExtremeWare `config qosprofile` command.

This command has been enhanced to allow you to configure more module-specific parameters on a port-by-port basis, including the ability to customize the QoS profile parameters for individual ingress or egress queues on a specific ATM port.

The syntax and description of the enhanced `config qosprofile` command are described below.

To configure the scheduling parameters for a specified QoS profile, use the following command:

```
config qosprofile <qosprofile> {minbw <percent>} {maxbw <percent>}
   {priority <level>} {minbuf <percent>} {maxbuf <percent>} {<portlist>}
   {egress | ingress}
```

The optional `egress` and `ingress` keywords apply only to ATM ports. As stated earlier, the ATM module supports eight egress queues and eight ingress queues per port, and the scheduling parameters for these queues are controlled by QoS profiles qp1-qp8, which means queue #0 is controlled by qp1, queue #1 is controlled by qp2, and so on.

The optional `portlist` parameter allows QoS profiles to be customized on a port-by-port basis for the ATM module. The `egress` and `ingress` keywords allow you to fine-tune the customization (down to a particular egress or ingress queue on a given port). If you do not enter either the `egress` or `ingress` keyword in the command, the configured parameters apply to the egress queue associated with the specified QoS profile by default.

The `minbw` parameter specifies the minimum percentage of the bandwidth guaranteed to be available to the specified queue for transmissions from the QoS profile. The value is an integer in the range from 0 through 100. The default value is 0. The sum of the minimum bandwidth parameters across all eight QoS profiles cannot exceed 90%.

The `maxbw` parameter specifies the maximum percentage of the bandwidth that the specified queue can use for transmissions from the QoS profile. The value is an integer in the range from 1 through 100. The default value is 100.

The optional priority keyword and level parameter specify the service priority for the specified queue. The service priority determines which traffic is scheduled when bandwidth is still available after the minimum requirements of all profiles have been satisfied. Settings for level include: low, lowHi, normal, normalHi, medium, mediumHi, high, or highHi. The default setting is low.

NOTE

The minbuf *and* maxbuf *keywords do not apply to ATM ports.*

Classification and Replacement Policies

This section deals primarily with classification operations performed by the ATM module.

Most of the existing ingress classification functions are supported for LLC Encapsulation for Routed Protocols or LLC Encapsulation for Bridged Protocols configured ATM ports. Functions such as access list and destination MAC address QoS policies are supported, as is the enable diffserv replacement command.

Egress frames are always assigned to a QoS profile based on their 802.1p priority. Thus, when an ATM port receives a frame from the switch fabric with a priority value *n*, that frame is assigned to egress QoS profile qp*n*+1.

The existing enable diffserv examination ports and disable diffserv examination ports commands are used on ATM ports to control whether the DiffServ code point (DSCP) is examined for ingress classification purposes.

When you enable the LLC Encapsulation for Bridged Protocols on an ATM port, non-IP frames that contain a VLAN tag are assigned to an ingress QoS profile based on their 802.1p priority value. You can configure this assignment using the config dot1p type command, which is used to specify the mappings between 802.1p priority values and QoS profiles. However, if an ATM port receives a frame with a priority value *n*, for which there is no mapping to one of the eight profiles (qp1-qp8), that frame is assigned to ingress QoS profile qp*n*+1.

If diffserv examination is not enabled, then the preceding 802.1p priority classification rules are applied to tagged IP frames as well.

In both cases, untagged frames are assigned to a single ingress QoS profile (provided that the port is an untagged member of a VLAN; if that is not the case, then untagged frames are discarded). This QoS profile defaults to qp1, but you can assign it to another profile using the config ports <portlist> qosprofile <qosprofile> command or the config vlan <vlan name> qosprofile <qosprofile> command (where the port-based QoS configuration has higher precedence than VLAN-based QoS).

Additionally, if you enable the LLC Encapsulation for Routed Protocols on an ATM port and do not enable diffserv examination on the port, then all ingress frames (received from the SONET link) are assigned to a single ingress QoS profile. The profile defaults to qp1, but you can configure it to another profile using the config ports <portlist> qosprofile <qosprofile> command or the config vlan <vlan name> qosprofile <qosprofile> command.

If you enable diffserv examination on an ATM port, then ingress IP frames are assigned to a QoS profile based on the DiffServ code point (regardless of whether you enabled either LLC Encapsulation for Bridged Protocols or LLC Encapsulation for Routed Protocols on the port). The existing config diffserv examination code-point command maps DiffServ code points to QoS profiles. This command has been enhanced for use with ATM ports. The syntax and description of the enhanced config diffserv examination code-point command are given below.

Also note that, in all cases, the 802.1p priority bits of ingress frames forwarded to the switch backplane are set based on the ingress QoS profile classification. More specifically, the 802.1p priority value is set to qp# – 1. For example, if the packet is classified to qp5, then the 802.1p priority value is set to 4.

Configuring DiffServ

All of the existing ExtremeWare DiffServ commands are supported by ATM ports with IP frames that are encapsulated for bridged or routed protocols. ATM ports also support a DiffServ code point (DSCP) mapping function that you configure using the `config diffserv dscp-mapping` command, which is described below. The DSCP is a 6-bit value in the IP-TOS byte of the IP packet header. For more information on DSCPs, see Chapter 7.

DiffServ Classification

When a packet arrives at the switch on an ingress port, the switch examines the first six of eight TOS bits, called the *code point*. The switch can assign the QoS profile used to subsequently transmit the packet based on the code point. The QoS profile controls a hardware queue used when transmitting the packet out of the switch, and determines the forwarding characteristics of a particular code point. The examination of DiffServ information is disabled by default. To enable examination of DiffServ information, use the command:

```
enable diffserv examination ports [<portlist> | all]
```

Changing DiffServ Code Point Assignments in the QoS Profile

Because the code point uses six bits, it has 64 possible values ($2^6 = 64$). By default, the values are grouped and assigned to the default QoS profiles listed in .

Table 52: Default Code Point-to-QoS Profile Mapping

Code Point	QoS Profile
0-7	Qp1
8-15	Qp2
16-23	Qp3
24-31	Qp4
32-39	Qp5
40-47	Qp6
48-55	Qp7
56-63	Qp8

To configure the mapping between a DiffServ code point and a specified QoS profile, use the following command:

```
config diffserv examination code-point <code_point>
   qosprofile <qosprofile> ports <portlist>
   {low-drop-probability | high-drop-probability}
```

The mapping is applied in the ingress direction—for IP packets received from the ATM link.

The optional low-drop-probability and high-drop-probability keywords apply only to ATM ports. If you do not enter either of these keywords in the command, the command uses low-drop-probability as the default.

The low-drop-probability and high-drop-probability keywords are useful in conjunction with the Weighted RED (WRED) implementation provided by ATM ports. This implementation supports two different drop probabilities: one for DiffServ code points designated as having low drop-probability; another for DiffServ code points designated as having high drop-probability. These keywords give you complete flexibility in assigning DiffServ code points to these two drop-probability levels.

Configuring DiffServ Code Point Mapping Tables

You can use the diffserv dscp-mapping command to configure a mapped relationship between an input DSCP and an associated output DSCP. Each ATM port supports three DSCP mapping tables: one of the tables is used in the ingress direction; two are used for egress flows (onto the ATM link). The two egress tables are for the congested and noncongested states, as determined by the RED algorithm. If RED is not enabled on the ATM port, the egress congested-state mapping table is not used.

In the ingress direction, the input DSCP of a packet received from the ATM link is replaced by an output DSCP before the packet is forwarded. In the egress direction, the operation is similar, except that the DSCP mapping occurs before the packet is transmitted onto the ATM link.

One potential use of the DSCP mapping capability is to reconcile varying DiffServ policies at the boundary between autonomous systems, such as at the boundary between two ISPs. The availability of different tables for the congested and noncongested states is useful in marking operations that increase the probability of packets being dropped during times of congestion, as discussed in the DiffServ Assured Forwarding RFC (RFC 2597).

NOTE

This command applies only to ATM ports with IP frames that are encapsulated for bridged or routed protocols. You should also be aware that DSCP mapping is performed even when the diffserv examination *function is disabled on the port.*

To configure the mapping between an input DSCP and an associated output DSCP, use the following command:

```
config diffserv dscp-mapping <input_codepoint>/<output_codepoint>
   ports <portlist> {egress {no-congestion | congestion} | ingress}
```

where:

input_codepoint	Specifies one of the 64 possible DiffServ code point values as the input code point.
output_codepoint	Specifies one of the 64 possible DiffServ code point values as the output code point.
egress	Applies the DSCP mapping to the egress direction.
no-congestion	Applies the DSCP mapping to the egress mapping table for the non-congested state.
congestion	Applies the DSCP mapping to the egress mapping table for the congested state.
ingress	Applies the DSCP mapping to the ingress direction.

If you omit the no-congestion and congestion keywords, the command applies the mapping to the tables for both states.

If you omit the egress and ingress keywords, the command applies the mapping to the egress direction, and automatically configures a symmetrical mapping (with the input_codepoint and output_codepoint values reversed) in the ingress direction.

By default, all the tables are initialized such that DSCPs are not altered by the mapping operations. For example, an input DSCP value of *n* is always mapped to an output DSCP value of *n*.

Resetting DiffServ Code Point Mapping Tables

To reset the DSCP mapping tables for a specified ATM port to their default values, use the following command:

```
unconfig diffserv dscp-mapping ports <portlist>
```

Replacing DiffServ Code Points

To replace DiffServ code points, you must use the following command to enable DiffServ replacement:

```
enable diffserv replacement ports [<portlist> | all]
```

You then change the 802.1p priority to DiffServ code point mapping to any code point value using the following command:

```
config diffserv replacement priority <vpri> code_point <code_point>
ports [<portlist> | all]
```

By doing so, the hardware queue used to transmit a packet determines the DiffServ value replaced in the IP packet.

To verify the DiffServ configuration, use the command:

```
show ports <portlist> info detail
```

Enhanced RED Support

Random Early Detection (RED) is a congestion avoidance mechanism. The basic idea behind RED is that most data transports detect packet loss and will, therefore, restrain transmission—if only temporarily—when they detect dropped packets. Consequently, if the switch needs to signal another device to slow transmission due to congestion, RED provides a way of intelligently dropping packets.

This section describes the changes and additions to ExtremeWare to support RED in conjunction with ATM modules that have IP frames encapsulated in bridged or routed protocols. The Extreme implementation of RED combines the functions of the RED algorithm with IP precedence to provide support for preferential traffic handling for higher-priority packets. This implementation provides weighted RED (WRED) functionality through two packet-drop probabilities (described below), so that a device can selectively drop lower-priority traffic when an interface begins to show signs of congestion. This capability is combined with DiffServ attributes to allow you to tailor performance characteristics for different classes of service.

Configuring RED Drop Probability

To configure the RED drop probability for a specified ATM port, use the following command:

```
config red [drop-probability | low-drop-probability | high-drop-probability]
   <percent> {ports <portlist>}
```

The optional `low-drop-probability`, `high-drop-probability`, and `ports` keywords are supported only for ATM ports.

If you omit the `ports` keyword, the command applies the setting to all ports.

The drop probability is specified as a percentage, where the `percent` parameter is an integer in the range from 1 to 100.

Weighted RED (WRED) functionality is supported through two different drop probabilities: a low-drop-probability and a high-drop-probability. The DiffServ code points of IP packets indicate whether the packet should be dropped with low probability or high probability, and the appropriate percentage is then applied if WRED is active.

NOTE

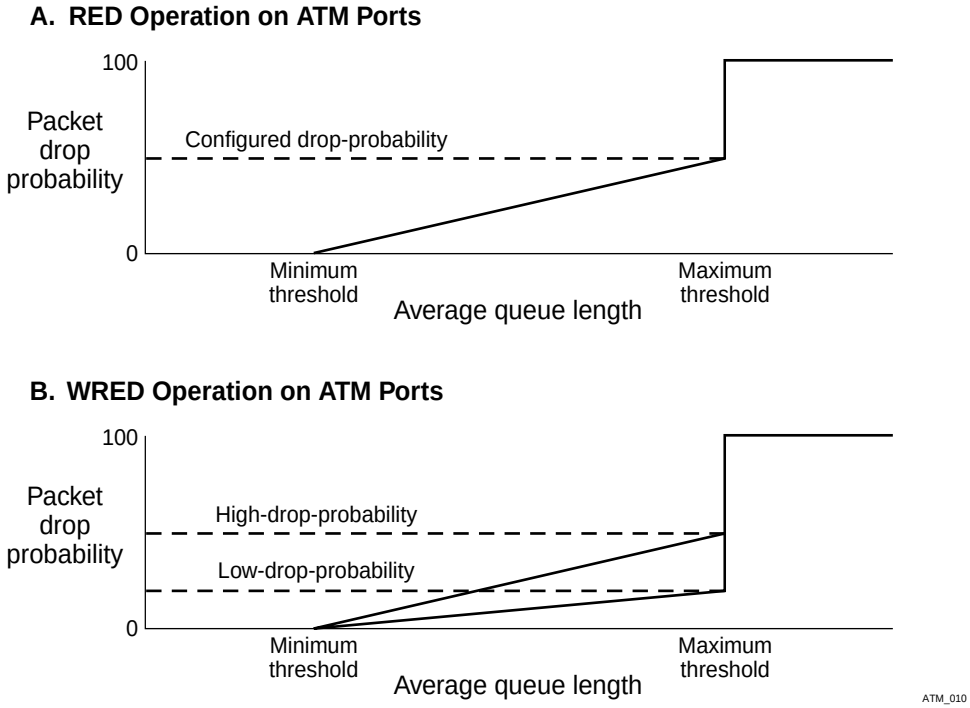
WRED is applied only to IP packets. The `config diffserv examination code-point` *command gives you complete flexibility in assigning DSCPs to the two different drop-probability levels. This configured mapping of DSCPs to drop-probability levels is used by WRED even if* `diffserv examination` *is disabled on the port.*

The `drop-probability` keyword indicates that the specified percentage should be used for both the low and high drop-probabilities. This effectively disables WRED and reverts to standard RED operation. For ATM ports, both the low and high drop-probabilities default to 10%.

The role of the configured drop probability in RED operation on ATM ports is illustrated in Figure 81A. RED is active when the average queue length is between the minimum and maximum thresholds. In this region, the probability that a given packet is dropped increases in a straight line up to the configured drop probability at the maximum threshold. All packets are dropped when the average queue length exceeds the maximum threshold.

The operation of WRED on ATM ports is depicted in Figure 81B. In this case, the drop probability depends not only on the average queue length, but also upon whether the DSCP indicates that the packet should be dropped with a low or high probability, which is to say, the DSCP of the packet controls which curve is used.

Figure 81: Comparisons of RED and WRED operation



Enabling and Disabling RED on ATM Ports

The existing ExtremeWare commands to enable and disable RED ports have been enhanced to provide RED configuration attributes for the ATM module. Because the ATM module supports eight egress queues per port, the commands were enhanced to allow the user a way to enable RED selectively on an individual port and queue basis. By default, RED is disabled.

To enable RED on a specified ATM port, use the following command:

```
enable red ports <portlist> {queue <queue#>}
```

To disable RED on a specified ATM port, use the following command:

```
disable red ports <portlist> {queue <queue#>}
```

The optional queue keyword applies only to ATM ports. You can use this keyword to enable or disable the RED function on an individual queue basis.

The queue# parameter is an integer in the range from 0 to 7, and identifies one of the eight egress queues. If you omit the queue keyword, the command applies to all of the queues for the ATM port.

Configuring the RED Minimum Queue Length Threshold

The packet drop probability is based, in part, on the RED minimum queue length threshold. When the average queue length exceeds this threshold, the RED algorithm is activated and begins dropping packets. The packet drop rate increases in a linear fashion as the average queue length increases or until the average queue length hits the maximum threshold.

NOTE

This command applies only to PoS and ATM ports.

To configure the minimum queue length threshold for RED operation on a specified ATM port, use the following command:

```
config red min-threshold <percent> ports <portlist>
```

The threshold value is specified as a percentage in the range from 1 to 100. For ATM ports, the minimum threshold is a percentage of 1000 packet buffers, and the maximum threshold is set to the value calculated by the formula:

*minimum ((3 * minimum threshold buffers), maximum available buffers)*

By default, the minimum threshold for ATM ports is 10%, or 100 buffers; thus, the default maximum threshold is 300 buffers.

You can use the `show ports info detail` command to display the settings of the minimum and maximum thresholds, displayed in terms of the number of buffers.

Use the `ports` keyword to configure the threshold parameter on specific ATM ports.

Support for Standard Per-Hop Behaviors

The per-hop behavior (PHB) describes the externally observable packet forwarding handling (or “behavior”) to be applied by the receiving network element when there are competing requests for resources such as bandwidth and buffer space. In the packet forwarding path, differentiated services are identified by mapping the differentiated services code point (DSCP) contained in the IP packet header to a specific forwarding behavior at each network element along its path. The DSCP is 6 bits wide, and takes the form *xxxxxx*, where *x* can be either 0 or 1. The DSCP field is capable of identifying one of 64 distinct code points. For purposes of code point allocation and management, the code point space is divided into three pools: one pool of 32 code points (pool 1) constitutes the recommended code points to be allocated as standards; a second pool of 16 code points (pool 2) is set aside for experimental or local use; a third pool of 16 code points (pool 3) that are initially set aside for experimental or local use, but that might be used for standard assignments if pool 1 is ever exhausted. The mapping of DSCPs to PHBs is a user-configurable function, as described below.

The current standards call for two PHBs: Assured Forwarding (AF) and Expedited Forwarding (EF). The EF PHB describes the required behavior for voice-over-IP service. The AF PHB consists of four independently forwarded AF classes: AF1, AF2, AF3, and AF4. Within each of these classes, an IP packet can be assigned to different levels of drop precedence (used to determine drop probability) depending on how many levels of drop precedence the implementation supports. RFC 2597 describes two schemes for drop-precedence levels: a three-level scheme (see Table 53) and a two-level scheme (see Table 54). The three-level scheme supports low, medium, and high drop-precedence levels for the AF classes; the two-level scheme supports low and high drop-precedence levels (and groups the medium

drop-precedence code-points with the high drop-precedence code-points). The Extreme implementation for the ATM module supports the two-level drop-precedence scheme.

Table 53: Assured Forwarding Classes and Three-Level Drop Precedence

Drop-Precedence Level	AF1	AF2	AF3	AF4
Low drop precedence	(AF11) 001010	(AF21) 010010	(AF31) 011010	(AF41) 100010
Medium drop precedence	(AF12) 001100	(AF22) 010100	(AF32) 011100	(AF42) 100100
High drop precedence	(AF13) 001110	(AF23) 010110	(AF33) 011110	(AF43) 100110

Table 54: Assured Forwarding Classes and Two-Level Drop Precedence

Drop-Precedence Level	AF1	AF2	AF3	AF4
Low drop precedence	(AF11) 001010	(AF21) 010010	(AF31) 011010	(AF41) 100010
High drop precedence	(AF12) 001100	(AF22) 010100	(AF32) 011100	(AF42) 100100
	(AF13) 001110	(AF23) 010110	(AF33) 011110	(AF43) 100110

In addition, a network element that complies with the DiffServ standards must also provide a recommended *default* code point, which must be unique for code points in the standard space. The default PHB describes the common, best-effort forwarding behavior offered by existing network elements, as defined in RFC 1812.

As an additional differentiation, a set of code points has been allocated for use as the Class Selector code points, which describe the minimum forwarding handling requirements needed to preserve compatibility with existing practices while respecting flexibility for the future.

Table 55 and the command examples that follow show how the standard per-hop behaviors (PHBs) might be mapped onto ExtremeWare QoS profiles qp1 through qp8.

Table 55: Mapping PHBs to QoS Profiles

PHB	Default	Class Selector		AF1	AF2	AF3	AF4	EF
QoS Profile	qp1	qp2	qp3	qp4	qp5	qp6	qp7	qp8
DSCP	000000	001000 010000 011000 100000 101000	110000 111000	001010 001100 001110	010010 010100 010110	011010 011100 011110	100010 100100 100110	101110

The DSCPs associated with a PHB are assigned to the appropriate QoS profile using the `config diffserv examination code-point` command. For example, the following command sets up the mapping for the EF PHB:

```
config diffserv examination code-point 46 qosprofile qp8 ports 2:1-2:2
```

Additional configuration steps for ATM ports in this example are as follows:

- Enable RED for all PHBs except the EF PHB. For example:

  ```
  enable red ports 2:1-2:2
  disable red ports 2:1-2:2 queue 8
  ```

- Configure a high drop-probability of 20% on the ATM ports. For example:

  ```
  config red high-drop-probability 20 ports 2:1-2:2
  ```

- Enable examination of DiffServ information. For example:

  ```
  enable diffserv examination ports 2:1-2:2
  ```

- Configure the default PHB. For example:

  ```
  config diffserv examination code-point 0 qosprofile qp1 ports 2:1-2:2
  ```

- Configure the Class Selectors. For example:

  ```
  config diffserv examination code-point 8 qosprofile qp2
     ports 2:1-2:2 high-drop-probability
  config diffserv examination code-point 16 qosprofile qp2
     ports 2:1-2:2 high-drop-probability
  config diffserv examination code-point 24 qosprofile qp2
     ports 2:1-2:2 high-drop-probability
  config diffserv examination code-point 32 qosprofile qp2
     ports 2:1-2:2 low-drop-probability
  config diffserv examination code-point 40 qosprofile qp2
     ports 2:1-2:2 low-drop-probability
  config diffserv examination code-point 48 qosprofile qp3
     ports 2:1-2:2 high-drop-probability
  config diffserv examination code-point 56 qosprofile qp3
     ports 2:1-2:2 low-drop-probability
  ```

- Configure the drop-probability for the DSCPs assigned to AF1 through AF4.

  For example, for AF1 (qp4):

  ```
  config diffserv examination code-point 10 qosprofile qp4
     ports 2:1-2:2 low-drop-probability
  config diffserv examination code-point 12 qosprofile qp4
     ports 2:1-2:2 high-drop-probability
  config diffserv examination code-point 14 qosprofile qp4
     ports 2:1-2:2 high-drop-probability
  ```

  For example, for AF2 (qp5):

  ```
  config diffserv examination code-point 18 qosprofile qp5
     ports 2:1-2:2 low-drop-probability
  config diffserv examination code-point 20 qosprofile qp5
     ports 2:1-2:2 high-drop-probability
  config diffserv examination code-point 22 qosprofile qp5
     ports 2:1-2:2 high-drop-probability
  ```

  For example, for AF3 (qp6):

  ```
  config diffserv examination code-point 26 qosprofile qp6
     ports 2:1-2:2 low-drop-probability
  config diffserv examination code-point 28 qosprofile qp6
     ports 2:1-2:2 high-drop-probability
  config diffserv examination code-point 30 qosprofile qp6
     ports 2:1-2:2 high-drop-probability
  ```

For example, for AF4 (qp7):

```
config diffserv examination code-point 34 qosprofile qp7
   ports 2:1-2:2 low-drop-probability
config diffserv examination code-point 36 qosprofile qp7
   ports 2:1-2:2 high-drop-probability
config diffserv examination code-point 38 qosprofile qp7
   ports 2:1-2:2 high-drop-probability
```

- Configure the congested-state mappings for DSCPs 10 (AF11), 18 (AF21), 26 (AF31), and 34 (AF41). For example:

```
config diffserv dscp-mapping 10/12 egress congestion
config diffserv dscp-mapping 18/20 egress congestion
config diffserv dscp-mapping 26/28 egress congestion
config diffserv dscp-mapping 34/36 egress congestion
```

- Use the EF PHB to configure bandwidth reservation and rate limiting. For example:

```
config diffserv examination code-point 46 qosprofile qp8 ports 2:1-2:2
config qosprofile qp8 minbw 10 maxbw 20 2:1-2:2 egress
config qosprofile qp8 minbw 10 maxbw 20 2:1-2:2 ingress
```

Displaying RED Configuration Information for ATM Module Ports

While the syntax of the existing `show ports info detail` command has not changed, the output of the command now displays the RED and DiffServ configuration parameters associated with ATM module ports.

To display QoS, RED, and DiffServ information for a specified ATM port, use the following command:

```
show ports info detail
```

NOTE

For ATM ports, the existing `show ports qosmonitor` *command has also been enhanced to display the number of packet transmissions and discards from each queue (in both egress and ingress directions).*

QoS Monitor

The QoS Monitor utility is supported for ATM module ports. The QoS Monitor and its associated ExtremeWare commands are described in Chapter 7.

Intra-Subnet QoS

Intra-Subnet QoS (ISQ) is not supported on switches that use the "*i*" chipset; the ATM module is supported only on switches that use the "*i*" chipset.

Limitations and Unsupported Features

This section describes additional command and configuration information related to the use of the ATM module. This section includes information on the following topics:

- Configuring Port Attributes on page 419
- Jumbo Frame Support on page 419
- Configuring IGMP Attributes on page 420
- Configuring Layer 2 and 3 Switching Attributes on page 420
- Configuring Access List Attributes on page 420
- Changing Image and Configuration Attributes on page 420

Configuring Port Attributes

The following ExtremeWare port commands are not supported for the ATM module:

- `show ports {<portlist>} collisions`
- `config ports <portlist> auto off {speed [10 | 100 | 1000]} duplex [half | full]`
- `config ports <portlist> auto on`
- `enable smartredundancy <portlist>`
- `enable sharing <port> grouping <portlist> {port-based | address-based | round-robin}`
- `enable mirroring to <port>`
- `disable learning ports <portlist>`
- `config mirroring add [vlan <vlan name> | port <port> | vlan <vlan name> ports <portlist>]`

Jumbo Frame Support

The jumbo frame size affects the size of the payload that can be transmitted or received on an ATM port.

If jumbo frame support is enabled on an ATM port, the following can occur:

- No frames received from the switch backplane will be discarded due to being too large. Nor will any IP frames be fragmented.
- PDUs received from the ATM link with routed protocol encapsulation will be discarded if the size of the IP packet exceeds *(configured JUMBO_FRAME_MTU -22*) octets.
- PDUs received from the ATM link with bridged protocol encapsulation will be discarded if the size of the Ethernet frame (including a VLAN tag but excluding the LAN FCS) exceeds *(CONFIGURED JUMBO_FRAME_MTU - 4*) octets. If the Ethernet frame does not include a VLAN tag field, then the frame will be discarded if the size of the Ethernet frame (excluding the LAN FCS) exceeds *(CONFIGURED JUMBO_FRAME_MTU - 8*) octets.

If jumbo frame support is not enabled on an ATM port, the following can occur:

- Frames received from the switch backplane, whose size exceeds 1522 octets, will not be forwarded onto the ATM link. IP frames that meet this criteria will be sent to the MSM CPU for fragmentation / Path MTU Discovery processing. Non-IP frames that meet this criteria will be discarded.
- PDUs received from the ATM link with routed protocol encapsulation will be discarded if the size of the IP packet exceeds 1500 octets.
- PDUs received from the ATM link with bridged protocol encapsulation will be discarded if the size of Ethernet frame (including a VLAN tag but excluding the LAN FCS) exceeds 1518 octets. If the Ethernet frame does not include a VLAN tag field, then the frame will be discarded if the size of the Ethernet frame (excluding the LAN FCS) exceeds 1514 octets.

Consider these factors when configuring jumbo frame support on an ATM port:

- When the jumbo frame size is changed from a value of 6129 or less to a value greater than 6129, any ATM module that has ports with jumbo frame support enabled must be rebooted for the change to take effect.

For more information on the ExtremeWare jumbo frame commands, see Chapter 4.

Configuring IGMP Attributes

For more information on the ExtremeWare IGMP commands, see Chapter 19

Configuring Layer 2 and 3 Switching Attributes

All of the IP routing protocols are supported for either L2 encapsulation or IP encapsulation: RIP, OSPF, BGP, DVMRP, and PIM.

When L2 encapsulation is enabled on an ATM port, IPX RIP and SAP are supported.

Configuring Access List Attributes

For more information on the ExtremeWare access list commands, see Chapter 11.

NOTE

On the ATM module, the access list functions apply to port pairs, where ports 1 and 2 are a pair, and ports 3 and 4 are a pair. This pairing scheme means that the ports in a given pair share the same access lists: ports 1 and 2 share the same lists, while ports 3 and 4 share their access lists. For example, if an access list is configured for port 1, that access list also applies to port 2, and vice versa.

Changing Image and Configuration Attributes

For more information about these commands and operations, see Appendix A.

23 Packet Over SONET (PoS) Modules

The Packet over SONET (PoS) modules are I/O modules for the BlackDiamond 6800 series chassis-based system. These modules connect a BlackDiamond 6800 series switch to the SONET infrastructure used by metropolitan area service providers and operators of server co-location networks.

This chapter includes information on the following topics:

- About the PoS Modules on page 421
- Configuring the PoS Module on page 426

About the PoS Modules

Two key applications for the PoS modules are: interconnecting metropolitan area networks across the SONET network infrastructure, and interconnecting server co-location network sites directly using SONET links.

In the first application, the metropolitan area network service provider can build service network sites in various cities, then use PoS modules in a BlackDiamond 6800 series switch to connect those cities to a carrier's SONET infrastructure.

In the second application, operators of server co-location networks can use PoS modules in BlackDiamond 6800 series switches to create a SONET-based connection between server co-location sites. The result is that their network is simpler to manage, and problems can be isolated and resolved more expediently.

Extreme Networks offers the PoS module in the following configurations:

- P3cMi: four OC-3 multimode, short-reach optical interfaces
- P3cSi: four OC-3 single-mode, intermediate-reach optical interfaces
- P12cMi: two OC-12 multimode, short-reach optical interfaces
- P12cSi: two OC-12 single-mode, intermediate-reach optical interfaces

NOTE

The "c" in the names of the modules indicates that the optical interfaces on these modules operate in concatenated mode, which enables all the bandwidth to be devoted to a single payload stream.

The P3cMi (multimode version) operates in the 1310 nanometer (nm) wavelength window at a typical maximum cable distance of 2 kilometers (km) or 1.24 miles (mi). The P12cMi (multimode version) also operates in the 1310 nanometer (nm) wavelength, but at a typical maximum cable distance of 500 meters (m) or 0.31 (mi). The P3cSi and P12cSi (single-mode versions) also operate in the 1310 nanometer (nm) wavelength window, but at a typical maximum cable distance of 15 km or 9.32 (mi). All four versions of the PoS module use industry-standard duplex SC optical fiber connectors.

Summary of Features

The PoS modules provide the following key networking functions:

- Support for both Synchronous Optical Network (SONET) and Synchronous Digital Hierarchy (SDH) modes of operation
- Support for the Point-to-Point Protocol (PPP) suite, including:
  - Link Control Protocol (LCP)
  - Link Maintenance option for LCP
  - Link Quality Report (LQR) Protocol
  - Password Authentication Protocol (PAP)
  - Challenge Handshake Authentication Protocol (CHAP)
  - IP Control Protocol (IPCP)
  - Bridging Control Protocol (BCP)
  - Extreme Discovery Protocol Control Protocol (EDPCP)
  - OSI Network Layer Control Protocol (OSINLCP)
  - Support for MultiProtocol Label Switching Control Protocol (MPLSCP) via PPP
- Efficient support for IP routing over SONET via IPCP
- Support for Transparent LAN Services (TLS) over SONET via BCP
- Support for jumbo frames
- Extensive support for Quality of Service (QoS) and Differentiated Services (DiffServ), including:
  - Eight ingress queues and eight egress queues per interface
  - Ingress and egress rate shaping and limiting
  - IEEE 802.1Q VLAN priorities
  - Weighted RED (WRED) congestion avoidance algorithm
  - Assured Forwarding and Expedited Forwarding RFCs
- Support for service provider specific features, such as:
  - Flexible remapping of DiffServ codepoints
  - Flexible remapping of IEEE 802.1Q VLAN IDs
  - VLAN tunneling via nested 802.1Q tags
  - Port tunneling of High-Level Data Link Control (HDLC) byte streams
- Support for NetFlow Version 1 per-flow statistics, including:
  - Capacity for two million flow records per PoS module
  - Scalability via distribution to groups of flow-record collector devices

  - Filters enabling statistics to be maintained for selected flows
  - Aggregation option for further reducing the volume of exported data
- Resiliency with fast recovery from SONET link failures via support for Automatic Protection Switching (APS) protocol in multiple configurations, including networks where the working and protection lines are:
  - Terminated in the same SONET module
  - Terminated in different SONET modules residing in the same BlackDiamond 6800 series system
  - Terminated in different SONET modules residing in different BlackDiamond 6800 series systems

Function Summary

The following sections provide brief descriptions of the key functions provided by the PoS modules. Each of these sections is expanded into greater detail in “Configuring the PoS Module” on page 426.

SONET and SDH

SONET and SDH are the two terms used to identify a time division multiplexing technology that is optimized for transporting voice traffic across a digital optical network, but that is also capable of providing high-speed capacity for transporting data.

The term SONET is used to identify the technology used within the North American digital network. Its standards are published by Bellcore and the American National Standards Institute (ANSI). The term SDH is used to identify the equivalent standard approved by the International Telecommunication Union (ITU) for use in Europe and elsewhere in the global digital network. Because SDH evolved out of SONET, the two standards are closely joined and have been widely accepted as a dominant choice for implementations requiring high transport capacity and resistance to failure.

PPP

PPP encompasses a suite of protocols designed to provide standard methods for transporting datagrams over point-to-point links. The use of PPP over SONET links is commonly referred to as Packet over SONET, or PoS. The Extreme Networks implementation of PPP for the PoS module provides support for the following protocols in the PPP suite:

- Link Control Protocol (LCP)
- Link Quality Report (LQR) Protocol
- Challenge Handshake Authentication Protocol (CHAP)
- Password Authentication Protocol (PAP)
- IP Control Protocol (IPCP)
- Bridging Control Protocol (BCP)
- Extreme Discovery Protocol Control Protocol (EDPCP)
- MultiProtocol Label Switching Control Protocol (MPLSCP)
- OSI Network Layer Control Protocol (OSINLCP)

MPLS

The PoS module ports provide MPLS support via a PPP link. The MPLS Control Protocol (MPLSCP) allows MPLS labeled packets to be transported across a PPP link.

Jumbo Frames

The PoS module ports provide jumbo frame support that is similar to that provided by Ethernet ports on a BlackDiamond 6800 series switch.

Jumbo frames are Ethernet frames that are larger than 1522 bytes, including four bytes used for the cyclic redundancy check (CRC). Extreme products support switching and routing of jumbo frames at wire-speed on all ports.

Jumbo frames are used between endstations that support larger frame sizes for more efficient transfers of bulk data. Both endstations involved in the transfer must be capable of supporting jumbo frames.

QoS and Differentiated Services

The PoS modules support eight ingress queues and eight egress queues per port. The scheduling parameters for these queues (minimum bandwidth, maximum bandwidth, priority level, etc.) are controlled by QoS profiles that you can customize for individual ingress or egress queues on a specific PoS port.

You can assign frames to queues based on IEEE 802.1p priorities, MPLS EXP values, Differentiated Services Code Points (DSCPs), or by configuring a QoS profile for the port or VLAN. You can tailor the DSCP-to-queue mapping for ingress or egress directions on a per-port basis. Most of the existing ingress classification functions, along with the DiffServ replacement functions, are also supported for PoS ports.

The supported DiffServ functions maximize user flexibility while providing all of the features needed to support the standard per-hop behaviors (PHBs), including:

- Default
- Class Selector
- Assured Forwarding
- Expedited Forwarding

The PoS modules also provide flexible support for the well-known Weighted RED (WRED) congestion avoidance algorithm.

Service Provider Features

The PoS modules provide the following features for service provider environments:

- DSCP mapping
- VLAN ID (VID) tag mapping
- VLAN ID (VID) tag nesting
- Port tunneling

You can use the `diffserv dscp-mapping` command to configure a mapped relationship between an input DSCP and an associated output DSCP. Each PoS port supports three DSCP mapping tables: one of the tables is used in the ingress direction; two are used for egress flows (onto the SONET link). The two egress tables are for the congested and noncongested states, as determined by the RED algorithm. If RED is not enabled on the PoS port, the egress congested-state mapping table is not used.

In the ingress direction, the input DSCP of a packet received from the SONET link is replaced by an output DSCP before the packet is forwarded. In the egress direction, the operation is similar, except that the DSCP mapping occurs before the packet is transmitted onto the SONET link.

One potential use of the DSCP mapping capability is to reconcile varying DiffServ policies at the boundary between autonomous systems, such as at the boundary between two ISPs. The availability of different tables for the congested and noncongested states is useful in marking operations that increase the probability of packets being dropped during times of congestion, as discussed in the DiffServ Assured Forwarding RFC (RFC 2597).

An analogous feature has been added for managing 802.1Q tags. The `dot1q tagmapping` command provides support for VLAN ID (VID) mapping tables. Each PoS port supports two VID tables: one table is used in the ingress direction; the other is used in the egress direction. Each of the tables enables an input VID to be mapped to an output VID. This feature is useful in reconciling policy differences at the boundary between the customer and the service provider.

Another related enhancement provides support for nested 802.1Q tags by allowing a *tag push* or *tag pop* attribute to be associated with a VID. The *push* attribute indicates that a new tag is to be added to the frame, while the *pop* attribute indicates that the top-level tag is to be removed from the frame. This capability is augmented by an option that allows the 802.1p priority of the frame to be either preserved or set to a user-configurable value when a new tag is pushed. These functions make it possible for service providers to tunnel customer-specific VLANs across a common SONET backbone in a very simple manner.

The PoS module also supports port tunneling. Port tunneling can be used to encapsulate and transport the raw High-Level Data Link Control (HDLC) encapsulated byte stream from one PoS port to another PoS port across an MPLS network. This allows service providers to tunnel different types of SONET HDLC streams across a non-SONET backbone like Ethernet.

NetFlow Statistics

Each PoS port can maintain and export statistics for the flows that traverse the associated SONET link.

Per-flow statistics are useful for many management purposes, including:

- Accounting and billing
- Network capacity planning and trend analysis
- Network monitoring
- Workload characterization
- User profiling
- Data warehousing and mining

Each PoS module can maintain two million flow records. Per-flow statistics are reported in the NetFlow, Version 1 format, which groups flow records together into UDP datagrams for export to a flow-collector device.

The PoS module also provides a NetFlow distribution feature to provide a growth path to more scalable and robust collection architectures. This feature allows a single PoS port to distribute statistics across multiple groups of flow-collector devices in a load-balanced manner. The function also includes a health-check feature that significantly improves the reliability of the collection architecture. The health-checker ensures that only responsive flow-collector devices are included in the effective export distribution lists.

To further enhance scalability, the PoS module also offers filters and filter-based aggregation options that allow you to configure a PoS port to maintain statistics selectively for only those flows matching specified filters. The aggregation options can further reduce the volume of exported data by enabling a single set of statistics to be maintained for all the flows that match an aggregation filter.

Automatic Protection Switching

Automatic Protection Switching, or APS, is a physical-layer resiliency feature specified in the SONET standards. Multiplex Section Protection, or MSP, is the APS equivalent in the SDH standard, which is also supported by the PoS module. Throughout this guide, the terms *APS* and *Automatic Protection Switching* are used to refer to the protection switching features of both standards.

Of the various protection switching modes specified in the SONET/SDH standards, the BlackDiamond 6800 series switches use the linear 1+1 architecture to protect tributary SONET lines. In the linear 1+1 architecture, there is one protection line for each working line. If the working line fails, traffic is automatically switched to the protection line. You can also control whether traffic switched to the protection line is automatically switched back to the working line when it is restored to service.

The Extreme Networks implementation supports network configurations where:

- Working and protection lines are terminated in the same PoS module.
- Working and protection lines are terminated in different PoS modules residing in the same BlackDiamond 6800 series switch.
- Working and protection lines are terminated in different PoS modules residing in different BlackDiamond 6800 series switches.

Configuring the PoS Module

This section describes the ExtremeWare commands that support the PoS module. For hardware installation information on the BlackDiamond 6800 series switch, see the *Extreme Networks Consolidated Hardware Guide*.

NOTE

Documentation for Extreme Networks products is available on the World Wide Web at the Extreme Networks home page at http://www.extremenetworks.com/.

This section includes information on the following topics:

- Basic PoS Module Configuration Information on page 427
- Configuring and Monitoring SONET Ports on page 434
- Configuring and Monitoring PPP Functions on page 440
- Configuring VLAN-Related Attributes on page 452
- Configuring Forwarding Database Attributes on page 455
- Configuring Spanning Tree Attributes on page 455
- Configuring QoS Functions on page 455
- Configuring and Monitoring Flow Statistics on page 466
- Configuring and Monitoring APS Functions on page 476
- Configuring Port Tunneling on page 493
- Limitations and Unsupported Commands on page 495

Basic PoS Module Configuration Information

This section uses several typical usage and configuration schemes to provide a brief overview of the PoS module configuration process as a general context for the detailed command description sections that follow.

Default PoS Module Configurations

When the BlackDiamond 6800 series switch is powered on, the ExtremeWare software determines which slots are occupied by I/O modules, determines whether it has a configuration for each module, and generates a default configuration for each slot that is occupied by an I/O module that has not yet been configured. The default configuration is the minimal set of configuration parameter settings that will allow the I/O module and its ports to function.

For the PoS modules, the default configuration depends on whether the module is an OC-3 module (P3cSi or P3cMi) or an OC-12 module (P12cSi or P12cMi). The OC-3 modules have some port-pairing considerations that affect configuration (see “PoS Port Configuration and Default VLAN Assignments” on page 427). In either case, the default configuration on the PoS module is for bridging (see “Default Configuration: Bridging Over PoS Ports” on page 428), with the Bridging Control Protocol (BCP) enabled, so that the module’s ports are brought up as members of the default VLAN and traffic is bridged between all ports in the VLAN. The default configuration includes values for the configurable SONET link parameters.

To perform routing over PoS ports using the IP Control Protocol (IPCP), or to take advantage of other features and capabilities, such as providing redundancy over the tributary links of the SONET network using Automatic Protection Switching (APS), you will need to perform additional configuration tasks. For examples of how to extend the configuration, see “Routing Over PoS Ports” on page 429 and “Automatic Protection Switching” on page 431.

PoS Port Configuration and Default VLAN Assignments

The ports on the PoS modules are identified by a port number that is a combination of the slot number where the module is installed and the port number on the module. The nomenclature for the port number is as follows:

```
slot:port
```

For example, you would refer to the four ports on an OC-3 PoS module installed in slot 4 of the BlackDiamond 6800 series chassis by the port numbers 4:1, 4:2, 4:3, and 4:4.

NOTE

For more information about port numbers and port configuration, see Chapter 4.

Because the default Point-to-Point Protocol (PPP) network control protocol is the Bridge Control Protocol (BCP), all PoS ports are initially enabled for bridging. By default, only ports 1 and 3 on the OC-3 PoS modules are assigned to the default VLAN, while ports 2 and 4 are not assigned to a VLAN.

Because the first port pair on the OC-3 PoS modules (ports 1 and 2) and the second port pair (ports 3 and 4) use a common link to the switch backplane, ports belonging to the same port pair cannot be assigned to the same VLAN. The only exception to this rule is when APS is defined and one of the two ports of a port pair is used as the working line port, while the second port is used as the protection line port.

NOTE

The port-pair restriction described above for the OC-3 PoS modules does not apply to the OC-12 PoS module.

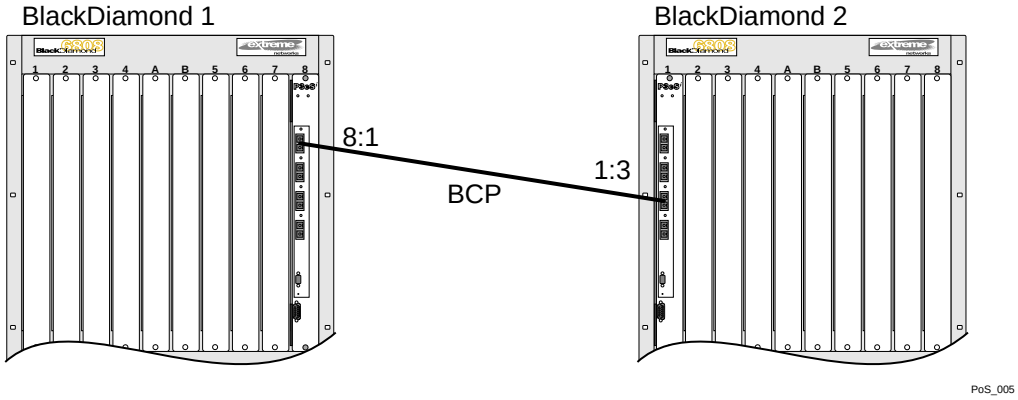
Default Configuration: Bridging Over PoS Ports

The default configuration of the OC-3 PoS module enables you to connect either port 1 or 3 of an OC-3 PoS module in a BlackDiamond 6800 series switch to either port 1 or 3 of an OC-3 PoS module in a second BlackDiamond switch. In this configuration, all ports reside in the default VLAN and traffic is bridged between all ports in the VLAN. If you enable the Spanning Tree protocol, you can connect more ports in parallel, but they will be blocked for traffic transmission. Loadsharing is not supported over PoS links.

Configuration Commands for BCP

The bridged network example shown in Figure 82 does not require additional configuration commands for BCP support, because the default SONET and PPP configuration values will bring up the ports as members of the default VLAN. However, the commands to enable BCP together with the default SONET values (see Table 56) are listed below for reference. The command `unconfig ppp ports <portlist>` will also reset the configuration to these default values.

Figure 82: Default configuration for BCP



Configuring Default SONET and PPP Settings

The following configuration commands apply to the PoS module installed in slot 8 of BlackDiamond switch 1, as shown in Figure 82.

```
config ppp echo off ports 8:1
config ppp authentication off ports 8:1
config ppp quality off ports 8:1
config ppp user "extreme" encrypted "f7P*8aPO+86+'RL8E?MDZBJV`F)UC.-"
   ports 8:1
config ppp bcp on ports 8:1
config ppp ipcp off ports 8:1
config ppp pos checksum 32 ports 8:1
config ppp pos scrambling on ports 8:1
config ppp delayed-down-time 1 ports 8:1
```

Table 56 lists the configurable SONET link parameters and their default values.

Table 56: SONET Parameters and Values

Parameter	Possible Values	Default Value
Framing	SONET or SDH	SONET
Clock source	internal or line	internal
Signal Failure threshold[1]	10^{-3} through 10^{-5}	10^{-5}
Signal Degrade threshold[2]	10^{-5} through 10^{-9}	10^{-6}
J0 Section Trace byte[3]	0 through 255	1
J0 Section Trace string[4]	Maximum of 15 characters	15 NULL characters
J1 Path Trace identifier string[5]	Maximum of 64 characters	IP address of port's VLAN (in dotted-decimal notation)
C2 Signal Label	0 through xFF	auto[6]

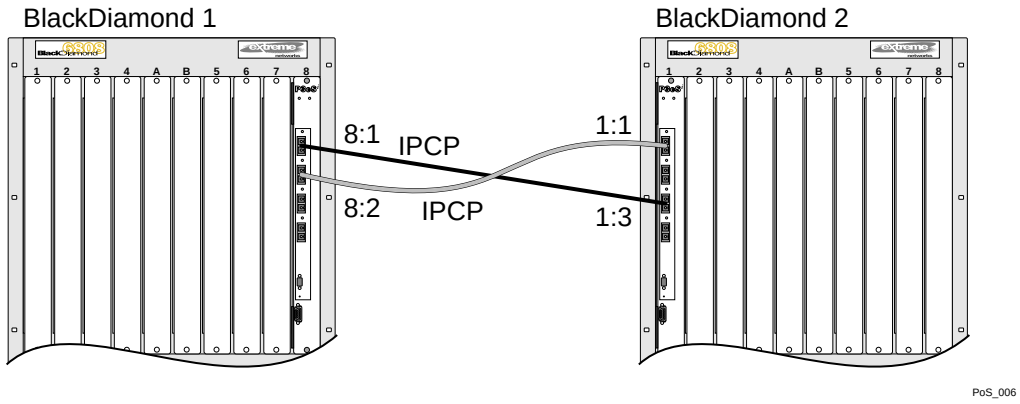
1. B2 bit error rate (BER) threshold; a Signal Failure (SF) event is generated if the BER exceeds the specified threshold.
2. B2 bit error rate (BER) threshold; a Signal Degrade (SD) event is generated if the BER exceeds the specified threshold.
3. The default value of 1 is per ANSI T1.105-1995. This parameter applies only when SONET framing is configured on the port.
4. This parameter applies only when SDH framing is configured on the port.
5. When SDH framing is configured on the port, only the first 15 characters of the string are applied.
6. Set automatically based on synchronous payload envelope (SPE) payload type.

Routing Over PoS Ports

While you can configure BCP to perform routing over PoS ports, IPCP might be a better choice than BCP in those cases where the link will carry only routed IP traffic, because it provides a more efficient encapsulation scheme than does BCP, and thereby increases the maximum link throughput.

To take best advantage of the wire-speed layer 3 routing capabilities of the BlackDiamond 6800 series switch using the PoS module, configure IPCP as the PPP network control protocol to route between the PoS ports and any other VLANs. If you do not configure APS, an IPCP port must be the only port in a VLAN.

Figure 83: IPCP configuration



Configuration Commands for IPCP

For the IPCP routing network configuration example shown in Figure 83, the default configuration parameter settings for PoS ports should be suitable for most installations. Thus, only minimal additional configuration is needed to get IPCP up and running on a PoS port. The necessary configuration steps are:

1. Create a VLAN for each SONET port using the `create vlan <vlan name>` command.
2. Add each SONET port to a VLAN using the `config vlan <vlan name> add ports <port>` command.
3. Define an IP router port on each VLAN by assigning an IP address to each VLAN using the `config vlan <vlan name> ipaddress <ipaddress> {<mask length>}` command, and enable IP forwarding using the `enable ipforwarding` command.
4. Disable BCP on the SONET ports using the `config ppp bcp off ports <portlist>` command, and then enable IPCP on the SONET ports using the `config ppp ipcp on ports <portlist>` command.

The following configuration commands apply to the PoS module installed in slot 8 of BlackDiamond switch 1, as shown in Figure 83.

```
config ppp bcp off ports 8:1, 8:2
config ppp ipcp on ports 8:1, 8:2
create vlan vlanipcp1
create vlan vlanipcp2
config vlanipcp1 ipaddress 192.168.100.1 /30
config vlanipcp2 ipaddress 192.168.200.1 /30
enable ipforwarding vlanipcp1
enable ipforwarding vlanipcp2
config vlanipcp1 add ports 8:1
config vlanipcp2 add ports 8:2
```

The following configuration commands apply to the PoS module installed in slot 1 of BlackDiamond switch 2, as shown in Figure 83.

```
config ppp bcp off ports 1:1, 1:3
config ppp ipcp on ports 1:1, 1:3
create vlan vlanipcp1
create vlan vlanipcp2
config vlanipcp1 ipaddress 192.168.100.2 /30
config vlanipcp2 ipaddress 192.168.200.2 /30
enable ipforwarding vlanipcp1
enable ipforwarding vlanipcp2
config vlanipcp1 add ports 1:3
config vlanipcp2 add ports 1:1
```

Automatic Protection Switching

The ExtremeWare software APS implementation enables PoS links to provide redundancy over the tributary links of the SONET network. You can configure three levels of APS redundancy:

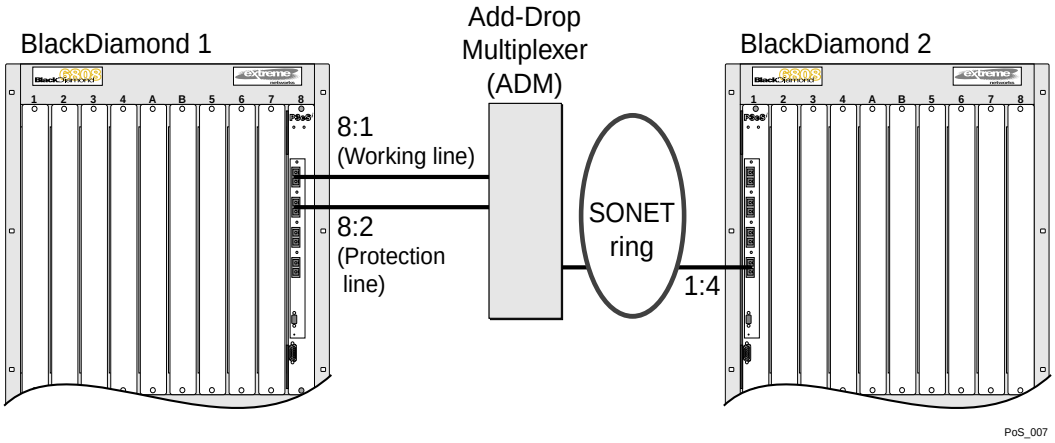
- Port redundancy (single PoS module configuration)
- Module redundancy (two PoS module configuration)
- Switch redundancy (two switch configuration)

These three APS redundancy options are described in the sections that follow. For more detailed information on the commands associated with APS, see “Configuring and Monitoring APS Functions” on page 476.

APS Port Redundancy

Figure 84 is an example of a single-module APS redundancy configuration, in which the working line and the protection line are terminated in the same PoS module in the BlackDiamond 6800 series switch. This configuration provides simple protection against line failures.

Figure 84: APS configuration, port redundancy



Configuration Commands for APS: Port Redundancy

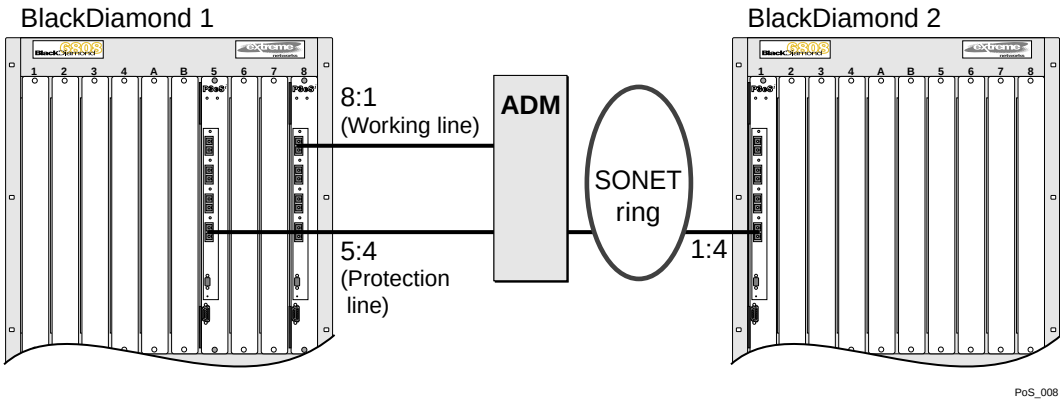
The following configuration commands apply to the PoS module installed in slot 8 of BlackDiamond switch 1, as shown in Figure 84.

```
create vlan apslbvlan
config vlan apslbvlan ipaddress 192.168.1.1 /30
enable loopback-mode apslbvlan
create aps 1
config aps 1 add 8:1 working
config aps 1 add 8:2 protection 192.168.1.1
enable aps
```

APS Module Redundancy

Figure 85 is an example of a two-module APS redundancy configuration, in which the working line and the protection line are terminated in two different PoS modules in the same BlackDiamond 6800 series switch. This configuration provides simple protection against both line and module failures.

Figure 85: APS configuration, module redundancy



Configuration Commands for APS: Module Redundancy

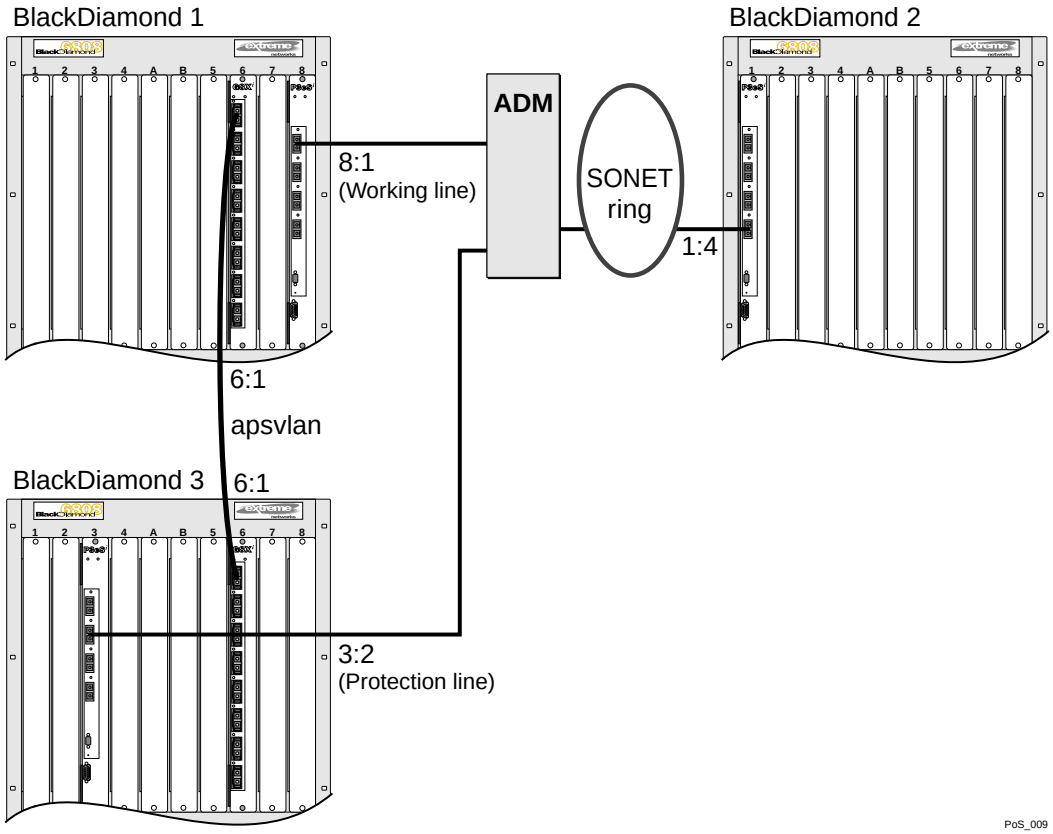
The following configuration commands apply to the two PoS modules installed in slots 5 and 8 of BlackDiamond switch 1, as shown in Figure 85.

```
create vlan apslbvlan
config apslbvlan ipaddress 192.168.1.1 /30
enable loopback-mode apslbvlan
create aps 1
config aps 1 add 8:1 working
config aps 1 add 5:4 protection 192.168.1.1
enable aps
```

APS Switch Redundancy

Figure 86 is an example of a two-switch APS redundancy configuration, in which the working line is terminated in a PoS module in one BlackDiamond switch, while the protection line is terminated in a different PoS module in a different BlackDiamond switch. This configuration expands protection to include line, module, and switch failures.

Figure 86: APS configuration for switch redundancy



Configuration Commands for APS: Switch Redundancy

The following configuration commands apply to the PoS module installed in slot 8 of BlackDiamond switch 1, as shown in Figure 86.

```
create vlan apsvlan
config apsvlan add port 6:1
config apsvlan ipaddress 192.168.1.1 /30
enable loopback-mode apsvlan
enable ipforwarding
create aps 1
configure aps 1 add 8:1 working
enable aps
```

The following configuration commands apply to the PoS module installed in slot 3 of BlackDiamond switch 3, as shown in Figure 86.

```
create vlan apsvlan
configure apsvlan add port 6:1
configure apsvlan ipaddress 192.168.1.2 /30
enable ipforwarding

create aps 1
configure aps 1 add 3:2 protection 192.168.1.1
enable aps
```

Configuring and Monitoring SONET Ports

This section provides information on the following topics:

- Configuring SONET Framing on page 434
- Configuring SONET Loopback (OC12) on page 434
- Configuring the Signal Fail Threshold on page 435
- Configuring the Signal Degrade Threshold on page 435
- Configuring the Section Trace Identifier on page 436
- Configuring the Path Trace Identifier on page 436
- Configuring the Signal Label on page 437
- Resetting SONET Configuration Parameter Values on page 437
- Displaying SONET Port Status Information on page 437

Configuring SONET Framing

You can configure each port for framing that complies with either the SONET standard or the SDH standard. SONET is primarily an American standard; SDH is the international version. The default is SONET.

To configure the framing for the specified SONET port, use the following command:

```
config sonet framing [sonet | sdh] ports <portlist>
```

The following command example selects SDH framing for port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
config sonet framing sdh ports 8:1
```

Configuring SONET Loopback (OC12)

SONET loopback is only available on OC-12 ports. Configuring loopback on a SONET port may be useful for diagnostics or network troubleshooting. When internal loopback is configured, the transmitted signal is looped back onto the receive interface. When line loopback is configured, the received signal is looped back onto the transmit interface.

To configure SONET loopback, use the following command:

```
config sonet loop [internal | line | off] ports <portlist>
```

To configure loopback on SONET port 1 of the PoS module installed in slot 8 of the BlackDiamond switch:

```
config sonet loop internal ports 8:1
```

Configuring SONET Clocking

You can configure each port on the PoS module to use either line clocking, where the clock source is recovered from the received bit stream, or internal clocking, where the clock source is based on an internal clock. The default is internal.

To configure the clocking source for the specified SONET port, use the following command:

```
config sonet clocking [line | internal] ports <portlist>
```

The following command example selects line clocking for port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
config sonet clocking line ports 8:1
```

Configuring the Signal Fail Threshold

A Signal Failure (SF) event is generated if the bit error rate (BER) for the SONET line exceeds the configured threshold. An SF event brings the port down. If Automatic Protection Switching (APS) is enabled on the port, an SF event initiates a line switch.

To configure the Signal Fail threshold for the specified SONET port, use the following command:

```
config sonet threshold signal fail <error_rate> ports <portlist>
```

The `error_rate` parameter is an integer in the range from 3 to 5, where the SF BER is 10^{-error_rate}. The default value of the `error_rate` parameter is 5, which equates to an SF bit error rate of 10^{-5}, or 1 per hundred thousand.

The following command example sets the Signal Fail threshold value to 3 for port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
config sonet threshold signal fail 3 ports 8:1
```

NOTE

ou can set the signal degrade threshold to a different value than the default value of 6 depending on your particular application's tolerance for errors. In general, you should not change the default setting unless you are an expert and have a specific reason for the change.

Configuring the Signal Degrade Threshold

A Signal Degrade (SD) event is generated if the BER for the SONET line exceeds the configured Signal Degrade threshold. If APS is enabled on the port, an SD event initiates a line switch.

To configure the Signal Degrade threshold for the specified SONET port, use the following command:

```
config sonet threshold signal degrade <error_rate> ports <portlist>
```

The `error_rate` parameter is an integer in the range from 5 to 9, where the SD bit error rate is 10^{-error_rate}. The default value of the `error_rate` parameter is 6, which equates to an SD bit error rate of 10^{-6}, or 1 per million.

The following command example sets the Signal Degrade threshold value to 8 for port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
config sonet threshold signal degrade 8 ports 8:1
```

NOTE

You can set the signal degrade threshold to a different value than the default value of 6 depending on your particular application's tolerance for errors. In general, you should not change the default setting unless you are an expert and have a specific reason for the change.

Configuring the Section Trace Identifier

Section trace is a maintenance feature of SONET. One byte of the Section Overhead associated with each SONET frame is used to carry information identifying the transmitting equipment.

To configure the Section Trace identifier for the specified SONET port, use the following command:

```
config sonet trace section [<id_byte> | string <id_string>] ports <portlist>
```

In this command, the Section Trace identifier can take one of two forms: an ID byte (`id_byte`) or an ID string (`id_string`).

The `id_byte` parameter is an integer in the range from 1 to 255, with a default value of 1. This parameter applies only when SONET framing is configured, in which case, the configured `id_byte` value is transmitted in each SONET frame.

The `id_string` parameter is a string of up to 15 characters. By default, the <id_string> parameter contains 15 NULL characters. This parameter applies only when SDH framing is configured, in which case the SDH framing cycles repetitively through a 15-character string, sending one character per frame. If the configured string contains fewer than 15 characters, it is padded to full length by NULL characters.

The following command example sets the Section Trace identifier to the string "1800wombat" for port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
config sonet trace section string 1800wombat ports 8:1
```

Configuring the Path Trace Identifier

Path trace is a maintenance feature of SONET. One byte of the Path Overhead associated with each SONET frame is used to carry information identifying the originating Path Terminating Equipment (PTE).

To configure the Path Trace identifier for the specified SONET port, use the following command:

```
config sonet trace path <id_string> ports <portlist>
```

The `id_string` parameter is a string of up to 64 characters. By default, the `id_string` parameter contains the IP address assigned to the VLAN to which the port belongs. This IP address is represented in dotted-decimal notation. If no IP address is assigned to the port's VLAN, the `id_string` parameter defaults to a string of 64 NULL characters.

When SONET framing is configured, a 64-character string is transmitted repetitively, one character per frame. If the configured string consists of fewer than 64 characters, it is padded to its full length with NULL characters.

When SDH framing is configured, the maximum length of the `id_string` parameter is 15 characters. If the configured string consists of more than 15 characters, it is truncated to 15 characters.

The following command example sets the Path Trace identifier to the string “parador” for port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
config sonet trace path parador ports 8:1
```

Configuring the Signal Label

The Signal Label field occupies one byte (C2) of the Path Overhead associated with each SONET frame. It is used to indicate the type of contents carried in the Synchronous Payload Envelope (SPE). For example, 0x16 indicates scrambled PPP/HDLC, while 0xCF indicates unscrambled PPP/HDLC.

To configure the C2 Signal Label value for the specified SONET port, use the following command:

```
config sonet signal label [auto | <hex_octet>] ports <portlist>
```

The `value` parameter is specified as a hexadecimal integer in the range from 00 to FF. It may be necessary to specify a particular Signal Label value in order to interoperate with implementations that do not follow the standard conventions for the Signal Label field.

To determine whether you need to specify a particular Signal Label value, perform the following tasks:

1. Use the `show sonet` command to display SONET port status information.
2. Look for a Path Payload Label Mismatch (PLM-P) event indicating that the received payload type does not match the expected payload.
3. Compare the contents of the received C2 field (Signal Label value) with the contents of the transmitted C2 field.

If no Signal Label value is specified, the command defaults to `auto`, which causes the value of the Signal Label field to be set automatically based on standard conventions for the given payload type.

The following command example sets the Signal Label to the hexadecimal value CF for port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
config sonet signal label CF ports 8:1
```

Resetting SONET Configuration Parameter Values

To reset the SONET configuration parameters for the specified SONET ports to their default values, use the following command:

```
unconfig sonet ports <portlist>
```

Displaying SONET Port Status Information

To display status information for the SONET ports, use the following command:

```
show sonet {<portlist>} {detail}
```

You can use the optional `portlist` parameter to narrow the range of status information the command displays; otherwise, the command displays the status information for all ports.

By default, the command displays a summary of status information for the specified ports. You can use the optional `detail` keyword to display detailed status information for the specified ports.

The summary of status information includes the following information for each port:

- Values of all port configuration parameters
- Port state
- Any active events

The detailed status information includes the summary information plus any SONET statistics (listed and described in Table 57).

Table 57: Summary of SONET Statistics

Statistic	Description
Section parity errors	Number of B1 parity errors detected
Line parity errors	Number of B2 parity errors detected
Path parity errors	Number of B3 parity errors detected
REI-L event counter	Number of B2 parity errors detected by peer LTE
REI-P event counter	Number of B3 parity errors detected by peer PTE
LOS event counter	Number of LOS events
LOF event counter	Number of LOF events
LOP event counter	Number of LOP events
AIS-L event counter	Number of AIS-L events
AIS-P event counter	Number of AIS-P events
RDI-L event counter	Number of RDI-L events
RDI-P event counter	Number of RDI-P events
PLM-P event counter	Number of PLM-P events
SF BER event counter	Number of SF BER events
SD BER event counter	Number of SD BER events

SONET Events

The PoS module can detect and report a variety of error and alarm conditions, some of which also trigger actions on the SONET link. Table 58 describes these events and their associated actions. Syslog messages are output for these events.

Table 58: SONET Events

Event	Description
Loss of Signal (LOS)	Loss of Signal is detected by the Section Terminating Equipment (STE) when an all-zeroes pattern on the incoming SONET signal lasts 100 microseconds or longer. This condition can be caused by loss of light.
	SONET Action: Send RDI-L upon LOS detection.
Loss of Frame (LOF)	Loss of Frame is detected by the STE when a Severely Errored Framing (SEF) defect on the incoming signal persists for 3 milliseconds.
	Related SONET Overhead: A1, A2 (framing pattern).
	SONET Action: Send RDI-L upon LOF detection.

Table 58: SONET Events (continued)

Event	Description
Loss of Pointer (LOP)	The Path Loss Of Pointer event is detected as a result of excess New Data Flags (NDFs) or invalid pointers in the H1/H2 fields of the received signal.
	Related SONET Overhead: H1,H2 contain NDF and pointer.
	SONET Action: Send RDI-P upon LOP detection.
Alarm Indication Signal—Line (AIS-L)	The Line Alarm Indication Signal is sent by the upstream STE to inform the LTE that a LOS or LOF defect has been detected. Extreme's SONET module never sends AIS-L. AIS-L was formerly known as Line Far End Receive Failure (FERF).
	Related SONET Overhead: K2 carries AIS-L.
	SONET Action: Send RDI-L upon reception of AIS-L.
Alarm Indication Signal—Path (AIS-P)	The Path Alarm Indication Signal is sent by the upstream LTE to inform the PTE that a LOS, LOF, AIS-L, or LOP defect has been detected. Extreme's SONET module never sends AIS-P. AIS-P was formerly known as Path Far End Receive Failure (FERF).
	Related SONET Overhead: H1,H2,H3 = 0 when indicating AIS-P.
	SONET Action: Send RDI-P upon receiving AIS-P.
Remote Defect Indicator—Line (RDI-L)	The Line Remote Defect Indication is sent by the downstream LTE when a LOS, LOF, or AIS-L defect is detected.
	Related SONET Overhead: K2 carries RDI-L.
Remote Defect Indicator—Path (RDI-P)	The Path Remote Defect Indication is sent by the downstream PTE when a LOP or AIS-P defect is detected.
	Related SONET Overhead: G1 carries RDI-P.
Remote Error Indicator—Line (REI-L)	The Line Remote Error Indicator conveys a count of detected B2 parity errors from the peer LTE.
	Related SONET Overhead: M1 carries REI-L.
Remote Error Indicator—Path (REI-P)	The Path Remote Error Indicator conveys a count of detected B3 parity errors from the peer PTE.
	Related SONET Overhead: G1 carries REI-P.
Path Payload Label Mismatch (PLM-P)	The Path Payload Label Mismatch event occurs when the received payload type does not match the expected payload. This event is commonly caused by a Signal Label or scrambling mode mismatch configuration error.
	Related SONET Overhead: C2 carries the Signal Label.
Signal Failure Bit Error Rate (SF BER)	The Signal Failure BER event occurs when the B2 bit error rate exceeds the configured SF threshold. This event is used for APS switching.
	Related SONET Overhead: B2 carries line parity.
	SONET Action: Send RDI-L upon detecting SF BER event.
Signal Degrade Bit Error Rate (SD BER)	The Signal Degrade BER event occurs when the B2 bit error rate exceeds the configured SD threshold. This event is used for APS switching.
	Related SONET Overhead: B2 carries line parity.

Table 58: SONET Events (continued)

Event	Description
Automatic Protection Switching (APS)	An APS event occurs when the value of K1 or K2 changes. This event is an input to the APS state machine, which is responsible for handling the event and outputting the appropriate syslog message. The LOS, LOF, AIS-L, SF BER, and SD BER events are also input to the APS state machine. Related SONET Overhead: K1,K2

Configuring and Monitoring PPP Functions

This section describes the commands you use to configure PPP attributes for PoS module ports.

This section provides information on the following topics:

- PPP Overview on page 440
- Configuring the PoS Checksum on page 444
- Configuring PoS Scrambling on page 444
- Configuring Link Maintenance on page 445
- Configuring PPP Link Quality Monitoring on page 445
- Configuring PPP Authentication on page 446
- Configuring the Name and Password for the Port on page 446
- Creating an Authentication Database Entry on page 447
- Configuring the Network Control Protocol on page 448
- Configuring the MPLS Control Protocol on page 449
- Configuring the Delayed-Down-Time Interval on page 450
- Displaying PPP Information on page 450
- Resetting PPP Configuration Parameter Values on page 451

PPP Overview

The Point-to-Point Protocol (PPP) encompasses a suite of protocols designed to provide standard methods for transporting datagrams over point-to-point links. The use of PPP over SONET links is commonly referred to as Packet over SONET, or PoS. The Extreme Networks implementation of PPP for the PoS module provides support for the following protocols in the PPP suite:

- Link Control Protocol (LCP)
- Link Quality Report (LQR) Protocol
- Challenge Handshake Authentication Protocol (CHAP)
- Password Authentication Protocol (PAP)
- IP Control Protocol (IPCP)
- Bridging Control Protocol (BCP)
- MultiProtocol Label Switching Control Protocol (MPLSCP)

- OSI Network Layer Control Protocol (OSINLCP)
- Extreme Discovery Protocol Control Protocol (EDPCP)

Link Control Protocol. The Link Control Protocol (LCP) establishes a logical connection with the peer LCP entity through an exchange of configuration packets. Data traffic cannot flow over the SONET link until LCP has successfully established this connection. LCP is also responsible for negotiating options that are independent of particular network layer protocols, such as the Quality Report, Authentication Protocol, and Maximum Receive Unit options.

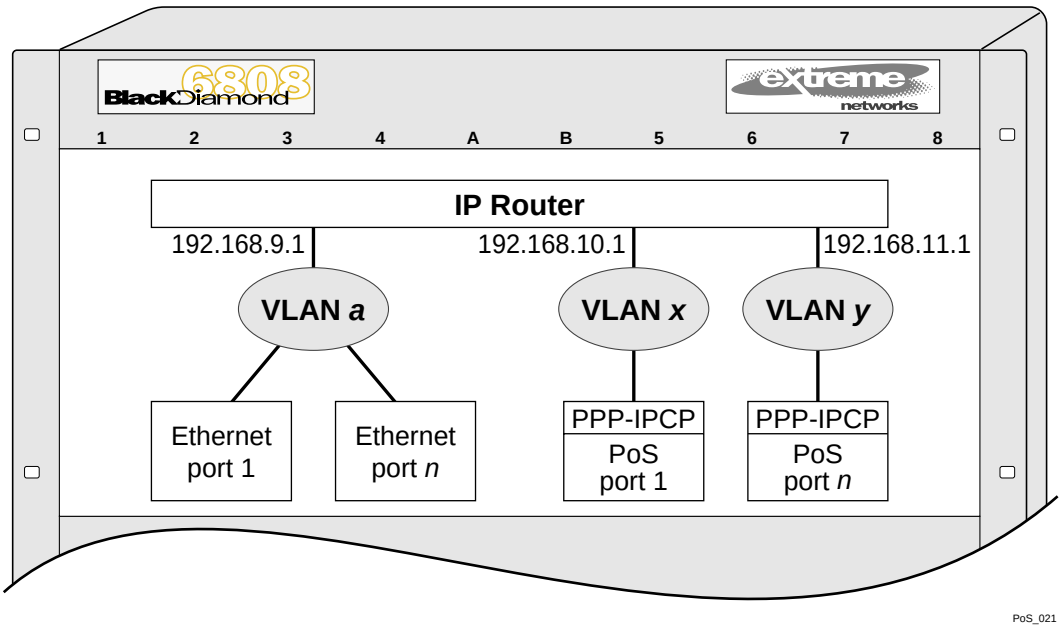
Quality Protocol Configuration Option. The LCP Quality Protocol configuration option can be used to specify the use of the Link Quality Report (LQR) Protocol to monitor the quality of the SONET link. If the LQR Protocol detects that the quality of the link is less than a configured threshold, all network layer protocols running over the link are brought down. This process of determining data loss and link viability is referred to as Link Quality Monitoring (LQM).

Link Maintenance Configuration Option. In addition to the LQR option, the Extreme Networks implementation of PPP also provides a Link Maintenance configuration option. When link maintenance is enabled on a port and that port is not receiving data packets, the link maintenance facility periodically transmits LCP echo-request packets. If an echo-reply is not received within a configured interval, LCP brings the link down.

Authentication Protocols. The Extreme Networks implementation of PPP uses the Challenge Handshake Authentication Protocol (CHAP) and the Password Authentication Protocol (PAP) to authenticate peer network elements. PAP is a simple protocol based on a clear-text user name and password pair, while CHAP is a stronger authentication protocol that uses the Message Digest, Version 5 (MD5) one-way hash algorithm. In the use of either protocol, if authentication fails, the connection with the peer is terminated.

IP Control Protocol. IPCP is a member of a family of Network Control Protocols (NCPs) defined for use with PPP. IPCP establishes and configures a connection to transport IP datagrams efficiently across a PPP link between two routers. When IPCP is enabled on a PoS port, all data forwarded over the SONET link must be routed by the BlackDiamond 6800 series switch, as illustrated in Figure 87.

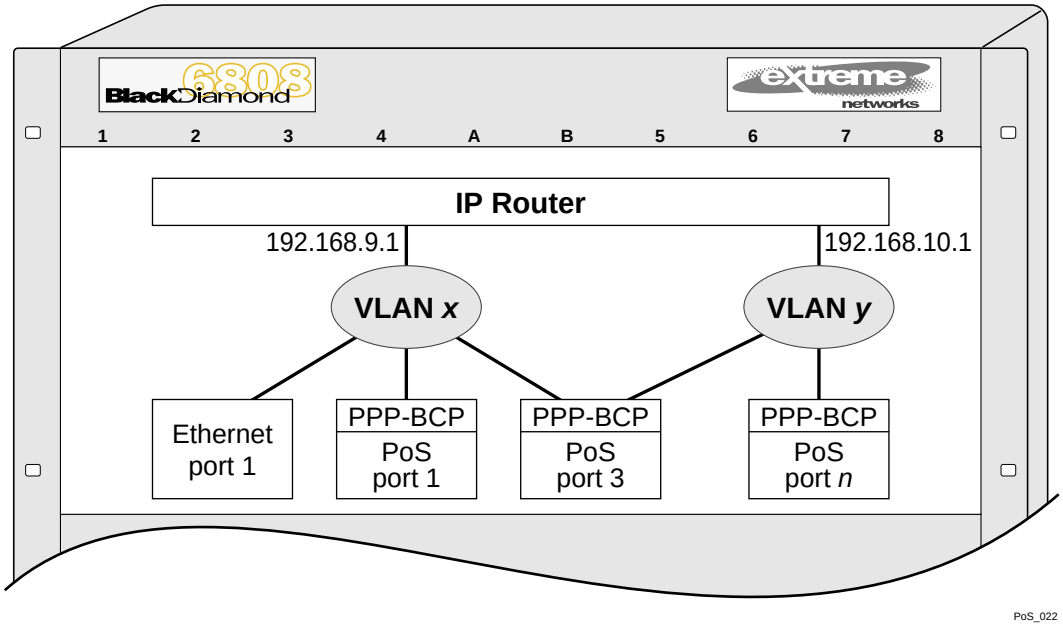
Figure 87: View of logical connectivity to PoS ports with IPCP enabled



Generally, when IPCP is enabled on a port, the port must be a member of one and only one VLAN. Furthermore, no other ports may be members of this VLAN, and IP routing is the only protocol supported on the VLAN. The one exception to this rule occurs when APS is enabled. A single VLAN may contain two IPCP-enabled ports if they are members of the same APS group.

Bridging Control Protocol. BCP establishes and configures a connection for transporting Ethernet MAC frames across a PPP link. The BCP link must be established successfully before data traffic can flow over the link. Because BCP carries Ethernet MAC frames, any protocol can be transported across a BCP connection. In a simplified sense, BCP allows the PoS link to appear as an Ethernet LAN segment to the rest of the switch, so BCP makes it possible for LAN services to be extended transparently across SONET wide-area networks. Therefore, the port can be a member of multiple VLANs, and frames can be either bridged or routed onto the link, as illustrated in Figure 88.

Figure 88: View of logical connectivity to PoS ports with BCP enabled



As Figure 88 shows, PoS ports 1 and 3 are bridged together along with Ethernet port 1 to form VLAN *x*, PoS port 3 belongs to both VLAN *x* and VLAN *y*, and routed connectivity exists between VLAN *x* and VLAN *y*.

BCP is defined in RFC 2878, which was recently approved by the IETF as an update to RFC 1638. Two features of the updated version are: support for IEEE 802.1Q VLANs, and inline management. The VLAN support enables a BCP entity to advertise its ability to accept frames containing a VLAN tag. Inline management refers to the capability of transporting the Spanning Tree Protocol and other bridge management protocols inline using the Bridged Data PPP Protocol ID (previously, RFC 1638 specified that Spanning Tree Protocol messages be transported using a unique PPP Protocol ID). Extreme's implementation supports these features as specified in the new RFC.

MultiProtocol Label Switching Control Protocol. MPLSCP establishes and configures a connection for transporting MPLS labeled frames across a PPP link. The MPLSCP connection must be established successfully before data traffic can flow over the link. Only unicast MPLS labeled packets are supported. Multicast MPLS labeled packets are discarded by the PoS port.

MPLSCP is not explicitly configured on a PoS port. Rather, MPLSCP is automatically enabled on a PoS port when the port is configured for IPCP, and MPLS is enabled on the VLAN that the PoS port is a member of. When MPLSCP is enabled on a PoS port, the port will transport IP and MPLS labeled packets, and the port must be a member of one and only one VLAN. Furthermore, no other ports may be members of this VLAN, and IP routing is the only protocol supported on the VLAN. The one exception to this rule occurs when APS is enabled. A single VLAN may contain two IPCP-enabled ports if they are members of the same APS group.

OSI Network Layer Control Protocol. OSINLCP establishes and configures a connection for transporting OSI network layer packets (NPDUs) across a PPP link. OSI network layer packets may be transported across a PPP link in one of two ways: as bridged data using BCP or as NPDUs over the link negotiated with OSINLCP. When BCP is enabled on a PoS port, OSI NPDUs are sent as bridged data encapsulated in IEEE 802.3 framed packets containing an LLC header. When OSINLCP is enabled on a PoS port, OSI NPDUs are sent using the link negotiated with OSINLCP.

OSINLCP is not explicitly configured on a PoS port, it is automatically enabled on a PoS port when the port is configured for IPCP and IS-IS is enabled on the VLAN that the PoS port is a member of. When OSINLCP is enabled on a PoS port, the port will transport IP as well as OSI network layer packets. As with IPCP, the port must be a member of one and only one VLAN. Furthermore, no other ports may be members of this VLAN, and IP routing is the only protocol supported on the VLAN. The one exception to this rule occurs when APS is enabled. A single VLAN may contain two IPCP-enabled ports if they are members of the same APS group.

Extreme Discovery Protocol Control Protocol. EDPCP supports the exchange of EDP control packets across PoS links. EDP is used to gather information about neighboring Extreme switches, and to exchange topology information. EDPCP uses PPP protocol ID 0x820D; EDP packets use PPP protocol ID 0x020D. These PPP protocol IDs were assigned by the Internet Assigned Numbers Authority (IANA). When the PPP peer is from a vendor other than Extreme, EDPCP is disabled on the link.

Creating a PPP User Account

The following command is an enhanced application of the existing ExtremeWare `create account` command. The `pppuser` keyword is used to specify the name of a local database entry that is used to authenticate PPP peers.

```
create account pppuser <name> {encrypted} {<password>}
```

The PPP use of this command is described in “Creating an Authentication Database Entry” on page 447.

Configuring the PoS Checksum

To configure the size of the HDLC Frame Check Sequence (FCS) to be used on the specified SONET port, use the following command:

```
config ppp pos checksum [32 | 16] ports <portlist>
```

Choose either the 32-bit FCS or the 16-bit FCS. A 32-bit FCS is the default. RFC 2615 recommends the use of the 32-bit FCS.

NOTE

For OC-3 applications, RFC 2615 allows the use of a 16-bit FCS, but recommends using a 32-bit FCS. You should limit your use of the 16-bit FCS to supporting interoperability with equipment that does not support the 32-bit FCS.

The following command example sets the FCS to 16 for port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
config ppp pos checksum 16 ports 8:1
```

Configuring PoS Scrambling

To enable or disable payload data scrambling on the specified port, use the following command:

```
config ppp pos scrambling [on | off] ports <portlist>
```

Choose either `on` or `off`. Scrambling is enabled by default.

RFC 2615 recommends that the SONET payload be scrambled. The option of disabling scrambling is provided for backward compatibility with an earlier PoS standard. Scrambling was introduced in RFC 2615 to alleviate potential security problems where malicious users might intentionally generate packets with bit patterns that create SONET synchronization problems.

The following command example turns off the scrambling function for port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
config ppp pos scrambling off ports 8:1
```

Configuring Link Maintenance

The Extreme Networks implementation of PPP provides a link maintenance configuration option. When link maintenance is enabled on a port and that port is not receiving data packets, the link maintenance facility periodically transmits Link Control protocol (LCP) echo-request packets. If an echo-reply is not received within a configured interval, LCP brings the link down.

To enable the link maintenance protocol on a specified PPP port, use the following command:

```
config ppp echo [<seconds> <consecutive_misses> | off] ports <portlist>
```

The `seconds` parameter is an integer in the range from 1 to 300 that specifies the period between transmissions of echo-request packets.

The `consecutive_misses` parameter is an integer in the range from 1 to 100 that determines how long PPP waits for a reply. If an echo-reply is not received within an interval of duration (*consecutive_misses* * *seconds*) seconds, the link is brought down.

When APS is enabled on a SONET port, link maintenance should also be enabled on that port.

The link maintenance protocol is off by default. If you enable link maintenance, the recommended `seconds` value is 3, and the recommended `consecutive_misses` value is 10.

The following example enables link maintenance on port 1 of a PoS module in slot 8 and sets `seconds` to 3 and `consecutive misses` to 10.

```
config ppp echo 3 10 ports 8:1
```

Configuring PPP Link Quality Monitoring

The Link Control Protocol (LCP) establishes a logical connection with the peer LCP entity through an exchange of configuration packets. Data traffic cannot flow over the SONET link until LCP has successfully established this connection. LCP also allows the negotiation of a quality monitoring protocol to monitor the viability of the PPP link on a continuous basis. This process of determining data loss and link viability is referred to as Link Quality Monitoring (LQM).

The LQM protocol uses the Link Quality Report (LQR) packet as a mechanism in the test of the PPP link. The LQM protocol periodically transmits LQR packets containing counts of packets and octets that have been transmitted and successfully received. This information enables the LQM protocol to determine the percentage of data that is being dropped due to poor link quality. If the drop percentage is greater than a configured threshold, all network-layer protocols are brought down. Bringing a poor-quality link down may be desirable when an alternate network path exists, or when billing is based on the amount of data transmitted. By default, LQM is off.

To enable the LQM protocol on a specified PPP port, use the following command:

```
config ppp quality [off | <required_percent> {<seconds>}] ports <portlist>
```

The `required_percent` parameter is an integer in the range from 1 to 99 that is used to determine the drop percentage threshold, where:

drop percentage threshold = (100–<required_percent>).

The optional `seconds` parameter is an integer in the range from 1 to 300. This parameter value determines how often quality reports should be received from the peer LQR entity. If you do not specify a value for the `seconds` parameter, the command uses the default value of 30 seconds.

It can take up to seven reporting intervals for LCP to bring a link down. If the link quality improves subsequent to being brought down, LCP automatically brings the link back up. This type of service restoration takes a minimum of seven reporting intervals.

The following example enables the LQM protocol on port 1 of a PoS module in slot 3 and sets `required_percent` to 95. Because no value is specified for the optional `seconds` parameter, the command uses the default of 30 seconds.

```
config ppp quality 95 ports 3:1
```

Configuring PPP Authentication

The Extreme Networks implementation of PPP uses the Challenge Handshake Authentication Protocol (CHAP) and the Password Authentication Protocol (PAP) to authenticate peer network elements. PAP is a simple protocol based on a clear-text user name and password pair, while CHAP is a stronger authentication protocol that uses the Message Digest, Version 5 (MD5) one-way hash algorithm. In the use of either protocol, if authentication fails, the connection with the peer is terminated.

To configure authentication on a specified PPP port, use the following command:

```
config ppp authentication [off | chap | pap | chap-pap] ports <portlist>
```

The default is authentication `off`, meaning the peer is not authenticated.

When you configure authentication using the `chap` keyword, the peer is authenticated using CHAP.

When you configure authentication using the `pap` keyword, the peer is authenticated using PAP.

When you configure authentication using the `chap-pap` keyword, a request is made to authenticate the peer using CHAP, but PAP may be used if the peer does not support CHAP.

The following command example turns on CHAP authentication for port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
config ppp authentication chap ports 8:1
```

Configuring the Name and Password for the Port

In the event a PPP peer requests authentication, the Extreme Networks implementation of PPP responds to the peer's CHAP or PAP authentication requests regardless of whether the port is configured to authenticate the peer.

To configure the name and password for a specified PPP port, use the following command:

```
config ppp user <name> {encrypted} {<password>} ports <portlist>
```

The name and password parameters can contain a maximum of 32 alphanumeric characters each. As an option, you can use double quotation characters as delimiters to enclose the name and password parameters.

If you do not specify a password parameter in this command, the command prompts you to enter the new password two times: the first time to set the new password; the second time to confirm the password.

The factory default value for both the name and password parameters is the word *extreme.*

NOTE

You should not attempt to use the encrypted *keyword. It is used by the switch when generating an ASCII configuration.*

The following command example sets the name to “titus” and sets the password to “1Afortune” for port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
config ppp user "titus" "1Afortune" ports 8:1
```

Creating an Authentication Database Entry

Responses to authentication requests include a username. When the requesting entity receives a response, it searches its local database for an entry with the specified username. When an entry is located, the associated password is used to validate the authentication response.

To create a local database entry that can be used to authenticate a PPP peer, use the following command:

```
create account pppuser <name> {encrypted} {<password>}
```

The name and password parameters are both character strings of up to 32 alphanumeric characters. Both strings must start with an alphabetic character, but can be any combination of alphanumerical characters thereafter. As an option, you can use double quotation characters as delimiters to enclose the name and password parameters.

If you do not specify a password string in this command, the command prompts you to enter the password two times: the first time to set the string; the second time to confirm it.

NOTE

You should not attempt to use the encrypted *keyword. It is used by the switch when generating an ASCII configuration.*

The following command example sets the authentication database name to “stretch” and sets the password to “baserunner” for port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
create account pppuser "stretch" "baserunner" ports 8:1
```

Configuring the Network Control Protocol

The Network Control Protocol is configured on a per-port basis, meaning that different ports on the same module can be running either the Bridging Control Protocol (BCP) or the IP Control Protocol (IPCP)—both protocols cannot be configured at the same time on any port.

Generally, when IPCP is configured on a port, that port must be a member of a single VLAN. Further, no other ports on this switch can be members of this VLAN, and IP routing is the only protocol supported on this VLAN. The one exception to this rule is when Automatic Protection Switching (APS) is enabled. In which case, a single VLAN may contain two ports configured for IPCP if they are both members of the same APS group.

NOTE

For more information about setting up VLANs, see Chapter 5.

BCP establishes and configures a connection for transporting Ethernet MAC frames across a PPP link. Because BCP carries Ethernet MAC frames, any protocol can be transported across a BCP connection. In a simplified sense, BCP allows the PoS link to appear as an Ethernet LAN segment to the rest of the switch, so BCP makes it possible for LAN services to be extended transparently across SONET wide-area networks. Therefore, the port can be a member of multiple VLANs, and frames can be either bridged or routed onto the link.

Generally, most of the switch capabilities provided for Ethernet ports are also available for PoS ports configured for BCP. One exception is that there are restrictions on which OC-3 PoS module ports can be bridged together (be configured as members of the same VLAN). Ports 1 and 2 on the same OC-3 PoS module cannot be bridged together, and ports 3 and 4 on the same OC-3 PoS module cannot be bridged together—unless they are members of the same APS group. There are no such restrictions on OC-12 PoS module ports.

To configure the Network Control Protocol for a specified PPP port, use the following command:

```
config ppp [bcp [on | off] | ipcp [on {peer-ipaddress <ipaddress>} | off]]
   ports <portlist>
```

By default, BCP is enabled on all PoS ports. BCP cannot be configured on a port unless IPCP is off; IPCP cannot be configured on a port unless BCP is off.

When used with IPCP, the optional `peer-ipaddress` keyword and parameter value provides a way to configure the IP address of the peer router. This capability is useful with peer routers that do not advertise their IP address through the IPCP IP-Address configuration option. If the peer router does advertise an IP address through IPCP, the configured value for `peer-ipaddress` is ignored.

The following command example turns IPCP off and BCP on for port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
config ppp ipcp off port 8:1
config ppp bcp on port 8:1
```

Configuring the MPLS Control Protocol

MPLSCP establishes and configures a connection for transporting MPLS labeled frames across a PPP link. The MPLSCP connection must be established successfully before MPLS labeled data traffic can flow over the link. Only unicast MPLS labeled packets are supported. Multicast MPLS labeled packets are discarded by the PoS port.

MPLSCP is not explicitly configured on a PoS port. However, MPLSCP is automatically enabled on a PoS port when the port is configured for IPCP and MPLS is enabled on the VLAN that the PoS port is a member of. When MPLSCP is enabled on a PoS port, the port will transport IP and MPLS labeled packets, and the port must be a member of one and only one VLAN. Furthermore, no other ports may be members of this VLAN, and IP routing is the only protocol supported on the VLAN. The one exception to this rule occurs when APS is enabled. A single VLAN may contain two IPCP-enabled ports if they are members of the same APS group.

NOTE

You must have a PoS module and an MPLS module installed in your BlackDiamond switch to use MPLS on a PoS port.

To configure MPLSCP on a PoS port, complete the following steps:

1. Create a VLAN for the PoS port using the `create vlan <vlan name>` command.
2. Add the PoS port to the VLAN using the `config vlan <vlan name> add ports <port>` command.
3. Define an IP router port on the VLAN by assigning an IP address to the VLAN using the `config vlan <vlan name> ipaddress <ipaddress> {<mask>}` command.
4. Disable BCP on the PoS port using the `config ppp bcp off ports <portlist>` command and enable IPCP on the PoS port using the `config ppp ipcp on ports <portlist>` command.
5. Configure MPLS on the VLAN using the `config mpls add vlan [<vlan name> | all]` command.

The following command example creates a VLAN named *vlan1* and configures MPLSCP on PoS port 8:1 on VLAN *vlan1*:

```
create vlan vlan1
config vlan vlan1 add ports 8:1
config vlan vlan1 ipaddress 192.168.100.1
config ppp bcp off ports 8:1
config ppp ipcp on ports 8:1
config mpls add vlan vlan1
```

For more information about MPLS and configuring MPLS, see Chapter 25.

Configuring the OSI Network Layer Control Protocol

OSINLCP implementation is based on RFC 1337. OSINLCP establishes and configures a connection for transporting OSI network layer packets (NPDUs) across a PPP link. OSI network layer packets may be transported across a PPP link in one of two ways: as bridged data using BCP or as NPDUs over the link negotiated with OSINLCP. When BCP is enabled on a PoS port, OSI NPDUs are sent as bridged data encapsulated in IEEE 802.3 framed packets containing an LLC header. When OSINLCP is enabled on a PoS port, OSI NPDUs are sent using the link negotiated with OSINLCP.

OSINLCP is not explicitly configured on a PoS port, it is automatically enabled on a PoS port when the port is configured for IPCP and IS-IS is enabled on the VLAN that the PoS port is a member of. When OSINLCP is enabled on a PoS port, the port will transport IP as well as OSI network layer packets. As with IPCP, the port must be a member of one and only one VLAN. Furthermore, no other ports may be members of this VLAN, and IP routing is the only protocol supported on the VLAN. The one exception to this rule occurs when APS is enabled. A single VLAN may contain two IPCP-enabled ports if they are members of the same APS group.

To configure OSINLCP on a PoS port, complete the following steps:

1. Create a VLAN for the PoS port using the `create vlan <name>` command.
2. Add the PoS port to the VLAN using the `config vlan <name> add ports <port>` command.
3. Define an IP router port on the VLAN by assigning an IP address using the `config vlan <name> ipaddress <ipaddress> {<mask>}` command.
4. Disable BCP on the SONET port using the `config ppp bcp off ports <portlist>` command, and then enable IPCP with `config ppp ipcp on ports <portlist>`.
5. Enable IS-IS on the VLAN using the `config isis add vlan <name>` command.

Configuring the Delayed-Down-Time Interval

The delayed-down-time interval is the amount of time that PPP waits before declaring a port down after a physical link failure has been detected. A non-zero value is useful when recovery from the link failure is fast, for example, when APS is enabled on a SONET port. In this case, APS may recover from the link failure before PPP responds, thereby minimizing network down time. Generally, you should set a non-zero value for the delayed-down-time interval any time APS is configured at either end of the link.

To configure the delayed-down-time interval for a specified PPP port, use the following command:

```
config ppp delayed-down-time <seconds> ports <portlist>
```

The value of the `seconds` parameter is an integer number in the range from 0 to 20 seconds. The default is 1 second.

NOTE

A delayed-down-time interval of one second is usually sufficient to accommodate APS line switches.

The following command example sets the delayed-down-time interval to 2 seconds for port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
config ppp delayed-down-time 2 ports 8:1
```

Displaying PPP Information

To display status information for PPP ports, use the following command:

```
show ppp {<portlist>} {detail}
```

If you enter the `show ppp` command without an argument or keyword, the command displays status information for all PPP ports. Use the optional `portlist` parameter to display status information for one or more specific ports.

By default, the command displays a summary of status information for the specified PPP port. Use the `detail` keyword to display detailed status information.

The summary display includes the following status information for each PPP port:

- Values of all PPP configuration parameters
- Physical link status
  - operational
  - down
  - LCP state
  - IPCP/BCP state
  - EDPCP state
  - MPLSCP state
  - OSINLCP state
  - link packet and octet counters

The detailed display includes the information reported in the summary display, and adds the following status and management counters:

- Detailed link status:
  - PPP link phase
- Detailed LCP status:
  - LCP options negotiated (local and remote)
  - LCP packet counters
  - Number of link-down events due to PPP maintenance
- Detailed authentication status:
  - Remote username (if applicable)
  - CHAP or PAP packet counters
- Detailed BCP or IPCP status:
  - Options negotiated (local and remote)
  - Packet counters
- Detailed LQM status:
  - Statistics from the most recent Link Quality Report (LQR)
  - Time since the most recent LQR
  - LQR packet counters
  - Number of link-down events due to LQM

Resetting PPP Configuration Parameter Values

To reset the PPP configuration parameters for the specified port to their default values, use the following command:

```
unconfig ppp ports <portlist>
```

Configuring VLAN-Related Attributes

The ExtremeWare software and the Extreme Networks switch architecture provide a range of Virtual Local Area Network (VLAN) features, which are described in detail in Chapter 5. This section describes how these features are supported on the PoS module.

NOTE

This section assumes some familiarity with the Extreme Networks implementation of VLAN features as described in Chapter 5.

PoS module ports do not support protocol-based VLANs or MAC address VLANs. Thus, there are restrictions on the use of the following commands:

- `config vlan <vlan name> [add | delete] ports <portlist> {tagged | untagged} {nobroadcast}`
- `config vlan <vlan name> protocol [<protocol_name> | any]`
- `enable mac-vlan mac-group [any | group_number] ports <portlist>`

The restrictions are as follows:

- A PoS port cannot be added to a VLAN if the VLAN is a protocol-based VLAN.
- A VLAN cannot be configured to be a protocol-based VLAN if the VLAN contains a PoS port.
- A MAC address VLAN cannot be enabled on a PoS port.

The `config vlan <vlan name> protocol any` command is supported, because it can be used to configure the default VLAN for PoS ports.

In the `config vlan <vlan name> [add | delete] ports <portlist> {tagged | untagged} {nobroadcast}` command, PoS ports support the optional `tagged` and `untagged` keywords when BCP is enabled, and ignore them when IPCP is enabled.

IPCP and BCP are mutually exclusive configuration options for a given PoS port: they cannot both be enabled simultaneously on the same PoS port. Generally, when IPCP is enabled on a port, the port must be a member of one and only one VLAN. Furthermore, no other ports may be members of this VLAN, and IP routing is the only protocol supported on the VLAN. The one exception to this rule occurs when APS is enabled. A single VLAN may contain two IPCP-enabled ports if they are members of the same APS group.

Configuring Tagged VLAN 802.1p and 802.1Q Functions

NOTE

The dot1q tag mapping and tag nesting commands are supported only by PoS ports and apply only when BCP is enabled on the PoS port.

The following ExtremeWare commands are supported for the PoS module:

- `config dot1q ethertype <ethertype>`
- `config dot1p type dot1p_priority <priority> qosprofile <qosprofile>`

NOTE

If a PoS port receives a frame with a priority value "n" that is not mapped to a profile in the range from qp1 through qp8, the frame is assigned to QoS profile qp_{n+1}.

The following commands provide PoS module support for managing 802.1Q tags:

- `config dot1q tagmapping`
- `config dot1q tagnesting`

Configuring VLAN Tag Mapping Tables

The `config dot1q tagmapping` command provides support for VLAN ID (VID) mapping tables. Each PoS port supports two VID tables: one table is used in the ingress direction; the other is used in the egress direction. These tables make it possible to map an input VID to an output VID, which can be useful in reconciling policy differences at the boundary between the customer and the service provider. The tables also allow the option of preserving the 802.1p priority or overwriting the priority with a configured value.

To configure the VLAN tag mapping tables for a PoS port, use the following command:

```
config dot1q tagmapping <input_vlanid/output_vlanid> ports <portlist>
   {egress {priority <priority>} | ingress {priority <priority>}}
```

The `input_vlanid` and `output_vlanid` parameters are both integers in the range from 1 to 4095 and must be separated by a slash character.

The `priority` parameter is an integer in the range from 0 to 7.

Use the `egress` keyword to apply the mapping of the input VLAN ID to the output VLAN ID to frames received from the switch backplane prior to transmitting them onto the PPP link. Use the `ingress` keyword to apply the mapping to input frames received from the PPP link. The mappings are applied after they are classified to a QoS profile. Frames containing the VLAN ID specified in `input_vlanid` are changed so that the VLAN ID is set to the value specified in `output_vlanid` before the frame is forwarded.

If you omit both the `egress` and the `ingress` keywords, the command automatically applies the specified mapping to the egress direction, and also applies a symmetrical mapping (with the `input_vlanid` and `output_vlanid` values reversed) to the ingress direction.

These tables also give you the option of preserving the 802.1p priority or overwriting the priority with a user-configured value. Using the `priority` keyword in the command indicates that the 802.1p priority field is to be set to the value specified in `priority`. To preserve the 802.1p priority, do not enter the `priority` keyword and value when using this command.

The default behavior is that the tables are initialized such that VLAN IDs are not altered by the mapping operations, and frame priority is preserved. For example, an input VLAN ID of *n* is always mapped to an output VLAN ID of *n*, and the 802.1p priority field is not changed.

Configuring VLAN Tag Nesting Attributes

The `config dot1q tagnesting` command provides support for 802.1Q tags by allowing a tag *push* or *pop* attribute to be associated with a VLAN ID. The push attribute indicates that a new tag is to be added to the frame, while the pop attribute indicates that the top-level tag is to be removed from the

frame. The command also gives you the option to preserve the 802.1p priority of the frame or set it to a configured value when a new tag is added (pushed) to the frame. VLAN ID (VID) mapping occurs before a new tag is pushed, and after a nested tag is popped.

To configure the VLAN tag nesting attributes for a PoS port, use the following command:

```
config dot1q tagnesting {<vlanid> | <vlanid_range>} [off | pop |
push <new_vlanid> {priority <priority>}] ports <portlist> {egress | ingress}
```

The `vlanid` parameter is an integer in the range from 1 to 4095. The `vlanid_range` parameter is specified in the form `start_vlanid-end_vlanid`, where the start and end values are both integers in the range from 1 to 4095 and must be separated by a hyphen.

The `push` keyword indicates that a new tag is to be added to frames containing the VID specified in `vlanid` or to one of the VIDs in the range specified in `vlanid_range`. The new tag added to frames contains the value specified in `new_vlanid`.

The `pop` keyword indicates that the top-level tag is to be removed from frames when that tag contains either the VID specified in `vlanid` or any one of the VIDs in the range specified in `vlanid_range`.

If you do not specify a VID or a range of VIDs, the command settings are applied to all VIDs.

Tag operations can be performed in either the egress direction (to the SONET link) or the ingress direction (from the SONET link). If you do not specify a direction, the default behavior is that tag operations are performed in the egress direction. If you do not use either the `egress` or `ingress` keyword and tag pushing is configured, a corresponding tag pop operation is automatically configured for the ingress direction. If you do not use either the egress or ingress keyword and tag nesting is disabled using the `off` keyword, tag nesting is disabled in both directions.

The optional `priority` keyword provides a way to overwrite the 802.1p priority with a user-configured value when a new tag is pushed. Using the `priority` keyword in the command indicates that the 802.1p priority field is to be set to the value specified in `priority`, which is an integer in the range from 0 to 7. To preserve the 802.1p priority, do not enter the `priority` keyword and value when using this command.

Default behavior is that tag nesting is disabled (off) for all VLAN IDs.

Tag push operations apply to egress frames only when the port is configured to transmit tagged frames for the associated VLAN. Tag nesting operations apply only to ingress frames that contain a VLAN tag. Tag nesting operations are applied after classification to a QoS profile.

NOTE

The default PPP MRU is sufficient for a single level of tag nesting (where the frame contains two VLAN tags) between two Extreme Networks switches. If higher levels of VLAN tag nesting are needed, jumbo frame support must be enabled.

NOTE

The DiffServ and RED functions are not performed by PoS ports when frames contain nested tags (more than one tag).

Generic VLAN Registration Protocol Functions

The Generic VLAN Registration Protocol (GVRP) is not supported on PoS module ports, so the following command will not work if you specify a PoS port:

```
config gvrp [listen | send | both | none] ports <portlist>
```

Configuring Forwarding Database Attributes

PoS ports support all of the existing ExtremeWare forwarding database (FDB) commands. For more information on these commands, see Chapter 6.

Configuring Spanning Tree Attributes

PoS ports support all of the existing ExtremeWare Spanning Tree commands. For more information on these commands, see Chapter 13.

Configuring QoS Functions

The ExtremeWare software and the Extreme Networks switch architecture provide a number of Quality of Service (QoS) functions, which are described in detail in Chapter 7. This section describes how these QoS functions, such as Differentiated Services (DiffServ) and Random Early Detection (RED) are supported on the PoS module.

NOTE

This section assumes some familiarity with the Extreme Networks implementation of QoS and DiffServ features as described in Chapter 7.

This section contains information on the following topics:

- Configuring a QoS Profile on page 455
- Classification and Replacement Policies on page 456
- Configuring DiffServ on page 457
- Enhanced RED Support on page 460

Configuring a QoS Profile

The SONET modules support eight ingress queues and eight egress queues per port. The scheduling parameters (minimum bandwidth, maximum bandwidth and priority level) for these queues are controlled by QoS profiles qp1 through qp8, which are defined using the existing ExtremeWare `config qosprofile` command.

This command has been enhanced to allow you to configure more module-specific parameters on a port-by-port basis, including the ability to customize the QoS profile parameters for individual ingress or egress queues on a specific SONET port.

The syntax and description of the enhanced `config qosprofile` command are described below.

To configure the scheduling parameters for a specified QoS profile, use the following command:

```
config qosprofile <qosprofile> {minbw <percent>} {maxbw <percent>}
   {priority <level>} {minbuf <percent>} {maxbuf <percent>} {<portlist>}
   {egress | ingress}
```

The optional `egress` and `ingress` keywords apply only to PoS ports. As stated earlier, the PoS modules support eight egress queues and eight ingress queues per port, and the scheduling parameters for these queues are controlled by QoS profiles qp1-qp8, which means queue #0 is controlled by qp1, queue #1 is controlled by qp2, and so on.

The optional `portlist` parameter allows QoS profiles to be customized on a port-by-port basis for the PoS modules. The `egress` and `ingress` keywords allow you to fine-tune the customization (down to a particular egress or ingress queue on a given port). If you do not enter either the `egress` or `ingress` keyword in the command, the configured parameters apply to the egress queue associated with the specified QoS profile by default.

The `minbw` parameter specifies the minimum percentage of the bandwidth guaranteed to be available to the specified queue for transmissions from the QoS profile. The value is an integer in the range from 0 through 100. The default value is 0. The sum of the minimum bandwidth parameters across all eight QoS profiles cannot exceed 90%.

The `maxbw` parameter specifies the maximum percentage of the bandwidth that the specified queue can use for transmissions from the QoS profile. The value is an integer in the range from 1 through 100. The default value is 100.

The optional `priority` keyword and `level` parameter specify the service priority for the specified queue. The service priority determines which traffic is scheduled when bandwidth is still available after the minimum requirements of all profiles have been satisfied. Settings for `level` include: low, lowHi, normal, normalHi, medium, mediumHi, high, or highHi. The default setting is low.

NOTE

The `minbuf` *and* `maxbuf` *keywords do not apply to PoS ports.*

Classification and Replacement Policies

This section deals primarily with classification operations performed by IPCP or BCP configured PoS ports.

Most of the existing ingress classification functions are supported for IPCP or BCP configured PoS ports. Functions such as access list and destination MAC address QoS policies are supported, as is the `enable diffserv replacement` command.

Egress frames are always assigned to a QoS profile based on their 802.1p priority. Thus, when a PoS port receives a frame from the switch fabric with a priority value *n*, that frame is assigned to egress QoS profile qp*n*+1.

The existing `enable diffserv examination ports` and `disable diffserv examination ports` commands are used on PoS ports to control whether the DiffServ code point (DSCP) is examined for ingress classification purposes.

When you enable the PPP Bridging Control Protocol (BCP) on a PoS port, non-IP frames that contain a VLAN tag are assigned to an ingress QoS profile based on their 802.1p priority value. You can configure this assignment using the `config dot1p type` command, which is used to specify the mappings between 802.1p priority values and QoS profiles. However, if a PoS port receives a frame with a priority value *n*, for which there is no mapping to one of the eight profiles (qp1-qp8), that frame is assigned to ingress QoS profile qp*n*+1.

If `diffserv examination` is not enabled, then the preceding 802.1p priority classification rules are applied to tagged IP frames as well.

In both cases, untagged frames are assigned to a single ingress QoS profile (provided that the port is an untagged member of a VLAN; if that is not the case, then untagged frames are discarded). This QoS profile defaults to qp1, but you can assign it to another profile using the `config ports <portlist> qosprofile <qosprofile>` command or the `config vlan <vlan name> qosprofile <qosprofile>` command (where the port-based QoS configuration has higher precedence than VLAN-based QoS).

Additionally, if you enable the PPP IP Control Protocol (IPCP) on a PoS port and do not enable `diffserv examination` on the port, then all ingress frames (received from the SONET link) are assigned to a single ingress QoS profile. The profile defaults to qp1, but you can configure it to another profile using the `config ports <portlist> qosprofile <qosprofile>` command or the `config vlan <vlan name> qosprofile <qosprofile>` command.

If you enable `diffserv examination` on a PoS port, then ingress IP frames are assigned to a QoS profile based on the DiffServ code point (regardless of whether you enabled either BCP or IPCP on the port). The existing `config diffserv examination code-point` command maps DiffServ code points to QoS profiles. This command has been enhanced for use with PoS ports. The syntax and description of the enhanced `config diffserv examination code-point` command are given below.

Also note that, in all cases, the 802.1p priority bits of ingress frames forwarded to the switch backplane are set based on the ingress QoS profile classification. More specifically, the 802.1p priority value is set to qp# – 1. For example, if the packet is classified to qp5, then the 802.1p priority value is set to 4.

When you enable MPLSCP on a PoS port, classification for MPLS labeled packets is done based only on the EXP bits in the label stack entry of the ingress frame. The EXP bits are used to map an ingress frame to an 802.1p priority and assigned to the corresponding ingress queue. Before the frame is forwarded to the switch backplane, the 802.1p bits in the frame are set based on the exp-to-dot1p mapping. You can use the `config mpls qos-mapping exp-to-dot1p` command to configure the EXP to 802.1p mapping. You can use the `config dot1p type dot1p_priority` command to configure the 802.1p to QoS mapping.

When you configure MPLSCP on a PoS port, other types of ingress commands such as `config diffserv examination code-point`, `config ports <portlist> qosprofile`, and `config vlan <vlan name> qosprofile` are supported only for IPCP data frames and not MPLS labeled frames. Similarly, egress replacement commands such as `enable dot1p replacement` and `enable diffserv replacement` are supported only for IPCP data frame and not MPLS labeled frames.

Configuring DiffServ

All of the existing ExtremeWare DiffServ commands are supported by PoS ports with IP frames that are encapsulated in BCP or IPCP, not MPLSCP (including the enhancements to the `config diffserv examination code-point` command, described earlier in this chapter). PoS ports also support a DiffServ code point (DSCP) mapping function that you configure using the `config diffserv dscp-mapping` command, which is described below. The DSCP is a 6-bit value in the IP-TOS byte of the IP packet header. For more information on DSCPs, see “Configuring DiffServ” in Chapter 7.

DiffServ Classification

When a packet arrives at the switch on an ingress port, the switch examines the first six of eight TOS bits, called the *code point*. The switch can assign the QoS profile used to subsequently transmit the packet based on the code point. The QoS profile controls a hardware queue used when transmitting the packet out of the switch, and determines the forwarding characteristics of a particular code point. The examination of DiffServ information is disabled by default. To enable examination of DiffServ information, use the command:

```
enable diffserv examination ports [<portlist> | all]
```

Changing DiffServ Code Point Assignments in the QoS Profile

Because the code point uses six bits, it has 64 possible values ($2^6 = 64$). By default, the values are grouped and assigned to the default QoS profiles listed in .

Table 59: Default Code Point-to-QoS Profile Mapping

Code Point	QoS Profile
0-7	Qp1
8-15	Qp2
16-23	Qp3
24-31	Qp4
32-39	Qp5
40-47	Qp6
48-55	Qp7
56-63	Qp8

To configure the mapping between a DiffServ code point and a specified QoS profile, use the following command:

```
config diffserv examination code-point <code_point>
   qosprofile <qosprofile> ports <portlist>
   {low-drop-probability | high-drop-probability}
```

The mapping is applied in the ingress direction—for IP packets received from the SONET link.

The optional `low-drop-probability` and `high-drop-probability` keywords apply only to PoS ports. If you do not enter either of these keywords in the command, the command uses `low-drop-probability` as the default.

The `low-drop-probability` and `high-drop-probability` keywords are useful in conjunction with the Weighted RED (WRED) implementation provided by PoS ports. This implementation supports two different drop probabilities: one for DiffServ code points designated as having low drop-probability; another for DiffServ code points designated as having high drop-probability. These keywords give you complete flexibility in assigning DiffServ code points to these two drop-probability levels.

Configuring DiffServ Code Point Mapping Tables

You can use the `diffserv dscp-mapping` command to configure a mapped relationship between an input DSCP and an associated output DSCP. Each PoS port supports three DSCP mapping tables: one of the tables is used in the ingress direction; two are used for egress flows (onto the SONET link). The two

egress tables are for the congested and noncongested states, as determined by the RED algorithm. If RED is not enabled on the PoS port, the egress congested-state mapping table is not used.

In the ingress direction, the input DSCP of a packet received from the SONET link is replaced by an output DSCP before the packet is forwarded. In the egress direction, the operation is similar, except that the DSCP mapping occurs before the packet is transmitted onto the SONET link.

One potential use of the DSCP mapping capability is to reconcile varying DiffServ policies at the boundary between autonomous systems, such as at the boundary between two ISPs. The availability of different tables for the congested and noncongested states is useful in marking operations that increase the probability of packets being dropped during times of congestion, as discussed in the DiffServ Assured Forwarding RFC (RFC 2597).

NOTE

This command applies only to PoS ports with IP frames that are encapsulated in BCP or IPCP, not MLSCP. You should also be aware that DSCP mapping is performed even when the `diffserv examination` *function is disabled on the port.*

To configure the mapping between an input DSCP and an associated output DSCP, use the following command:

```
config diffserv dscp-mapping <input_codepoint>/<output_codepoint>
   ports <portlist> {egress {no-congestion | congestion} | ingress}
```

where:

`input_codepoint`	Specifies one of the 64 possible DiffServ code point values as the input code point.
`output_codepoint`	Specifies one of the 64 possible DiffServ code point values as the output code point.
`egress`	Applies the DSCP mapping to the egress direction.
`no-congestion`	Applies the DSCP mapping to the egress mapping table for the non-congested state.
`congestion`	Applies the DSCP mapping to the egress mapping table for the congested state.
`ingress`	Applies the DSCP mapping to the ingress direction.

If you omit the `no-congestion` and `congestion` keywords, the command applies the mapping to the tables for both states.

If you omit the `egress` and `ingress` keywords, the command applies the mapping to the egress direction, and automatically configures a symmetrical mapping (with the `input_codepoint` and `output_codepoint` values reversed) in the ingress direction.

By default, all the tables are initialized such that DSCPs are not altered by the mapping operations. For example, an input DSCP value of *n* is always mapped to an output DSCP value of *n*.

Resetting DiffServ Code Point Mapping Tables

To reset the DSCP mapping tables for a specified PoS port to their default values, use the following command:

```
unconfig diffserv dscp-mapping ports <portlist>
```

Replacing DiffServ Code Points

To replace DiffServ code points, you must use the following command to enable DiffServ replacement:

```
enable diffserv replacement ports [<portlist> | all]
```

You then change the 802.1p priority to DiffServ code point mapping to any code point value using the following command:

```
config diffserv replacement priority <vpri> code_point <code_point>
ports [<portlist> | all]
```

By doing so, the hardware queue used to transmit a packet determines the DiffServ value replaced in the IP packet.

To verify the DiffServ configuration, use the command:

```
show ports <portlist> info detail
```

Enhanced RED Support

Random Early Detection (RED) is a congestion avoidance mechanism. The basic idea behind RED is that most data transports detect packet loss and will, therefore, restrain transmission—if only temporarily—when they detect dropped packets. Consequently, if the switch needs to signal another device to slow transmission due to congestion, RED provides a way of intelligently dropping packets.

This section describes the changes and additions to ExtremeWare to support RED in conjunction with PoS modules that have IP frames encapsulated in BCP or IPCP, not MPLSCP. The Extreme implementation of RED combines the functions of the RED algorithm with IP precedence to provide support for preferential traffic handling for higher-priority packets. This implementation provides weighted RED (WRED) functionality through two packet-drop probabilities (described below), so that a device can selectively drop lower-priority traffic when an interface begins to show signs of congestion. This capability is combined with DiffServ attributes to allow you to tailor performance characteristics for different classes of service.

Configuring RED Drop Probability

To configure the RED drop probability for a specified PoS port, use the following command:

```
config red [drop-probability | low-drop-probability | high-drop-probability]
   <percent> {ports <portlist>}
```

The optional `low-drop-probability`, `high-drop-probability`, and `ports` keywords are supported only for SONET ports.

If you omit the `ports` keyword, the command applies the setting to all ports.

The drop probability is specified as a percentage, where the `percent` parameter is an integer in the range from 1 to 100.

Weighted RED (WRED) functionality is supported through two different drop probabilities: a low-drop-probability and a high-drop-probability. The DiffServ code points of IP packets indicate

whether the packet should be dropped with low probability or high probability, and the appropriate percentage is then applied if WRED is active.

NOTE

WRED is applied only to IP packets. The `config diffserv examination code-point` *command gives you complete flexibility in assigning DSCPs to the two different drop-probability levels. This configured mapping of DSCPs to drop-probability levels is used by WRED even if* `diffserv examination` *is disabled on the port.*

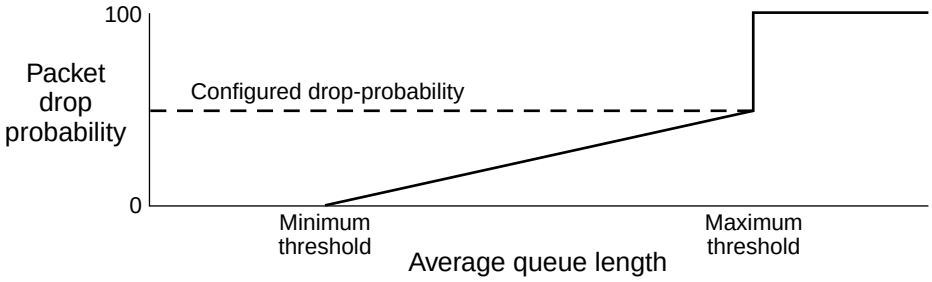
The `drop-probability` keyword indicates that the specified percentage should be used for both the low and high drop-probabilities. This effectively disables WRED and reverts to standard RED operation. For SONET ports, both the low and high drop-probabilities default to 10%.

The role of the configured drop probability in RED operation on SONET ports is illustrated in Figure 89A. RED is active when the average queue length is between the minimum and maximum thresholds. In this region, the probability that a given packet is dropped increases in a straight line up to the configured drop probability at the maximum threshold. All packets are dropped when the average queue length exceeds the maximum threshold.

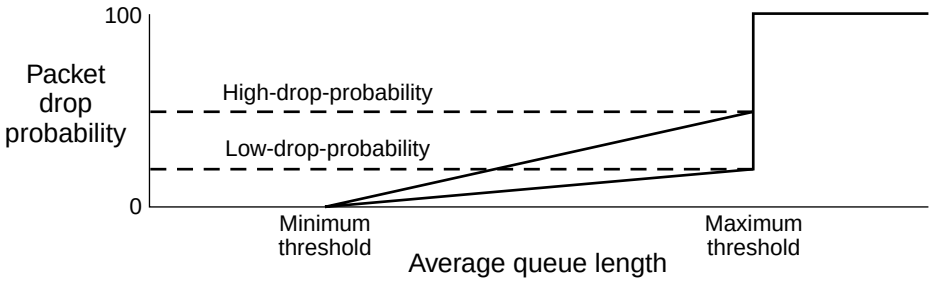
The operation of WRED on SONET ports is depicted in Figure 89B. In this case, the drop probability depends not only on the average queue length, but also upon whether the DSCP indicates that the packet should be dropped with a low or high probability, which is to say, the DSCP of the packet controls which curve is used.

Figure 89: Comparisons of RED and WRED operation

A. RED Operation on SONET Ports



B. WRED Operation on SONET Ports



Enabling and Disabling RED Ports

The existing ExtremeWare commands to enable and disable RED ports have been enhanced to provide RED configuration attributes for the PoS modules. Because the PoS modules support eight egress queues per port, the commands were enhanced to allow the user a way to enable RED selectively on an individual port and queue basis. By default, RED is disabled.

To enable RED on a specified PoS port, use the following command:

```
enable red ports <portlist> {queue <queue#>}
```

To disable RED on a specified PoS port, use the following command:

```
disable red ports <portlist> {queue <queue#>}
```

The optional queue keyword applies only to SONET ports. You can use this keyword to enable or disable the RED function on an individual queue basis.

The queue# parameter is an integer in the range from 0 to 7, and identifies one of the eight egress queues. If you omit the queue keyword, the command applies to all of the queues for the PoS port.

Configuring the RED Minimum Queue Length Threshold

The packet drop probability is based, in part, on the RED minimum queue length threshold. When the average queue length exceeds this threshold, the RED algorithm is activated and begins dropping packets. The packet drop rate increases in a linear fashion as the average queue length increases or until the average queue length hits the maximum threshold.

NOTE

This command applies only to SONET ports.

To configure the minimum queue length threshold for RED operation on a specified PoS port, use the following command:

```
config red min-threshold <percent> ports <portlist>
```

The threshold value is specified as a percentage in the range from 1 to 100. For SONET ports, the minimum threshold is a percentage of 1000 packet buffers, and the maximum threshold is set to the value calculated by the formula:

*minimum ((3 * minimum threshold buffers), maximum available buffers)*

By default, the minimum threshold for SONET ports is 10%, or 100 buffers; thus, the default maximum threshold is 300 buffers.

You can use the `show ports info detail` command to display the settings of the minimum and maximum thresholds, displayed in terms of the number of buffers.

Use the `ports` keyword to configure the threshold parameter on specific SONET ports.

Support for Standard Per-Hop Behaviors

The per-hop behavior (PHB) describes the externally observable packet forwarding handling (or "behavior") to be applied by the receiving network element when there are competing requests for resources such as bandwidth and buffer space. In the packet forwarding path, differentiated services are identified by mapping the differentiated services code point (DSCP) contained in the IP packet header to a specific forwarding behavior at each network element along its path. The DSCP is 6 bits wide, and takes the form *xxxxxx*, where *x* can be either 0 or 1. The DSCP field is capable of identifying one of 64 distinct code points. For purposes of code point allocation and management, the code point space is divided into three pools: one pool of 32 code points (pool 1) constitutes the recommended code points to be allocated as standards; a second pool of 16 code points (pool 2) is set aside for experimental or local use; a third pool of 16 code points (pool 3) that are initially set aside for experimental or local use, but that might be used for standard assignments if pool 1 is ever exhausted. The mapping of DSCPs to PHBs is a user-configurable function, as described below.

The current standards call for two PHBs: Assured Forwarding (AF) and Expedited Forwarding (EF). The EF PHB describes the required behavior for voice-over-IP service. The AF PHB consists of four independently forwarded AF classes: AF1, AF2, AF3, and AF4. Within each of these classes, an IP packet can be assigned to different levels of drop precedence (used to determine drop probability) depending on how many levels of drop precedence the implementation supports. RFC 2597 describes two schemes for drop-precedence levels: a three-level scheme (see Table 60) and a two-level scheme (see Table 61). The three-level scheme supports low, medium, and high drop-precedence levels for the AF classes; the two-level scheme supports low and high drop-precedence levels (and groups the medium drop-precedence code-points with the high drop-precedence code-points). The Extreme implementation for the PoS module supports the two-level drop-precedence scheme.

Table 60: Assured Forwarding Classes and Three-Level Drop Precedence

Drop-Precedence Level	AF1	AF2	AF3	AF4
Low drop precedence	(AF11) 001010	(AF21) 010010	(AF31) 011010	(AF41) 100010
Medium drop precedence	(AF12) 001100	(AF22) 010100	(AF32) 011100	(AF42) 100100
High drop precedence	(AF13) 001110	(AF23) 010110	(AF33) 011110	(AF43) 100110

Table 61: Assured Forwarding Classes and Two-Level Drop Precedence

Drop-Precedence Level	AF1	AF2	AF3	AF4
Low drop precedence	(AF11) 001010	(AF21) 010010	(AF31) 011010	(AF41) 100010
High drop precedence	(AF12) 001100	(AF22) 010100	(AF32) 011100	(AF42) 100100
	(AF13) 001110	(AF23) 010110	(AF33) 011110	(AF43) 100110

In addition, a network element that complies with the DiffServ standards must also provide a recommended *default* code point, which must be unique for code points in the standard space. The default PHB describes the common, best-effort forwarding behavior offered by existing network elements, as defined in RFC 1812.

As an additional differentiation, a set of code points has been allocated for use as the Class Selector code points, which describe the minimum forwarding handling requirements needed to preserve compatibility with existing practices while respecting flexibility for the future.

Table 62 and the command examples that follow show how the standard per-hop behaviors (PHBs) might be mapped onto ExtremeWare QoS profiles qp1 through qp8.

Table 62: Mapping PHBs to QoS Profiles

PHB	Default	Class Selector		AF1	AF2	AF3	AF4	EF
QoS Profile	qp1	qp2	qp3	qp4	qp5	qp6	qp7	qp8
DSCP	000000	001000 010000 011000 100000 101000	110000 111000	001010 001100 001110	010010 010100 010110	011010 011100 011110	100010 100100 100110	101110

The DSCPs associated with a PHB are assigned to the appropriate QoS profile using the `config diffserv examination code-point` command. For example, the following command sets up the mapping for the EF PHB:

```
config diffserv examination code-point 46 qosprofile qp8 ports 2:1-2:2
```

Additional configuration steps for SONET ports in this example are as follows:

- Enable RED for all PHBs except the EF PHB. For example:

  ```
  enable red ports 2:1-2:2
  disable red ports 2:1-2:2 queue 8
  ```

- Configure a high drop-probability of 20% on the SONET ports. For example:

  ```
  config red high-drop-probability 20 ports 2:1-2:2
  ```

- Enable examination of DiffServ information. For example:

  ```
  enable diffserv examination ports 2:1-2:2
  ```

- Configure the default PHB. For example:

  ```
  config diffserv examination code-point 0 qosprofile qp1 ports 2:1-2:2
  ```

- Configure the Class Selectors. For example:

  ```
  config diffserv examination code-point 8 qosprofile qp2
     ports 2:1-2:2 high-drop-probability
  config diffserv examination code-point 16 qosprofile qp2
     ports 2:1-2:2 high-drop-probability
  config diffserv examination code-point 24 qosprofile qp2
     ports 2:1-2:2 high-drop-probability
  config diffserv examination code-point 32 qosprofile qp2
     ports 2:1-2:2 low-drop-probability
  config diffserv examination code-point 40 qosprofile qp2
     ports 2:1-2:2 low-drop-probability
  config diffserv examination code-point 48 qosprofile qp3
     ports 2:1-2:2 high-drop-probability
  config diffserv examination code-point 56 qosprofile qp3
     ports 2:1-2:2 low-drop-probability
  ```

- Configure the drop-probability for the DSCPs assigned to AF1 through AF4.

  For example, for AF1 (qp4):

  ```
  config diffserv examination code-point 10 qosprofile qp4
     ports 2:1-2:2 low-drop-probability
  config diffserv examination code-point 12 qosprofile qp4
     ports 2:1-2:2 high-drop-probability
  config diffserv examination code-point 14 qosprofile qp4
     ports 2:1-2:2 high-drop-probability
  ```

  For example, for AF2 (qp5):

  ```
  config diffserv examination code-point 18 qosprofile qp5
     ports 2:1-2:2 low-drop-probability
  config diffserv examination code-point 20 qosprofile qp5
     ports 2:1-2:2 high-drop-probability
  config diffserv examination code-point 22 qosprofile qp5
     ports 2:1-2:2 high-drop-probability
  ```

  For example, for AF3 (qp6):

  ```
  config diffserv examination code-point 26 qosprofile qp6
     ports 2:1-2:2 low-drop-probability
  config diffserv examination code-point 28 qosprofile qp6
     ports 2:1-2:2 high-drop-probability
  config diffserv examination code-point 30 qosprofile qp6
     ports 2:1-2:2 high-drop-probability
  ```

  For example, for AF4 (qp7):

  ```
  config diffserv examination code-point 34 qosprofile qp7
     ports 2:1-2:2 low-drop-probability
  config diffserv examination code-point 36 qosprofile qp7
     ports 2:1-2:2 high-drop-probability
  config diffserv examination code-point 38 qosprofile qp7
     ports 2:1-2:2 high-drop-probability
  ```

- Configure the congested-state mappings for DSCPs 10 (AF11), 18 (AF21), 26 (AF31), and 34 (AF41). For example:

  ```
  config diffserv dscp-mapping 10/12 egress congestion
  config diffserv dscp-mapping 18/20 egress congestion
  config diffserv dscp-mapping 26/28 egress congestion
  config diffserv dscp-mapping 34/36 egress congestion
  ```

- Use the EF PHB to configure bandwidth reservation and rate limiting. For example:

  ```
  config diffserv examination code-point 46 qosprofile qp8 ports 2:1-2:2
  config qosprofile qp8 minbw 10 maxbw 20 2:1-2:2 egress
  config qosprofile qp8 minbw 10 maxbw 20 2:1-2:2 ingress
  ```

Displaying RED Configuration Information for PoS Module Ports

While the syntax of the existing `show ports info detail` command has not changed, the output of the command now displays the RED and DiffServ configuration parameters associated with PoS module ports.

To display QoS, RED, and DiffServ information for a specified PoS port, use the following command:

```
show ports info detail
```

NOTE

For PoS ports, the existing `show ports qosmonitor` *command has also been enhanced to display the number of packet transmissions and discards from each queue (in both egress and ingress directions).*

QoS Monitor

The QoS Monitor utility is supported for PoS module ports. The QoS Monitor and its associated ExtremeWare commands are described in Chapter 7.

Intra-Subnet QoS

Intra-Subnet QoS (ISQ) is not supported on switches that use the "*i*" chipset; the PoS module is supported only on switches that use the "*i*" chipset.

Configuring and Monitoring Flow Statistics

Each PoS port can maintain and export traffic statistics for the flows that traverse the associated SONET link. A flow is defined as a unidirectional sequence of packets between a particular source device and destination device that share the same protocol and transport-layer information. Flows are defined by the following fields: source IP address, destination IP address, source port, destination port, protocol type, and SONET interface. Per-flow statistics are useful for many management purposes, including:

- Accounting and billing
- Network capacity planning and trend analysis
- Network monitoring
- Workload characterization
- User profiling
- Data warehousing and mining

Flow Statistics Background Information

Each PoS module can maintain two million flow records. Per-flow statistics are exported in the NetFlow Version 1 record format described in Table 63. NetFlow records are unidirectional in nature, which implies that two flow records are maintained for a typical TCP connection: one record for flow in the ingress direction; a second for the flow in the egress direction. Also, records are maintained only for TCP and UDP flows.

Table 63: NetFlow Version 1 Record Format

Field Name	Octets	Field Description
srcaddr	4	Source IP address
dstaddr	4	Destination IP address
nexthop	4	IP address of next-hop router; set to zero for per-flow statistics; set to xFFFF for filter-based aggregated statistics
input	2	Input interface index; set to index of PoS interface for ingress flows received from the SONET link; set to zero for egress flows that are being transmitted over the SONET link
output	2	Output interface index; set to index of PoS interface for egress flows that are being transmitted over the SONET link; set to zero for ingress flows received from the SONET link
dPkts	4	Number of packets sent in this flow
dOctets	4	Number of octets sent in this flow
First	4	SysUptime when flow record was created
Last	4	SysUptime at most-recent, or last packet of flow
srcport	2	Source port number, valid only for TCP and UDP flows
dstport	2	Destination port number, valid only for TCP and UDP flows
pad	2	Unused field
prot	1	Number identifying the IP protocol; for example, 6=TCP and 17=UDP
tos	1	IP Type-of-Service (TOS) field value from initial packet that caused this flow record to be created
tcp_flags	1	Cumulative OR of TCP flags field, valid only when *prot*=6
pad	11	Unused field

Flow records are grouped together into UDP datagrams for export to a flow-collector device. A NetFlow Version 1 export datagram can contain up to 25 flow records. Figure 90 shows the format of the export datagram; Table 64 describes the export datagram header.

Figure 90: Format of NetFlow export datagram

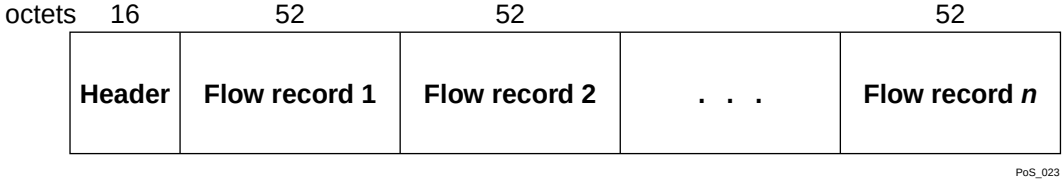


Table 64: Format of NetFlow Version 1 Export Datagram Header

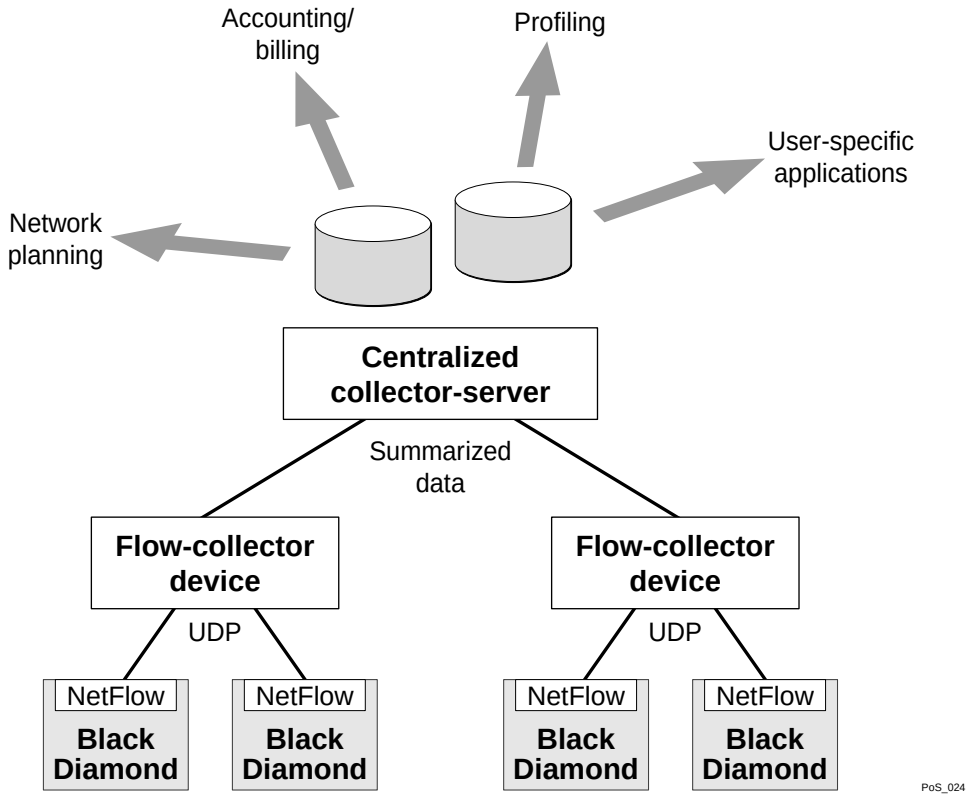
Field Name	Octets	Field Description
version	2	Header version=1.
count	2	Number of flow records in datagram.
SysUptime	4	Current time in milliseconds since the switch booted.
unix_secs	4	Current count of seconds since 0000 UTC 1970.
unix_nsecs	4	Current count of residual nanoseconds since 0000 UTV 1970.

The IP addresses (or hostnames) and UDP port numbers of the available flow collectors can be configured on a per-switch basis. The flow collection architecture example in Figure 91 illustrates how multiple BlackDiamond switches might export flow records to flow-collector devices that, in turn, feed records into a central collector-server. Other flow-collector architectures are also possible. For example, each SONET port might export statistics to a dedicated flow-collector device.

The ExtremeWare NetFlow implementation for the PoS module also enables a single SONET port to distribute statistics across multiple groups of flow-collector devices. This NetFlow distribution feature enables a scalable collection architecture that is able to accommodate high volumes of exported data. The NetFlow distribution feature is enabled by configuring *export distribution groups* that contain the addresses of multiple flow-collector devices. The feature uses a distribution algorithm that ensures all of the records for a given flow are exported to the same collector. The algorithm also ensures that the flow records for both the ingress and egress directions of a TCP or UDP connection are exported to the same collector when both flows traverse the SONET link and both filters are configured to export to the same group. For example, a potentially different group can be associated with a filter. The flow records that match the filter are then sent to one of the flow collector devices in that group. You could also establish redundancy by allowing multiple flow collector devices per group so that data is still collected as long as there is one working flow collector device in that group.

To implement flow-collector devices, you can choose from commercial software products and public-domain software packages.

Figure 91: NetFlow Collection Architecture Example



Collection Port and Filtering Options

By default, each PoS port maintains statistics for all the flows traversing the SONET link in both the ingress and egress directions. However, generalized filtering options exist that enable a port to maintain statistics only for ingress flows, only for egress flows, or only for selected ingress and/or egress flows.

You can use these filtering options to configure a PoS port to maintain statistics selectively for only those flows that match a specified filter. Up to 16 filters are supported for each PoS port: eight filters for ingress flows; eight filters for egress flows. The filters consist of a {*value,mask*} pair for each of the following flow components: destination IP address, source IP address, destination port, source port, and protocol. Conceptually, the filters work by logically ANDing the contents of each of these five components of a forwarded flow with the associated *masks* from the first filter. Statistics are maintained if the results of the AND operations match the configured filter values for all fields of the five flow components. If there is not a match on all fields of the five components, then the operation is repeated for the second filter, and so on. If there is no match for any of the filters, then statistics are not maintained for the flow.

Collection Architecture Scalability and Reliability

By supporting statistics distribution across groups of flow-collector devices, the NetFlow distribution function enables a scalable collection architecture that is able to accommodate high volumes of exported data. The function also includes a health-check feature that significantly improves the reliability of the collection architecture. The health-checker ensures that only responsive flow-collector devices are included in the effective export distribution lists.

Up to 32 export distribution groups can be configured on a Black Diamond 6800 series switch. Each of these groups can contain the addresses of up to eight flow-collector devices. A particular export group can then be specified for each filter, which provides a high-degree of flexibility.

A filter-based aggregation capability is also offered to further enhance scalability. Each filter can be configured to be either a *per-flow filter* or an *aggregation* filter. When a flow matches a filter that is configured as an aggregation, normal per-flow statistics are not maintained for the flow. Instead, a single set of statistics is maintained for all the flows that match the aggregation filter, which can substantially reduce the volume of exported data.

Aggregated flow statistics are also exported in the NetFlow Version 1 format. The *nexthop* field of the flow record (see Table 63) is set to xFFFF to indicate that the record is associated with a filter-based aggregation. The *srcaddr*, *dstaddr*, *srcport*, *dstport*, and *prot* fields of an aggregated flow record are set to the corresponding value components of the associated filter specification.

Export Criteria

TCP flow records are exported when the associated connection is terminated. Flow records are also exported on an age basis. All flow records, including aggregation records, are examined at least once every 30 minutes. If the age of the flow is greater than a configurable time, the record is exported. If the flow is still active, a new flow record will be created when the next packet arrives.

The PoS module transmits a NetFlow Export Datagram when 25 flow records are ready for export, or when at least one flow has been awaiting export for one second.

Enabling and Disabling Flow Statistics

To enable the flow statistics function on the specified SONET port, use the following command:

```
enable flowstats ports <portlist>
```

The flow statistics function is disabled by default.

NOTE

Flow statistics are collected only on SONET ports that are configured to use the IP Control Protocol (IPCP). No flow statistics are collected on ports that are configured to use the Bridging Control Protocol (BCP). You will not be prevented from enabling the flow statistics function on ports not configured for IPCP, but statistics will not be collected on those ports.

To disable the flow statistics function on the specified SONET port, use the following command:

```
disable flowstats ports <portlist>
```

The flow statistics function is disabled by default.

Configuring the Export Destination

A single SONET port can distribute statistics across multiple groups of flow-collector devices. This NetFlow distribution capability makes it possible to create a collection architecture that scales to accommodate high volumes of exported data. It also offers a health-checking function that improves the reliability of the collection architecture by ensuring that only responsive flow-collector devices are included in active export distribution lists.

The distribution algorithm ensures that all the records for a given flow are exported to the same collector. The algorithm also ensures that flow records for both the ingress and egress directions of a

TCP or UDP connection are exported to the same collector (when both flows traverse the same SONET link and both filters are configured to export to the same group).

NetFlow distribution is enabled by configuring export distribution groups that identify the addresses of multiple flow-collector devices. You can configure up to 32 export distribution groups on a BlackDiamond 6800 series switch, and each group can contain as many as eight flow-collector devices.

To configure the export groups and flow-collector devices to which NetFlow datagrams are exported, use the following command:

```
config flowstats export {<group#>} [add | delete]
   [<ipaddress> | <hostname>] <udp_port>
```

The optional group# parameter is an integer in the range from 1 through 32 that identifies the specific group for which the destination is being configured. If you do not specify a value for the group# parameter, the parameter value defaults to 1.

You can use the add and delete keywords to add or delete flow-collector destinations.

To export NetFlow datagrams to a group, you must configure at least one flow-collector destination. By default, no flow-collector destinations are configured. To configure a flow-collector destination, use either an IP address and UDP port number pair or a hostname and UDP port number pair to identify the flow-collector device to which NetFlow export datagrams are to be transmitted. You can configure up to eight flow-collector destinations for each group. When multiple flow-collectors are configured as members of the same group, the exported NetFlow datagrams are distributed across the available destinations.

Configuring the Source IP Address

To configure the IP address that is to be used as the source IP address for NetFlow datagrams to be exported, use the following command:

```
config flowstats source ipaddress <ipaddress>
```

No NetFlow datagrams are exported until the source IP address is configured. Depending on how it is configured, a flow-collector device can use the source IP address of received NetFlow datagrams to identify the switch that sent the information.

NOTE

The configured IP address should be associated with a VLAN that has loopback-mode enabled.

The following command example specifies that the IP address 192.168.100.1 is to be used as the source IP address for exported NetFlow datagrams.

```
config flowstats source ipaddress 192.168.100.1
```

Configuring Flow Record Timeout

Flow records are exported on an age basis: All flow records are examined at least once every 30 minutes. If the age of the flow record is greater than the configured timeout, the record is exported. If the flow is still active, a new flow record will be created when the next packet arrives.

To configure the timeout value for flow records on the specified SONET port, use the following command:

```
config flowstats timeout <minutes> ports <portlist>
```

The timeout value is the number of minutes to use in deciding when to export flow records. The number is an integer in the range from 1 to 1440. The default timeout is 5 minutes.

The following command example specifies a 10-minute timeout for exported NetFlow datagrams on port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
config flowstats timeout 10 ports 8:1
```

Configuring a Flow Record Filter

You can configure a SONET port to maintain statistics selectively for only those flows that match a specified filter. Each port on an PoS module supports 16 filters: eight filters for ingress flows; eight filters for egress flows.

To configure a flow record filter for the specified SONET port, use the following command:

```
config flowstats filter <filter#> {aggregation} {export <group#>}
   ports <portlist> [ingress | egress] <filterspec>
```

where:

`filter#`	The `filter#` parameter is an integer in the range from 1 to 8 that operates with either the `ingress` or `egress` keyword to identify the filter that is being defined.
`aggregation`	To reduce the volume of exported data, use this optional keyword to maintain a single set of statistics for all the flows that match the specified filter.
`export <group#>`	To specify a particular export distribution group on a per-filter basis, use the optional `export` keyword with a group number value to identify the set of flow collector devices to which records for flows matching the filter are to be exported. If you do not specify a value for `group#`, the value defaults to 1.
`ingress`	Use this keyword to specify that the filter being defined in the command is one of the eight filters to be applied to ingress flows.
`egress`	Use this keyword to specify that the filter being defined in the command is one of the eight filters to be applied to egress flows.

`filterspec`	Each filter is defined using a *value*/*filtermask* pair for each of the five components in the following sequence:
	
	{destination IP address, source IP address,
	destination port number, source port number, protocol}
	
	in the form:
	
	`[{dest-ip <ipaddress_value/ipaddress_filtermask>}`
	`{source-ip <ipaddress_value/ipaddress_filtermask>}`
	`{dest-port <port_value/port_filtermask>}`
	`{source-port <port_value/port_filtermask>}`
	`{protocol <protocol_value/protocol_filtermask>} |`
	`match-all-flows | match-no-flows]`
	
	The `ipaddress_filtermask`, `port_filtermask`, and `protocol_filtermask` parameters are configured using hexadecimal notation.
	
	You can also use either the `match-all-flows` keyword or the `match-no-flows` keyword in place of settings for the five components. The `match-all-flows` keyword adjusts the *value*/*filtermask* settings for all the components to 0/0 such that the filter matches any flow. The `match-no-flows` keyword adjusts the *value*/*filtermask* settings for all the components such that the filter does not match any flow.
	
	By default, filter #1 is configured to `match-all-flows`, and the remaining filters are configured to `match-no-flows`.
	
	Conceptually, the filters work by ANDing the contents of each of the five components of a forwarded flow with the associated masks from the first defined filter (filter #1). Statistics are maintained if the results of the AND operations match the configured filter values for all fields of the sequence. If there is no match, then the operation is repeated for filter #2, and so on. If there is no match for any of the filters, then statistics are not maintained for the flow. Filters for any or all of the sequence components can be configured with a single command.

The following command example configures a filter to collect statistics on ingress flows destined for 192.168.1.1 from the 192.169.0.0/16 subnet with a destination port of 80 using protocol 6.

```
config flowstats filter 1 export 1 ports all ingress
   dest-ip 192.168.1.1/FFFFFFFF source-ip 192.169.0.0/FFFF0000
   dest-port 80/FFFF source-port 0/0 protocol 6/FF
```

Likewise, the following command example configures a filter to collect statistics on egress traffic from the 192.168.0.0/16 subnet to 192.169.1.1 with a destination port of 80 using protocol 6.

```
config flowstats filter 1 export 1 ports all egress
   dest-ip 192.169.1.1/FFFFFFFF source-ip 192.168.0.0/FFFF0000
   dest-port 80/FFFF source-port 0/0 protocol 6/FF
```

The following command example configures a filter to collect aggregate statistics for all egress traffic flowing from the 192.170.0.0/16 subnet to the 192.171.255.255 subnet.

```
config flowstats filter 2 aggregation export 1 ports all egress
   dest-ip 192.171.0.0/FFFF0000 source-ip 192.170.0.0/FFFF0000
   dest-port 0/0 source-port 0/0 protocol 0/0
```

Likewise, the following command example configures a filter to collect aggregate statistics for all ingress traffic flowing from the 192.171.0.0/16 subnet to the 192.170.0.0/16 subnet.

```
config flowstats filter 2 aggregation export 1 ports all ingress
   dest-ip 192.170.0.0/FFFF0000 source-ip 192.171.0.0/FFFF0000
   dest-port 0/0 source-port 0/0 protocol 0/0
```

Finally, the following command examples configure two filters—an egress filter and an ingress filter—to collect statistics on any remaining flows that did not match the ingress and egress filters defined in the four previous command examples.

```
config flowstats filter 3 export 1 ports all egress match-all-flows
config flowstats filter 3 export 1 ports all ingress match-all-flows
```

Enabling and Disabling a Flow Record Filter

To enable a specified flow record filter for the specified SONET port, use the following command:

```
enable flowstats filter <filter#> ports <portlist> [ingress | egress]
```

By default, filter #1 is enabled on all SONET ports for both ingress and egress flows, and all remaining filters are disabled.

To disable a specified flow record filter for the specified SONET port, use the following command:

```
disable flowstats filter <filter#> ports <portlist> [ingress | egress]
```

where:

`filter#`	The `filter#` parameter is an integer in the range from 1 to 8 that operates with either the `ingress` or `egress` keyword to identify the filter that is being enabled or disabled.
`ingress`	Use this keyword to specify that the filter being enabled or disabled is one of the eight filters to be applied to *ingress* flows.
`egress`	Use this keyword to specify that the filter being enabled or disabled is one of the eight filters to be applied to *egress* flows.

The following command example enables ingress filter #2 on port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
enable flowstats filter 2 ports 8:1 ingress
```

The following command example disables ingress filter #2 on port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
disable flowstats filter 2 ports 8:1 ingress
```

Enabling and Disabling Flow Statistics Ping-Check

To enable the flow statistics ping-check function for a specified group of collector devices, use the following command:

```
enable flowstats ping-check <group#>
```

If you do not specify a value for the `group#` parameter, the ping-check function is enabled for all collector groups.

The ping-check function is enabled by default.

When the ping-check function is enabled, each of the flow collector devices is pinged periodically to check its network connectivity. If a flow collector device is repetitively unresponsive, it is temporarily removed from the export distribution list for that group. The flow collector device will be returned to the export distribution list automatically when subsequent ping checks are consistently successful.

The following command example enables the ping-check function for export group 2.

```
enable flowstats ping-check 2
```

To disable the flow statistics ping-check function for a specified group of collector devices, use the following command:

```
disable flowstats ping-check <group#>
```

If you do not specify a value for the group# parameter, the ping-check function is disabled for all collector groups.

The following command example disables the ping-check function for export group 2.

```
disable flowstats ping-check 2
```

Unconfiguring Flow Statistics

To reset the flow statistics configuration parameters for a specified SONET port to their default values, use the following command:

```
unconfig flowstats ports <portlist>
```

NOTE

This command does not affect the enabled or disabled status of flow statistics collection, nor does it affect the configured export destinations.

The following command example resets the flow statistics configuration parameters for port 1 of the PoS module installed in slot 8 of the BlackDiamond switch to their default values.

```
unconfig flowstats ports 8:1
```

Displaying Flow Statistics Status Information

To display status information for the flow statistics function, use the following command:

```
show flowstats {<portlist> | export {<group#>} {detail}}
```

where:

portlist	Use this optional parameter to specify the SONET port for which status information is to be displayed.
export	Use this optional keyword to display status information for export groups, which are configured on a switch-wide basis.
group#	Use this optional parameter with the export keyword to display status information for a specific export group. If you do not specify a value for the group# parameter, the export keyword by itself displays status information for all export groups.
detail	Use this optional keyword to display detailed export group status information.

If you enter the `show flowstats` command with none of the optional keywords or parameters, the command displays a summary of status information for all ports.

The summary status display for a port includes the following information:

- Values for all flow statistics configuration parameters
- Count of flow records that have been exported
- Counts of the number of packets/bytes for which flow statistics were not maintained because of insufficient resources

The summary status display for an export group includes the following information:

- Values for all configuration parameters
- Status of each export destination device

The detailed status display for an export group includes the summary information, plus the following management information:

- Counts of the flow records that have been exported to each flow collector destination
- Counts of the number of times each flow collector destination has been taken out of service due to health-check (ping check) failures

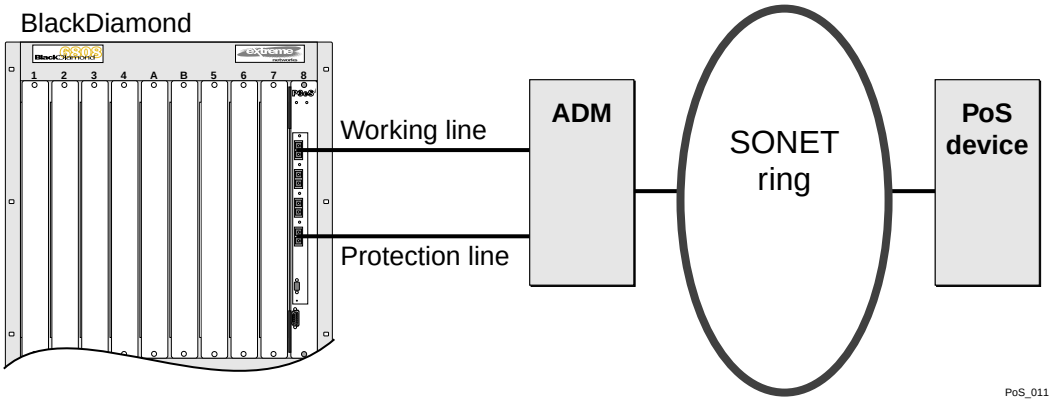
MIB Support for Flow Statistics

Because there are no standard MIBs defined for managing the NetFlow function, Extreme Networks has defined and implemented an enterprise MIB that provides read-only support (GET operations but not SET operations) for NetFlow configuration parameters and status information. Any of the parameters that can be set with the `config flowstats` commands can be accessed using the MIB, and any of the status information displayed by the `show flowstats` command can also be read using the MIB. For more information on the MIB, see Appendix B, “Supported MIBs and Standards.”

Configuring and Monitoring APS Functions

Automatic Protection Switching, or APS, is a resiliency feature specified in the SONET standards. Of the different modes of operation defined in the APS specifications, the BlackDiamond 6800 series switch supports the Linear 1+1 APS architecture to protect tributary SONET lines connecting switches to Add-Drop Multiplexers (ADMs). Linear APS can be contrasted with the Ring APS architectures, which protect the lines between the equipment comprising a SONET ring. Figure 92 is an example of the Linear 1+1 architecture, where there is one protection line for each working line, and the ADM transmits the same data to both the working line and the protection line.

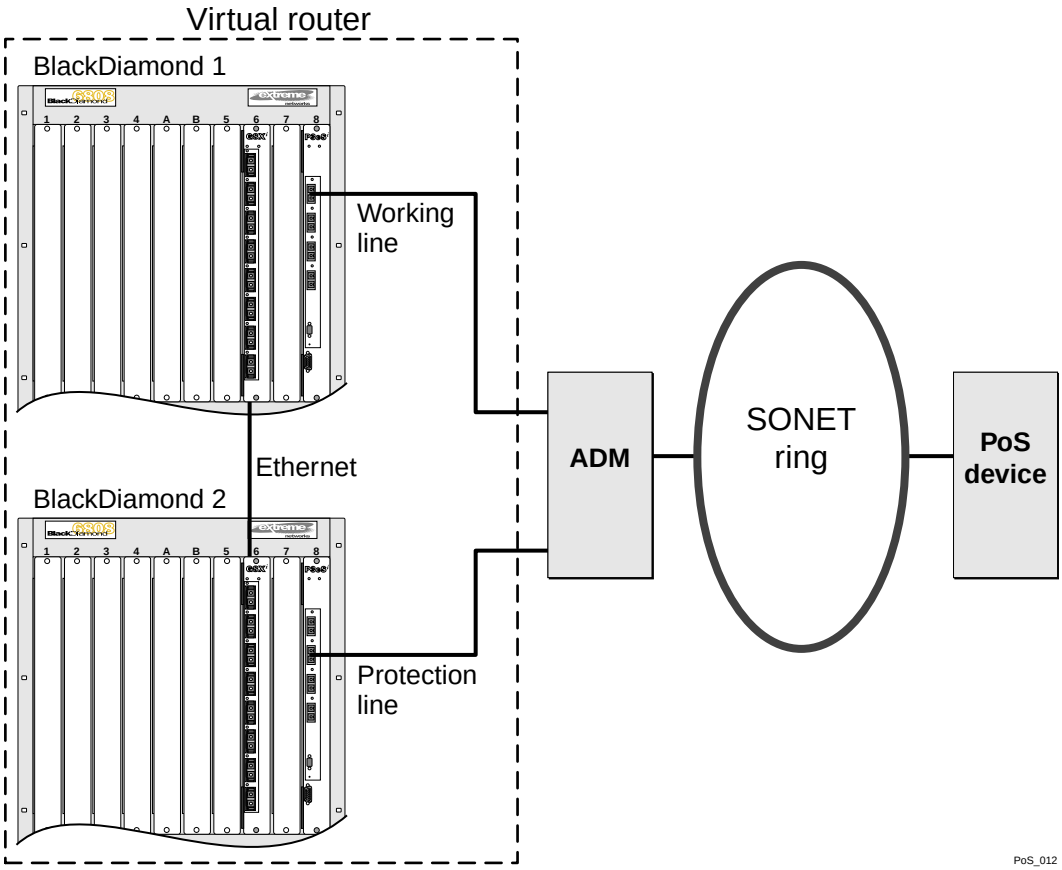
Figure 92: Linear 1+1 APS architecture



The APS standards specify both unidirectional and bidirectional-switching modes. In the bidirectional mode, both ends must select, or receive data from, the same line. Thus, switching from one line to another must be coordinated. This synchronization is achieved using APS protocols that are carried in the K1 and K2 bytes of the SONET line overhead. The K1 and K2 bytes must be transmitted on the protection line, and may also be transmitted on the working line; however, receivers cannot assume that the K1 and K2 bytes will be transmitted on the working line.

Bidirectional switching is advantageous for data communication applications where the working line and the protection line are terminated in different switches, as depicted in Figure 93. Because the working and protection lines form a single SONET interface with respect to the rest of the network, it is clearly more straightforward and efficient for one switch to handle all the payload transmission and reception responsibilities for the interface. Consequently, the BlackDiamond 6800 series switch supports bidirectional switching, but not unidirectional switching.

Figure 93: Linear 1+1 APS architecture with two switches



The 1+1 architecture can also operate in *revertive* or *nonrevertive* mode, which allows you to determine what action should be taken when traffic is active on the protection line and the working line becomes operational. The BlackDiamond 6800 series switch supports both revertive and non-revertive modes of operation.

In revertive mode, when traffic is active on the protection line and the working line becomes operational, traffic will be switched automatically from the protection line to the working line.

Conversely, in nonrevertive mode, when traffic is active on the protection line and the working line becomes operational, traffic will remain on the protection line (until either manual intervention or a failure on the protection line forces a switch back to the working line).

APS Network Configuration Options

Three basic APS configurations are supported:

- Two-switch configuration, where the working line is terminated in one BlackDiamond switch and the protection line is terminated in another.
- Two-module configuration, where the working line and the protection line are terminated in two different SONET modules that reside in the same BlackDiamond chassis.
- Single-module configuration, where the working line and the protection line are terminated in the same BlackDiamond SONET module.

Because the two-switch configuration is the most advanced, it is discussed first, followed by the two simpler configurations.

In the two-switch configuration (see Figure 94), the two BlackDiamond switches form a virtual APS switch. The PoS interface in BlackDiamond switch #1 is configured to be the working line, while the PoS interface in BlackDiamond switch #2 is configured to be the protection line. The same IP address is configured for both PoS interfaces. In this example, the common IP address is 192.168.10.1. The use of a common IP address enables the neighboring PPP router to view the virtual APS switch as a single router entity; the neighboring router is unaware that its partner is actually two cooperating switches. Figure 95 illustrates the logical PPP connectivity between the virtual APS router and the neighboring PPP router.

NOTE

Note: The two-switch configuration is supported only if PPP is configured on the PoS ports. The two-switch configuration is not supported if HDLC tunneling is configured on the PoS ports.

Figure 94: Virtual APS router configuration

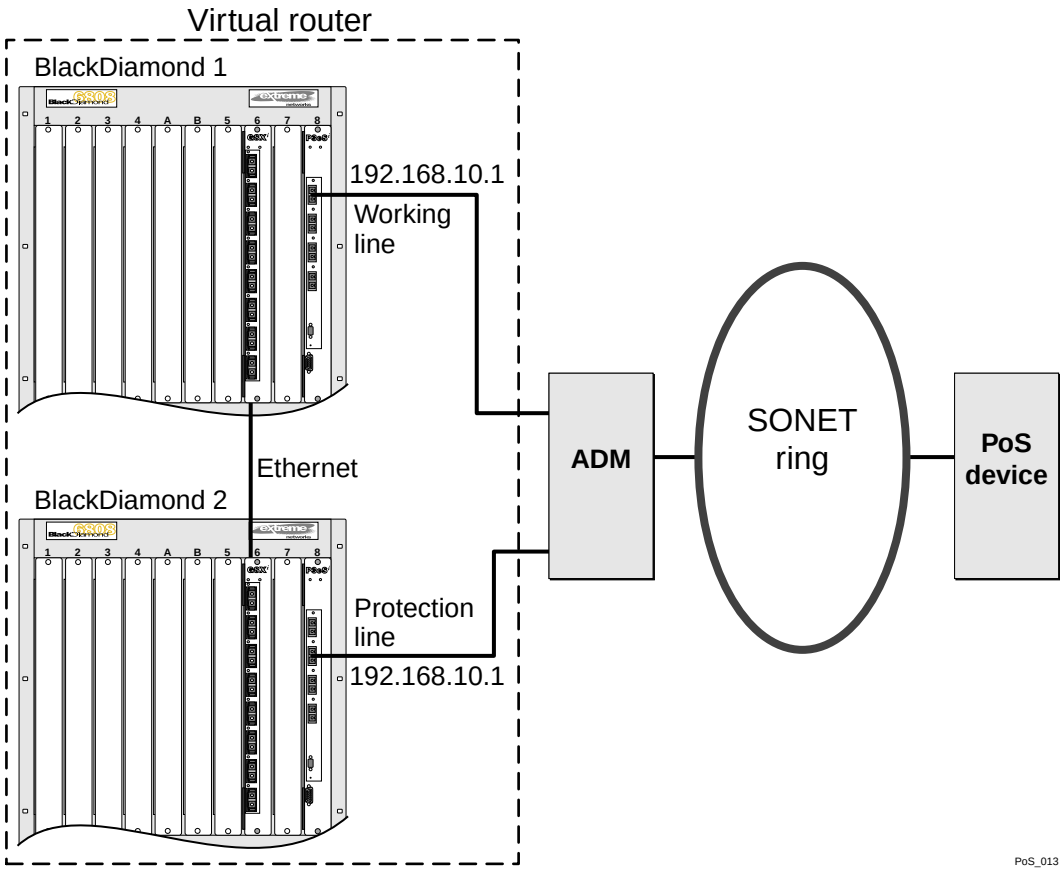
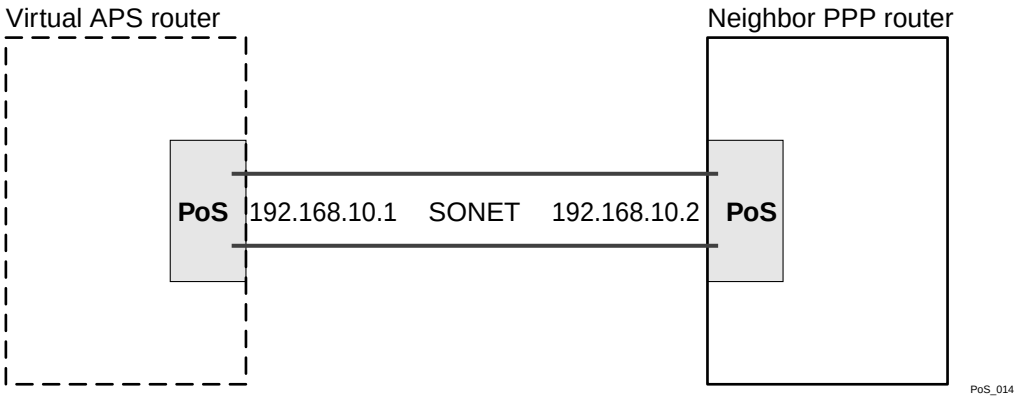


Figure 95: Logical PPP connectivity to virtual APS router



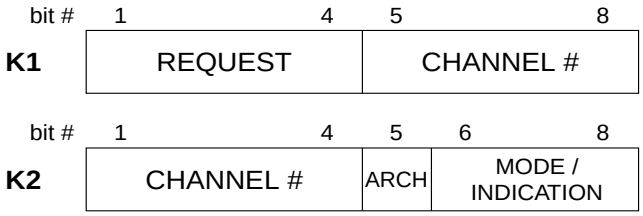
Another important characteristic of the virtual APS router configuration shown in Figure 94 is the Ethernet link between BlackDiamond #1 and BlackDiamond #2. This Ethernet link provides an out-of-band communications channel that provides a way for the two switches to synchronize their use of the SONET interfaces. For example, if BlackDiamond #1 detects poor signal quality on the working line, it sends a message over the Ethernet link to BlackDiamond #2, which initiates a switch to the protection line. The Ethernet link is also used to carry heartbeat messages that enable the protection switch to take over if the working switch fails.

The two-module and single-module configurations are similar to the two-switch configuration, except that there is no out-of-band Ethernet communications link. These configurations are simpler, because a single switch manages both the working line and the protection line. One advantage of the simpler single-switch configurations is faster network-recovery times following a line or module failure. The single-module configuration protects against line failures, while the two-module configuration protects against both line and module failures. The two-switch configuration further expands the protection scope to include line, module, and switch failures.

Sample Line-Switching Scenario

In the following sample line-switching scenario, the working router initiates the APS switch to the protection line. In this sample scenario, assume that the working line is active, and that the working router initiates a switch to the protection line upon detecting a signal fail or signal degrade condition on the working line. The working router initiates the line switch by sending a message to the protection router over the out-of-band Ethernet connection. All APS-related Ethernet communications between the working router and the protection router are via UDP. Upon receiving the message, the protection router invokes the APS protocol to request that the ADM switch to the protection line. The APS protocol is carried in the K1 and K2 bytes of the SONET overhead. The format of the K1 and K2 bytes is illustrated in Figure 96.

Figure 96: Format of SONET K1 and K2 Bytes



Legend

REQUEST

0000	No Request
0001	Do Not revert (nonrevertive only)
0010	Reverse Request (bidirectional only)
0100	Exercise
0110	Wait-To-Restore (revertive only)
1000	Manual Switch
1010	Signal Degrade
1100	Signal Fail
1110	Forced Switch
1111	Lockout of Protection

CHANNEL #

K1 - number of channel issuing request (1=>working, 0=>protection)
K2 - 0 if channel # in received K1=0, else channel # bridged to protection line

ARCHITECTURE

0 => provisioned for 1+1 architecture

MODE / INDICATION

100	Provisioned for Unidirectional Switching Mode
101	Provisioned for Bidirectional Switching Mode
110	Line Remote Defect Indication (RDI-L)
111	Line Alarm Indication Signal (AIS-L)

PoS_019

Based on the K1 and K2 definitions, Table 65 shows the detailed APS protocol exchanges for switching from the working line to the protection line. The example assumes the switch occurs because a Signal Degrade condition is detected on the working line. All APS protocol exchanges occur on the protection line, between the protection router and the ADM.

Table 65: APS Protocol for Switch from Working Line to Protection Line

Protect Router → ADM		**ADM → Protect Router**		**Comments**
K1 Byte	**K2 Byte**	**K1 Byte**	**K2 Byte**	
0000 0000	0000 0 101	0000 0000	0000 0 101	No failures; working line active. Example is provisioned for 1+1 architecture and bidirectional switching mode.

Table 65: APS Protocol for Switch from Working Line to Protection Line (continued)

Protect Router → ADM		ADM → Protect Router		Comments
K1 Byte	**K2 Byte**	**K1 Byte**	**K2 Byte**	
1010 0001	0000 0 101	0000 0000	0000 0 101	Protection router receives Signal Degrade message from working router over Ethernet link, and sends Signal Degrade request for channel 1 (the working line) to the ADM.
1010 0001	0000 0 101	0010 0001	0001 0 101	ADM acknowledges the Signal Degrade request by sending Reverse Request for channel 1 in K1; K2 indicates that the ADM has bridged channel 1 to the protection line.
1010 0001	0001 0 101	0010 0001	0001 0 101	Protection router selects (receives) channel 1 data from the protection line based on received K2, and uses K2 to indicate that channel 1 is bridged to the protection line.
1010 0001	0001 0 101	0010 0001	0001 0 101	ADM selects (receives) channel 1 data from the protection line based on received K2.

After the APS line switch has completed, the protection router sends a message to the working router over the Ethernet link. The message indicates that the line switch has been performed. The working router responds by taking down the SONET interface and initiating a routing topology update. Similarly, the protection router brings the SONET interface up and advertises availability of routes accessible via the SONET interface. The neighboring PPP router will think that its partner (which is now the protection router) has renegotiated the link. On the LAN side, packets with destinations accessible via the SONET interface will be forwarded to the protection router. These packets may be forwarded to the protection router as a result of the routing topology updates or the Extreme Standby Router Protocol (ESRP).

APS Benefits

In this section, we examine the benefits provided by APS. A typical redundant switch configuration is illustrated in Figure 97. In this scheme, both BlackDiamond switches have two SONET interfaces that are connected to different ADMs. In this configuration, no switch, PoS interface, SONET line, or ADM represents a single point-of-failure. Compare this with the APS configuration depicted in Figure 98.

Figure 97: Typical redundant switch configuration without APS

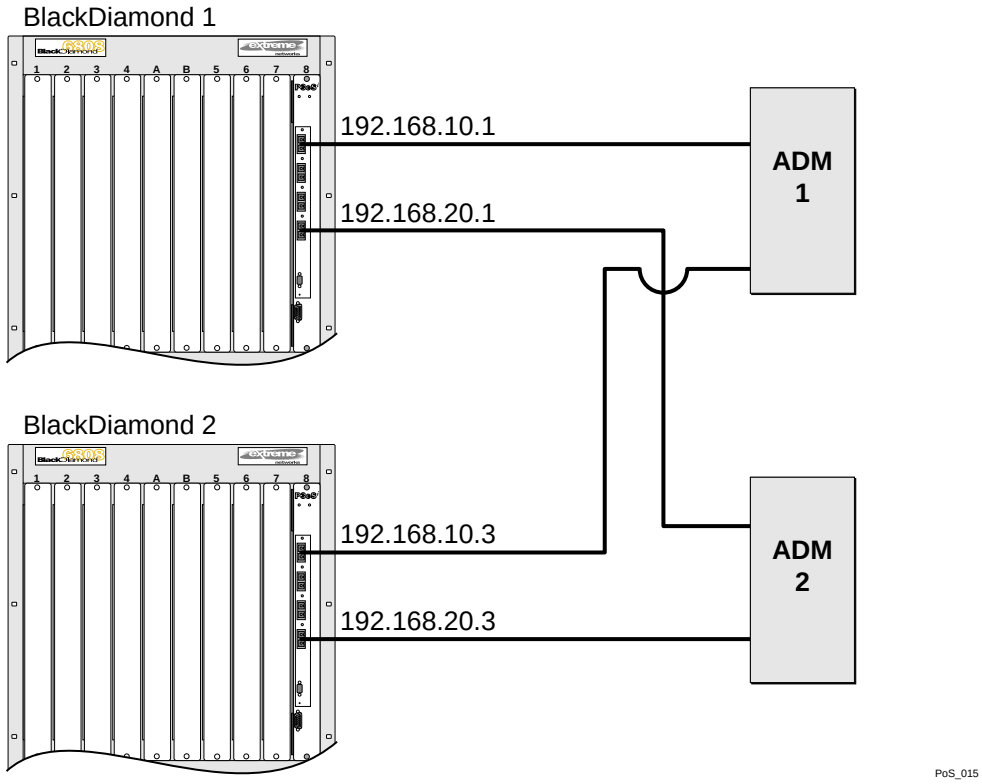
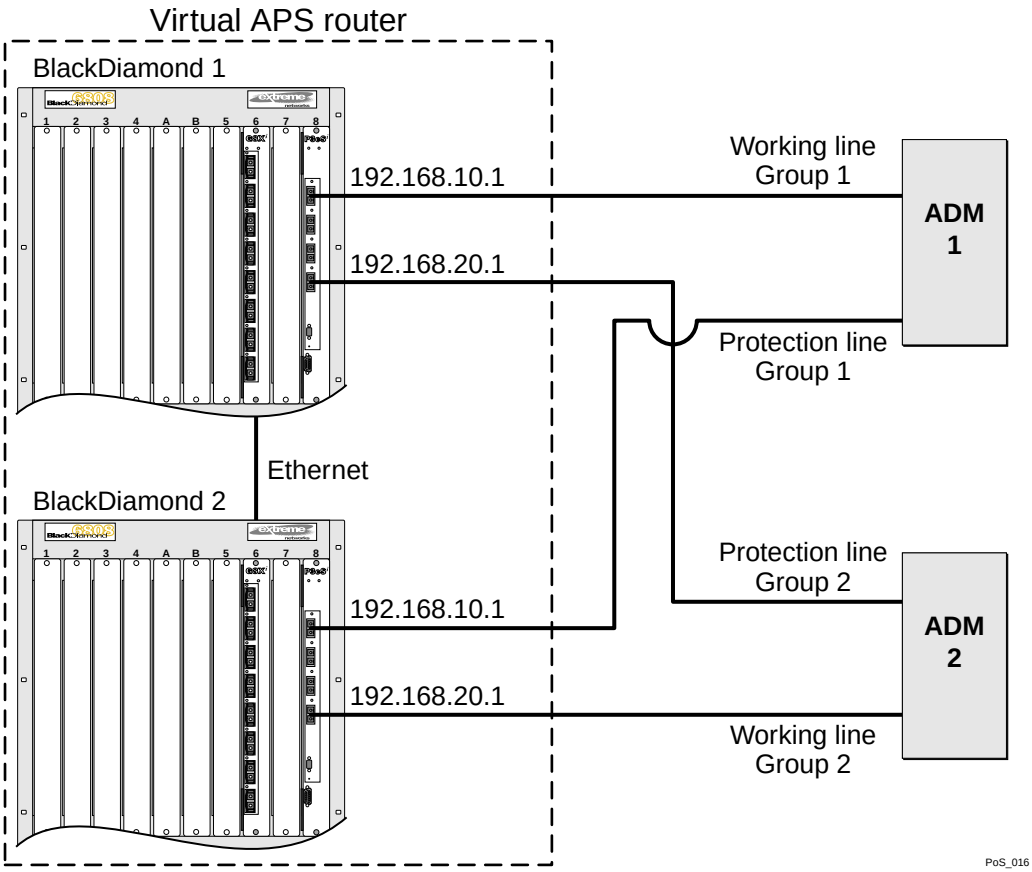


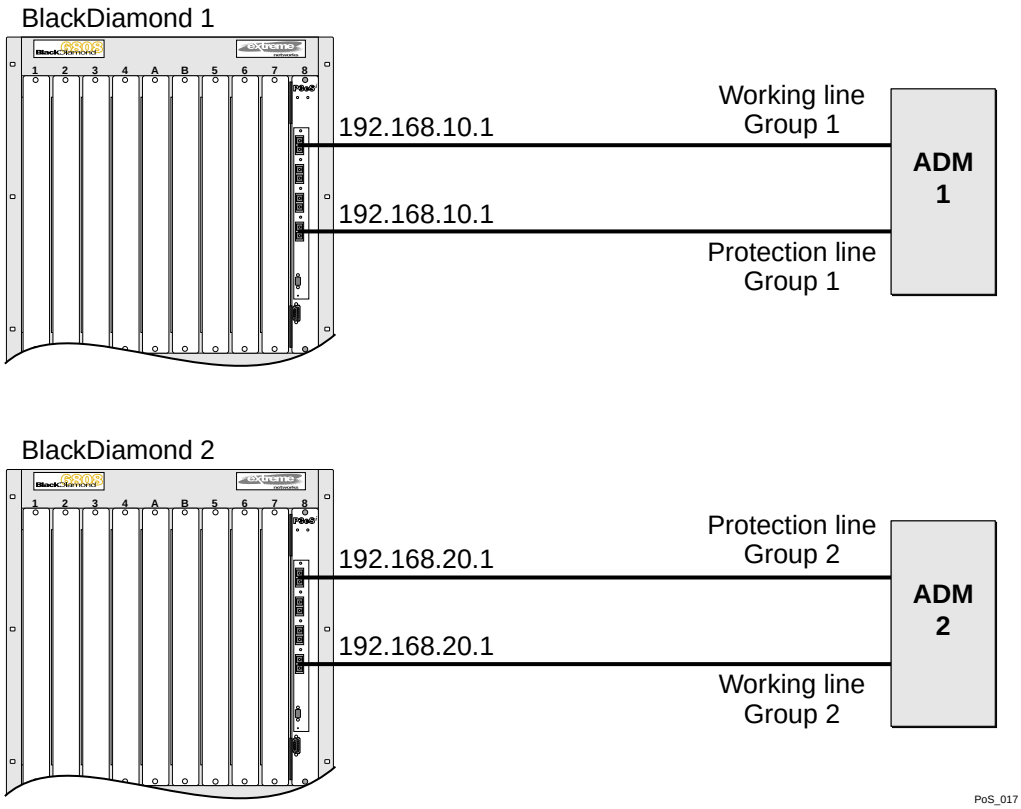
Figure 98: Redundant switch configuration with APS



While these two configurations appear similar, the significant difference between them is that the BlackDiamond switches in Figure 98 appear to the rest of the network as two PoS interfaces (IP addresses 192.168.10.1 and 192.168.20.1), as opposed to the four PoS interfaces shown in Figure 97 (IP addresses 192.168.10.1, 192.168.20.1, 192.168.10.3, and 192.168.20.3). The configuration in Figure 98 enables customers to purchase half the SONET bandwidth without sacrificing resiliency. In fact, the APS configuration offers increased resiliency by virtue of not reducing maximum throughput as a result of a single line or switch failure. Furthermore, if the extra bandwidth is needed, two larger bandwidth interfaces are more efficient than four smaller bandwidth interfaces, due to suboptimal load-balancing.

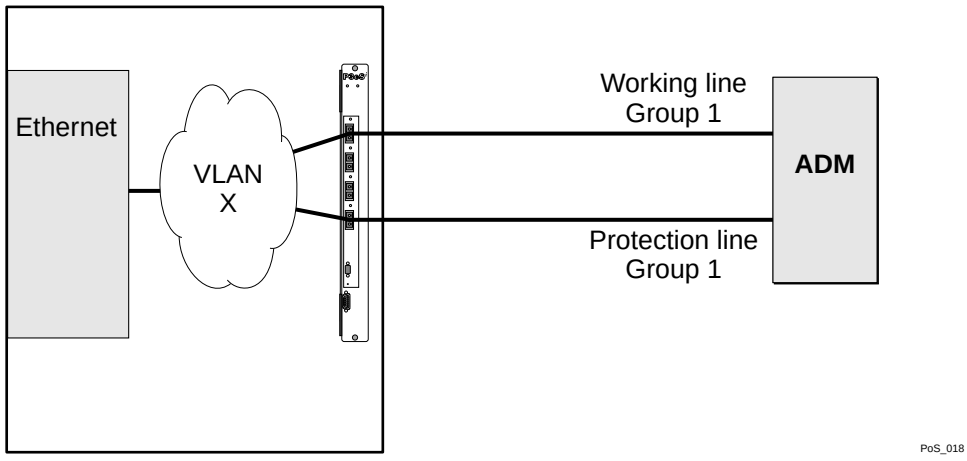
Figure 99 shows an APS configuration that provides faster network recovery from SONET line failures or degradations. Recovery is faster in this case because no routing topology updates are needed. Recovery is isolated to the switch and ADM pair connected to the failed line, and consists of performing an APS line switch operation. The downside of the configuration shown in Figure 99, relative to Figure 98, is that failure of a BlackDiamond switch will reduce the maximum SONET bandwidth by half. Note that failure of an ADM will also halve the maximum available bandwidth in either configuration.

Figure 99: APS configuration providing faster recovery from line failure



As mentioned earlier, APS can also be applied to the interconnection of bridges. Figure 100 illustrates a configuration where two PoS ports are members of the same VLAN. Assume that, in this example, both PoS ports are configured to run BCP on the common VLAN and bridge traffic for the VLAN across the SONET link. Assigning the two PoS ports to the same APS group improves the resiliency of the bridged network by enabling faster recovery from SONET line failures relative to that achieved by the Spanning Tree Protocol (STP). This recovery is accomplished by simply performing a local APS line switch. Because APS recovers at layer 1, the Spanning Tree Protocol does not need to be informed of the line failure, and therefore, no time-consuming STP reconvergence is necessary.

Figure 100: APS in bridging configuration



Enabling and Disabling APS

To enable the APS function for the entire switch, use the following command:

```
enable aps
```

To disable the APS function for the entire switch, use the following command:

```
disable aps
```

Creating and Deleting an APS Group

An APS group includes one working line and one protection line. The working line and protection line can reside on the same BlackDiamond switch or on two different BlackDiamond switches. The group is identified by a unique number.

To create an APS group, use the following command:

```
create aps <group#>
```

The group# parameter is an integer in the range from 1 through 65535 that identifies the APS group to be created. The APS group numbers must be unique across all BlackDiamond switches that are cooperating to provide the APS function. The group numbers must also be used in a consistent manner across BlackDiamond switches. For example, if the working line is assigned to group #1 on BlackDiamond #1, and the associated protection line resides on BlackDiamond #2, the protection line must also be assigned to group #1 on BlackDiamond #2. The group# is used to identify the partner line, which can be either the working line or the protection line, in Ethernet messages exchanged by BlackDiamond switches that are cooperating to provide the APS function.

The following command example creates APS group 1001 on the BlackDiamond switch:

```
create aps 1001
```

To delete an APS group, use the following command:

```
delete aps <group#>
```

The group# parameter is an integer in the range from 1 to 65535 that identifies the APS group to be deleted.

The following command example deletes APS group 1001:

```
delete aps 1001
```

Adding a Port to an APS Group

To add a SONET port to an APS group, use the following command:

```
config aps <group#> add <port> [working | protection <ipaddress>]
```

The group# parameter is an integer in the range from 1 to 65535 that identifies the APS group to which the specified port is to be added.

The port parameter identifies the SONET port that is to be added to the APS group.

You must also specify whether the port is the APS working or protection line. You can add only one working line and one protection line to an APS group. If you designate the port the protection line, then you must also specify the IP address (ipaddress parameter) of the BlackDiamond switch where the

working line resides. This IP address is used to send APS control messages to the BlackDiamond switch containing the working line.

NOTE

The configured IP address should be associated with an Ethernet VLAN that has loopback mode enabled to minimize the impact of network outages on APS functionality. Also, when using APS to protect links on different BlackDiamond 6800 series switches, the network connecting the working and protection switches must always have sufficient bandwidth to support APS control transfers.

In routing configurations, the working line and the protection line should represent the same IP address from the perspective of the neighboring PPP switch. When the working line and protection line reside in the same BlackDiamond switch, both ports should be members of the same VLAN. The case where both the working line and the protection line for an APS group reside in the same BlackDiamond switch is the only situation where IPCP can be enabled on multiple SONET ports that are members of the same VLAN. In general, if IPCP is enabled on a PoS module port, that port can be a member of only one VLAN and no other ports on that switch can be members of that VLAN.

The following command example adds port 1 of the module installed in slot 8 of the BlackDiamond switch to APS group 1001 as the working line.

```
config aps 1001 add 8:1 working
```

Deleting a Port from an APS Group

To delete a SONET port from an APS group, use the following command:

```
config aps <group#> delete <port>
```

The `group#` parameter is an integer in the range from 1 to 65535 that identifies the APS group from which the specified port is to be deleted.

The `port` parameter identifies the SONET port that is to be deleted from the APS group.

NOTE

Deleting the working line from an APS group initiates a switch to the protection line, but deleting the active protection line from an APS group does not initiate a switch to the working line.

The following command example deletes port 1 of the module installed in slot 8 of the BlackDiamond switch from APS group 1001.

```
config aps 1001 delete 8:1
```

Configuring APS Authentication

The authentication string is used to validate APS control frames received over an Ethernet link. If authentication fails, the associated APS control frame is discarded.

To configure authentication of APS control messages, use the following command:

```
config aps <group#> authenticate [off | on <string>]
```

The group# parameter is an integer in the range from 1 to 65535 that identifies the APS group to which the authentication command applies.

You must also specify whether authentication is to be turned off or turned on. The default setting is off.

If you are enabling authentication, you must also specify a text authentication string of no more than eight alphanumeric characters as part of the command. If the working line and the protection line for an APS group reside in different BlackDiamond switches, the same authentication string must be configured at both BlackDiamond switches; otherwise, authentication will not work.

The following command example enables APS authentication for group 1001, with “seer5dog” as the authentication string.

```
config aps 1001 authenticate on seer5dog
```

Configuring Nonrevertive or Revertive Mode

You can configure the APS action that should be taken when traffic is active on the protection line and the working line becomes operational.

The default switching mode is nonrevertive switching, which means traffic remains on the protection line until either manual intervention or a failure on the protection line forces a switch back to the working line.

If you configure revertive switching mode on an APS group, traffic is switched automatically from the protection line to the working line after the user-defined Wait-To-Restore (WTR) period. The WTR period minimizes frequent switching due to intermittent errors on the working line by restoring service only when no errors are detected on the working line during the WTR period.

NOTE

A longer WTR period provides more protection against frequent switching by waiting to assure that the working line is fully operational, but prolongs the time it takes to restore traffic to the working line after it is fully operational.

To configure APS operation in either nonrevertive or revertive switching mode, use the following command:

```
config aps <group#> [nonrevert | revert <minutes>]
```

The group# parameter is an integer in the range from 1 to 65535 that identifies the APS group to which the configuration command applies.

The minutes parameter is an integer in the range from 0 to 12. If you select revertive switching mode, you must enter a value for minutes.

NOTE

This command applies only to SONET ports performing the protection line function.

The following command example configures APS group 1001 to operate in revertive switching mode, with a WTR of 5 minutes.

```
config aps 1001 revert 5
```

Configuring APS Timers

To set the values of the timers used in the APS hello protocol that is exchanged between the working and protection switches for an APS group, use the following command:

```
config aps <group#> timers <seconds> <consecutive_misses>
```

The group# parameter is an integer in the range from 1 to 65535 that identifies the APS group to which this configuration command applies.

The seconds parameter is an integer in the range from 1 to 300 that specifies the amount of time the protection switch waits between transmissions of hello packets to the working switch. The default value is 1.

The consecutive_misses parameter is an integer in the range from 1 to 100 that controls the time interval the protection switch waits before assuming that the working switch has failed. If the working switch does not respond within consecutive_misses hello intervals, or (consecutive_misses * seconds) seconds, the protection switch assumes that the working switch has failed and initiates a line switch. The default value is 5.

NOTE

In some cases, even if the working switch and working line are both operational, congestion might temporarily slow the response time of the working switch to the point that the protection switch assumes the working switch has failed, causing premature or unnecessary line switches. While setting larger values for seconds *and* consecutive_misses *will protect against premature or unnecessary line switches, they can also delay a line switch when an actual switch failure occurs.*

NOTE

This command applies only to SONET ports performing the protection line function.

The following command example configures the timers for APS group 1001 to 1 second and 3 consecutive misses.

```
config aps 1001 timers 1 3
```

Configuring APS Lockout

You can specify that an APS group operates in lockout mode, which means switches from the working line to the protection line are prohibited until you turn off lockout mode for that APS group. You should use this command when you want to prevent a switchover to the protection line, such as when the protection line is being reprovisioned, repaired, or debugged.

To control whether a switch to the protection line is locked out, use the following command:

```
config aps <group#> lockout [off | on]
```

The group# parameter is an integer in the range from 1 to 65535 that identifies the APS group to which the lockout command applies.

By default, lockout mode is off.

NOTE

This command applies only to SONET ports performing the protection line function. Also, the settings from this command are not preserved when the switch reboots.

The following command example turns on lockout mode for APS group 1001.

```
config aps 1001 lockout on
```

Configuring Forced Switch Mode

You can request that an APS group be forced to use the working line as the active line, or be forced to use the protection line as the active line. Use this command when you plan to perform service on the other link and don't want a switchover to occur.

To request that an APS group be forced to use a specified line as the active line, use the following command:

```
config aps <group#> force [off | working | protection]
```

The group# parameter is an integer in the range from 1 to 65535 that identifies the APS group to which the force command applies.

The off keyword turns off forced switch mode. By default, force switch mode is off.

The working keyword forces the specified APS group to use the working line as the active line. The protection keyword forces the specified APS group to use the protection line as the active line.

A forced switch is a high priority request. Only three events can override a forced switch request:

- A config aps force off command
- A config aps lockout on command (that was either in effect before the force command or issued after the force command)
- A Signal Fail condition detected on the protection line

NOTE

This command applies only to SONET ports performing the protection line function. Also, the settings from this command are not preserved when the switch reboots.

The following command example forces APS group 1001 to use the protection line as the active line:

```
config aps 1001 force protection
```

Configuring Manual Switch Mode

You can manually determine whether an APS group uses its working line as the active line, or uses its protection line as the active line. One potential use of this capability is to perform a manual switch back to the working line after an error condition has cleared without waiting for the full Wait-To-Restore period to elapse.

To manually determine whether an APS group uses its working line or its protection line as the active line, use the following command:

```
config aps <group#> manual [off | working | protection]
```

The `group#` parameter is an integer in the range from 1 to 65535 that identifies the APS group to which the command applies.

The `off` keyword turns off manual switch mode. By default, manual switch mode is off.

The `working` keyword causes the specified APS group to use the working line as the active line. The `protection` keyword causes the specified APS group to use the protection line as the active line.

A manual switch is a lower priority request than a forced switch. The following events can override a manual switch:

- A `config aps manual off` command
- A `config aps force working` or a `config aps force protection` command
- A `config aps lockout on` command
- A detected Signal Fail or Signal Degrade line condition

NOTE

This command applies only to SONET ports performing the protection line function. Also, the settings from this command are not preserved when the switch reboots.

The following command example configures APS group 1001 to use its working line as the active line:

```
config aps 1001 manual working
```

Resetting APS Group Configuration Parameters

To reset the APS group configuration parameters to their default values, use the following command:

```
unconfig aps <group#>
```

The `group#` parameter is an integer in the range from 1 to 65535 that identifies a particular APS group.

NOTE

This command does not affect the ports that have been added to the APS group, but does cancel any outstanding `lockout`, `force`, *or* `switch` *requests.*

The following command example resets the configuration parameters of APS group 1001 to their default values:

```
unconfig aps 1001
```

Displaying APS Group Status Information

To display APS group status information, use the following command:

```
show aps {<group#>} {detail}
```

The optional group# parameter is an integer in the range from 1 to 65535 that identifies a particular APS group for which status is to be shown.

If you enter the show aps command without an argument or keyword, the command displays a summary of status information for all configured APS groups. You can use the detail keyword to display more detailed status information.

Summary status includes the following information for each APS group:

- Provisioned values of all APS configuration parameters, including SONET port numbers and whether the ports are performing the working or protection line function.
- An indication of whether the line associated with each configured port is active or inactive from an APS perspective, along with a timestamp indicating when the last APS state change occurred.
- An indication of whether an error condition currently exists on the line associated with each configured port, along with a timestamp indicating when the last error occurred (errors include Signal Fail and Signal Degrade Events).
- An indication of whether a Signal Fail (SF) or Signal Degrade (SD) Event due to an excessive Bit Error Rate (BER) currently exists on the line associated with each configured port. The BER thresholds that cause SF and SD Events can be specified as part of configuring a SONET port.
- Counts of the number of SF and SD Events initiated by each configured port due to an excessive BER.
- A count of the number of APS Authentication Failures, which is a count of the number of received APS control packets that have been discarded due to authentication failures.

Detailed status includes the information reported in the summary status along with additional status and management counters. Detailed status only applies to ports performing the protection line function.

Detailed management counters reported for each protection-line port include:

- Automatic line switches initiated by the working-line switch, by the protection-line switch, and by the ADM
- Line switches initiated due to external commands, such as through either the config aps <group#> force command or the config aps <group#> manual command)
- Line switches completed successfully
- Hello Protocol failures (this count is included as a component of the counter for automatic line switches initiated by the protection-line switch)
- APS mode mismatch failures, which occur when the ADM indicates that it is provisioned for the 1:n APS architecture, or when the ADM indicates that it is provisioned for unidirectional-switching mode
- Protection switching byte failures, which occur when the received K1 byte is either inconsistent or contains an invalid request code

- Channel mismatch failures, which occur when the channel number in the transmitted K1 byte does not match the channel number in the received K2 byte
- Far-end protection line failures, which occur when a Signal Fail request code is received on the protection line

Additional detailed status information reported for each protection-line port includes:

- Current contents of received K1 and K2 bytes
- Contents of K1 and K2 bytes that are currently being transmitted
- Indication of whether an APS Mode Mismatch Failure is currently active
- Indication of whether a Protection Switching Byte Failure is currently active
- Indication of whether a Channel Mismatch Failure is currently active
- Indication of whether a Far-End Protection Line Failure is currently active

MIB Support for APS

Because no standard MIBs are defined for managing the APS function, Extreme Networks has defined and implemented an enterprise MIB that provides read-only support (GET operations but not SET operations) for APS configuration parameters and status information. Any of the parameters that can be set with the `config aps` commands can be accessed using the MIB, and any of the status information displayed by the `show aps` command can also be read using the MIB. For more information on the MIB, see Appendix B.

Configuring Port Tunneling

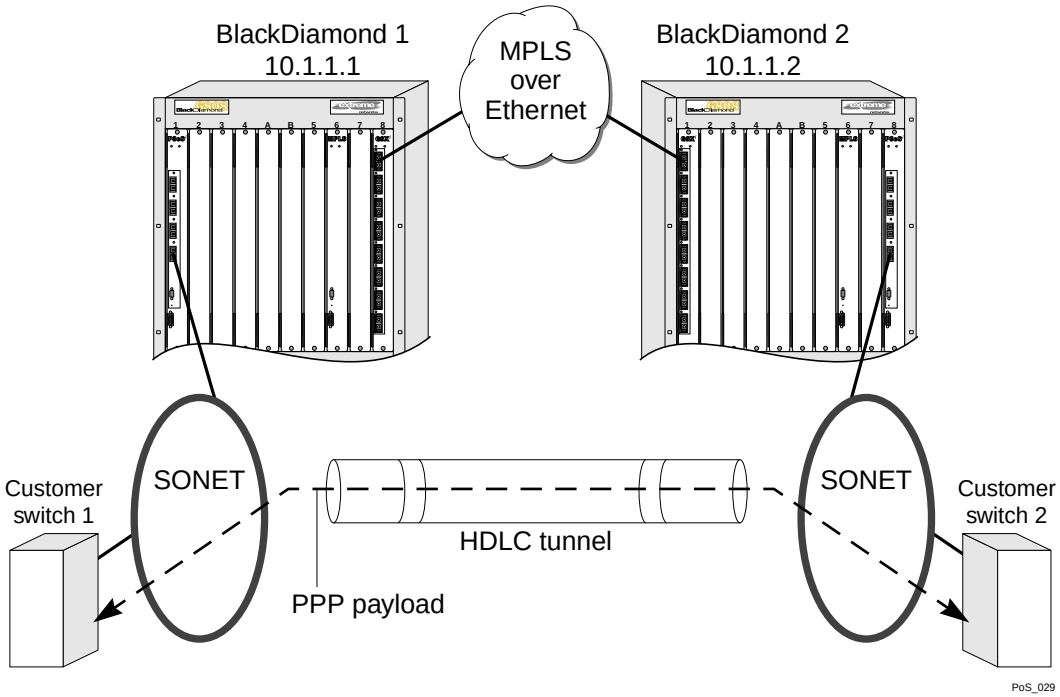
Port tunneling can be used to encapsulate and transport the raw High-Level Data Link Control (HDLC) encapsulated byte stream from one PoS port to another PoS port across an MPLS network. This allows service providers to tunnel different types of SONET HDLC streams across a non-SONET backbone like Ethernet. The initial implementation of port tunneling requires an MPLS backbone network.

The following ExtremeWare port command has been added to support HDLC tunneling on a PoS module:

```
config ports <portlist> tunnel hdlc [off | mpls]
```

After you configure the PoS port, you can tunnel HDLC encapsulated frames from a PoS port across a SONET or Ethernet based MPLS network. The ingress PoS port encapsulates the entire HDLC frame, including the HDLC header and FCS, inside an Ethernet/MPLS header. HDLC control bytes are de-stuffed on the ingress PoS port. The egress PoS port strips the Ethernet/MPLS header and forwards the HDLC frame. HDLC control bytes are stuffed on the egress PoS ports. HDLC idle bytes, x7E, are not tunneled, but runts and aborted frames are tunneled. Figure 101 displays port tunneling between PoS port 1:4 on BlackDiamond switch 1 and PoS port 8:4 on BlackDiamond switch 2 with a PPP link between Customer switch 1 and Customer switch 2. PPP is not terminated on either BlackDiamond switch 1 or BlackDiamond switch 2.

Figure 101: Port tunneling via a PPP link



When you configure a PoS port for HDLC tunneling, make sure PPP is not configured and BCP and IPCP are off. Furthermore, the PoS port should be the only port in the VLAN, and an MPLS tls-tunnel should be configured for this VLAN. For more information about MPLS and MPLS commands, see the *MPLS Installation and User Guide*. The payload inside the HDLC can be PPP or another HDLC encapsulated protocol. SONET Automatic Protection Switching (APS) is supported between tunneled PoS ports on the same module or different modules in the same switch. APS is not supported for tunneled PoS ports on different switches. By default, HDLC tunneling is turned off on PoS ports.

The following sections describe how to configure a port tunnel.

Configuring the PoS Port Tunnel

The following configuration commands apply to the PoS module installed in slot 1 of BlackDiamond switch 1, as shown in Figure 101.

```
config ppp ipcp off port 1:4
config ppp bcp off port 1:4
create vlan customerx
config vlan customerx add port 1:4
config ports 1:4 tunnel hdlc mpls
```

The following configuration commands apply to the PoS module installed in slot 8 of BlackDiamond switch 2, as shown in Figure 101.

```
config ppp ipcp off port 8:4
config ppp bcp off port 8:4
create vlan customerx
config vlan customerx add port 8:4
config ports 8:4 tunnel hdlc mpls
```

NOTE

The PoS port should be the only port in the VLAN.

Configuring the Ethernet Module

The following configuration commands apply to the Ethernet module installed in slot 8 of BlackDiamond switch 1, as shown in Figure 101.

```
create vlan mplsCloud
config vlan mplsCloud add port 8:1
config vlan mplsCloud ipaddress 10.1.1.1/24
enable ipforwarding mplsCloud
config ospf routerid automatic
config ospf add vlan mplsCloud area 0.0.0.0
enable ospf
```

The following configuration commands apply to the Ethernet / MPLS module installed in slot 1 of BlackDiamond switch 2, as shown in Figure 101.

```
create vlan mplsCloud
config vlan mplsCloud add port 1:1
config vlan mplsCloud ipaddress 10.1.1.2/24
enable ipforwarding mplsCloud
config ospf routerid automatic
config ospf add vlan mplsCloud area 0.0.0.0
enable ospf
```

Configuring the MPLS tls-Tunnel

The following configuration commands create an MPLS tls-tunnel between BlackDiamond switch 1 and BlackDiamond switch 2, as shown in Figure 101.

```
config mpls add vlan mplsCloud
config mpls add tls-tunnel BD2 10.1.1.2 customerX tls-labels 8F100 8F200
enable mpls
```

The following configuration commands create an MPLS tls-tunnel between BlackDiamond switch 2 and BlackDiamond switch 1, as shown in Figure 101.

```
config mpls add vlan mplsCloud
config mpls add tls-tunnel BD1 10.1.1.1 customerX tls-labels 8F200 8F100
enable mpls
```

Limitations and Unsupported Commands

This section describes additional command and configuration information related to the use of the PoS modules. This section includes information on the following topics:

- Configuring General Switch Attributes on page 496
- PoS Module Limitations on page 496
- Configuring Port Attributes on page 496

- Configuring Access List Attributes on page 498
- Configuring Access List Attributes on page 498
- Configuring Access List Attributes on page 498
- Changing Image and Configuration Attributes on page 498

Configuring General Switch Attributes

The PoS module supports all of the general ExtremeWare switch commands.

PoS Module Limitations

The following limitations apply to PoS modules:

- EAPS, ESRP, VRRP, and GVRP are not supported on SONET interfaces
- Protocol and MAC-based VLANs are not supported on SONET interfaces
- EMISTP and PVSTP are not supported over SONET interfaces
- No ISIS support over ATM IP PVCs
- PoS/ATM bridging is not compatible with MPLS/ARM when two MSMs are installed

Configuring Port Attributes

The following ExtremeWare port commands are not supported for the PoS module:

- `show ports {<portlist>} collisions`
- `config ports <portlist> auto off {speed [10 | 100 | 1000]} duplex [half | full]`
- `config ports <portlist> auto on`
- `enable smartredundancy <portlist>`
- `enable sharing <port> grouping <portlist> {port-based | address-based | round-robin}`
- `enable mirroring to <port>`
- `disable learning ports <portlist>`
- `config mirroring add [vlan <vlan name> | port <port> | vlan <vlan name> ports <portlist>]`

Jumbo Frame Support

The Extreme Networks implementation of PPP supports the Link Control Protocol (LCP) maximum receive unit (MRU) option, which specifies the maximum number of octets that a PPP information field can contain and still be received successfully. In the Extreme Networks implementation, the advertised MRU size depends mainly on two factors:

- Whether IPCP or BCP is enabled on the PoS port
- Whether jumbo frame support is enabled on the PoS port

If IPCP is configured on the port and jumbo frame support is not enabled, the Extreme Networks implementation of PPP advertises an MRU of 1500 octets and requires that the peer have an MRU of at least 1500 octets.

If BCP is configured on the port and jumbo frame support is not enabled, the advertised MRU is 24 octets larger than in the corresponding IPCP case. The additional octets are needed to accommodate the larger frame size associated with the bridged format, which includes the MAC header. If VLAN tags are to be transmitted, the peer's MRU must be at least 1520 octets; otherwise, the peer's MRU must be a minimum of 1516 octets.

If IPCP is configured on the port and jumbo frame support is enabled on the port, the advertised MRU size in octets is calculated using the following formula:

(configured jumbo frame MTU – 22)

and the peer is also required to have an MRU at least this large.

If BCP is configured on the port and jumbo frame support is enabled on the port, the peer's MRU must be (configured jumbo frame MTU – 6) octets at a minimum, and at least (configured jumbo frame MTU – 2) octets if VLAN tags are to be transmitted.

Consider these factors when configuring jumbo frame support on a PoS port:

- Because the jumbo frame MTU setting affects the PPP MRU setting of the PoS port and the peer, changing the jumbo frame MTU setting can have the following results:
  - Temporary disruption of the logical connection because the Link Control Protocol might need to terminate the logical connection and then re-establish it with larger MRU sizes.
  - Longer term disruption of the logical connection because of the requirement that the logical connection can only be established when (a) jumbo frame support is enabled on the peer PoS port, and (b) the same jumbo frame MTU size must be configured on both ends of the logical connection when the peer is also a BlackDiamond switch.
- When the jumbo frame size is changed from a value of 8191 or less to a value greater than 8192, any PoS modules that have ports with jumbo frame support enabled must be rebooted for the change to take effect.
- The peer MRU is always allowed to be greater than or equal to the MRU size of the local port.
- Fragmentation and path MTU discovery is performed, but is based on checking the peer's MRU in conjunction with the IP MTU configured for the egress VLAN (which can be set using the `config ip-mtu <number> vlan <vlan name>` command), rather than the jumbo frame MTU setting.

For more information on the ExtremeWare jumbo frame commands, see Chapter 4.

Configuring Access List Attributes

For more information on the ExtremeWare access list commands, see Chapter 11.

NOTE

On the OC-3 PoS module, the access list functions apply to port pairs, where ports 1 and 2 are a pair, and ports 3 and 4 are a pair. This pairing scheme means that the ports in a given pair share the same access lists: ports 1 and 2 share the same lists, while ports 3 and 4 share their access lists. For example, if an access list is configured for port 1, that access list also applies to port 2, and vice versa. This restriction does not apply to the OC-12 PoS module.

Changing Image and Configuration Attributes

The PoS module supports all of the ExtremeWare commands associated with managing image and configuration attributes. For more information about these commands and operations, see Appendix A.

24 T1, E1, and T3 WAN Modules

This chapter describes the T1, E1, and T3 features that can be configured in the ExtremeWare. It covers the following topics:

- Overview on page 499
- Configuring WAN Physical Links on page 500
- Monitoring WAN Physical Links on page 503
- Configuring PPP and MLPPP on page 507
- WAN Multilink Configuration Examples on page 510
- VLAN Tunneling (VMANs) on page 512

Overview

In this document, WAN refers to either T1, E1, or T3 technologies. T1 is a mature technology originally developed for voice telephone transmission. It was used to aggregate a number of voice lines into a single connection to the telephone network. Today, T1 is also used to transmit digital data using widely available equipment and established wiring commonly available in diverse locations.

A similar technology standard is in use in Europe, namely E1. T1 and E1 are similar, but not identical.

Higher bandwidth characterizes T3 connections. Essentially, a T3 connection is equivalent to a bundle of 28 T1 connections. Extreme Networks support unchannelized T3 only.

Red, Blue, and Yellow Alarms

WAN links have error detection built into the link hardware. The hardware can detect different types of errors, labeled red, blue and yellow alarms.

A red alarm occurs when the signal is lost or an out of frame error occurs. An out of frame error can be caused when the framing type configured for the local interface does not match the framing type of the incoming signal or when the incoming signal does not contain a framing pattern.

A yellow alarm is also called a Remote Alarm Indication (RAI). When the remote end of a link does not receive a signal, it will transmit a yellow alarm signal back to the local end.

A blue alarm is also called an Alarm Indication Signal (AIS). A blue alarm indicates that a device somewhere upstream has experienced a loss of signal.

Alarms affecting a link can be viewed by using one of the show commands, for example, `show ports t1 alarms`.

Configuring WAN Physical Links

There are a number of parameters that can be configured for a WAN link. If you have control of both sides of the link, then the default configuration is probably the best choice. If you must connect to a line controlled by another organization, you will need to configure the line to correspond with the settings at the other end. Some parameters are only configurable, or only apply to some of the WAN link types. The following list of parameters also displays which types of WAN links allow you to configure that parameter:

- Cable Length (T1, T3)
- Clock Source (T1, E1, T3)
- Facility Data Link (T1)
- Framing (T1, E1, T3)
- Inband Loopback Detection (T1)
- Linecoding (T1)
- Receiver Gain (E1)
- SNMP Alerts (T1, E1, T3)
- Timeslots (E1)
- Yellow Alarms (T1)

Cable Length

Longer cable lengths cause greater losses for signals, so transmitter hardware must transmit at a higher level to transmit data successfully. However, too high a signal level can cause crosstalk from one cable to another. The cablelength parameter allows you to control the transmitter signal level for your conditions. Typically, your service provider will suggest the correct level.

The parameter values available differ for T1 and T3 links. For E1, the parameter value is not changeable, but is always set to 120 Ohms. However, for E1 links you can configure the receiver gain to meet your conditions. See “Receiver Gain” on page 502.

For short haul connections (less than 1000 feet) the typical equipment uses less sensitive receivers. The transmitter level for T1 is set by selecting a cable length in feet, from the following values: 133, 266, 399, 533 or 655. For T3, select from the following values: 249 or 900. Choose the next higher value if the cable length provided by your service provider does not match one of these values. For example, choose 133 for a 50 foot cable and 533 for a 450 foot cable. The default value is 133, which corresponds to cables in the range of 0-133 feet.

For longer distances (up to 6000 feet) T1 equipment uses more sensitive receivers, and crosstalk is more likely to occur. Under these conditions, the transmitter level is set by selecting a transmitter attenuation level in dB from the following values: -22.5, -15, -7.5, or 0.

From lowest to highest transmitter level, use the following values for the `config port t1 cablelength` command: -22.5 db, -15 db, -7.5 db, 0 db, 133 feet, 266 feet, 399 feet, 533 feet, and 655 feet.

To configure the cable length, use one of the following commands:

```
config ports <portlist> t1 cablelength [0 | -7.5 | -15 | -22.5] db
config ports <portlist> t1 cablelength [133 | 266 | 399 | 533 | 655] feet
config ports <portlist> t3 cablelength [249 | 900] feet
```

Clock Source

A clock is used to synchronize data transmission on the line. Generally, one end of the link provides the master clock, and the other end of the link recovers the clock from the signal on the line. By default the clock source is derived from the line. If needed, an internal clock is available. To configure the clock source, use the following command:

```
config ports <portlist> [t1 | e1 | t3] clocksource [internal | line]
```

NOTE

If the clock source is configured as "line", but the clock cannot be recovered from the signal on the line, the hardware will use the internal clock instead.

Facility Data Link

Facility data link (FDL) for T1 links uses twelve bits in the ESF frame to signal information about line and connection status. Since FDL is only meaningful for ESF framing, FDL settings are ignored when a port is configured for SF framing. See "Inband Loopback Detection" for information on configuring framing.

The two T1 standards supported for FDL are ATT, described by the ATT 54016 specification, and ANSI, described by the T1.403 standard. The default value is off. To configure FDL, use the following command:

```
config ports <portlist> t1 fdl [off | att | ansi]
```

Framing

Framing is used to synchronize data transmission on the line. Framing allows the hardware to determine when each packet starts and ends. The two choices for T1 framing are Super Frame (SF), also known as D4, and Extended Super Frame (ESF). The ESF scheme is a newer standard and is enabled by default. To choose the T1 framing scheme, use the following command:

```
config ports <portlist> t1 framing [esf | sf]
```

If you choose to use SF framing, you should disable yellow alarm detection for the T1 line. SF framing may generate false yellow alarms. See "Yellow Alarms" on page 503 for more details.

The framing choices for E1 are CRC4 or no-CRC4. To choose the E1 framing scheme, use the following command:

```
config ports <portlist> e1 framing [crc4 | no-crc4]
```

The framing choices for T3 are C-bit and M13. To choose the T3 framing scheme, use the following command:

```
config ports <portlist> t3 framing [c-bit | m13]
```

Inband Loopback Detection

When inband loopback detection is enabled, a specific sequence of data in the signal payload from the remote end of the T1 link will cause the local end to enter network line loopback mode and send any received signal back to the remote end. Inband loopback detection is only possible if the FDL standard is configured as ATT. See “Facility Data Link” on page 501 for more details. By default, inband loopback detection is off. See “Loopback” on page 503 for more information about loopback modes. To configure inband loopback detection, use the following command:

```
config ports <portlist> t1 lbdetect [off | inband]
```

Linecoding

Linecoding is the convention used to encode signals for transmission over the line.

For T1 connections you can choose from two linecoding standards, bipolar eight zero suppression (B8ZS) or alternate mark inversion (AMI). The default value is B8ZS. To configure linecoding, use the following command:

```
config ports <portlist> t1 linecoding [b8zs | ami]
```

Receiver Gain

The receiver gain for E1 links can be configured to improve performanance of the link. Changing the receiver gain can help to receive the E1 signal or to reduce crosstalk. Receiver gain is only configurable for E1 links. To configure receiver gain, use the following command:

```
config ports <portlist> e1 receivergain [-12 | -43] db
```

SNMP Alerts

If the WAN module hardware detects a red, yellow, or blue alarm, the alarms are displayed by using a show command. Additionally, the module can be configured to send an SNMP alert to the SMMi in the switch when red, yellow, or blue alarms are detected. If the module is configured to send SNMP alerts, and the switch is configured to send SNMP trap messages, then the switch will send a message to any SNMP trap receivers that have been configured. To configure SNMP trap receivers, and for more information about configuring SNMP in ExtremeWare, see the *ExtremeWare Software User Guide.*

The module can also be configured not to send an SNMP alert to the SMMi. Any red, yellow, or blue alarms will not be reported to the SNMP trap receivers. The default value for SNMP alerts is enabled. To configure whether SNMP alerts are generated from WAN alarms, use the following command:

```
config ports <portlist> [t1 | e1 | t3] snmp alert [enable | disable]
```

Timeslots

The E1 signal is divided into thirty-two timeslots, numbered 0 through 31. The first timeslot (0) is reserved and cannot be used to transmit data. The timeslot numbered 16 is often used for voice phone calls in installations that combine voice and data. For installations that use the full E1 bandwith for data communications, you will not need to configure which timeslots are used. For installations that do not use the total E1 bandwith, your E1 provider will tell you which timeslots to use.

To configure which timeslots to use for your E1 link, use the following command:

```
config ports <portlist> e1 timeslots <timeslots>
```

A timeslot list uses a dash to represent a range of numbers and a comma to separate single numbers or ranges. Valid timeslots range from 1 to 31. For example, to specify timeslots 1 through 15 and 17 through 31 for the E1 port 1 on slot 4, use the following command:

```
config ports 4:1 e1 timeslots 1-15,17-31
```

Yellow Alarms

A yellow alarm occurs on a device when its signal is not received at the remote end. It is also called a Remote Alarm Indication (RAI). You can disable detection and generation of yellow alarms for a T1 port. When SF framing is used, yellow alarm detection and generation should be set to off, because detection of yellow alarms is not reliable when data traffic is transmitted with SF framing (data traffic often contains bit combinations that do not occur for encoded voice traffic). The default value for yellow alarm generation and detection is both. To configure yellow alarms, use the following command:

```
config ports <portlist> t1 yellow [detection | generation | both | off]
```

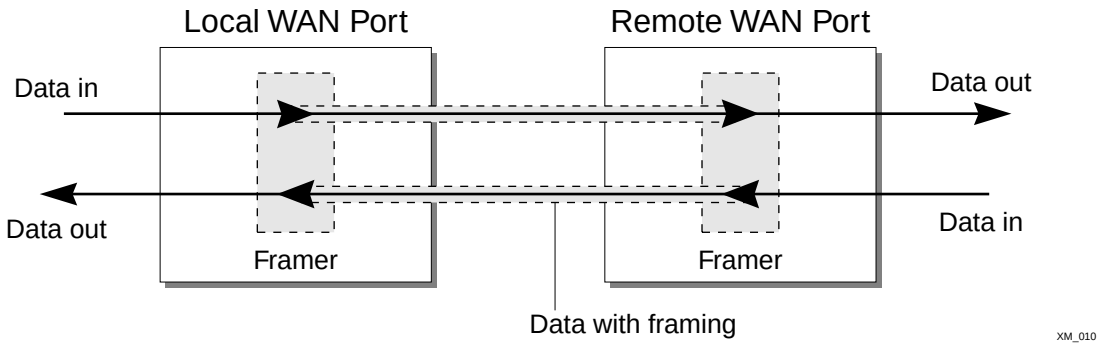
Monitoring WAN Physical Links

T1, E1, and T3 devices have a built-in facility designed for troubleshooting the physical link, called loopback. The link can also be monitored using show commands to display the current configuration of the link, any alarms on the link, link statistics, and link errors.

Loopback

The WAN device can be set up to loopback, that is, return a transmitted signal back to the sender so it can be compared with the original. There are several different types of loopback available to test different parts of the device and the line, as specified in the T1, E1, and T3 standards.

Figure 102: Normal operation of WAN link



During normal operation of a link, as the local data stream enters the framer, the appropriate framing bits are inserted into the data, and the framed signal is transmitted to the remote end. At the remote end, the process is reversed as the framing bits are discarded and the data stream is passed to the remote system.

Loopback can be enabled on the near-end of a WAN link, but only the T1 and T3 modules can enable loopback on the far-end of a link. The near-end loopback modes are controlled directly by the hardware on the near-end. Far-end loopback modes require the cooperation of the far-end hardware. A message is sent to the far-end to cause it to enter a far-end loopback mode. When loopback is enabled on a WAN port, the green port LED will blink.

Near-end Loopback Modes

The near-end of T1 links can be enabled for the following three loopback modes:

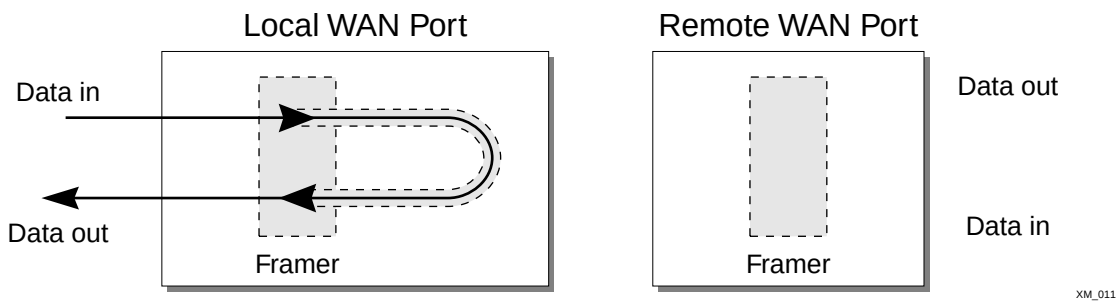
- Local
- Network Line
- Network Payload

The near-end of E1 and T3 links can be enabled for the following two loopback modes:

- Local
- Network Line

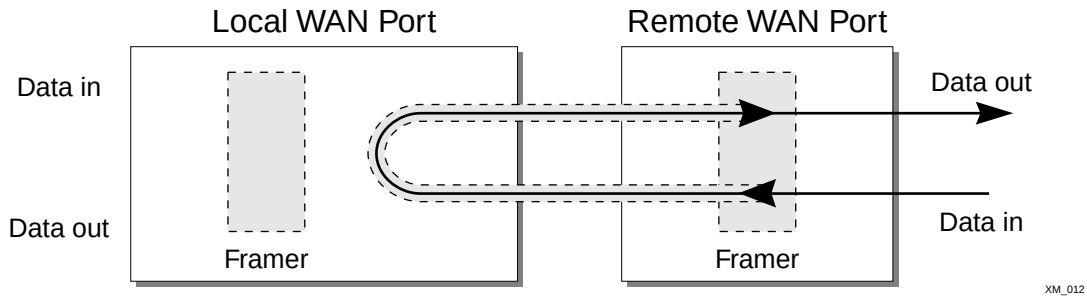
The local loopback mode reflects the data stream internally to the near-end. The network line loopback mode reflects the signal to the far-end. The network payload mode reflects the data carried in the signal and regenerates framing information back to the far-end.

Figure 103: Local loopback mode



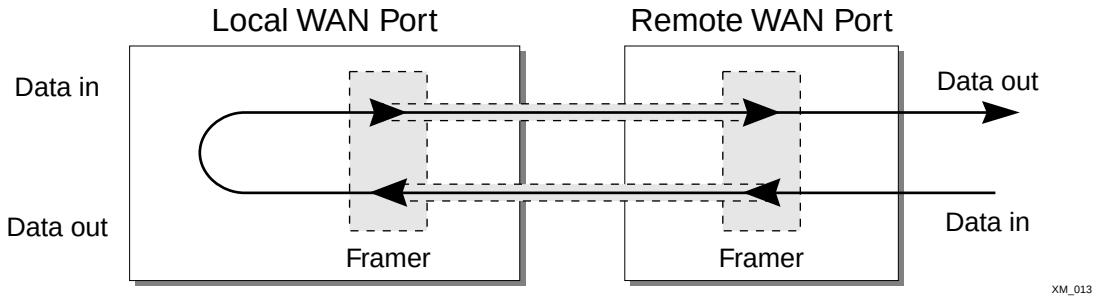
Local Loopback Mode. When the local port is enabled for local loopback, the local data stream goes into the framer and the framing bits are inserted into the data, but the data is not transmitted to the remote end. Instead, it is sent back through the local framer, the framing bits are discarded, and the original data is returned. This mode tests the local end.

Figure 104: Network line loopback mode



Network Line Loopback Mode. When the local port is enabled for network line loopback mode, the received signal is sent back to the remote end without reframing the data. This mode primarily tests the integrity of the line from the remote side.

Figure 105: Network payload loopback mode



Network Payload Loopback Mode. When the local port is enabled for network payload mode, the framer removes the framing bits from the received signal and recovers the transmitted data. This same data is then reframed and transmitted back to the remote end. This mode tests the line and the local circuitry from the remote side.

Far-End Loopback Modes

The far-end of T1 links can be enabled for the following two loopback modes:

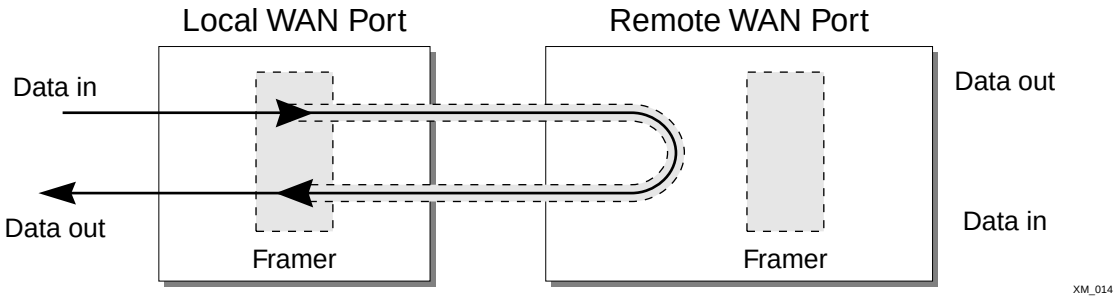
- Remote Line
- Remote Payload

The far-end of T3 links can be enabled for the following loopback mode:

- Remote Line

The remote line mode reflects the received signal back to the near-end. The remote payload mode reflects the data and regenerates the framing information back to the near-end.

Figure 106: Remote line loopback mode

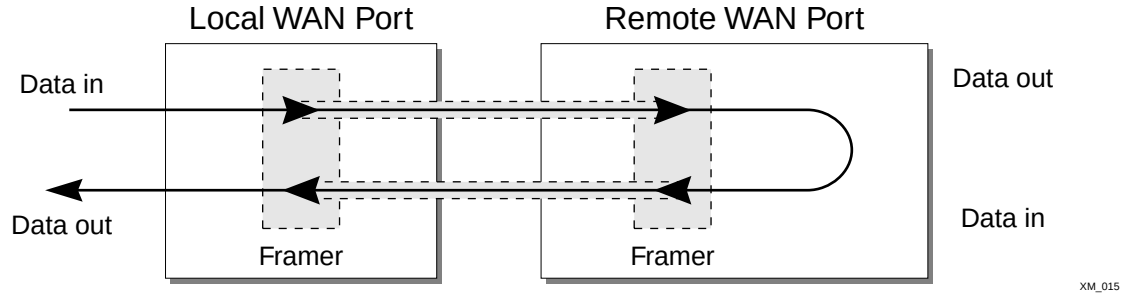


Remote Line Loopback Mode. When the local port is enabled for remote line loopback mode, it sends a request to the remote end to enter the equivalent of network line loopback mode. The signal transmitted to the remote end will be retransmitted as received back to the local end.

NOTE

If the T1 line is configured to use the ATT FDL standard, the remote end must be configured to detect inband loopback requests for the remote end to enter remote line loopback mode.

Figure 107: Remote payload loopback mode



Remote Payload Loopback Mode. When the local port is enabled for remote payload loopback mode, it sends a request to the remote end to enter the equivalent of network payload loopback mode. When the remote end enters loopback mode, the framer at the remote end removes the framing bits from the received signal and recovers the transmitted data. This same data is then reframed and transmitted back to the local end.

Enabling Loopback Mode

To enable a local loopback mode, use one of the following commands:

```
enable ports <portlist> [t1 | e1 |t3] loopback [local | network line]
enable ports <portlist> t1 loopback network payload
```

To enable a remote loopback mode, use one of the following commands:

```
enable ports <portlist> t1 loopback remote [line | payload]
enable ports <portlist> t3 loopback remote line
```

Disabling Loopback Mode

Use the following command to return the near and remote side of a T1, E1 or T3 link from loopback mode to normal mode:

```
disable ports <portlist> [t1 | e1 | t3] loopback
```

You can also use the following command to return the remote T1 or T3 port to normal function from loopback mode:

```
enable ports <portlist> [t1 | t3] loopback remote loopdown
```

Configuring PPP and MLPPP

Point-to-Point Protocol (PPP) is used across the entire range of communication speeds and devices found on the internet. Typically, PPP uses Layer 3 to connect two broadcast networks, say two Ethernet LANs, into a single WAN by transporting IP packets over a link. PPP can also use Layer 2 to bridge VLAN traffic.

Multilink PPP (MLPPP) is a protocol for combining a number of PPP links into one bundle that transports traffic over the links in the bundle. Multilink PPP is supported for T1 and E1 technologies in ExtremeWare, but not for T3. Instead, a T3 link is configured as a single PPP link.

A multilink group is a bundle of individual PPP links that are configured to work together as a single link. With a multilink group configured, it is easy to add or remove PPP links in order to provide appropriate bandwidth. The multilink group balances traffic among the individual PPP links and properly sequences packets across the multilink group.

Typically, you would create a multilink group, configure the multilink group by adding T1 or E1 ports and configuring PPP/MLPPP parameters, add the multilink group to a VLAN, and finally, enable the multilink group.

For a T3 port, you would configure its PPP parameters and add it to a VLAN.

This section covers the following topics:

- Multilink PPP and Multilink Groups on page 508
- Configuring a PPP/MLPPP Link on page 508

Multilink PPP and Multilink Groups

Each multilink PPP group is given a name, up to 16 characters in length. All named components of the switch configuration must have unique names, so multilink groups and VLANs cannot have identical names. See the *ExtremeWare Software User Guide* for more information on allowable names for named components. Components are named using the `create` command. Once a component is named, you do not need to use the keyword for the component (see the shortcut below).

Create the multilink group using the following command:

```
create multilink <groupname>
```

Once the multilink group is created, assign ports to it. All T1/E1 ports must be added as tagged ports. If the ports are configured as IPCP ports, then the tags will be stripped as traffic passes over the link. BCP-configured ports will pass the tag across the link. See the section “Encapsulation” for more information. Add ports by using the following command:

```
config multilink <groupname> add ports <portlist> tag
```

or you can use the following shortcut:

```
config <groupname> add ports <portlist> tag
```

If the first port added to a multilink group is already configured for PPP, the multilink group will inherit the configuration of the first port. Any other ports added to the link will be configured to match the multilink configuration. The next section lists the configuration commands for multilink groups and single PPP links.

Once the multilink group has been configured, it is added to a VLAN so that it can pass traffic from the VLAN across the link. To add a multilink group to a VLAN, use the following command:

```
config vlan <vlan name> add multilink <groupname>
```

Typically the last step in configuring a multilink group is to use the following command to enable it:

```
enable multilink <groupname>
```

Any changes to an enabled multilink group will not take effect until the multilink group is restarted. To restart a multilink group, use the following command:

```
restart multilink <groupname>
```

Configuring a PPP/MLPPP Link

All of the PPP configuration commands can be used to configure a single port or to configure a multilink group, so the following sections for PPP links also apply to MLPPP links. To configure a PPP/MLPPP link you will need to choose the authentication and encapsulation for the link.

If you change the configuration of an enabled PPP or MLPPP link, the changes will not take effect until the link is restarted. To restart a PPP link, use the following command:

```
restart ports <portlist>
```

To restart an MLPPP link, use the following command:

```
restart multilink <groupname>
```

Authentication

By default, no authentication is configured on PPP links since the WM-4T1i module will typically be used with leased lines—where both sides of the link are controlled and authentification is not required. If authentication is needed, the WM-4T1i module supports either PAP or CHAP. Password authentication protocol (PAP) authenticates a user as the connection is established by sending a username and password. Challenge Handshake Authentication Protocol (CHAP) authenticates a user by sending a challenge across the link. The remote end calculates a response based on the user password and sends the response back across the link. CHAP is a more secure authentication protocol than PAP. The link can also be configured to attempt to use CHAP first, followed by PAP, if CHAP fails.

To configure authentication on a PPP link, use the following command:

```
config ppp authentication [off | chap | pap | chap-pap] [ports <portlist> | multilink
<groupname>]
```

PPP Link Username. When the local end of a link initiates a PPP connection, the local end must send the appropriate authentication information. For PAP it sends the username and password, for CHAP it sends the username and must respond correctly to the challenge, and for no authentication it sends nothing. To configure the username and password used to initiate the link, use the following command:

```
config ppp user <username> {encrypted} <password> [ports <portlist> | multilink
<groupname>]
```

The encrypted keyword is used to hide the password when the switch configuration is displayed; it does not control whether the password is encrypted across the link during authentication.

PPP User Accounts. When the remote end initiates the link, the local end must verify the authentication information. The local end maintains a list of authorized user accounts and passwords. To add a user to the list, use the following command:

```
create account pppuser <name> {encrypted} {<password>}
```

Encapsulation

The packets passed over the PPP/MLPPP link can use either bridged or routed encapsulation. You would use bridged packets if you plan to have VLANs span the link. You would use routed packets if the link connects two different routed networks or separate VLANs.

Using bridged packets allows the VLAN tags to be carried across the PPP/MLPPP link. Bridged packets are transported using the PPP Bridging Control Protocol (BCP), described in RFC 2878, except in the case of Legacy BCP, described below. When the encapsulation is set to BCP, 802.1Q and 802.1p information is preserved and transported across the link. On a WAN module, a VLAN may only contain one BCP encapsulated link, but you may have multiple VLANs span the link.

Routed packets are transported across a PPP/MLPPP link using IP Control Protocol (IPCP), described in RFC 1332. This is the encapsulation that is familiar to most users of PPP. The routed packets do not contain Ethernet headers so cannot preserve VLAN tags. However, the WAN ports still must be added as tagged ports to the VLAN that contains them. The module uses the tags internally and strips them off before the packets are transmitted. The IP addresses used for the PPP/MLPPP link are taken from the IP address assigned to the VLAN at each end of the link. The VLAN that contains the IPCP encapsulated PPP/MLPPP ports cannot contain other ports. In other words, the only ports allowed in the VLAN are those that make up the IPCP encapsulated link. There can only be one VLAN spanning an IPCP-encapsulated link.

You must have one and only one encapsulation type configured on a PPP/MLPPP link. Setting BCP encapsulation off implies that IPCP encapsulation is on. The default setting is BCP encapsulation on and IPCP encapsulation off. To configure encapsulation, use the following command:

```
config ppp [bcp [on | off] | ipcp [on | off]] [ports <portlist> | multilink
<groupname>]
```

Legacy BCP. Some routers supported by other vendors implemented BCP using an older standard, RFC 1638. For interoperability, the Extreme Networks implementation supports both standards. The limitation with RFC 1638-based BCP is that 802.1Q tags are not supported. So Legacy BCP cannot support multiple VLANs or preserve 802.1p priority across the PPP link. Both types of BCP can operate over single and multilink PPP.

When BCP is negotiated over a link, RFC 2878 BCP is initially proposed. If the peer only supports Legacy BCP (RFC 1638), then the link is made using Legacy BCP. Since the WAN module ports are always configured as tagged ports, the VLAN tag is removed in the egress direction and inserted in the egress direction when BCP is operating in Legacy mode.

There is no Legacy BCP specific configuration, and the display for the command `show ppp info` is identical for BCP and Legacy BCP. To determine if the link is using Legacy BCP, use the following command:

```
show log warning
```

and look for the message:

```
BCP: Legacy BCP UP;Only a single VLAN over BCP is supported
```

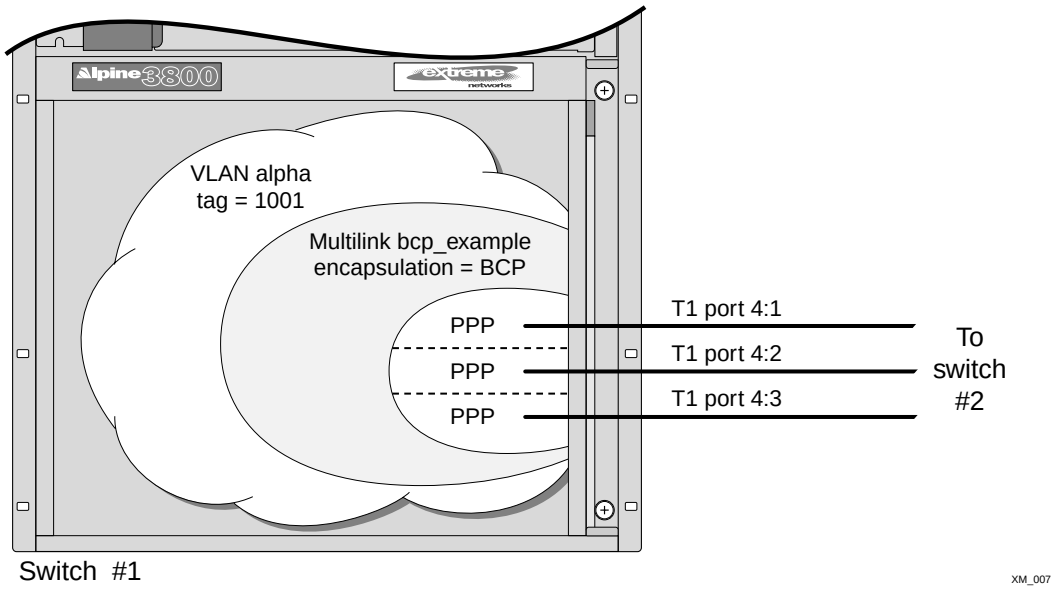
WAN Multilink Configuration Examples

The following examples show how to configure WAN links with multilink groups.

Configuring a Bridged PPP/MLPPP Link Example

The following example shows how to configure a BCP-encapsulated multilink group. BCP is the default encapsulation, so it is not explicitly included in this example. While only one VLAN is shown in this example, you may configure multiple VLANs across the link. The `config ports t1 clocksource` command is included to show where you might need to configure the T1 parameters for your link. Each T1 port in the multilink group will have the same T1 and PPP configurations. If you change the configuration for a single port, the change will affect the entire group.

Figure 108: BCP multilink example

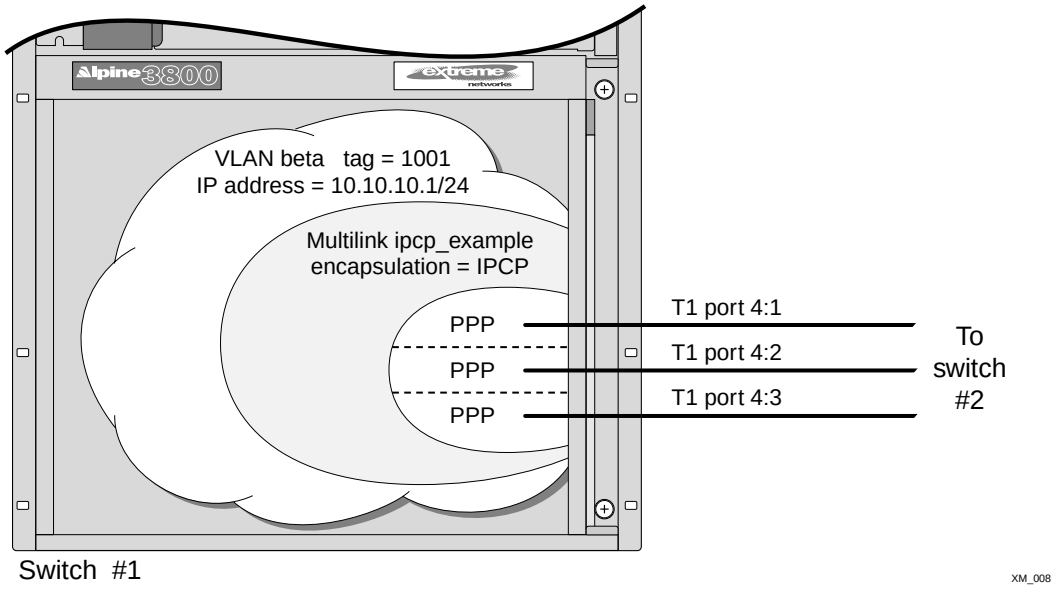



```
create vlan alpha
config alpha tag 1001
create multilink bcp_example
config ports 4:1-4:3 t1 clocksource internal
config bcp_example add ports 4:1-4:3 tag
config alpha add multilink bcp_example
enable bcp_example
```

Configuring a Routed PPP/MLPPP Link Example

The following example shows how to configure a IPCP-encapsulated multilink group. The VLAN that contains the IPCP-encapsulated multilink group cannot contain any other ports, and only one VLAN is allowed across the link. Notice that the T1 ports must be added as tagged ports even though the tag will be removed before the packet is transmitted over this link.

Figure 109: IPCP multilink example




```
create vlan beta
config beta tag 1001
config beta ipaddress 10.10.10.1/24
create multilink ipcp_example
config ipcp_example add ports 4:1-4:3 tag
config ppp ipcp on ports 4:1-4:3
config beta add multilink ipcp_example
enable ipcp_example
```

VLAN Tunneling (VMANs)

The procedure for creating VMANs over Ethernet links is described in Chapter 5, “Virtual LANs (VLANs)”. Here is the procedure from Chapter 5:

To configure a VMAN tunnel, follow these steps:

1. Modify the 802.1Q Ethertype the switch uses to recognize tagged frames. Extreme Networks recommends the use of IEEE registered Ethertype 0x88a8 for deploying vMANs. (You will need to reboot the switch after modifying the 802.1Q Ethertype.)
2. Configure the switch to accept larger MTU size frames (jumbo frames).
3. Create tunnels by creating VLANs and configuring member ports as tagged on switch-to-switch ports and untagged on the ingress/egress or termination ports of the tunnel.

However, some of the commands needed for the steps are different for the WAN ports. For WAN links, PPP is used to transport the packets, so an additional command, `config ppp mru`, is used for step 2 to allow the larger frame sizes to be transported. For step 3, the command, `enable vman termination`, is used for the ingress/egress ports to allow untagged packets to enter and leave the ports. In general, WAN ports are tagged ports, but for this special VMAN termination usage, the ports deliver unencapsulated packets (the WAN ports are still added as tagged ports in the CLI).

The PPP type must be set to BCP, not IPCP, but this is not shown in the examples since BCP is the default. PPP also adds some overhead to the packets, therefore the PPP MRU size is set to a higher value than the Ethernet jumbo frame size. For multilink groups, the overhead is six bytes. For single PPP links, the overhead is two bytes.

There are two cases to consider: VMAN tunnels transported switch-to-switch across a WAN link and WAN ports as ingress/egress ports of a tunnel.

NOTE

When you modify the 802.1Q Ethertype, you must reboot the switch for the change to take effect.

VMAN Transport by WAN Links

VMAN transport refers to a port that transports one or more VMAN tunnels across a link. Typically, you would configure a group of T1 or E1 ports as a multilink group for VMAN transport. A T3 link cannot be configured as a multilink group, so the second example below must be used for a T3 link.

In the two following examples, the WAN ports act as a trunk to transport the tunnels, while the Ethernet ports act as ingress/egress ports to the VMAN tunnel.

Multilink VMAN Transport Example

In this first example, the WAN ports 1:1 and 1:2 are configured as the multilink group *link1*, used to transport the two VMAN tunnel VLANS *tunnel1* and *tunnel2* across the VMAN cloud, while the Ethernet ports 2:1-2:2 deliver untagged *tunnel1* VLAN packets and Ethernet ports 2:3-2:4 deliver untagged *tunnel2* VLAN packets.

```
config dot1q ethertype 88a8
enable jumbo-frame ports 1:1-1:2
config jumbo-frame size 1530
create multilink link1
config multilink link1 ports 1:1-1:2
config ppp mru 1536 multilink link1
create vlan tunnel1
config vlan tunnel1 tag 50
config vlan tunnel1 add multilink link1 tagged
create vlan tunnel2
config vlan tunnel2 tag 60
config vlan tunnel2 add multilink link1 tagged

config vlan tunnel1 add port 2:1-2:2 untag
config vlan tunnel2 add port 2:3-2:4 untag
```

Single PPP Link VMAN Transport

In this second example, the WAN port 1:1 is used like the multilink group in the first example to transport the two VMAN tunnel VLANs *tunnel1* and *tunnel2* across the VMAN cloud, while the Ethernet ports 2:1-2:2 deliver untagged *tunnel1* VLAN packets and Ethernet ports 2:3-2:4 deliver untagged *tunnel2* VLAN packets.

```
config dot1q ethertype 88a8
enable jumbo-frame ports 1:1
```

```
config jumbo-frame size 1530
config ppp mru 1532 1:1
create vlan tunnel1
config vlan tunnel1 tag 50
config vlan tunnel1 add port 1:1 tagged
create vlan tunnel2
config vlan tunnel2 tag 60
config vlan tunnel2 add port 1:1 tagged

config vlan tunnel1 add port 2:1-2:2 untag
config vlan tunnel2 add port 2:3-2:4 untag
```

VMAN Termination at WAN ports

VMAN termination is the VMAN tunnel ingress/egress port that delivers the VLAN packets. You can configure a group of T1 or E1 ports as a multilink group for VMAN termination, or a single port can act as the ingress/egress port for the tunnel. A T3 link cannot be configured as a multilink group, so the second example below must be used for a T3 link.

Opposite to the previous two examples, for the next two examples, the Ethernet ports act as a trunk to transport the tunnels, while the WAN ports act as ingress/egress ports to the VMAN tunnel.

Multilink VMAN Termination

In this first example, the WAN ports 1:1 and 1:2 are configured as the multilink group *link1*, used to terminate the VMAN tunnel VLAN *tunnel1*. Ports 1:3 and 1:4 are configured as the multilink group *link2* to terminate the VMAN tunnel VLAN *tunnel2*. The Ethernet ports 2:1-2:2 provide the tunnel transport across the VMAN cloud.

```
config dot1q ethertype 88a8
enable jumbo-frame ports 2:1-2:2
config jumbo-frame size 1530
create vlan tunnel1
config vlan tunnel1 tag 50
config vlan tunnel1 add port 2:1-2:2 tagged
create vlan tunnel2
config vlan tunnel2 tag 60
config vlan tunnel2 add port 2:1-2:2 tagged

create multilink link1
config multilink link1 add ports 1:1-1:2
enable vman termination multilink link1
config dot1q ethertype 8100 link1
config vlan tunnel1 add multilink link1
create multilink link2
config multilink link1 add ports 1:3-1:4
enable vman termination multilink link2
config dot1q ethertype 8100 link1
config vlan tunnel2 add multilink link2
```

Single PPP Link VMAN Termination

In this second example, the WAN port 1:1 is configured as a single PPP link, used to terminate the VMAN tunnel VLAN *tunnel1*. Port 1:3 is configured to terminate the VMAN tunnel VLAN *tunnel2*. The Ethernet ports 2:1-2:2 provide the tunnel transport across the VMAN cloud.

```
config dot1q ethertype 88a8
enable jumbo-frame ports 2:1-2:2
config jumbo-frame size 1530
create vlan tunnel1
config vlan tunnel1 tag 50
config vlan tunnel1 add port 2:1-2:2 tagged
create vlan tunnel2
config vlan tunnel2 tag 60
config vlan tunnel2 add port 2:1-2:2 tagged

enable vman termination ports 1:1,1:3
config dot1q ethertype 8100 port 1:1,1:3
config vlan tunnel1 add port 1:1 tag
config vlan tunnel2 add port 1:3 tag
```

25 MultiProtocol Label Switching (MPLS) Module

The MPLS module is a self-contained module for the BlackDiamond 6800 series chassis-based system. Unlike other BlackDiamond modules, there are no external network interfaces on the MPLS module. Instead, the MPLS module provides advanced IP services for the other input/output (I/O) modules installed in the chassis. The MPLS module contains a powerful set of packet processing resources that operate in a one-armed fashion: receiving frames from the switch fabric, processing the frames, and transmitting the frames back into the switch fabric.

This chapter covers the following topics:

- About MPLS on page 517
- About the MPLS Module on page 527
- Configuring the MPLS Module on page 528
- Configuring the Label Distribution Protocol (LDP) on page 533
- MPLS and IP Routing on page 538
- Configuration Example on page 542

About MPLS

MPLS is a technology that allows routers to make protocol-independent forwarding decisions based on fixed-length labels. The use of MPLS labels enables routers to avoid the processing overhead of delving deeply into each packet and performing complex route lookup operations based upon destination IP addresses.

In an MPLS environment, incoming packets are initially assigned “labels” by a Label Edge Router (LER). The labels allow the packets to be more efficiently handled by MPLS-capable routers at each point along the forwarding path.

An MPLS label essentially consists of a short fixed-length value carried within each packet header and that identifies a Forwarding Equivalence Class (FEC). The FEC tells the router how to handle the packet. An FEC is defined to be a group of packets that are forwarded in the same manner. Examples of FECs include an IP prefix, a host address, or a VLAN ID. The label concept in MPLS is analogous to other connection identifiers, such as an ATM VPI/VCI or a Frame Relay DLCI.

By mapping to a specific FEC, the MPLS label efficiently provides the router with all of the local link information needed for immediate forwarding to the next hop. MPLS creates a Label Switched Path (LSP) along which each Label Switch Router (LSR) can make forwarding decisions based solely upon the content of the labels. At each hop, the LSR simply strips off the existing label and applies a new one that tells the next LSR how to forward the packet.

Overview of MPLS

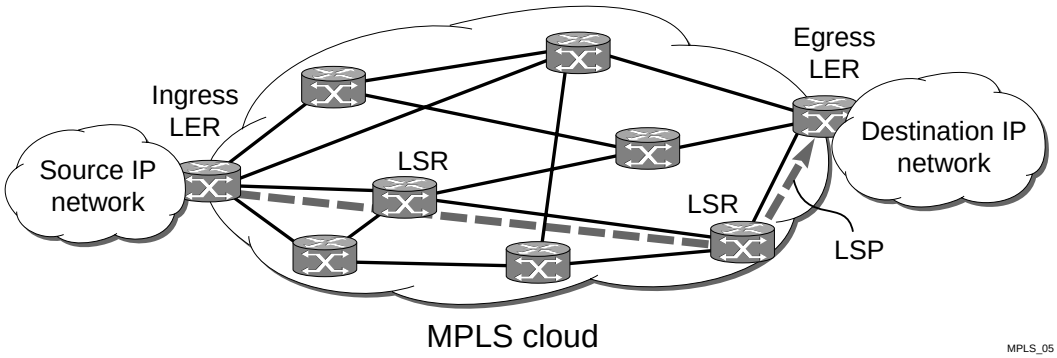
MPLS encompasses a growing set of protocols defined by the IETF. True to its name, MPLS is based on a label-switching forwarding algorithm. ATM and Frame Relay are examples of other protocols that use label-switching forwarding algorithms.

Conceptually, label switching is straightforward. A label is a relatively short, fixed-length identifier that is used to forward packets received from a given link. The label value is locally significant to a particular link and is assigned by the receiving entity.

Because labels are relatively short (for example, 20 bits in a MPLS shim header), the label of a received packet can be used as an index into a linear array containing the forwarding database. Forwarding database entries indicate the outgoing port and any label(s) to be applied to forwarded frames. Thus, forwarding may consist of a simple lookup and replacement of the incoming label with the appropriate outgoing label (otherwise known as *label swapping*).

Figure 110 illustrates an MPLS network.

Figure 110: MPLS network



MPLS Module Limitations

The following limitations apply to the MPLS module:

- The only applicable QoS commands are `dot1p-to-exp` and `exp-to-dot1p`
- SLB and Flow Redirection are mutually exclusive functions with MPLS
- Port state changes on TLS VLANs as a result of EAPS, VRRP, and STP state changes are not supported
- MPLS does not advertise a label mapping for a default route
- There is no support for indirect LSPs across ISIS networks
- No native MPLS RIP support is provided (labels can be advertised for RIP routes exported into OSPF)
- MPLS does not advertise label mappings for BGP routes exported into OSPF

- IP multicast MPLS is not supported
- IPX MPLS is not supported
- GVRP is not supported over MPLS LSPs
- PoS/ATM bridging is not compatible with MPLS when two MSMs installed
- ARM and MPLS modules cannot be installed in the same switch
- Commands with port parameters are not directly applicable to the MPLS module

MPLS Terms and Acronyms

Table 66 defines common MPLS terms and acronyms.

Table 66: MPLS Terms and Acronyms

Term or Acronym	Description
CSPF	Constrained Shortest Path First. Route selection determined by an algorithm based on available link bandwidth and path cost.
DoD	Downstream-on-Demand. Distribution of labels as a result of explicit upstream label requests.
DU	Downstream Unsolicited. Distribution of labels downstream without an explicit label request.
FEC	Forward Equivalence Class. A group of packets that are forwarded in the same manner (for example, over the same Label Switched Path).
Label	A short, fixed-length identifier used to forward packets from a given link.
Label stack	A set of one or more MPLS labels used by MPLS to forward packets to the appropriate destination.
Label swapping	Lookup and replacement of an incoming label with the appropriate outgoing label.
LDP	Label Distribution Protocol. A protocol defined by the IETF used to establish an MPLS Label Switched Path (LSP).
LER	Label Edge Router. A Label Switch Router that is at the beginning (ingress) or end (egress) of a Label Switched Path.
LSP	Label Switched Path. The unidirectional MPLS connection between two routers over which packets are sent.
LSR	Label Switch Router. A router that receives and transmits packets on an MPLS network.
MPLS	MultiProtocol Label Switching. A set of protocols defined by the IETF used to transmit information based on a label-switching forwarding algorithm.
NHLFE	Next Hop Label Forwarding Entry. The NHLFE represents the MPLS router next hop along the LSP.
PHP	Penultimate Hop Popping. A label stack optimization used for conserving the number of allocated labels.
RSVP	Resource ReSerVation Protocol. A resource setup protocol designed for an integrated services network.
RSVP-TE	The combination of RSVP and MPLS label signaling to provide traffic engineered LSPs as specified in draft-ietf-mpls-rsvp-lsp-tunnel-09.txt.
Shim header	MPLS-specific header information that is inserted between layer-2 and layer-3 information in the data packet.

Table 66: MPLS Terms and Acronyms (continued)

Term or Acronym	Description
SP	Service Provider. An entity that provides network services for individuals or organizations.
TE	Traffic Engineering. The provisioning of an autonomous flow along a specified network path.
TLS	Transparent LAN Services. A method for providing layer-2 virtual private networks (VPNs).
TLS Tunnel	A specific type of VC tunnel that carries only VLAN tagged Ethernet traffic.
Tunnel LSP	Any active RSVP-TE LSP used to forward IP traffic through an MPLS network.
VC	Virtual Circuit. A logical point-to-point connection.
VC Tunnel	A two label stack LSP used to tunnel a specific type of traffic. The type of traffic carried over the VC tunnel is negotiated when VC tunnel is established.
VPLS	Virtual Private LAN Services. A multipoint Layer-2 VPN service that has the property that all VC tunnels within a VPN are signaled with the same vcid, where the vcid represents the VPN identifier.
VPN	Virtual Private Network. A logical private network domain that spans a public or service provider network infrastructure.

Label Switched Paths

Protocols that use label switching are connection-oriented. In MPLS, the connections are called *Label Switched Paths* (LSPs) and are unidirectional in nature.

LSPs are established using LDP or RSVP-TE. Once established, an LSP can be used to carry IP traffic or to tunnel other types of traffic, such as bridged MAC frames. The tunnel aspects of LSPs, which are important in supporting virtual private networks (VPNs), result from the fact that forwarding is based solely on labels and not on any other information carried within the packet.

Label Advertisement Modes. MPLS provides two modes for advertising labels:

- Downstream-on-demand (DoD)
- Downstream unsolicited (DU)

Using DoD mode, label bindings are only distributed in response to explicit requests. A typical LSP establishment flow begins when the ingress LER originates a label request message to request a label binding for a particular FEC (for a particular IP address prefix or IP host address). The label request message follows the normal routed path to the FEC. The egress LER responds with a label mapping message that includes a label binding for the FEC. The label mapping message then follows the routed path back to the ingress LSR, and an unsolicited label binding is provided by each LSR along the path. LSP establishment is complete when the ingress LER receives the label mapping message.

Conversely, using DU mode, an LSR may distribute label bindings to LSRs that have not specifically requested them. These bindings are distributed using the label mapping message, as in downstream-on-demand mode. From an LDP message perspective, the primary difference using DU mode is the lack of a preceding label request message.

Architecturally, the difference is more significant, because the DU mode is often associated with a topology-driven strategy, where labels are routinely assigned to entries as they are inserted into the

routing database. In either case, an LSR only uses a label binding to switch traffic if the binding was received from the current next hop for the associated FEC.

Both label advertisement modes can be concurrently deployed in the same network. However, for a given adjacency, the two LSRs must agree on the discipline. Negotiation procedures specify that DU mode be used when a conflict exists. Label request messages can still be used when MPLS is operating in unsolicited mode.

The Extreme LDP implementation supports DU mode only. RSVP-TE, by definition, is DoD.

Label Retention Modes. MPLS provides two modes for label retention:

- Conservative
- Liberal

Using conservative label retention mode, an LSR retains only the label-to-FEC mappings that it currently needs (mappings received from the current next hop for the FEC). Using liberal retention mode, LSRs keep all the mappings that have been advertised to them. The trade-off is memory resources saved by conservative mode versus the potential of quicker response to routing changes made possible by liberal retention (for example, when the label binding for a new next hop is already resident in memory).

The Extreme MPLS implementation supports liberal label retention, only.

LSP Control Modes. MPLS provides two LSP control modes:

- Independent
- Ordered

Using independent LSP control, each LSR makes independent decisions to bind labels to FECs. By contrast, using ordered LSP control, the initial label for an LSP is always assigned by the egress LSR for the associated FEC (either in response to a label request message or by virtue of sending an unsolicited label mapping message).

More specifically, using ordered LSP control, an LSR only binds a label to a particular FEC if it is the egress LSR for the FEC, or if it has already received a label binding for the FEC from its next hop for the FEC. True to its name, the mode provides a more controlled environment that yields benefits such as preventing loops and ensuring use of consistent FECs throughout the network.

The Extreme MPLS implementation supports ordered LSP control, only.

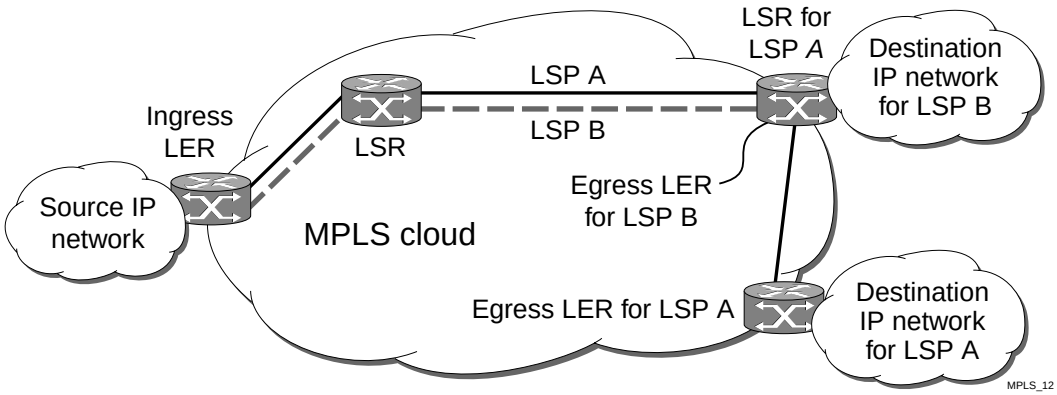
Label Switch Routers

MPLS protocols are designed primarily for routed IP networks and are implemented by *Label Switch Routers* (LSRs). The router where an LSP originates is called the *ingress* LSR, while the router where an LSP terminates is called the *egress* LSR.

Ingress and egress LSRs are also referred to as *Label Edge Routers* (LERs). For any particular LSP, a router is either an ingress LER, an intermediate LSR, or an egress LER. However, a router may function as an LER for one LSP, while simultaneously function as an intermediate LSR for another LSP.

Figure 111 illustrates the three types of LSRs.

Figure 111: LSR types



The functions of the LSR types are described in Table 67.

Table 67: LSR Functions

LSR	Function
Ingress LER	Inserts one or more labels into packets transmitted onto an LSP.
Intermediate LSR	Forwards packets via label swapping.
Egress LER	Removes the last label(s) before forwarding packets received from an LSP.

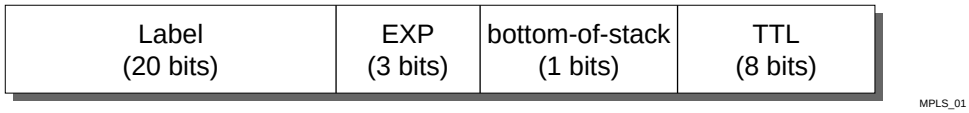
Supporting Quality of Service Features

Quality of Service (QoS) LSP support is an important attribute of MPLS. MPLS supports the Differentiated Services (DiffServ) model of QoS. The DiffServ QoS model is supported by mapping different traffic classes to different LSPs, or by using the EXP bits in the MPLS shim header to identify traffic classes with particular forwarding requirements.

MPLS Layer

MPLS can be thought of as a *shim-layer* between layer 2 and layer 3 of the protocol stack. MPLS provides connection services to layer-3 functions while making use of link-layer services from layer-2. To achieve this, MPLS defines a *shim header* that is inserted between the link layer header and the network layer header of transmitted frames. The format of a 32-bit MPLS shim header is illustrated in Figure 112.

Figure 112: MPLS shim header



MPLS Label Stack

The MPLS shim header is also referred to as a *label stack*, because it can contain multiple entries. Each entry contains the following fields:

- 20-bit label
- 3-bit experimental (EXP) field

  The EXP field can be used to identify different traffic classes to support the DiffServ QoS model.
- 1-bit bottom-of-stack flag

  The bottom-of-stack bit is set to 1 to indicate the last stack entry.
- 8-bit Time-To-Live (TTL) field.

  The TTL field is used for loop mitigation, similar to the TTL field carried in IP headers.

The format of an MPLS label stack containing two entries is shown in Figure 113.

Figure 113: MPLS label stack

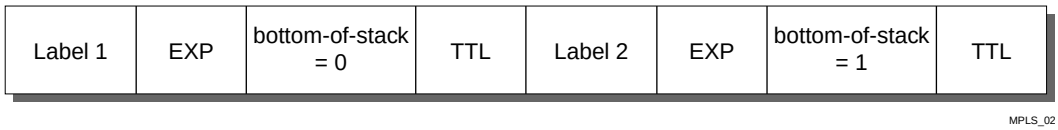


Figure 114 illustrates the format of a unicast MPLS frame on an Ethernet link. The MAC addresses are those of the adjacent MPLS router interfaces. The x8847 Ethertype value indicates that the frame contains a MPLS unicast packet. A different Ethertype value (x8848) is used to identify MPLS multicast packets.

Figure 114: MPLS unicast frame on Ethernet

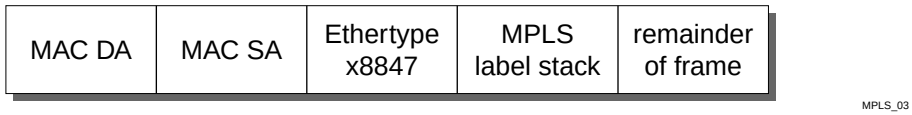
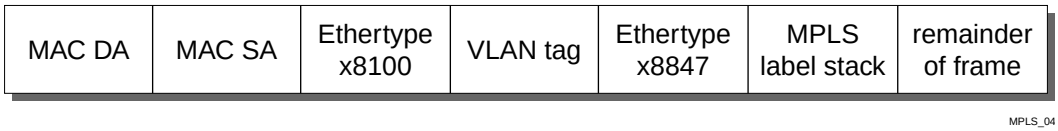


Figure 115 shows the format of a unicast MPLS frame that contains an 802.1Q VLAN tag. In both cases, the Ethertype values no longer identify the network layer protocol type. This implies that, generally, the protocol type must be inferable from the MPLS label value(s). For example, when only one type of protocol is carried on a given LSP.

Figure 115: MPLS unicast frame on tagged Ethernet VLAN



The approach of the shim header encapsulation is similar for Packet over SONET (PoS) interfaces running PPP. For PoS interfaces running PPP, the MPLS shim header follows the PPP Protocol ID (PID) field. A PID of x0281 is used to indicate MPLS unicast, while a PID of x0283 identifies MPLS multicast.

MPLS can also take advantage of technologies that can carry labels in the link layer header. For example, MPLS labels can be carried in the VPI/VCI fields of ATM cell headers. Frame Relay provides another example; an MPLS label can be carried in the DLCI field.

NOTE

For more detailed information on MPLS encapsulations, see RFC 3032, MPLS Label Stack Encoding.

Penultimate Hop Popping

Penultimate hop popping (PHP) is an LSR label stack processing optimization feature. When enabled, the LSR can "pop" (or discard) the remaining label stack and forward the packet to the last router along the LSP as a normal Ethernet packet.

By popping the label stack one hop prior to the LSP egress router, the egress router is spared having to do two lookups. After the label stack has been popped by the penultimate hop LSR, the LSP egress router must only perform an address lookup to forward the packet to the destination.

PHP label advertisements using implicit NULL labels can be optionally enabled. Support for receiving implicit NULL label advertisements by neighbor LSRs is always enabled. For example, if an LSR advertises implicit NULL labels for IP prefixes, the neighbor LSRs must support PHP.

Label Binding

Label binding is the process of, and the rules used to, associate labels with FECs. LSRs construct label mappings and forwarding tables that comprise two types of labels: labels that are locally assigned and labels that are remotely assigned.

Locally assigned labels are labels that are chosen and assigned locally by the LSR. For example, when the LSR assigns a label for an advertised direct interface. This binding information is communicated to neighboring LSRs. Neighbor LSRs view this binding information as remotely assigned.

Remotely assigned labels are labels that are assigned based on binding information received from another LSR.

Label Space Partitioning

The Extreme MPLS implementation supports approximately 64 K locally-assigned labels. The label space is partitioned as described in Table 68.

Table 68: MPLS Label Space Partitions

Label Range	Label Partition Description
x00000-x0000F	Defined/reserved by MPLS standards specified in RFC 3032.
x00010-x0BBFF (48,112)	**LSR Partition**—Used to identify intermediate LSR LSPs.
x8C000-x8FFFF (16,384)	**TLS LER Partition**—Used to identify the VLAN for which TLS traffic is destined when performing the egress LER function.
xCBC00-xCBFFF (1024)	**IP LER Partition**—Used for mappings to IP FECs when performing the egress LER function.

The partitioning described in Table 68 maximizes forwarding performance, and supports efficient load sharing of MPLS traffic across the Gigabit Ethernet backplane links of high-speed input/output modules.

The data path uses the least significant 16 bits of the label (bits 0-15) as an index when a label lookup is required. The next 2 bits of the label (bits 16-17) are currently not used by the data path. The most significant 2 bits of the label (bits 18-19) are used to identify the partition. The data path uses the label partition bits in conjunction with the bottom-of-stack flag to efficiently determine how a label should be processed, as described in Table 69.

Table 69: Label Processing by the NP Data Path

Partition	Bottom-of-stack	Label Processing
LSR	Don't Care	Perform label lookup.
IP	Yes	Remove MPLS header and perform normal IP forwarding.
TLS	Yes	Remove MPLS header and parse encapsulated Ethernet frame as if it were received.
IP or TLS	No	Pop the label and repeat processing on the next label.

The MPLS module does not limit the number of labels that can be popped by the egress LSR function, as indicated in Table 69.

When the switch performs label swapping as a transit or intermediate LSR, no hard limits are imposed on the maximum size of the label stack, other than the constraint of not exceeding the maximum frame size supported by the physical links comprising the LSP. You should enable jumbo frame support on the ports that are members of an MPLS VLAN. The jumbo frame size should be set to accommodate the addition of a maximally-sized label stack. For example, a jumbo frame size of at least 1530 bytes is needed to support a two-level label stack on a tagged Ethernet port and a jumbo frame size of at least 1548 bytes is needed to support a TLS encapsulated MPLS frame.

About MPLS Layer-2 VPNs

As networks grow and become more pervasive, the need to separate the physical network infrastructure from the logical network or VLAN organization has become increasingly important. By logically separating the network topology from the service provided by the physical network, services are more easily managed, reliability through increased redundancy is improved, and you gain more efficient use of the physical network infrastructure.

By mapping a VLAN to a specific set of MPLS tunnels, you can create virtual private networks (VPNs). Within a VPN, all traffic is opaquely transported across the service provider network. Each VPN can be managed and provisioned independently.

VPNs may have two or more customer points of presence (PoP). All PoPs are interconnected using point-to-point tunnels. If there are two PoPs in the VPN, the VPN is considered to be point-to-point. If there are more than two PoPs in the VPN, the VPN is considered to be multipoint. Multipoint VPNs can be fully-meshed or hub-and-spoke.

Layer-2 VPNs are constructed from a set of interconnected point-to-point MPLS tunnels. Tunnel endpoint nodes operate as virtual VPN switches, bridging traffic between tunnels and the local egress VLAN. MAC caching is integrated into the MPLS module. Source MAC addresses within each VPN are associated with the tunnel from which the packet is received. Up to 256K MAC addresses can be

cached. Within a VPN, once a MAC address has been learned, unicast traffic destined to the cached MAC address is transmitted over a single tunnel. Integrated VPN MAC caching enhancement increases network performance and improves VPN scalability.

For information about configuring MPLS Layer-2 VPNs, see Chapter 27.

About IP Unicast Forwarding

IP unicast forwarding is performed on the MPLS module to facilitate implementation of MPLS and accounting. When MPLS or accounting functions are enabled, the MPLS module, rather than the switch fabric hardware, performs layer-3 IP unicast forwarding. Layer-2 switching and Layer-3 IP multicast forwarding are unaffected.

The MSM distributes its IP unicast routing table, ARP table, MPLS incoming label mappings (ILMs), FEC-to-NHFLE database, and interface IP addresses to each MPLS module so that every MPLS module contains the same IP routing database.

Each MPLS module has sufficient capacity to support 256K IP longest prefix match lookup route entries. Each route entry also supports up to four equal-cost paths. IP forwarding is configurable per VLAN.

Each MPLS module IP routing database provides an aggregate IP forwarding throughput of up to 4 Gbps. The total forwarding throughput for a single BlackDiamond chassis can be scaled up to 16 Gbps by adding up to four MPLS modules. MPLS modules interface to the BlackDiamond switch fabric via four 1 Gbps internal links. IP unicast traffic is internally forwarded from the BlackDiamond I/O modules using one of three backplane load-sharing policies: port-based, address-based, or round-robin. See Chapter 16 for more information.

About Destination-Sensitive Accounting

Destination-sensitive accounting allows you to bill your customers at different rates depending upon the destination of the IP unicast packets they send.

Destination-sensitive accounting categorizes IP unicast packets according to two parameters:

- The ID of the VLAN from which the packet was received
- The accounting bin number associated with the route used to forward the packet

For each category, 64-bit counts of both the number of packets and number of bytes forwarded, including those locally delivered to the MSM CPU, are collected. Eight accounting bin numbers, with values from 0-7, are available for each of the possible 4096 VLAN IDs. This yields a maximum of 32768 sets of accounting statistics.

You use accounting statistics to bill your customers. For a given set of statistics, the source VLAN ID identifies the customer and the accounting bin number corresponds to a billing rate.

Use the ExtremeWare `route-map` function to configure policies that assign accounting bin numbers to IP routes. Bin 0 is the default bin. Any route that does not have an explicit bin assignment via the `route-map` function defaults to bin 0.

You retrieve accounting statistics via the command-line interface (CLI) and Simple Network Management Protocol (SNMP).

About the MPLS Module

The MPLS module contains a powerful set of network processors specifically programmed to implement the MPLS function. The card has no external ports, but contains four full-duplex gigabit Ethernet internal ports to the BlackDiamond backplane switch fabric. Each internal processor provides media speed packet processing for two internal full-duplex gigabit Ethernet ports. The MPLS module operates in a one-armed fashion: receiving frames from the switch fabric, processing the frames, and transmitting the frames back into the switch fabric to the appropriate I/O module output port.

NOTE

MPLS modules are only compatible with "i" series MSM modules.

Summary of Features

The MPLS module includes the following features:

- **MultiProtocol label switching (MPLS)**—MultiProtocol Label Switching (MPLS) is a forwarding algorithm that uses short, fixed-length labels to make next-hop forwarding decisions for each packet in a stream.
- **Selective Longest Prefix Match—**IP unicast packets are routed in the ARM hardware using a longest prefix match (LPM) algorithm. This differs from the BlackDiamond switch fabric, which uses an exact match algorithm. The BlackDiamond switch fabric has great forwarding capacity, but the ARM module has better handling of large numbers (hundreds of thousands) of destination IP addresses to match each packet's destination IP address. To take advantage of the BlackDiamond switch fabric forwarding capacity and the ARM module's scalability, the ARM module can be configured to use the BlackDiamond switch fabric for some routes and the ARM's LPM for others. This feature is called Selective Longest Prefix Match (Selective-LPM).
- **Destination-sensitive accounting**—Counts of IP packets and bytes are maintained based on the IP routes used to forward packets. Destination-sensitive accounting gives you the flexibility to bill your customers at predetermined and different rates. The rates are based on the customers' IP unicast packet destinations.

  The accounting feature categorizes IP unicast packets using two parameters, input VLAN ID and accounting bin number. The VLAN ID is used to identify from which customer the packet is received. The accounting bin number is associated with the route used to forward the packet. External billing application servers can correlate the accounting bin number to a specific billing rate.

Configuring the MPLS Module

This section describes how to configure the MPLS module. For hardware installation information for the BlackDiamond 6800 series switch, see the *Extreme Networks Consolidated Hardware Guide*.

NOTE

Documentation for Extreme Networks products is available at the Extreme Networks home page at http://www.extremenetworks.com/.

This section describes how to configure:

- MPLS interfaces
- LDP
- OSPF support
- QoS support
- Filter support

Configuring MPLS Interfaces

To configure MPLS interfaces, first enable MPLS on the router by using the following command:

```
enable mpls
```

Next, enable MPLS on a specific VLAN or on all VLANs, using the following command:

```
config mpls add vlan [<vlan name> | all] {ldp | rsvp-te}
```

MPLS must be enabled on all VLANs that transmit or receive MPLS-encapsulated frames. Using the `config mpls add vlan` command causes the LDP neighbor discovery process to begin on the specified VLAN.

NOTE

The specified VLAN must be configured with an IP address, and have IP forwarding enabled. IGMP snooping must also be enabled on the switch.

If `all` VLANs are selected, MPLS is enabled on all VLANs that have an IP address and IP forwarding enabled. This command optionally enables LDP or RSVP-TE for the specified VLAN. If not specified, both LDP and RSVP-TE are enabled on the specified VLAN.

If you have enabled MPLS on an OSPF interface that is used to reach a particular destination, make sure that you enable MPLS on all additional OSPF interfaces that can reach that same destination (for example, enable MPLS on all VLANs that are connected to the backbone network).

Configuring the Maximum Transmission Unit Size

After you have enabled MPLS, you can configure the maximum transmission unit (MTU) size using the following command:

```
config mpls vlan [<vlan name> | all] ip-mtu <number>
```

This command configures the IP MTU for frames transmitted onto MPLS LSPs via the specified egress VLAN. The default settings is 1496 bytes. If `all` is selected, the configuring MTU applies to all MPLS-enabled VLANs.

This command applies to the ingress LSR only when a received IP packet is destined for an MPLS LSP. In this case, if the length of the IP packet exceeds the configured MTU size for the egress VLAN and the Don't Fragment (DF) bit is *not* set in the IP header of the packet, the packet is fragmented before it is forwarded onto an MPLS LSP. If the DF bit is set in the packet header, Path MTU Discovery starts.

Fragmentation is based on either the minimum value of the configured MPLS IP MTU size or the configured IP MTU size for the egress VLAN. (The IP MTU size is configured using the `config ip-mtu <number> vlan <vlan name>` command.)

You should configure the MPLS IP MTU so that the addition of the MPLS label stack the link layer header does not cause the packet to be too large to be transmitted on the egress ports. To avoid potential problems, you should enable jumbo frame support on all ports that are members of an MPLS VLAN.

Configuring the Propagation of IP TTL

To enable or disable the propagation of the IP time-to-live (TTL) function, use the following command:

```
config mpls propagate-ip-ttl [enabled | disabled]
```

This command enables and disables the propagation of the IP TTL value for routed IP packets. The default setting is enabled.

NOTE

You must maintain identical `propagate-ip-ttl` *settings on all LERs in the MPLS domain. Not doing so may cause packets to loop endlessly and not be purged from the network if a routing loop is inadvertently introduced.*

When `propagate-ip-ttl` is disabled, the LSP is viewed as a point-to-point link between the ingress LSR and the egress LSR. Intermediate LSRs in the MPLS network are not viewed as router hops (from an IP TTL perspective). In this case, the IP TTL is decremented once by the ingress LSR and once by the egress LSR. When disabled, the MPLS TTL is set to 255 by the ingress LSR and is independent of the IP TTL.

When `propagate-ip-ttl` is enabled, each LSR is viewed as a router hop (from an IP TTL perspective). When a packet traverses an LSP, it emerges with the same TTL value that it would have had if it had traversed the same sequence of routers without being label-switched. When enabled, the MPLS TTL field is initially set by the IP TTL field at the ingress LSR, and the IP TTL field is set to the MPLS TTL by the egress LSR.

Configuring Penultimate Hop Popping

To enable or disable PHP, use the following command:

```
config mpls php [enabled | disabled]
```

This command enables or disables whether PHP is requested by the egress LER.

When PHP is enabled, PHP is requested on all LSPs for which the switch is the egress LER.

PHP is requested by assigning the Implicit Null Label in an advertised mapping. PHP is always performed when requested by an egress LSR (for example, when the switch is acting as an intermediate LSR). The Implicit Null Label is always used in conjunction with routes exported by OSPF, regardless of the PHP configuration.

This command can only be executed when MPLS is disabled. The default setting is disabled.

Configuring QoS Mappings

To configure QoS mappings, use the following command:

```
config mpls qos-mapping [dot1p-to-exp | exp-to-dot1p] [all |
<input_value>]/<output_value>
```

This command configures MPLS QoS mappings. If `all` is specified, all input values are mapped to the specified `<output_value>`. The valid range of integers for the `<input_value>` and the `<output_value>` is 0 to 7. By default, the mapping tables are initialized such than an `<input_value>` of *n* is mapped to an `<output_value>` of *n*.

Two mappings are supported:

- dot1p-to-exp
- exp-to-dot1p

Dot1p-to-exp Mappings

The dot1p-to-exp mappings are used by the ingress LSR. When a non-MPLS ingress frame arrives at the MPLS module, the frame always contains an IEEE 802.1p priority field.

The value of the priority field is set based on the QoS classification performed by the ingress I/O module. The ingress I/O modules assign each packet to a hardware queue, based on the configured ExtremeWare QoS policies. There is a one-to-one mapping between the hardware queue and the 802.1p priority values that are inserted into frames forwarded to the MPLS module. For example, the 802.1p priority value is set to 0 for frames forwarded from hardware queue 0, set to 1 for frames forwarded from hardware queue 1, and so on.

The dot1p-to-exp table maps 802.1 priority values to MPLS EXP values. The table is completely flexible, such that any 802.1p priority `<input_value>` can be mapped to any EXP `<output_value>`. The EXP output_value is set in the MPLS header of the packet as it is forwarded to the MPLS network.

Exp-to-dot1p Mappings

The exp-to-dot1p mappings are used when the switch performs label swapping as an intermediate LSR and when the switch is the egress LSR. In both of these cases, the MPLS module receives an MPLS-encapsulated frame.

The EXP field in the frame is used as an `<input_value>` to the exp-to-dot1p table. The corresponding `<output_value>` is an 802.1p priority value. The 802.1p priority value is inserted into the frame before the frame is forwarded by the MPLS module.

The exp-to-dot1p table is completely flexible, such that any EXP `<input_value>` can be mapped to any 802.1p priority `<output_value>`.

The exp-to-dot1p table is also used by Packet over SONET (PoS) ports when classifying MPLS-encapsulated packets received from the SONET link. When a PoS port receives an MPLS-encapsulated packet from the SONET link, the packet is classified based on the EXP value in the MPLS shim header. The EXP value from the received frame is used as an index into the exp-to-dot1p mapping table to retrieve and 802.1p priority value. The frame is then assigned to a QoS profile, based on the retrieved 802.1p priority value. The mappings between 802.1p priority values and QoS profiles are configured using the following command:

```
config dot1p type
```

NOTE

For more information on QoS, see Chapter 7. For more information on the PoS module, see Chapter 23.

Resetting MPLS Configuration Parameter Values

To reset MPLS configuration parameters to their default values, use the following command:

```
unconfig mpls
```

This command resets the following configuration parameters:

- IP-MTU
- LDP propagation filter settings on all VLANs
- LDP advertisement filter settings
- LDP session timers
- RSVP-TE interface parameters
- RSVP-TE profile parameters
- Settings for propagate-ip-ttl
- QoS mapping tables

To restore the default values for the QoS mapping tables, use the following command:

```
unconfig mpls qos-mapping [dot1p-to-exp | exp-to-dot1p]
```

The default contents of either QoS mapping table maps an input value of *n* to an output value of *n*.

Displaying MPLS Configuration Information

You can display MPLS information about the following topics:

- MPLS configuration information for the entire switch or for a specific VLAN
- MPLS forwarding entry information
- MPLS LDP peer information
- MPLS RSVP-TE peer information
- MPLS label mapping information
- MPLS QoS mapping information

Displaying MPLS Configuration Information

To display MPLS configuration information, use the following command:

```
show mpls {vlan <vlan name>} {detail}
```

When the vlan parameter is omitted, this command displays the values of all MPLS configuration parameters that apply to the entire switch, the current status of peer LSRs, and a list of the VLANs for which MPLS is enabled.

When the vlan parameter is specified, this command displays the current values of the MPLS configuration parameters that are specific to the VLAN.

If the optional detail keyword is specified, additional detailed VLAN information is displayed.

Displaying MPLS Interface Information

To display MPLS interface information, use the following command:

```
show mpls interface {ldp | targeted-ldp | rsvp-te} {vlan <vlan name>}
```

When the optional parameters are omitted, this command displays information for all of the configured MPLS VLAN interfaces. When the ldp, rsvp-te, or targeted-ldp parameters are supplied, this command will display only those interfaces of that type.

When the vlan parameter is specifed, this command displays the current values of the MPLS interface parameters that are specific to the VLAN.

Displaying MPLS Forwarding Entry Information

To display MPLS forwarding entry information, use the following command:

```
show mpls forwarding {summary | host <ipaddress> | prefix <ipaddress/masklength>}
{detail | inactive}
```

This command displays information from the Forwarding Equivalence Class (FEC)-to-Next Hop Label Forwarding Entry (NHLFE) database. This command also displays information for RSVP-TE LSPs.

If the host or prefix keywords are specified, summary information is displayed for a single FEC. Use the summary keyword to display summary route information associated with labeled paths.

By default, the information displayed includes:

- Next hop IP address
- Outgoing label
- Interface number of the outgoing VLAN

If the detail keyword is specified, the following additional information is displayed:

- Outgoing port number
- Counts of packets and bytes that have been transmitted using the database entry

By default, information is displayed for active mappings. To display information for liberally-retained inactive mappings, use the inactive keyword. An inactive mapping is a mapping that was received from an LDP peer, but is not being used to reach the associated FEC. Using the inactive keyword causes inactive mappings to be displayed. The inactive keyword does not apply to RSVP-TE LSPs, because RSVP-TE operates in downstream-on-demand mode.

Displaying MPLS Label Mapping Information

To display MPLS label mapping information, use the following command:

```
show mpls label {summary {detail}| fec {detail} | <label_number> {detail} | host
<ipaddress> {detail} | prefix <ipaddress/masklength> {detail} | rsvp-te <ipaddress>
{detail}}
```

This command displays information from the Incoming Label Map (ILM), which is used when forwarding packets that arrive labeled as MPLS packets.

When the `label_number` parameter is omitted, summary information is displayed for all incoming label assignments that have been made by the switch. When the `label_number` is specified, summary information is displayed for the label.

Use the `fec` keyword to display the label associated with an FEC. You can specify both host and prefix FEC types. The `summary` keyword displays the number of labels allocated from each label range partition.

By default, the information displayed includes:

- Next hop IP address
- Outgoing and incoming labels
- Interface number of the outgoing VLAN
- FEC associated with the incoming label

If the detail keyword is specified, the following additional information is displayed:

- Outgoing port number
- Counts of packets and bytes that have been received with the incoming label
- Counts of packets and bytes that have been transmitted with the outgoing label
- LSP type

This command also displays information from the Incoming Label Map (ILM) for RSVP-TE LSPs.

Displaying MPLS QoS Mapping Information

To display MPLS QoS mapping information, use the following command:

```
show mpls qos-mapping
```

Configured mappings for both dot1p-to-exp and exp-to-dot1p are displayed.

Configuring the Label Distribution Protocol (LDP)

This section describes the Label Distribution Protocol (LDP), part of MPLS, and covers the following topics:

- Overview of MPLS on page 518
- Configuring LDP on page 534
- Configuration Example on page 542

Overview of LDP

The Label Distribution Protocol (LDP) is a protocol defined by the IETF for the purpose of establishing an MPLS LSP. Using LDP, peer LSRs exchange label binding information to create the LSP.

LDP Neighbor Discovery

LDP includes a neighbor discovery protocol that runs over UDP. Using the basic discovery mechanism, each LSR periodically multicasts a hello message to a well-known UDP port to which all LSRs listen. These hello messages are transmitted to the *all routers on this subnet* multicast group. When a neighbor is discovered, a hello-adjacency is formed and the LSR with the numerically greater IP address is denoted as the active LSR.

Hello messages must continue to be received periodically for the hello-adjacency to be maintained. The hold time that specifies the duration for which a hello message remains valid defaults to 15 seconds in the basic discovery mechanism and can be negotiated by the peer LSRs as part of the HELLO exchange. During the HELLO exchange, each LSR proposes a value and the lower of the two is used as the hold time.

Targeted LDP Sessions between nondirectly connected LSRs are supported using an extended discovery mechanism. In this case, targeted hello messages are periodically sent to a specific IP address. The default HELLO time for targeted LDP sessions is 45 seconds.

After the hello-adjacency is formed, the active LSR initiates establishment of a TCP connection to the peer LSR. At this point, an LDP session is initiated over the TCP connection. The LDP session consists of an exchange of LDP messages that are used to setup, maintain, and release the session.

Advertising Labels

You can control whether labels are advertised for:

- Direct routes
- RIP routes exported by OSPF
- Static routes exported by OSPF

To conserve label space, the Implicit NULL Label is advertised for RIP and static routes exported by OSPF. The Implicit NULL Label is advertised for direct routes when PHP is enabled.

Propagating Labels

LDP propagates labels for FECs that exactly match a routing table entry, with the exception of mappings for 32-bit prefixes corresponding to OSPF router IDs (where the router ID IP addresses are dynamically learned from the advertising router field of received OSPF router and AS external LSAs).

Configuring LDP

This section describes the following tasks:

- Configuring LDP on a VLAN on page 535
- Configuring LDP Filters on page 535
- Configuring LDP Session Timers on page 536

- Restoring LDP Session Timers on page 537
- Displaying LDP Peer Information on page 537

Configuring LDP on a VLAN

To configure LDP on a VLAN, use the following command:

```
config mpls add vlan [<vlan name> | all] {ldp}
```

This command enables LDP on one of all VLAN. If not specified, both LDP and RSVP-TE are enabled on the specified VLAN.

To disable LDP on a VLAN, use the following command:

```
config mpls delete vlan [<vlan name> | all] {ldp}
```

This command disables LDP on one or all VLANs. This command terminates all LDP sessions and all established LDP LSPs.

Configuring LDP Filters

You can configure two types of LDP filters:

- Label propagation filters
- Label advertisement filters

Configuring an LDP Label Propagation Filter. To configure an LDP label propagation filter, use the following command:

```
config mpls vlan [<vlan name> | all] ldp propagate [all | none | route-map
<route_map>]
```

This command configures a filter to be used by LDP when propagating unsolicited label mappings to all LDP neighbors on the specified VLAN. If all VLANs are selected, the settings of this command apply to all MPLS-enabled VLANs.

You can configure the propagation filter, as follows:

- `all`—Unsolicited label mappings are propagated to the VLAN. This is the default setting.
- none—No unsolicited label mappings are propagated to the VLAN.
- `route-map` `<route_map>`—The specified route map is used to permit or deny the propagation of unsolicited label mappings to the VLAN.

  The only supported route map match operation keyword is `nlri-list`. If selected, the access_profile parameter of the `nlri-list` keyword is compared to the FEC that is associated with each label mapping.

NOTE

For more information on route maps, see the ExtremeWare Software Users Guide.

Configuring an LDP Label Advertisement Filter. To configure an LDP label advertisement filter, use the following command:

```
config mpls ldp advertise [direct | rip | static] [all | none | route-map <route_map>]
```

This command configures a filter to be used by LDP when originating unsolicited label mapping advertisements to LDP neighbors.

You can configure how the advertisement filter is applied, as follows:

- `direct`—The advertisement filter is applied to the FECs associated with direct routes exported by OSPF.
- `rip`—The advertisement filter is applied to the FECs associated with RIP routes exported by OSPF.
- `static`—The advertisement filter is applied to the FECs associated with static routes exported by OSPF.

You can configure the advertisement filter, as follows:

- `all`—All unsolicited label mappings are originated for all routes of the specified type (direct, RIP, or static). This is the default setting for direct routes.
- `none`—No unsolicited label mappings are originated for all routes of the specified type. This is the default setting for RIP and static routes.
- `route-map <route_map>`—The specified route map is used to permit or deny the origination of unsolicited label mappings for all routes of the specified type.

  The only supported route map match operation keyword is `nlri-list`. If selected, the access_profile parameter of the `nlri-list` keyword is compared to the FEC that is associated with each route.

RIP and static routes are advertised with the Implicit NULL label and direct routes are advertised with an MPLS label, unless PHP is enabled.

You can control the number of labels advertised using the `config mpls ldp advertise` command. Advertising labels for a large number of routes may increase the required number of labels that must be allocated by LSRs. Take care to insure that the number of labels advertised by LERs does not overwhelm the label capacity of the LSRs.

Configuring LDP Session Timers

To configure LDP session timers, use the following command:

```
config mpls [ldp | targeted-ldp] [hello | keep-alive] <hold_time> <interval_time>
```

LDP session timers are separately configurable for LDP and targeted LDP sessions. The `hello <hold_time> <interval_time>` parameter specifies the amount of time (in seconds) that a hello message received from a neighboring LSR remains valid. If a hello message is not received from a particular neighboring LSR within the specified `hello <hold_time>`, the hello-adjacency is not maintained with that neighboring LSR.

The session `keep-alive <hold_time> <interval_time>` parameter specifies the time (in seconds) during which an LDP message must be received for the LDP session with a particular peer LSR to be maintained. If an LDP PDU is not received within the specified session `keep-alive <interval_time>`, the corresponding LDP session is torn down.

The minimum and maximum values for both the `hello <hold_time> <interval_time>` and `keep-alive <hold_time> <interval_time>` are 6 and 65,534, respectively.

The default values are as follows:

- ldp hello <hold_time> – 15
- targeted-ldp hello <hold_time> – 45
- ldp hello <interval_time> – 5
- targeted-ldp hello <interval_time> – 15
- ldp keep-alive <hold_time> – 40
- targeted-ldp keep-alive <hold_time> – 60
- ldp keep-alive <interval_time> – 13
- targeted-ldp keep-alive <interval_time> – 20

This command can only be executed when MPLS is disabled.

Restoring LDP Session Timers

To restore the default values for LDP session timers, use the following command:

```
unconfig mpls
```

This command can only be executed when MPLS is disabled.

Displaying LDP Peer Information

To display MPLS LDP peer information, use the following command:

```
show mpls ldp {<ipaddress>} {detail}
```

This command displays information about the status of LDP peers. Summary information is displayed for all known LDP peers and LDP peer sessions. If you specify the `<ipaddress>` of the LDP peer, information for a single LDP peer is displayed. To display additional information in the comprehensive detailed format, use the `detail` keyword.

By default the information displayed includes:

- Peer type (targeted or not targeted)
- Peer sessions
- Peer state
- Uptime

If you specify the `detail` keyword, the following additional information is displayed:

- Discontinuity time
- Negotiated label distribution
- Next hop address

MPLS and IP Routing

This section describes how MPLS and IP routing work together to forward information on your network.

This section covers the following topics:

- Routing Using LSPs on page 538
- LSPs and IBGP Next Hops on page 541
- Optimized Forwarding of Non-MPLS IP Traffic on page 541

MPLS provides a great deal of flexibility for routing packets. Received IP unicast frames can be transmitted over LSPs or routed normally. If a matching FEC exists for the received packet, the packet is transmitted over an LSP that is associated with the FEC. The packet is encapsulated using an MPLS shim header before being transmitted.

Received MPLS packets can be label switched or routed normally toward the destination. Packets that are in the middle of an LSP are label switched. The incoming label is swapped for a new outgoing label and the packet is transmitted to the next LSR. For packets that have arrived at the end of an LSP (the egress end of the LSP), the label is popped. If this label is the bottom of the stack, the shim header is stripped and the packets are routed to the destination as normal IP packets.

NOTE

Multicast routing is not supported.

An MPLS domain is generally defined to be an OSPF or IS-IS autonomous system (AS). You can use MPLS to reach destinations inside one of these AS types. You can also use MPLS to reach destinations outside of an OSPF AS.

Routing Using LSPs

This section describes the following topics:

- Routing Using Direct and Indirect LSPs on page 538
- LSP Precedence and Interaction on page 540
- Equal Cost LSPs on page 540
- Overriding IBGP Metrics for RSVP-TE LSPs on page 541

Routing Using Direct and Indirect LSPs

Using MPLS, two types of LSPs can be used to route a packet to its destination:

- Direct LSP

  An LSP is considered direct with respect to an FEC if it has been associated with the FEC via LDP or RSVP-TE. Direct LSPs are supported for both OSPF and IS-IS IGP networks.

- Indirect LSP

  An LSP is considered indirect with respect to an FEC if it has been associated with the FEC via a routing protocol. Indirect LSPs are supported for both OSPF and IS-IS IGP networks only.

Figure 116 illustrates the concept of direct and indirect LSPs.

Figure 116: Direct and indirect LSPs

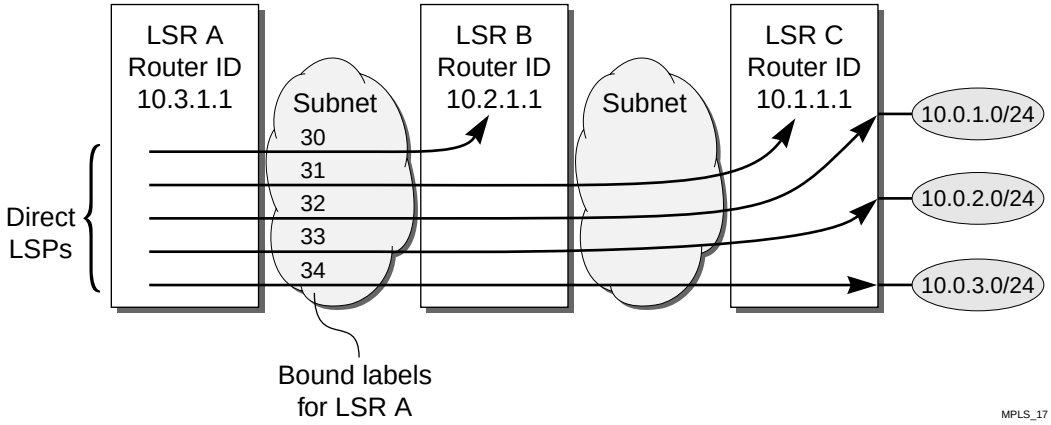


Table 70 describes the label bindings in the MPLS forwarding table for LSR A that are maintained for FECs reachable via LSR A to LSR C, shown in Figure 116.

Table 70: Label Bindings for LSR A

Destination	Next Hop	Direct LSP Label	Indirect LSP Label
10.1.1.1/32	10.2.1.1	31	30
10.0.1.0/24	10.2.1.1	32	31
10.0.2.0/24	10.2.1.1	33	31
10.0.3.0/24	10.2.1.1	34	31

A direct LSP is always preferred over an indirect LSP. When a route table entry is added or updated, MPLS first checks for the existence of a direct LSP. If a direct LSP exists, the information is simply added to the route table entry at that time.

Managing indirect LSP entries is more involved. The OSPF Shortest Path First (SPF) algorithm determines the availability of indirect LSPs through an egress router. The intra-area SPF algorithm begins with the calculating router as the root of a graph. The graph is expanded by examining the networks connected to the root and then the routers connected to those networks. Continuing in this manner, the graph is built as a series of parent and child nodes. A check is made for a direct LSP as each entry is added. A check is also made for an indirect LSP that can be inherited from the parent node. Thus, for each route table entry, the modified SPF algorithm determines whether a direct LSP is available and whether an indirect LSP is available for use whenever a direct LSP is not present.

This design allows label mapping changes for direct LSPs to be managed without requiring an SPF recalculation. An SPF recalculation is performed when advertisements and withdrawals of label mappings for /32 FECs are received, which is analogous to the situation where an OSPF link changes state.

The modification to the SPF algorithm described above is important, because it enables the capabilities provided by LDP or RVSP-TE LSPs to be fully utilized, while minimizing the resources devoted to label management.

For example, in a network where all the LSRs implement this feature (such as an all-Extreme MPLS network), labels only need to be advertised for the router IDs of the LSRs. Yet, LSPs can still be used to route traffic destined for any OSPF route.

More specifically, LSPs can be used for all routes advertised by OSPF, with the possible exception of LDP LSPs to routes summarized by OSPF area border routers (ABRs). The problem with using routes summarized by OSPF ABRs is that route summarization can prevent label mappings from being propagated for the links internal to the area being summarized, since a LSR will typically only propagate labels for FECs that exactly match a routing table entry.

LSP Precedence and Interaction

LSPs can be LDP or RSVP-TE based, and can be either direct or indirect with respect to a given set. RSVP-TE based LSPs are preferred over LDP LSPs and direct LSPs are preferred over indirect LSPs. Routed IP traffic always flows over an LSP, if one is available. Therefore, if an LSP is established or torn down, routed IP traffic may flow over a more preferred or next best LSP, respectively. These changes take place whenever there is an OSPF routing topology change, LDP label advertisement event, or RSVP-TE signaling action.

Traffic is never load-shared across LSPs of different types. For example, if multiple LSPs exist for an FEC that has one RSVP-TE LSP and four equal-cost LDP LSPs, all IP routed traffic for the FEC flows across the single RSVP-TE LSP (not load-shared among the five active LSPs). If the RSVP-TE LSP is torn down, the IP routed traffic is then load-shared across the four remaining equal-cost LDP LSPs.

Equal Cost LSPs

Traditional IP routers provide session-level IP traffic load distribution across equal cost routed paths. When MPLS is enabled, multiple equal cost routed paths may result in multiple active LSPs for a given FEC. If a label binding for the FEC exists, only the multipath route entries for the FEC that have a label binding are included in the load distribution forwarding table for the FEC. Thus, load distribution of IP traffic is performed over MPLS LSPs or over traditional IP routed paths, but not both simultaneously. MPLS LSPs are always preferred over IP routed paths.

The MPLS module supports distributing IP traffic to an FEC across a maximum of four LSPs. If more than four LSPs are available for an FEC, only four LSP are used. Ingress IP traffic is load-balanced across multiple LSPs using a hashing algorithm based on the IP addresses of the packet. The IP hash algorithm is based on a hash of the source and destination IP addresses. LSR traffic is load balanced across multiple LSPs using a hash algorithm based only on the label stack and MAC addresses of the packet. The label stack and MAC address hash algorithm is based on a hash of the source and destination MAC addresses and the label stack.

TLS tunnels use a two-label stack to tunnel Layer 2 traffic across an IP MPLS domain. If multiple equal-cost LSPs exist to the egress tunnel LSR, TLS tunnel traffic is distributed across the LSPs using multiple two-label stack MPLS headers. Each two-label stack MPLS header has a different outer label, each outer label representing a different NHLFE, with the same inner label representing the TLS VLAN. TLS tunnels can be logically bound to multiple equal-cost LSPs.

As stated earlier, up to four equal-cost LSPs are supported per FEC. Non-IP ingress tunnel traffic is distributed across TLS tunnel LSPs based on the MAC addresses of the packet. Ingress IP tunnel traffic is distributed based on the IP addresses of the packet. The distribution hash algorithms are similar to those previously discussed.

Overriding IBGP Metrics for RSVP-TE LSPs

By default, RSVP-TE LSPs inherit the underlying IGP path cost. You can override the path cost by configuring the LSP IGP metric. The IGP metric can only be specified for RSVP-TE LSPs. RSVP-TE LSPs can be assigned a fixed cost metric, independent of the actual topological IGP cost metric. By controlling the path cost for RSVP-TE LSPs, you can manipulate how different traffic flows are tunneled across an MPLS domain. For example, if the RSVP-TE IGP path cost is set higher than its actual IGP metric, the LSP is not used to transport IP routed traffic, but can still be used to transport TLS VLAN traffic.

LSPs and IBGP Next Hops

You can also use indirect LSPs to reach BGP next hops. For example, an IBGP session is established across the OSPF/MPLS backbone, and the communicating routers run both OSPF and IBGP. When an IBGP route is installed, MPLS determines whether a direct LSP exists to the destination and whether an indirect LSP exists to the BGP next hop. If an indirect LSP exists to the BGP next hop, the LSP is included in the indirect LSP field of the route table entry. If an LSP to an EBGP next hop is not available, a check is made for an LSP to the ASBR used to reach the BGP next hop.

The recalculation requirements for BGP are similar to those for OSPF; when an indirect LSP to an ASBR (corresponding to a BGP next hop router) changes state; the BGP routing table entries must be checked to ensure their LSP information is still valid.

Multivendor Support for Indirect LSPs

To support the use of indirect LSPs, Extreme LSRs automatically advertise a label mapping for a /32 LSP to its OSPF router ID (configured using the `config ospf routerid` command).

Unfortunately, some MPLS implementations do not support indirect LSPs, and they require that a label mapping be advertised for each FEC. If your MPLS network includes equipment that does not support indirect LSPs, you must use configuration commands to explicitly control the advertising of labels.

Optimized Forwarding of Non-MPLS IP Traffic

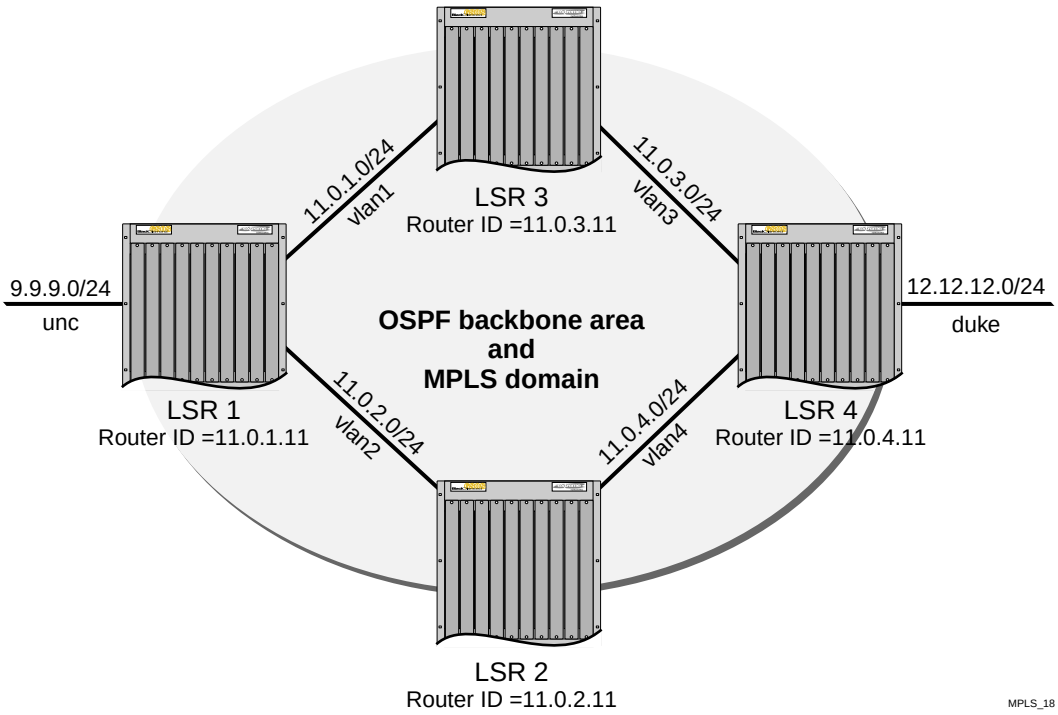
By default, IP packets received by the switch are passed to the MPLS module for IP forwarding. This allows IP packets to be forwarded into LSPs. However, not all IP routes necessarily have LSPs as their next hops. When the MPLS module finds that the route for an IP packet has a normal IP next hop (no LSP to the destination IP address), it sends the destination IP address of the packet to the MSM. The MSM then installs an IP FDB entry for that IP address. From that point, until a routing change causes the IP FDB entry to be deleted or the destination IP address becomes reachable via a newly established LSP, IP packets for that IP address are forwarded by the switch without going through the MPLS module.

This installation of IP FDB entries is disabled when Destination-Sensitive Accounting is enabled.

Configuration Example

The network configuration, shown in Figure 117, illustrates how to configure a BlackDiamond switch to support a routed MPLS network.

Figure 117: MPLS configuration example



The four switches, labeled LSR 1, LSR 2, LSR 3, and LSR 4, have the same physical hardware configuration. Each switch contains an F48ti module, a G8xi module, an MPLS module, and an MSMi module. The switches are all interconnected via Gigabit Ethernet to form the OSPF backbone area and the MPLS domain. In this example, two directly connected OSPF-disabled VLANs are shown: *unc* and *duke*. Traffic between *unc* and *duke* follows routed paths over indirect LSPs established between LSR 1 and LSR 4.

The commands used to configure LSR 1 are described below. The remaining LSRs are configured similarly.

The following commands configure the module types for the specific BlackDiamond slots:

```
config slot 2 module f48t
config slot 3 module g8x
config slot 7 module mpls
```

The following command sets the maximum jumbo frame size for the switch chassis to 1600:

```
config jumbo-frame size 1600
```

The following commands create the VLANs:

```
create vlan vlan1
create vlan vlan2
create vlan unc
```

The following commands configure the VLAN IP address and assign ports participating in each VLAN:

```
config vlan vlan1 ipaddress 11.0.1.1/24
config vlan vlan1 add port 3:2 untagged
config vlan vlan2 ipaddress 11.0.2.1/24
config vlan vlan2 add port 3:3 untagged
config vlan unc ipaddress 9.9.9.0/24
config vlan unc add port 2:24 untagged
```

The following commands enable IP packet forwarding for the specified VLANs:

```
enable ipforwarding vlan1
enable ipforwarding vlan2
enable ipforwarding unc
```

The following commands enable IP forwarding on the configured VLANs. The MTU size is increased on the MPLS VLANs to accommodate the MPLS shim header:

```
enable ipforwarding vlan vlan1
config ip-mtu 1550 vlan vlan1
enable ipforwarding vlan vlan2
config ip-mtu 1550 vlan vlan2
enable ipforwarding vlan unc
```

The following command enables MPLS on VLANs vlan1 and vlan2:

```
config mpls add vlan vlan1
config mpls add vlan vlan2
```

The following command globally enables MPLS on the switch:

```
enable mpls
```

The following commands add vlan1 and vlan2 to the backbone area, each with a cost of 10. The 0.0.0.0 (backbone) area does not need to be created because it exists by default:

```
config ospf add vlan vlan2 area 0.0.0.0
config ospf vlan vlan2 cost 10
config ospf add vlan vlan1 area 0.0.0.0
config ospf vlan vlan1 cost 10
```

The following command enables distribution of local (direct) interfaces into the OSPF area:

```
enable ospf export direct cost 10 ase-type-1
```

The following commands configure the OSPF router ID on the switch and enable the distribution of a route for the OSPF router ID in the router LSA. Originating the router ID as a host route allows other routers in the same OSPF area to establish indirect LSPs for external routes to this router:

```
config ospf routerid 11.0.1.11
enable ospf originate-router-id
```

The following command enables OSPF:

```
enable ospf
```

MPLS Configuration Constraints

MPLS has the following configuration constraints:

- **GVRP**—GVRP is not supported over MPLS LSPs.
- **Server Load Balancing (SLB)**—SLB and MPLS are mutually exclusive functions. Both functions cannot be simultaneously enabled.
- **IP flow redirection**—IP flow redirection commands and MPLS are mutually exclusive functions. Both functions cannot be enabled simultaneously.
- **IGMP snooping**—OSPF and LDP session establishment require the MSM to receive and process IP multicast frames. Therefore, IGMP snooping must be enabled to support MPLS.

26 Configuring RSVP-TE

This chapter describes the Resource Reservation Protocol (RSVP), traffic engineering (TE) extensions to RSVP, and how you configure RSVP-TE using ExtremeWare.

This chapter covers the following topics:

- RSVP Elements on page 546
- Traffic Engineering on page 550
- RSVP Features on page 551
- Configuring RSVP-TE on page 554
- Configuration Example on page 560

RSVP is a protocol that defines procedures for signaling QoS requirements and reserving the necessary resources for a router to provide a requested service to all nodes along a data path.

RSVP is not a routing protocol. It works in conjunction with unicast and multicast routing protocols. An RSVP process consults a local routing database to obtain routing information. Routing protocols determine where packets get forwarded; RSVP is concerned with the QoS of those packets that are forwarded in accordance with the routing protocol.

Reservation requests for a flow follow the same path through the network as the data comprising the flow. RSVP reservations are unidirectional in nature, and the source initiates the reservation procedure by transmitting a path message containing a traffic specification (Tspec) object. The Tspec describes the source traffic characteristics in terms of peak data rate, average data rate, burst size, and minimum/maximum packet sizes.

RSVP-TE is a set of traffic engineering extensions to RSVP. RSVP-TE extensions enable RSVP to be used for traffic engineering in MPLS environments. The primary extensions add support for assigning MPLS labels and specifying explicit paths as a sequence of loose and strict routes. These extensions are supported by including label request and explicit route objects in the path message. A destination responds to a label request by including a label object in its reserve message. Labels are then subsequently assigned at each node the reserve message traverses. Thus, RSVP-TE operates in downstream-on-demand label advertisement mode with ordered LSP control.

NOTE

ExtremeWare does not support native RSVP. RSVP is supported only on TE LSPs.

RSVP Elements

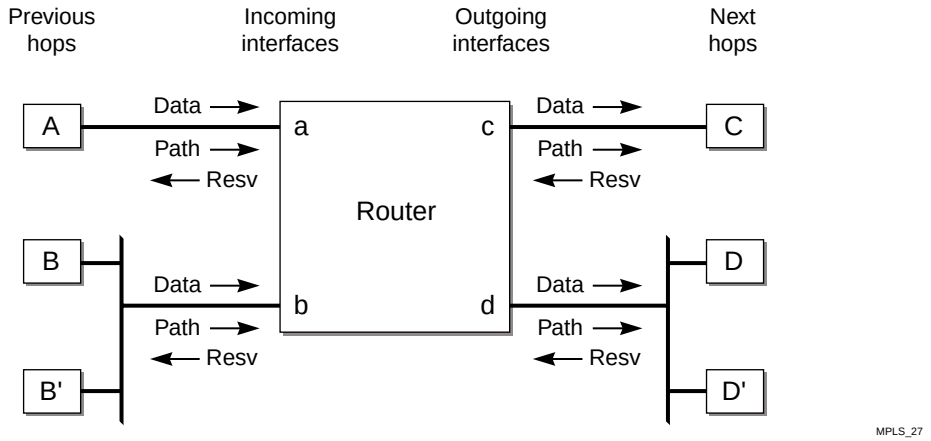
This section describes the following elements of the RSVP protocol:

- Message Types on page 546
- Reservation Styles on page 548
- Bandwidth Reservation on page 548

Message Types

RSVP has two basic message types, path message and reserve message, as shown in Figure 118.

Figure 118: RSVP Messages



In addition to the path and reserve messages, RSVP has the following additional message types:

- Path error message
- Reservation error message
- Path tear message
- Reserve tear message
- Reservation confirm message

Path Message

The RSVP path message is used to store state information about each node in the path. Each RSVP sender periodically transmits a path message downstream along the route for each data path. The path state includes, at minimum, the IP address of the previous hop node. This IP address is used to route the reserve message on a hop-by-hop basis, in the reverse direction.

In addition to the previous hop address, the path message contains the sender Tspec and Adspec. The reservation message carries the flowspec.

Reservation Message

Each receiver host transmits an RSVP reservation request to its upstream neighbor. Reservation messages follow the reverse path that the data packets use. The reservation message creates and maintains a reservation state in each node on the path.

Reservation messages are eventually delivered to the sender, so that the sender can configure appropriate traffic control parameters for the first hop node.

Path Error Message

The path error message is used to report errors that are encountered when processing path or reservation messages. Path error messages travel upstream towards the sender. Path error messages do not modify the state of any node; they are only reported to the sender.

Reservation Error Message

The reservation error message is used to report errors that are encountered when processing reserve messages. In addition, reservation error messages are used to report the spontaneous disruption of a reservation. Reservation error messages travel downstream to the receiver.

Path Tear Message

The path tear message is used to delete a matching path state. When used for a multicast session, path tear messages can only match the path state for the incoming interface on which the path tear message arrived. If there is no matching path state, the path tear message is discarded.

Path tear messages are initiated by senders or by the expiration of the path state timeout. Path tear messages travel downstream towards all receivers. The routing of a path tear message is identical to the corresponding path message.

When a path state is deleted as the result of the path tear message, the related reservation state must also be adjusted to maintain consistency in the node. The adjustment depends on the reservation style.

Reservation Tear Message

The reservation tear message deletes the matching reservation state. If there is no matching reservation state, the message is discarded. The reservation tear message can delete any subset of the filter specification in FF-style or SE-style reservation state. Reservation styles are described in Table 71.

Reservation tear messages are initiated explicitly by receivers or by a node in which the reservation state has timed out. Reservation tear messages travel upstream towards all matching senders.

Reservation Confirm Message

The reservation confirmation message is used to acknowledge a reservation request. Reservation confirmation messages are sent to the receiver host.

Reservation Styles

A reservation style is a set of options that is included in the reservation request.

One reservation style concerns how reservations requested by different senders within the same session are handled. This type of reservation style is handled in one of two ways: either create a *distinct* reservation for each sender in the session, or use a single reservation that is *shared* among all packets of the selected senders.

Another reservation style concerns how senders are selected. Again, there are two choices: an *explicit* list of all selected senders or a *wildcard* that implies all senders in the session.

Table 71 describes the relationship between reservation attributes and styles

Table 71: Reservation Attributes and Styles

Sender Selection	Distinct Reservation Style	Shared Reservation Style
Explicit	Fixed filter (FF)	Shared explicit (SE)
Wildcard	Not defined	Wildcard filter (WF)

The following sections describe the three reservation styles:

- Fixed filter
- Shared explicit
- Wildcard

Fixed Filter

The fixed filter (FF) reservation style uses a distinct reservation and an explicit sender selection. A fixed filter reservation creates a distinct reservation for data packets for a particular sender.

Shared Explicit

The shared explicit (SE) reservation style uses a shared reservation and an explicit sender selection. A shared explicit reservation creates a single reservation that is shared by selected upstream senders. This style permits a receiver to specify the set of senders to be included.

The Extreme MPLS implementation does not support SE reservation style.

Wildcard

The wildcard (WF) reservation style uses the shared reservation and wildcard sender options. A wildcard reservation creates a single reservation that is shared by data flows from all upstream senders.

The Extreme MPLS implementation does not support WF reservation style.

Bandwidth Reservation

As mentioned previously, RSVP reservations are unidirectional in nature. The source initiates the reservation procedure by transmitting a path message containing a Sender Tspec object. The Tspec describes the source traffic characteristics in terms of peak data rate, average data rate, burst size, and minimum/maximum packet sizes. The path message can also contain an optional AdSpec object that is

updated by network elements along the path to indicate information such as the availability of particular QoS services, the maximum bandwidth available along the path, the minimum path latency, and the path maximum transmission unit (MTU).

LSRs make a bandwidth reservation on a per-LSP basis. Only Controlled-Load[1] service requests are supported. When bandwidth is requested, it is possible for the the LSP to be established, even when the requested bandwidth is not reserved. You must verify that the requested bandwidth was actually reserved. In cases when the bandwidth reserved is less than the amount requested, you can manually tear down the LSP and resignal it using a different path. CSPF is not supported. To specify a best effort LSP, configure the reserved bandwidth as zero.

Bandwidth Accounting

ExtremeWare RSVP-TE supports the accounting of bandwidth reserved. The available bandwidth specified in the Adspec object is not modified when the path message is forwarded to the LSP endpoint. As reserve messages are processed, the reserved bandwidth specified in the Flowspec is added to the total reserved bandwidth for the appropriate VLANs. LSP path message setup and hold priorities are not used to preempt previously established LSPs established through an Extreme LSR.

ExtremeWare does not support SE style labels. Therefore, increasing the reserved bandwidth parameter for an LSP will force the LSP to be torn down. If the LSP is torn down, the LSP is resignaled with the new reserved bandwidth value. There are no guarantees that the LSRs along the path will be able to accommodate the increased bandwidth reservation request.

RSVP State

State is installed at each device traversed by the path message, but no resources are reserved. Among other things, the state identifies the adjacent RSVP nodes, which describes the path for the reservation. Resources are not actually reserved until the receiver responds to the path message with a reserve message.

Upon receiving a path message, a destination may examine the Tspec and the AdSpec from the sender, in conjunction with local status/policy information, to determine the actual QoS specification that is to be included in the reserve message. The reserve message follows the reverse of the path established by the path message and the appropriate resources are reserved at each node.

The state maintained by RSVP is temporary, or *soft*. Consequently, path and reserve messages must be periodically retransmitted to maintain an active reservation. Soft state is advantageous because it naturally adapts to changing network conditions, such as topology changes that alter the routed path for a flow. However, the increased control traffic load can be a scalability concern. For this reason, considerable work has been done towards reducing RSVP refresh overhead through the implementation of RFC 2961, *RSVP Overhead Refresh Reduction Extensions*. One aspect of RSVP refresh reduction enables a very long refresh timer by adding support for reliable delivery of RSVP control messages. Prior to refresh reduction, the refresh timer had to be relatively short to ensure timely reservation establishment in the event of a dropped packet. Further reductions are achieved through a mechanism called *summary refresh*, which involves transmitting only the message identifiers associated with the RSVP messages to be refreshed, instead of transmitting the entire unchanged contents of the RSVP messages, and bundling the message identifiers for multiple refresh operations into a single packet.

1. Controlled Load service is defined in RFC 2211.

Traffic Engineering

This section describes RSVP traffic engineering and the following topics:

- RSVP Tunneling on page 550
- RSVP Objects on page 550

RSVP Tunneling

An RSVP tunnel sends traffic from an ingress node through an LSP. The traffic that flows through the LSP is opaque (or tunneled) to the intermediate nodes along the path. Traffic flowing through the tunnel to an intermediate node along the path is identified by the previous hop and is forwarded, based on the label value(s), to the downstream node.

RSVP tunnels can:

- Establish tunnels with or without QoS requirements.
- Dynamically reroute an established tunnel.
- Observe the actual route traversed by a tunnel.
- Identify and diagnose tunnels.
- Use administrative policy control to preempt an established tunnel.
- Perform downstream-on-demand label allocation, distribution, and binding.

RSVP Objects

This section describes the RSVP objects that are used to establish RSVP-TE LSPs:

- Label
- Label request
- Explicit route
- Record route
- Session attribute

Label

The label object is carried in the reservation message and is used to communicate a next hop label for the requested tunnel endpoint IP address upstream to towards the sender.

Label Request

A label request object specifies that a label binding for the tunneled path is requested. It also provides information about the network layer protocol that is carried by the tunnel. The network layer protocol sent through a tunnel is not assumed to be IP and cannot be deduced from the layer-2 protocol header, which simply identifies the higher layer protocol as MPLS. Therefore, the layer-3 Protocol ID (PID) value must be set in the Label Request Object, so that the egress node can properly handle the tunneled data. Extreme switches only support the IP PID value (0x0800).

To create an RSVP-TE LSP, the sender on the MPLS path creates an RSVP path message and inserts the label request object into the path message.

Explicit Route

The explicit route object specifies the route of the traffic as a sequence of nodes. Nodes may be loosely or strictly specified.

The explicit route object is used by the MPLS sender if the sender knows about a route that:

- Has a high likelihood of meeting the QoS requirements of the tunnel
- Uses the network resources efficiently
- Satisfies policy criteria

If any of the above criteria are met, the sender can decide to use the explicit route for some or all of its sessions. To do this, the sender node adds an explicit route object to the path message.

After the session has been established, the sender node can dynamically reroute the session (if, for example, if discovers a better route) by changing the explicit route object.

Record Route

The record route object is used by the sender to receive information about the actual route traversed by the RSVP-TE LSP. It is also used by the sender to request notification if there are changes to the routing path. Intermediate or transit nodes can optionally use the RRO to provide loop detection.

To use the object, the sender adds the record route object to the path message.

Session Attribute

The session attribute object can also be added to the path message. It is used for identifying and diagnosing the session. The session attribute includes the following information:

- Setup and hold priorities
- Resource affinities
- Local protection

RSVP Features

This section covers the following features of RSVP:

- Route recording
- Explicit route path LSPs
- Redundant LSPs
- Improving LSP scaling

Route Recording

The route a path takes can be recorded. Recording the path allows the ingress LER to know, on a hop-by-hop basis, which LSRs the path traverses. Knowing the actual path of an LSP can be especially useful for diagnosing various network issues.

Network path recording is configurable per LSP. If enabled, the record route object (RRO) is inserted into the path message using a single RRO subobject, representing the ingress LER. When a path message is received by an Extreme LSR that contains an RRO, an RRO IPv4 subobject representing the /32 address of the outgoing interface of the path message is pushed onto the top[1] of the first RRO. If the setup of an LSP originates from an Extreme LER for which route recording is enabled, the path message is originated with an RRO containing a single RRO subobject specifying the outgoing interface address of the path message. A similar RRO is constructed as the RESV message goes from egress node to ingress node.

The label recording flag is not supported by Extreme LSRs. This flag instructs all LSRs along the LSP to include the advertised downstream label in a label object as part of the RRO. If an Extreme LSR receives a path message with the label recording flag set in the RRO, the LSR does not push a label subobject onto the RRO.

If a path message is received that contains an RRO, the Extreme LSR uses the RRO to perform loop detection. The RRO is scanned to verify that the path message has not already traversed this LSR. If the RRO contains an IPv4 subobject that represents a local LSR interface, the path message is dropped and a "Routing Problem" error message is sent to the originating LER with an error value of "Loop detected."

Explicit Route Path LSPs

An explicit route is a specified path through a routed network topology. The path may be strictly or loosely specified. If strictly specified, each node or group of nodes along the path must be configured. Thus, no deviation from the specified path is allowed.

Loosely specified paths allow for local flexibility in fulfilling the requested path to the destination. This feature allows for significant leeway by the LSR in choosing the next hop when incomplete information about the details of the path is generated by the LER. Each node along the path may use other metrics to pick the next hop along the path, such as bandwidth available, class of service, or link cost.

An explicit routed path is encoded using the explicit route object (ERO) and is transmitted in the path message. The ERO consists of a list of subobjects, each of which describes an abstract node. By definition, an abstract node can be an IPv4 Prefix, IPv6 Prefix, or an autonomous system (AS) number. ExtremeWare RSVP-TE supports IPv4 abstract nodes, only. They can be an IP prefix interface address or an OSPF router-id. The /32 IP address may represent the OSPF router ID, direct interface, or loopback address.

Received path messages with EROs that contain any other subobject type result in the transmittal of an "Unknown object class" error message. All LSRs along the specified path must support the inclusion of the ERO in the path message for an explicitly routed path to be successfully set up.

All ERO subobjects describing the path must be defined by the ingress LER.

Redundant LSPs

Two methods are available for provisioning redundant RSVP-TE LSPs at the ingress LER. The first uses the concept of secondary or backup LSPs and the second relies on equal-cost LSP route metrics.

Redundant RSVP-TE LSPs can be configured to provide alternate paths in the event that the primary path fails. Secondary paths are fully provisioned preestablished RSVP-TE LSPs that are maintained as inactive TE /32 routes to the path endpoint. If the primary path is torn down, the primary path TE /32 route is removed from the routing table, and a TE /32 route representing one of the active secondary

1. RRO is organized as a LIFO stack.

paths is installed as the preferred path for the LSP. If multiple secondary are paths available, the secondary path is randomly selected. If the primary path is reestablished, the primary path TE /32 route is reinstalled as the preferred path.

Stateful failovers can be managed by configuring only secondary paths for an LSP. When no primary paths are configured for an LSP, a TE /32 route representing one of the secondary paths is installed in the route table. If the secondary path fails, for which a TE /32 route has been installed in the route table, another secondary TE /32 route representing separate path is installed in the route table (provided one is configured and active). Secondary path TE /32 routes remain the preferred route unless a primary path is configured for the LSP, the active secondary path fails, or the active secondary path is deleted. Thus, no switch-back to the original secondary path is performed if the original secondary path fails and is later reestablished.

Parallel RSVP-TE LSPs can exist to the same endpoint. Parallel LSPs exist when multiple paths are configured to the same egress LSR, with each LSP having a configured metric that is less than, or equal to, the interior gateway protocol (IGP) metric. In both cases, a TE /32 route to the egress LER is installed in the route table of the ingress LER for all of the best equal-cost RSVP-TE paths. Traffic is distributed across up to four TE /32 routes based on a MAC and IP address hash algorithms. If one of the LSPs fail, the traffic is redistributed across the remaining active LSPs. In this example, no LSP secondary paths are required.

Ping Health Checking

After an LSP has been established, the egress LSR may be optionally pinged to determine end-to-end path connectivity. If a ping response is not received within [2 * *ping-interval* – 1] seconds, the LSP is considered unavailable. You can specify how frequently an ICMP echo request is transmitted to the egress LER IP address on the established LSP.

Improving LSP Scaling

You can improve LSP scaling by configuring the following RSVP-TE parameters:

- `refresh-time`—The refresh-time specifies the interval for sending refresh path messages. RSVP refresh messages provide soft state link-level keep-alive information for previously established paths and enable the switch to detect when an LSP is no longer active. RSVP sessions are torn down if an RSVP refresh message is not received from a neighbor within [(*keep-multiplier* + 0.5) * 1.5 * *refresh-time*] seconds. The valid refresh-time may be set to any value between one and 36000 seconds. The default setting is 30 seconds. Configuring a longer refresh time reduces both switch and network overhead.
- `summary-refresh-time`—The summary-refresh-time, specified in tenths of a second, indicates the time interval for sending summary refresh RSVP messages. The summary-refresh-time must be less than the configured refresh-time. The default summary-refresh-time is zero, indicating that no summary refresh RSVP messages are sent. The summary-refresh-time value may be set to any value between zero to 100 (or 10 seconds). If configured, the bundled and summary refresh RSVP messages are only sent to RSVP-TE peers supporting RSVP refresh reduction.
- `bundle-time`—The bundle-time, specified in tenths of a second, indicates the maximum amount of time a transmit buffer is held so that multiple RSVP messages can be bundled into a single PDU. The default bundle-time is zero, indicating that RSVP message bundling is not enabled. The bundle-time value can be set to any value between zero and 30 (or 3 seconds).

Configuring RSVP-TE

This section describes the following tasks:

- Configuring RSVP-TE on a VLAN on page 554
- Configuring RSVP-TE Protocol Parameters on page 554
- Configuring an RSVP-TE Path on page 555
- Configuring an Explicit Route on page 556
- Configuring an RSVP-TE Profile on page 557
- Configuring an Existing RSVP-TE Profile on page 558
- Configuring an RSVP-TE LSP on page 558
- Adding a Path to an RSVP-TE LSP on page 559
- Displaying RSVP-TE LSP Configuration Information on page 559
- Displaying the RSVP-TE Routed Path on page 560
- Displaying the RSVP-TE Path Profile on page 560
- Displaying the RSVP-TE LSP on page 560

Configuring RSVP-TE on a VLAN

To configure RSVP-TE on one or all VLANs, use the following command:

```
config mpls add vlan [<vlan name> | all] {rsvp-te}
```

To disable RSVP-TE on a VLAN, use the following command:

```
config mpls delete vlan [<vlan name> | all] {rsvp-te}
```

This command disables RSVP-TE on one or all VLANs. Deleting RSVP-TE causes all TE LSPs to be released, and prevents TE LSPs from being established or accepted on the specified VLAN.

Configuring RSVP-TE Protocol Parameters

To configure RSVP-TE protocol parameters, use the following command:

```
config mpls rsvp-te vlan [<vlan name> | all] {hello-interval <seconds>} {refresh-time
<seconds>} {summary-refresh-time <tenth-seconds>} {bundle-time <tenth-seconds>}
{keep-multiplier <number>}
```

This command configures the RSVP-TE protocol parameters for the specified VLAN. The RSVP-TE keyword `all` indicates that the configuration changes apply to all RSVP-TE enabled VLANs.

The `hello-interval` time specifies the RSVP hello packet transmission interval. The RSVP hello packet is used by the switch to detect when a RSVP-TE peer is no longer reachable. If an RSVP hello packet is not received from a peer with [hello-interval * `keep-multiplier`] seconds, the peer is declared down and all RSVP sessions to and from that peer are torn down. The default `hello-interval` time is zero, indicating that RSVP hellos are not enabled. The hello-interval may be set to any value between zero and 60 seconds.

The `refresh-time` parameter specifies the interval for sending refresh path messages. RSVP refresh messages provide “soft state” link-level keep-alive information for previously established paths and

enables the switch to detect when an LSP is no longer active. RSVP sessions are torn down if an RSVP refresh message is not received from a neighbor within [(keep-multiplier + 0.5) * 1.5 * refresh-time] seconds. The default refresh-time is 30 seconds and the default keep-multiplier value is three. The minimum and maximum refresh-time values are one and 36,000 seconds (or ten hours) respectively. The minimum and maximum keep-multiplier values are one and 255 respectively.

The bundle-time, specified in tenths of a second, indicates the maximum amount of time a transmit buffer is held so that multiple RSVP messages can be bundled into a single PDU. The default bundle-time is zero, indicating that RSVP message bundling is not enabled. The bundle-time value may be set to any value between zero and 30 (or 3 seconds).

The summary-refresh-time, specified in tenths of a second, indicates the time interval for sending summary refresh RSVP messages. The summary-refresh-time must be less than the configured refresh-time. The default summary-refresh-time is zero, indicating that no summary refresh RSVP messages are sent. The summary-refresh-time value may be set to any value between zero to 100 (or 10 seconds).

If configured, the bundled and summary refresh RSVP messages are only sent to RSVP-TE peers supporting RSVP refresh reduction.

Configuring an RSVP-TE Path

To add an RSVP-TE routed path, use the following command:

```
config mpls rsvp-te add path <path_name> [<ipaddress> | <host_name>] {from
<local_endpoint_vlan>}
```

The <path_name> and <ipaddress> or <host_name> must be specified for the path. The <path_name> parameter is a character string that is to used to identify the path within the switch. The <path_name> string must begin with an alphabetic character, and may contain up to 31 additional alphanumeric characters. Each <path_name> represents a routed path to a single IP destination.

If the <host_name> is specified, the DNS client on the switch must be configured so that the <host_name> can first be resolved to an IP address. Alternate routed paths to the same IP destination may be configured by adding additional <path_names> and specifying the same <ipaddress> or <host_name> as the path endpoint.

The RSVP-TE path is not signaled until an LSP is added with the specified <path_name>. If no explicit route objects are configured, the path will follow the best-routed path to the configured <ipaddress> (or IP address obtained from DNS name resolution). Optionally, the from keyword can be used to specify the <local_endpoint_vlan> from which the path is signaled. The maximum number of configurable paths is 255.

To delete an RSVP-TE path, use the following command:

```
config mpls rsvp-te delete path [<path_name> | all]
```

This command deletes a configured MPLS RSVP-TE routed path with the specified <path_name>. All associated configuration information for <path_name> is deleted. A path cannot be deleted as long as the <path_name> is associated with an LSP. If the all keyword is specified, all paths not associated with an LSP are deleted.

Configuring an Explicit Route

To add an RSVP-TE explicit route, use the following command:

```
config mpls rsvp-te path <path_name> add ero [ipaddress <ipaddress/masklength> |
<host_name>] {strict | loose} {order <number>}
```

This command adds an IP address to the explicit route object (ERO) for the specified path name. The RSVP-TE routed path may be described by a configured sequence of the LSRs and/or subnets traversed by the path. Each defined LSR or subnet represents an ERO subobject. Up to 64 subobjects can be added to each path name.

When specifying an LSR using the `<host_name>` parameter, the DNS client on the switch must be configured so that the `<host_name>` can first be resolved to an IP address. The `ipaddress` keyword identifies an LSR using either a /32 address, which may represent an LSR router ID, loopback address, or direct router interface, or an IP prefix, which represents a directly connected subnet. Each IP address or prefix is included in the ERO as an IPv4 subobject.

If the IP address is specified as `strict`, the strict subobject must be topologically[1] adjacent to the previous subobject as listed in the ERO. If the IP address is specified as `loose`, the loose subobject is not required to be topologically adjacent to the previous subobject as listed in the ERO. If omitted, the default subobject attribute is `loose`. Each IP address or prefix is included in the ERO as an IPv4 subobject.

If the subobject matches a direct router interface or a directly attached subnet, the switch verifies that the path message is received on the matching router interface. If the LSR specified matches the OSPF router ID or a configured loopback IP address, the router interface which the packet is received is ignored.

The LSR path order is optionally specified using the `order` keyword. The `order number` parameter is an integer value from 1 to 65535. IP prefixes with a lower number are sequenced before IP prefixes with a higher number. You can specify multiple paths and assign them an order number. The order number determines the path that the LSP follows. Thus, the LSP path follows the configured path of the IP prefix with the order value from low to high. If the `order` keyword is not specified, the number value for the LSR defaults to a value 100 higher than the current highest number value.

If the list of IP prefixes, added to the path, does not reflect an actual path through the network topology, the path message is returned with an error from a downstream LSR and the LSP is not established.

The order of a configured subobject can not be changed. The ERO subobject must be deleted and re-added using a different order. If a subobject is added to or deleted from the ERO while the associated LSP is established, the path is torn down and is resignaled using the new ERO.

Duplicate ERO subobjects are not allowed. Defining an ERO for the path is optional. If you do not configure an ERO, the path is signaled along the best-routed path and the ERO is not included in the path message. When the last subobject in the ERO of the path message is reached and the egress IP node of the path has not been reached, the remaining path to the egress node is signaled along the best-routed path. Specification of an ERO could lead to undesirable routed paths, so you should be careful when terminating the ERO routed-path definition prior to the configured path egress node.

1. The LSP next hop matches either the interface IP address or the OSPF router-id of the immediate neighbor LSR.

To delete an RSVP-TE explicit route, use the following command:

```
config mpls rsvp-te path <path_name> delete ero [all | ipaddress
<ipaddress/masklength> | <host_name> | order <number>]
```

This command deletes an LSR or subnet from the ERO for the specified path name. The LSR is specified using the `ipaddress`, `<host_name>`, or `order` parameter. If an LSR is deleted from an ERO while the associated LSP is established, the path is torn down and is resignaled using a new ERO. Use the `all` keyword to delete the entire ERO from the path name. When there is no configured ERO, the path is no longer required to take an explicit routed path. The path is then signaled along the best-routed path and no ERO is included in the path message.

Configuring an RSVP-TE Profile

To add an RSVP-TE profile, use the following command:

```
config mpls rsvp-te add profile <profile_name> {bandwidth <bps>} {hop-count <number>}
{setup-priority <priority>} {hold-priority <priority>} {retry-timeout <seconds>}
{ping-interval <seconds>} {metric [<metric> | igp-tracking]} {record [enabled |
disabled]}
```

A profile is a set of attributes that are applied to the LSP when the LSP is configured using the `config mpls rsvp-te add lsp` command. A default profile is provided which cannot be deleted, but can be applied to any configured LSP. The profile name for the default profile is *default*. The default profile parameter values are initially set to their respective default values. The maximum number of configurable profiles is 255 (one of which is reserved for the default profile).

The `bandwidth` parameter specifies the desired reserved bandwidth for the LSP. Any positive integer bps value is valid. Optionally, you can append the characters, k for kilobits, m for megabits, or g for gigabits, to the bps value to specify the unit of measure. If the k, m, or g, character is omitted, the unit of measure is assumed to be kilobits. The default bandwidth bps value is zero, which indicates that the QoS for the LSP is best effort. ExtremeWare does not support bandwidth reservation.

The `setup-priority` and `hold-priority` are optional parameters indicating the LSP priority. During path set up, if the requested bandwidth cannot be reserved through the LSR, the `setup-priority` parameter is compared to the `hold-priority` of existing LSPs to determine if any of the existing LSPs need to be preempted to allow a higher priority LSP to be established. Lower numerical values represent higher priorities. The `setup-priority` range is 0 to 7 and the default value is 7. The `hold-priority` range is also 0 to 7 and is set equal to the `setup-priority` by default. ExtremeWare does not support LSP preemption.

The `retry-timeout` keyword specifies the maximum number of seconds the switch allows for LSP setup. If the LSP cannot be established within `retry-timeout` seconds, the LSP is resignaled. The default value for `retry-timeout` is 30 seconds with a configurable range of 5 to 600 seconds. The `hop-count` parameter limits the number of LSRs the path can traverse, including the ingress and egress router. The default `hop-count` value is 255 with a configurable range of two to 255.

After an LSP has established, the egress LSR may be optionally pinged to determine end-to-end path connectivity. If a ping response is not received within [2 * `ping-interval` – 1] seconds, the LSP is considered unavailable. The `ping-interval` keyword specifies how frequently an ICMP echo request is transmitted to the egress LSR IP address on the established LSP. The default `ping-interval` is zero, which indicates no end-to-end LSP health checking is performed. You can set the `ping-interval` value to any interval between 0 and 60 seconds.

The route metric is used to determine if an established RSVP-TE LSP will actually be used to send data. Whenever the configured metric is less than, or equal, to the calculated IGP metric, the LSP is used for sending routed IP traffic. In this case, the LSP is also used to send TLS data when the TLS tunnel is configured by specifying the tunnel LSP endpoint IP address. Traffic is distributed across up to four equal-cost LSPs. The valid metric values range from 1 to 65535. Specifying the igp-tracking keyword forces the route metric to track the underlying IGP metrics. If no IGP metric exists for the LSP (for example, the LSP traverses a RIP network), the metric is ignored. Tracking IGP metrics is the default behavior.

The record keyword is used to enable hop-by-hop path recording. The enabled keyword causes the record route object (RRO) to be inserted into the path message. The RRO is returned in the reserve message and contains a list of IPv4 subobjects that describe the RSVP-TE path. Path recording by default is disabled. When disabled, no RRO is inserted into the path message.

To delete an RSVP-TE path profile, use the following command:

```
config mpls rsvp-te delete profile [<profile_name> | all]
```

This command deletes a configured RSVP-TE profile with the specified profile name. The default profile cannot be deleted. If a profile is associated with a configured LSP, the profile cannot be deleted. If you specify the all keyword, all profiles not associated with an LSP are deleted (except for the default profile).

Configuring an Existing RSVP-TE Profile

To configure an existing RSVP-TE profile, use the following command:

```
config mpls rsvp-te profile <profile_name> {bandwidth <bps>} {hop-count <number>}
{setup-priority <priority>} {hold-priority <priority>} {retry-timeout <seconds>}
{ping-interval <seconds>} {metric [<metric> | igp-tracking]} {record [enabled |
disabled]}
```

This command configures RSVP-TE attributes for the specified profile. The <profile_name> must have been previously added. All of the LSP profile values are updated dynamically. For LSPs configured with this profile, the LSP parameters are updated automatically with the sending of the next refresh path message. If the metric is changed, all LSPs using this profile are rechecked against the calculated IGP metric. In some cases, the LSP may be torn down because of a profile configuration change. For example, if the bandwidth value is increased, the LSRs along the existing path may not be able to accommodate the additional reserved bandwidth. In this scenario, the LSP is torn down and resignaled.

Configuring an RSVP-TE LSP

To add an RSVP-TE LSP, use the following command:

```
config mpls rsvp-te add lsp <lsp_name> path <path_name> {<profile_name>} {primary |
secondary}
```

Both the <lsp_name> and <path_name> must be specified. The <lsp_name> parameter is a character string that is to be used to identify the LSP within the switch. The <lsp_name> string must begin with an alphabetic character and can contain up to 31 additional alphanumeric characters. The <profile_name> is optional. If omitted, the default profile is applied to the LSP. The LSP is immediately signaled as soon as it is configured. The maximum number of configurable LSPs is 1024.

To delete an RSVP-TE LSP, use the following command:

```
config mpls rsvp-te delete lsp [<lsp_name> | all]
```

Deleting an LSP name disassociates all configured paths with this LSP and all configuration information for the LSP name is deleted. LSPs cannot be deleted if the specified <lsp_name> has been configured as the LSP for a TLS tunnel. If you specify the all keyword, all LSPs not associated with a TLS tunnel are deleted.

Adding a Path to an RSVP-TE LSP

To add a path to an RSVP-TE LSP, use the following command:

```
config mpls rsvp-te lsp <lsp_name> add path <path_name> {<profile_name>} {secondary | primary}
```

The <lsp_name> must represent a configured LSP. Only one primary path and up to two secondary paths can be added per <lsp_name>. The <path_name> specified defaults to primary when no primary path has been configured for <lsp_name> and defaults to secondary if the primary path has been previously configured for <lsp_name>.

You do not need to configure the primary path for an LSP. Each <path_name> added to an <lsp_name> must be unique, but a <path_name> can be associated with multiple LSP names.

All configured primary and secondary paths for the <lsp_name> must have the same endpoint IP address. For example, three paths can be configured for the <lsp_name>, but all paths should represent different topological paths through the network to the same LSP endpoint.

Adding a secondary <path_name> designates a path as a hot-standby redundant path, used in the event that the primary or secondary path cannot be established or fails. Provided the <path_name> has not already been established, all path names are signaled as soon as they are associated with an <lsp_name>. If the primary <path_name> fails, is not configured, or cannot be established after the specified LSP retry-timeout, one of the configured secondary paths may become the active path for <lsp_name>. All of the secondary paths have equal preference; the first one available is chosen. If at any time the primary path is established, <lsp_name> immediately switches to using the primary path. If a secondary path fails while in use, the remaining configured secondary paths can become the active path for <lsp_name>.

To delete a path from an RSVP-TE LSP, use the following command:

```
config mpls rsvp-te lsp <lsp_name> delete path <path_name>
```

When you issue this command, the LSP associated with the path is immediately torn down. If the deleted path represents the in-use LSP for <lsp_name> and another secondary path is configured, the LSP immediately fails over to an alternate LSP. Because at least one path must be defined for each LSP, the last configured path cannot be deleted from the LSP.

Displaying RSVP-TE LSP Configuration Information

To display RSVP-TE LSP configuration information, use the following command:

```
show mpls rsvp-te {<ipaddress>} {detail}
```

This command displays information about the status of RSVP-TE enabled interfaces. Summary information is displayed for all known RSVP-TE peers including the peer IP address and peer status. If you specify the ipaddress of the RSVP-TE interface, the information for a single RSVP-TE interface is displayed. Additional information is displayed in the detailed format if you specify the optional detail keyword. The more detailed RSVP-TE information includes the number and type of RSVP messages transmitted through the local RSVP-TE interface.

Displaying the RSVP-TE Routed Path

To display the RSVP-TE routed path, use the following command:

```
show mpls rsvp-te path {<path_name>} {detail}
```

This command displays the configuration and status information for MPLS RSVP-TE routed paths. Information is listed in tabular format and includes the path name, path endpoint LSR IP address, and local VLAN (if configured). If the path endpoint is specified as a host name, the host name and the DNS resolved IP address are both displayed. If a specific path name is specified, only information for the specified path is displayed. If you specify the optional `detail` keyword, the list of subobjects specified for the explicit route object and any LSPs that are configured to use the path are displayed.

Displaying the RSVP-TE Path Profile

To display the RSVP-TE path profile, use the following command:

```
show mpls rsvp-te profile {<profile_name>}
```

By default, this command displays all configured profile parameters for the specified profile. If the profile name is omitted, the profile parameter values for all configured LSP profiles are displayed.

Displaying the RSVP-TE LSP

To displays the RSVP-TE LSP, use the following command:

```
show mpls rsvp-te lsp {<lsp_name>} {detail}
```

This command displays the configuration and status information for RSVP-TE LSPs. Information is listed in tabular format and includes the LSP name, LSP state, active path name, bandwidth requested, bandwidth actually reserved, ERO flag, egress LSR, LSP up-time, and RSVP error codes (if LSP setup failed). If you specify a specific LSP name, only information for the specified LSP is displayed. If you specify the optional `detail` keyword, additional information is displayed for each LSP. The detailed information includes a list of all configured paths, including the path state, error codes for the LSP associated with each path, up-time for each LSP, the RRO (if enabled) for each LSP, the bound profile name, and a list of TLS tunnels configured to use the LSP.

Configuration Example

RSVP-TE LSPs comprise profiles, paths, and the actual LSP. This section describes how to configure an RSVP-TE LSP.

Configuring RSVP LSPs is a multi-step process with some optional steps, depending on the specific requirements of the LSP. Conceptually, a number of mandatory elements must be configured to create an RSVP-TE LSP. In addition, you can also configure optional elements. In certain configurations, there are also order dependencies.

The profile contains constraints that you wish to apply to the LSP. These constraints may affect the path selected across the MPLS domain in order to meet. Examples of profile parameters include bandwidth, setup, and hold priority relative to other configured LSPs.

The path can be used to specify the local and remote endpoints for the LSP and, optionally, the explicit path across the MPLS domain that the LSP should follow.

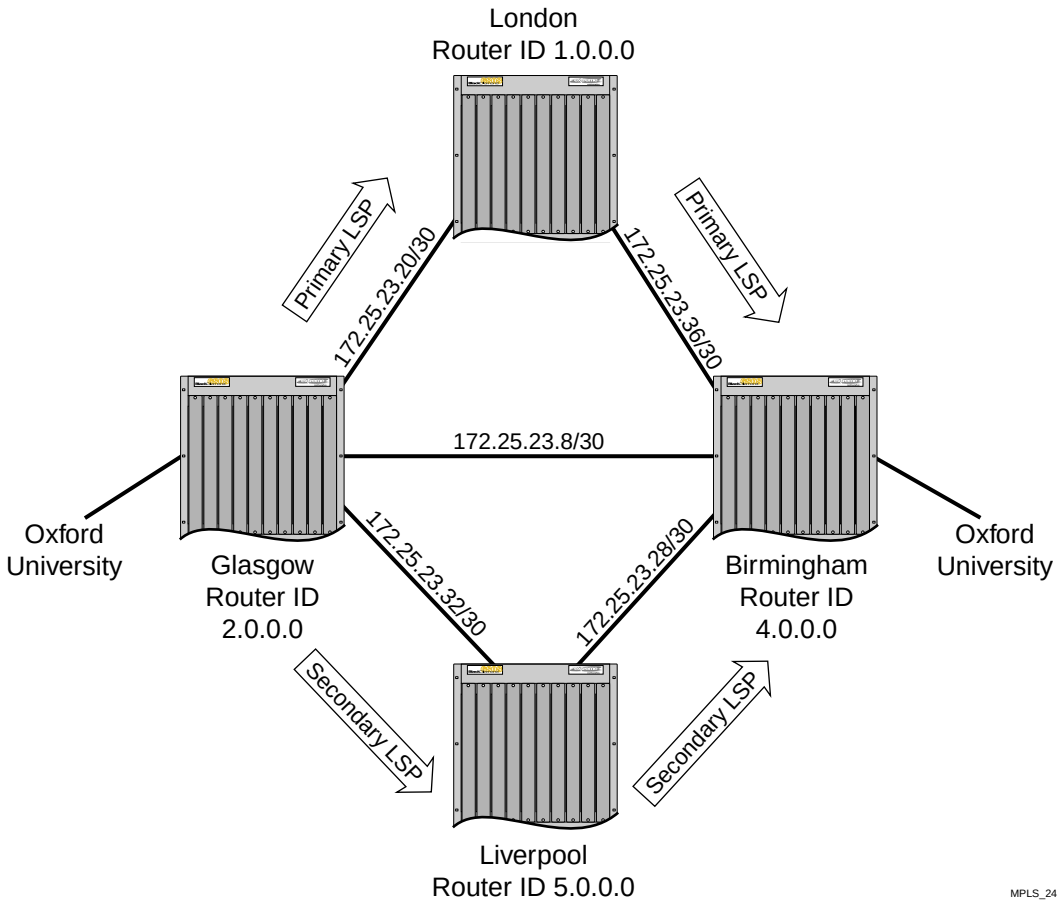
The ERO is an object, sent as part of the LSP setup request (path message), explicitly specifies the path across the MPLS domain the setup request should follow. You can configure a loose or strict path.

Certain elements of configuration are order dependent. For example if you specify a profile or path when creating an LSP, those path or profile definitions must already exist. Similarly a path must exist before an ERO is created, as the ERO is added explicitly to the path.

The typical steps used to configure and verify an RSVP-TE LSP are as follows:

1. Configure a path (mandatory).
2. Configure a profile (optional).
3. Configure an ERO for a path (optional).
4. Configure a primary/secondary LSP (mandatory).
5. Add a secondary LSP (optional).
6. Verify LSP status (recommended).

Figure 119: RSVP-TE Configuration Example



The configuration example, shown in Figure 119, creates primary and secondary LSP between the node Glasgow and and the node Birmingham. The steps specifically create an LSP between Glasgow and Birmingham based on an explicitly routed path via London with bandwidth, and setup and hold priority profile requirements. A secondary path is also created which, in the event of failure of a link or

node on the primary path, activates the secondary path for the LSP. This path is Glasgow, Birmingham via Liverpool.

NOTE

An initial step of adding RSVP-TE to a VLAN must be carried out for all VLANs over which the user wishes RSVP-TE LSPs to be signaled. This is a one-time operation.

The following commands add RSVP signaling capabilities to the specified VLANs:

```
config mpls add vlan gla-lon rsvp-te
config mpls add vlan gla-liv rsvp-te
```

The following commands create an LSP profile named Glasgow-Birmingham-pro. LSPs that use the Glasgow-Birmingham-pro profile are signaled with a reserved bandwidth of 10 Mbps and an LSP setup and hold priority of 5.

```
config mpls rsvp-te add profile Glasgow-Birmingham-pro bandwidth 10m setup-priority 5
hold-priority 5
```

The following commands define the primary and secondary paths between Glasgow and Birmingham. The paths are defined such that they originate from a loopback VLAN called *loop* and terminate at the endpoint 4.0.0.0.

```
config mpls rsvp-te add path Glasgow-Birmingham-pri-path 4.0.0.0 from loop
config mpls rsvp-te add path Glasgow-Birmingham-sec-path 4.0.0.0 from loop
```

The following commands strictly pin each path to an LSR, such that each path takes a different route to the endpoint 4.0.0.0. Path Glasgow-Birmingham-pri-path is routed through LSR 1.0.0.0 and path Glasgow-Birmingham-sec-path is routed through LSR 5.0.0.0.

```
config mpls rsvp-te path Glasgow-Birmingham-pri-path add ero ipaddress 1.0.0.0 strict
config mpls rsvp-te path Glasgow-Birmingham-sec-path add ero ipaddress 5.0.0.0 strict
```

The following commands configure two RSVP-TE LSPs; one is the primary and the other is a secondary or backup LSP. Each LSP uses the same profile but different paths.

```
config mpls rsvp add lsp Glasgow-Birmingham-lsp path Glasgow-Birmingham-pri-path
Glasgow-Birmingham-pro primary

config mpls rsvp lsp Glasgow-Birmingham-lsp add path Glasgow-Birmingham-sec-path
Glasgow-Birmingham-pro secondary
```

NOTE

The secondary LSP is signaled, however it remains in a standby state unless the primary path becomes unavailable.

By default, a TLS tunnel flows over any available LSP. However, a TLS tunnel can be specifically directed to use a configured RSVP-TE based LSP. Configuration is no different from configuring an LDP-based TLS tunnel, except that the RSVP-TE LSP is explicitly specified. The following command specifically directs the TLS tunnel to use a previously configured RSVP-TE:

```
config mpls add tls-tunnel Glasgow-Birmingham-cust1 lsp Glasgow-Birmingham-lsp
oxford-university vcid 50 from 2.0.0.0
```

27 Configuring MPLS Layer-2 VPNs

This chapter describes Layer-2 VPN services and the following topics:

- Overview of MPLS Layer-2 VPNs on page 563
- TLS VPN Characteristics on page 566
- Configuring MPLS Layer-2 VPNs on page 566
- TLS VPN Configuration Examples on page 570
- Using ESRP with MPLS TLS on page 574

Overview of MPLS Layer-2 VPNs

The idea behind transparent LAN services (TLS) over MPLS is to enable Layer-2 virtual private networking (VPN) service offerings in a simple manner that is easy to deploy and operate. Layer-2 VPN services, based on a combination of Ethernet and MPLS/IP technologies, are designed to enable service providers to offer Ethernet business private line services. These services are also referred to as Transparent LAN Services (TLS) or Virtual Private LAN Services (VPLS). Layer-2 VPN services use a simple Layer-2 interface at the customer edge combined with the resilience and scalability of an MPLS/IP core to provide VPN connectivity.

Layer-2 VPN Services

There are two basic types of Layer-2 VPN services. The first is a *VLAN* service. This service transparently interconnects two or more VLAN segments together over an MPLS network. The configured VLAN IDs for the customer switch interfaces are not required to match, as long as the TLS egress LSR overwrites the VLAN tag with the locally defined VLAN ID, or if the local VLAN is untagged, strips the 802.1Q tag completely. The second service is a *port* service. This service transparently interconnects two or more ports together over an MPLS network. Traffic is transported unmodified between ports.

Extremeware supports both services, but only the VLAN service is interoperable with other vendor implementations. Port-based TLS service requires that the dot1q tag ethertype be configured to 9100. By changing the configured dot1q ethertype value, the Ethernet switch ports treat 8100 tagged traffic as untagged and insert a new dot1q tag with the configured ethertype value. By inserting a new dot1q tag, all traffic received on a single port can be aggregated into a single VLAN and transported across an MPLS domain as a VLAN service. All TLS edge switches must be configured to use the same dot1q ethertype value.

MPLS VC Tunnels

MPLS virtual circuit (VC) tunnels are logical connections between two LERs over an LSP. Like ATM VCs, these connections can be signaled (dynamic) or statically configured. Dynamic TLS tunnel connections are commonly referred to as VC tunnels, because the TLS tunnel label is signaled based on the configured VC identifier (vcid). The signaled VC label is used to create a two-label stack LSP. The outer label is the LSP label obtained from LDP or RSVP-TE and the inner label is the signaled VC label. LERs also signal the VC type when attempting to establish a VC tunnel. Extremeware only supports the VLAN VC type and reject all other VC types, including the Ethernet VC type used to signal Ethernet port service.

VLAN type VC tunnels are also referred to as TLS tunnels. Static TLS tunnels are not signaled. The ingress and egress VC label for each TLS tunnel must be configured at each end of the tunnel. Both static and dynamic TLS tunnels can be configured simultaneously, but both share the same 16K TLS LER label space partition.

Transporting 802.1Q Tagged Frames

When an 802.1Q Ethernet frame is encapsulated for transport over a VC tunnel, the entire frame is included, except for the preamble and FCS. The 4-byte VLAN tag field is transmitted as is, but may be overwritten by the egress LER. The option to overwrite the VLAN tag allows two (possibly independently administered) VLAN segments with different VLAN IDs to be treated as a single VLAN.

Establishing LDP LSPs to TLS Tunnel Endpoints

The TLS tunnel endpoint is identified using an IP address configuration parameter, and LDP must set up a tunnel LSP to the configured IP address before Layer-2 traffic can be transported. To ensure that the tunnel LSP is established, both an OSPF route and a MPLS label mapping must be advertised for the configured IP address.

When the peer LSR is also an Extreme switch, the following options are available for ensuring that an OSPF route is advertised for the tunnel endpoint IP address:

- A route is advertised when OSPF is enabled on the VLAN to which the IP address is assigned (using the `config ospf add vlan` command on the peer switch).
- A route is advertised when the peer switch is configured to distribute direct routes into the OSPF domain (via the `enable ospf export direct` command). The export option should be used when the tunnel LSP needs to cross OSPF area boundaries or when the Extreme Standby Routing Protocol (ESRP) is enabled on the VLAN to which the IP address is assigned.

In either case, LDP must be configured to advertise label mappings for direct routing interfaces.

In some configurations, you may want to enable loopback mode on the VLAN to which the tunnel endpoint IP address is assigned. One situation where loopback mode may be useful is when multiple physical interfaces, associated with different VLANs, are connected to the MPLS backbone. In this case, use of loopback-mode can provide redundancy by enabling TLS traffic to continue even when the physical interfaces associated with the tunnel endpoint IP address VLAN fail.

LSP Selection

By default, a TLS tunnel will use any available LSP to the TLS tunnel endpoint IP address. If there are multiple equal cost LSPs, the TLS tunnel is load shared across up to four LSPs. Optionally, a TLS tunnel can be configured to use a specific RSVP-TE LSP. If the RSVP-TE LSP metric is set higher than its

underlying IGP metric, the LSP is not used to forward normal routed IP and is only used to forward TLS VLAN traffic.

Layer-2 VPN Domains

Layer-2 VPN domains can be created by configuring multiple TLS tunnels for a single VLAN. Each TLS tunnel connects the local TLS VLAN instance to an egress LER, to form a Layer-2 VPN domain. Integrated MAC caching is supported on the MPLS module. This allows the switch to learn MAC addresses of devices that are located on the TLS tunnel egress LER. If the destination MAC address is known, the packet is forwarded into the learned TLS tunnel or onto the local VLAN. If the destination MAC is unknown, or the packet is a broadcast or multicast packet, the packet can be flooded in one of two configurable modes.

- Spoke

  Packets received from the local VLAN are flooded into all TLS tunnels. Packets received from a TLS tunnel are retransmitted out every TLS tunnel and the local TLS VLAN, except for the interface that the packets were received.

- Core

  Packets received from the local VLAN are flooded into all TLS tunnels. Packets received from a TLS tunnel are forwarded to the local TLS VLAN and flooded to all spoke TLS tunnels.

MAC Learning

Learned MAC addresses are associated with the TLS tunnel from which the packet was received. The learned MAC address is always inserted into the FDB as though it was learned on the local VLAN (and not the VLAN identified in the dot1q tag in the received TLS tunnel packet). MAC addresses learned from TLS tunnels use the same FDB aging timers as those MAC addresses learned on Ethernet interfaces. Any MAC address associated with a TLS tunnel is automatically cleared from the FDB when the VC label for the TLS tunnel is withdrawn.

MAC addresses may appear to move between TLS tunnels. This can occur for various legitimate reasons. The FDB aging timers will clear stale MAC entries, but in certain redundant configurations, it is possible for MAC addresses to become associated with an incorrect TLS tunnel. To prevent these scenarios from causing lengthy connectivity interruptions, the Extreme switch relearns source MAC addresses on all received packets and withdraws VC labels for the associated TLS tunnels when a local TLS VLAN goes down. By always relearning MAC addresses, MAC addresses are more likely to be associated with the correct TLS tunnel. Withdrawing a VC label when a local TLS VLAN goes down forces the remote LSR to remove stale MAC addresses from its FDB associated with the TLS tunnel of the withdrawn VC label. Thus, all egress LERs are assured of relearning the new location of any MAC address that may have been previously associated with the down VLAN. If the VC label was withdrawn due to a down local TLS VLAN, the VC label is readvertised when at least one other local TLS VLAN port becomes active.

Spanning Tree Protocols

There is some debate as to the benefit of supporting Spanning Tree Protocols (STP) within a Layer-2 VPN. The idea is that STPs could be used to provide redundant VPN data paths that could be unblocked if the STP detects a spanning tree topology failure. In general, it is believed that introducing TLS VPN STPs increases network complexity with very little real benefit. Because each TLS tunnel is carried over an LSP, MPLS already provides a sufficient level redundancy. For example, if a TLS tunnel

is using an LDP established LSP, provided there are parallel routed paths to the TLS tunnel endpoint, the TLS tunnel will automatically shift from a withdrawn or failed LSP to the next best available LSP. For tunnel LSPs established using RSVP-TE, secondary LSPs can be configured that can be hot-swapped in the event of a primary LSP failure. Thus, even though the underlying tunnel LSP may have changed, the Layer-2 VPN data plane remains unaffected.

TLS VPN Characteristics

Characteristics of TLS include:

- Use of LDP or RSVP-TE to establish tunnel LSPs.
- Tunnel support for dynamic TLS tunnels using Targeted LDP sessions or static TLS tunnels using configured VC labels.
- Tunnel endpoints are identified via configured IP addresses or specified RSVP-TE LSPs.

VLAN label mappings are configured at both ends of a TLS tunnel. Support for signalling VLAN label to VLAN ID mappings using configured VC ID and Group ID (as specified in the Martini IETF drafts) or using the manually configured ingress and egress VLAN labels.

- All tunneled frames are in tagged Ethernet format.
- Support is provided for tunneling frames received from Ethernet ports or PoS ports running the Bridge Control Protocol (BCP).
- VLAN IDs can be different at each end of a TLS tunnel, the VLAN ID is set by the egress switch to match that of the locally configured VLAN.
- Support for full-mesh and hub-and-spoke VPN architectures with an integrated 256k tunnel MAC cache.
- Support for up to 8 tunnel endpoints per VPN and up to 16k total tunnels per LER.
- Tunnel traffic can be load-shared across up to four equal cost LSPs.

Configuring MPLS Layer-2 VPNs

This section describes how to configure MPLS Layer-2 VPNs, and includes the following topics:

- Adding a TLS Tunnel on page 566
- Deleting a TLS Tunnel on page 568
- Displaying TLS Configuration Information on page 568

Adding a TLS Tunnel

To add a static labeled TLS tunnel, use the following command:

```
config mpls add tls-tunnel <tunnel_name> [lsp <lsp_name> | <ipaddress> |<host_name>]
<local_vlan_name> tls-labels <ingress_label> <egress_label> {mode [core |spoke]}
```

To add a dynamic labeled TLS tunnel (martini-draft compliant), use the following command:

```
config mpls add tls-tunnel <tunnel_name> [lsp <lsp_name> | <ipaddress> | <host_name>]
<local_vlan_name> vcid <vcid> {<groupid>} {from [<local_endpoint_ipaddress> |
<local_endpoint_vlan>]} {mode [core | spoke]}
```

The <tunnel_name> parameter is a character string that is to be used to identify the TLS tunnel within the switch. It must begin with an alphabetic character and can contain up to 31 additional alphanumeric characters.

The <ipaddress> parameter identifies the peer LSR that is the endpoint of the tunnel. This IP address should be configured with a 32-bit prefix on the peer LSR. When the peer LSR is also an Extreme switch, either OSPF must also be enabled on the VLAN to which the IP address is assigned (using the config ospf add vlan command on the peer switch), or the peer switch must be configured to distribute direct routes into the OSPF domain (using the enable ospf export direct command). The ospf export command should be used when the tunnel LSP needs to cross OSPF area boundaries or when ESRP is enabled on the VLAN to which the IP address is assigned.

The TLS tunnel peer may also be specified with the host_name parameter. If the tunnel peer LSR is specified using this parameter, the DNS client must be configured so that the host name can first be resolved to an IP address. TLS tunnel endpoints that begin with an alphabetic character are assumed to be host names and DNS resolution is attempted.

The <lsp_name> parameter can be used to explicitly identify the RSVP-TE LSP path to the egress TLS LSR. When an LSP name is specified, a targeted LDP session is established across the specified RSVP-TE LSP. The LSP endpoint specified by the associated path is used as the endpoint for the targeted LDP session.

The <local_vlan_name> parameter identifies the Layer-2 traffic that is to be transported. All of the local traffic received by the switch for this VLAN is transported across the tunnel.

The tls-labels parameters specify the innermost labels of the tunnel label stack and are used to configure static TLS label tunnels. The <egress_label> is inserted into the MPLS header of Layer-2 frames forwarded onto the tunnel LSP by this switch, and must be meaningful to the peer TLS node.

All traffic received from the tunnel LSP that contains the <ingress_label> is forwarded to the local VLAN identified by the <local_vlan_name> parameter.

When ingress traffic is forwarded to the local VLAN, the VLAN ID is set to the VLAN ID of the local VLAN, without regard to the VLAN ID in the MAC header of the frame received from the tunnel LSP. Thus, there is no requirement that all sites of an extended VLAN be configured to use the same VLAN ID. This can simplify network management in some situations.

The tls-labels parameters are specified using hexadecimal notation. The value of the ingress_label parameter must be unique within the switch (the same <ingress_label> value cannot be used for two different tunnels). The valid range of the ingress label parameter is [8C000..8FFFF].

The valid range of the <egress_label> parameter is [00010..FFFFF]. If the peer LSR is also an Extreme switch, then the <egress_label> must be in the range [8C000..8FFFF].

Because LSPs are unidirectional in nature, coordinated configuration is required at both tunnel endpoint switches. The <egress_label> at one tunnel endpoint switch must match the <ingress_label> at the other tunnel endpoint switch, and vice versa.

The <vcid> and <groupid> parameters are used to configure dynamic TLS tunnels when full martini-draft TLS tunnel compliance is desired. The vcid and groupid values are advertised on a targeted LDP session to the specified tunnel endpoint IP address in a martini-draft defined FEC-TLV. Each LER advertises the vcid, groupid, and VLAN label in the Label Mapping message across an LDP

session. This three-tuple TLS tunnel information allows each egress LER to dynamically bind the TLS tunnel to a local VLAN. The vcid is a non-zero 32-bit ID that defines the tunnel connection and the optionally specified groupid is a 32-bit value that defines logical virtual tunnel connection group. The groupid value defaults to zero if not explicitly configured.

The optional `from` parameter defines the `<local_endpoint_ipaddress>` from which the dynamic TLS tunnel is established. Since dynamic TLS tunnels must first establish an LDP session to the endpoint prior to exchanging tunnel vcid parameters, the TLS endpoint switch must be capable of accepting LDP Targeted Hello messages for the configured TLS tunnel's targeted ipaddress. By default, the `local_endpoint_ipaddress` is the configured OSPF Router ID. The from parameter must be specified when dynamic TLS tunnels are used in conjunction with ESRP. The `local_endpoint_ipaddress` should be configured to match the local ESRP VLAN's interface IP address. This allows dynamic TLS tunnels to properly fail over to the slave switch when both the master and the slave switch are configured with the same `local_endpoint_ipaddress`.

Optionally, the `local_endpoint_vlan` may be specified in place of the `local_endpoint_ipaddress`. There is no TLS tunnel functional difference between these two configuration parameters. If the `local_endpoint_vlan` parameter is specified, the local endpoint IP address used for the TLS tunnel is the IP interface address of the specified `local_endpoint_vlan`.

The optional `mode` parameter configures the broadcast and unknown packet-forwarding behavior for the TLS tunnel. The flood mode options are core and spoke. When two or more TLS tunnels are configured for the same TLS VLAN, each configured TLS tunnel and the local TLS VLAN are treated as separate bridge ports within a single L2 broadcast domain. When the mode is configured as spoke, all received flood traffic (for example, broadcast, multicast, and unknown unicast packets) is retransmitted out every TLS tunnel and the local TLS VLAN, except for the interface that the packet was received. When the mode is configured as core, flood traffic received from a TLS tunnel is forwarded to the local TLS VLAN and is flooded to all spoke TLS tunnels. Flood traffic received from the local TLS VLAN is retransmitted onto every TLS tunnel regardless of its configured mode. The default mode is `core`.

Deleting a TLS Tunnel

To delete one or all TLS tunnels, use the following command:

```
config mpls delete tls-tunnel [<tunnel_name> | group {<groupid>} | all]
```

This command deletes the TLS tunnel with the specified tunnel name. Specify the `<groupid>` if you want to delete all TLS tunnels belonging to a specific group. Use the `all` keyword to delete all TLS tunnels.

Displaying TLS Configuration Information

To display TLS configuration information, use the following command:

```
show mpls tls-tunnel {detail | summary | <tunnel_name> {detail} | vlan <vlan name> |
sorted vcid {detail}}
```

This command displays configuration and status information for one or all TLS tunnels. The information displayed for each tunnel includes:

- The values of all configuration parameters for the tunnel.
- The current status of the tunnel LSP.

If the optional `detail` keyword is specified, TLS tunnel information is displayed using the comprehensive detail format. This format includes transmit and receive counts in terms of packets and bytes.

If the optional `summary` keyword is specified, summary TLS tunnel counts are displayed. The summary counters displayed include the total number of active static and dynamic TLS tunnels.

If the `vlan <vlan name>` keyword is specified, only information about TLS tunnels associated with this local VLAN are displayed

If the `sorted vcid` keyword is specified, the dynamic TLS tunnels are displayed in ascending order based on their vcid.

The example MPLS TLS network configuration provided is based on the routed MPLS network configuration shown in Figure 120.

TLS VPN Configuration Examples

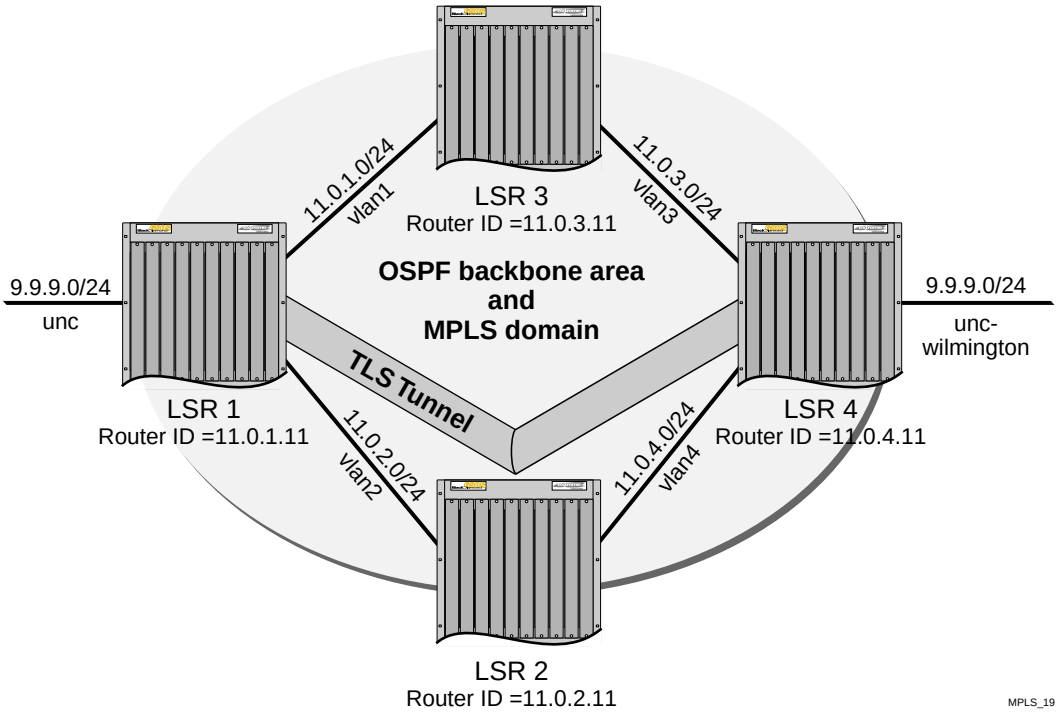
This section provides the following TLS configuration examples:

- Basic MPLS TLS Configuration Example on page 570
- Configuration Example Using PPP Transparent Mode on page 573

Basic MPLS TLS Configuration Example

This MPLS TLS network configuration shown in Figure 120, is based on the routed MPLS network configuration example, shown in Figure 120.

Figure 120: MPLS TLS configuration example



In this configuration example, a new VLAN, *unc-wilmington*, is configured on LSR 4, with a router interface of 9.9.9.1/24. Because TLS provides Layer-2 transport capabilities over MPLS, both TLS VLANs are part of the same IP subnet. Exporting of direct interfaces is disabled so that external OSPF routes are not exported into the backbone area.

The commands used to create a TLS Tunnel between LSR 1 and LSR 4 follow.

The following command creates a TLS tunnel to LSR 4 (11.0.4.11) for traffic originating from VLAN *unc*:

```
config mpls add tls-tunnel rt40 11.0.4.11 unc tls-labels 8f001 8f004
```

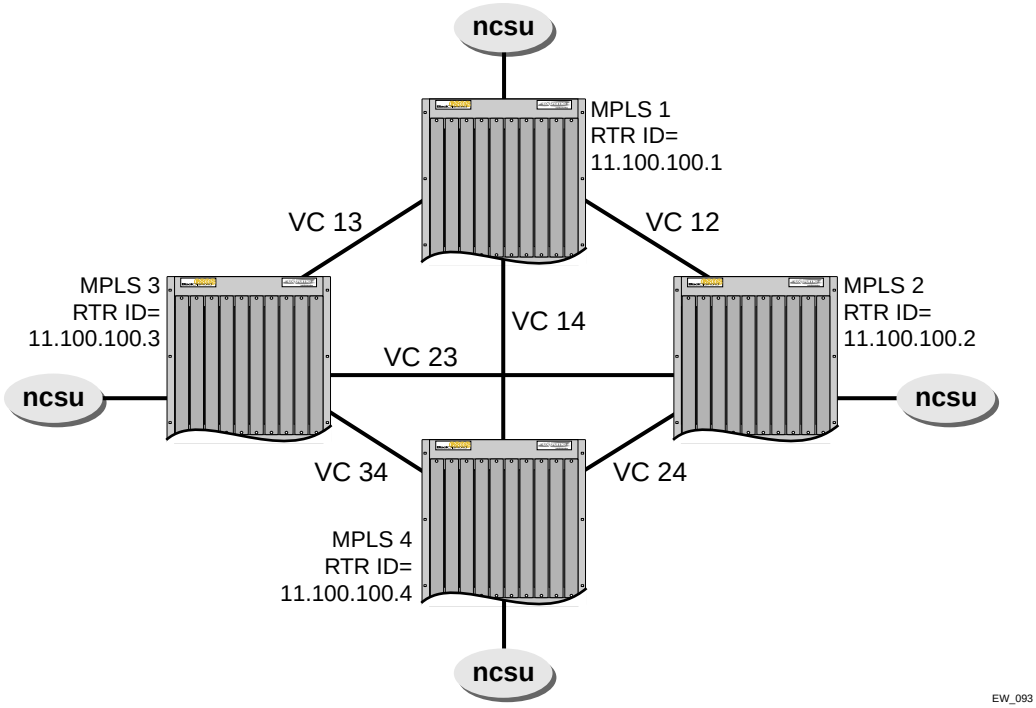
The following command creates a TLS tunnel to LSR 1 (11.0.1.11) for traffic originating from VLAN *unc-wilmington*:

```
> config mpls add tls-tunnel rt40 11.0.1.11 unc-wilmington tls-labels 8f004 8f001
```

Full Mesh TLS Configuration

The example, shown in Figure 121, configures a four node full-mesh MPLS TLS configuration. Each LER MPLS configuration includes a TLS tunnel to every other LER. The egress VLAN for the VPN is called *ncsu*. The target IP address (e.g. 11.100.100.2) shown in each TLS configuration command must be either a Router ID or Loopback VLAN interface address.

Figure 121: Full mesh Configuration Example



Each of the following commands configure a TLS tunnel to an LER for which the VLAN *ncsu* has a PoP. In order for each TLS tunnel to become active, a matching TLS tunnel definition with the same VC ID must be configured on the target LER.

mpls1

```
config mpls add tls t12 11.100.100.2 ncsu vcid 1 mode core
config mpls add tls t13 11.100.100.3 ncsu vcid 1 mode core
config mpls add tls t14 11.100.100.4 ncsu vcid 1 mode core
```

mpls2

```
config mpls add tls t12 11.100.100.1 ncsu vcid 1 mode core
config mpls add tls t23 11.100.100.3 ncsu vcid 1 mode core
config mpls add tls t24 11.100.100.4 ncsu vcid 1 mode core
```

mpls3

```
config mpls add tls t13 11.100.100.1 ncsu vcid 1 mode core
config mpls add tls t23 11.100.100.2 ncsu vcid 1 mode core
config mpls add tls t34 11.100.100.4 ncsu vcid 1 mode core
```

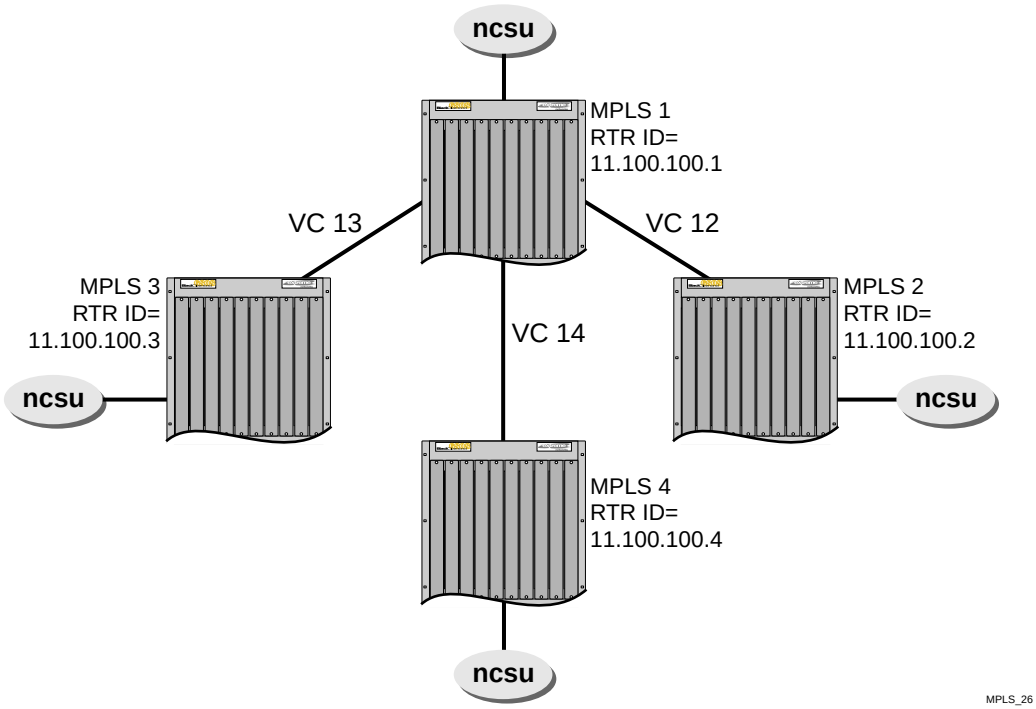
mpls4

```
config mpls add tls t14 11.100.100.1 ncsu vcid 1 mode core
config mpls add tls t24 11.100.100.2 ncsu vcid 1 mode core
config mpls add tls t34 11.100.100.3 ncsu vcid 1 mode core
```

Hub and Spoke TLS Configuration

The following example, shown in Figure 122 , configures a four node hub-and-spoke MPLS TLS configuration. The hub LER MPLS configuration includes a TLS tunnel to every other LER. Each spoke LER MPLS configuration includes a TLS tunnel to only the hub LER. The egress VLAN for the VPN is called ncsu. The target IP address (e.g. 11.100.100.2) shown in each TLS configuration command must be either a Router ID or Loopback VLAN interface address.

Figure 122: Hub and spoke configuration example



Each of the following commands configure a TLS tunnel to an LER for which the VLAN ncsu has a PoP. In order for each TLS tunnel to become active, a matching TLS tunnel definition with the same VC ID must be configured on the target LER.

mpls1

```
config mpls add tls t12 11.100.100.2 ncsu vcid 1 mode spoke
config mpls add tls t13 11.100.100.3 ncsu vcid 1 mode spoke
config mpls add tls t14 11.100.100.4 ncsu vcid 1 mode spoke
```

mpls2

```
config mpls add tls t12 11.100.100.1 ncsu vcid 1 mode spoke
```

mpls3

```
config mpls add tls t13 11.100.100.1 ncsu vcid 1 mode spoke
```

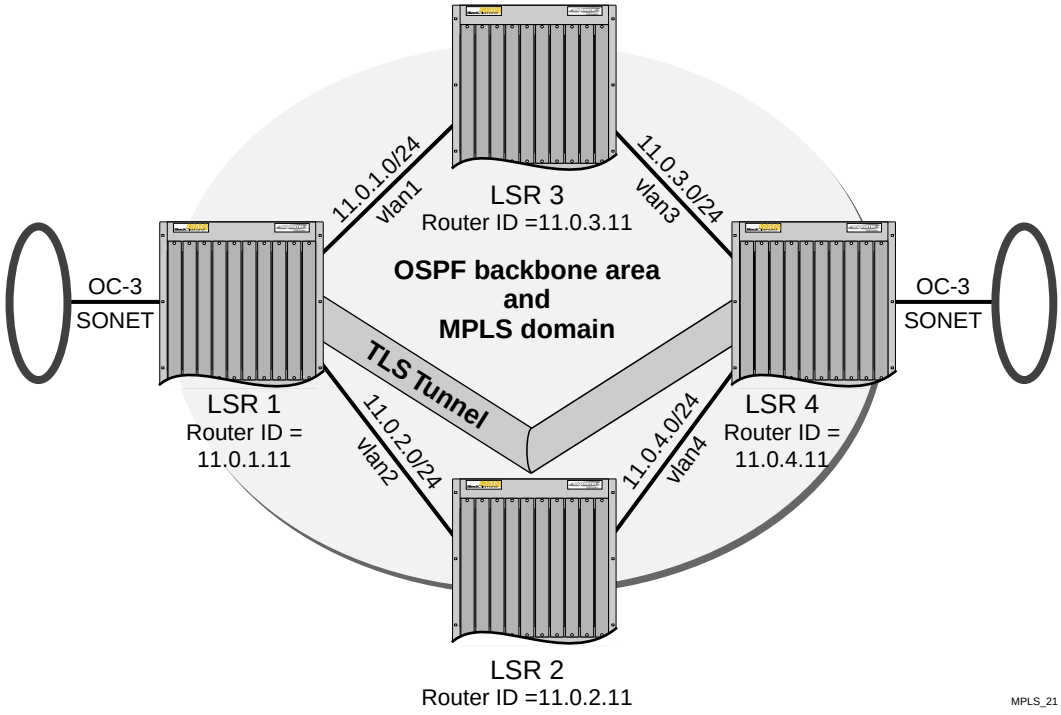
mpls4

```
config mpls add tls t14 11.100.100.1 ncsu vcid 1 mode spoke
```

Configuration Example Using PPP Transparent Mode

The configuration example, shown in Figure 123, illustrates how to configure a pair of BlackDiamond switches so that SONET PPP traffic is transparently transported across an MPLS domain. If an OC-3 or OC-12 SONET module is installed in the BlackDiamond chassis, PPP traffic received on a SONET port that is a member of a TLS VLAN is transparently transported across the MPLS domain to the destination switch to be transmitted out of a matching SONET interface.

Figure 123: TLS configuration example using PPP transparent mode



The configuration commands for this example follow.

The following command configures the OC-3 module for slot 1:

```
configure slot 1 module oc3
```

The following command creates the VLAN that is used to configure the TLS tunnel for transparently transporting PPP traffic:

```
create vlan sonet
```

The following command adds port 1 of the OC-3 module in slot 1 to the *sonet* VLAN. There is a one-to-one mapping between SONET ports and SONET TLS VLANs, so each SONET TLS VLAN can have only a single SONET port, and no other port, as a member:

```
config vlan sonet add port 1:1
```

The following commands disable BCP mode and enable POS transparent mode on the OC-3 interface that is a member of the TLS VLAN:

```
config ppp bcp off port 1:1
config ppp pos transparent-mode on port 1:1
```

The following command creates the TLS tunnel to LSR 4 for SONET PPP traffic received on VLAN *sonet:*

```
config mpls add tls-tunnel sonet 11.0.4.11 tls-vlan 8f002 8f005
```

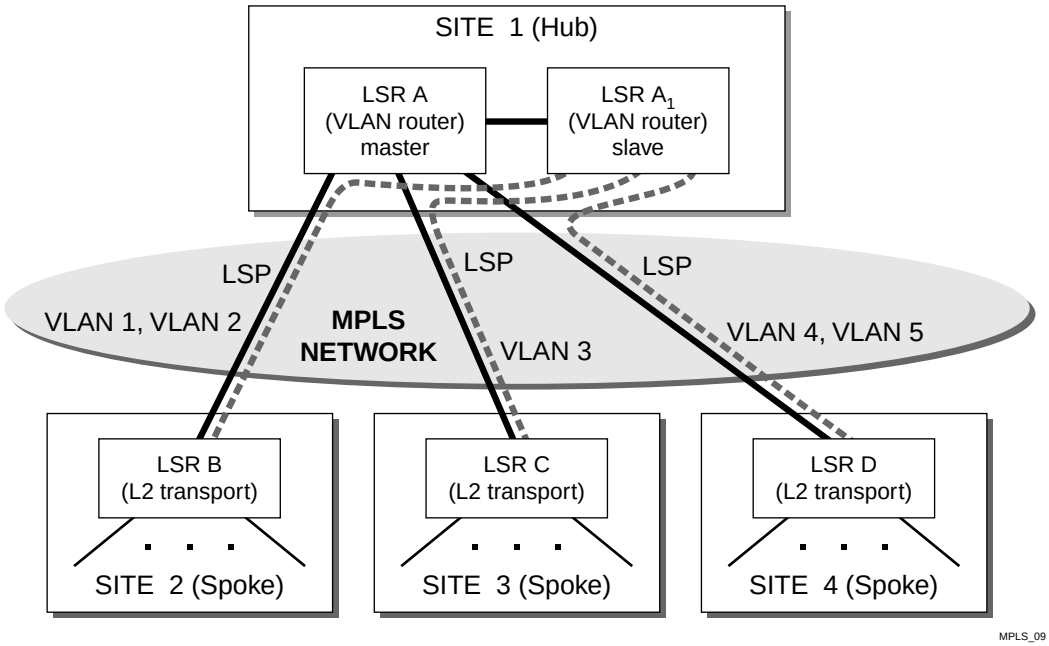
The SONET configuration for LSR 4 is exactly the same as the configuration for LSR 1, but the TLS tunnel is targeted towards LSR 1, as follows:

```
config mpls add tls-tunnel sonet 11.0.1.11 tls-vlan 8f005 8f002
```

Using ESRP with MPLS TLS

ESRP can be used in conjunction with TLS to provide redundancy. For example, consider adding a second LSR to the hub, as shown in Figure 124.

Figure 124: Using ESRP with TLS



ESRP is run over the Ethernet VLAN connecting the two hub-LSRs, and the redundant IP address configured for ESRP is also being used as the tunnel endpoint address.

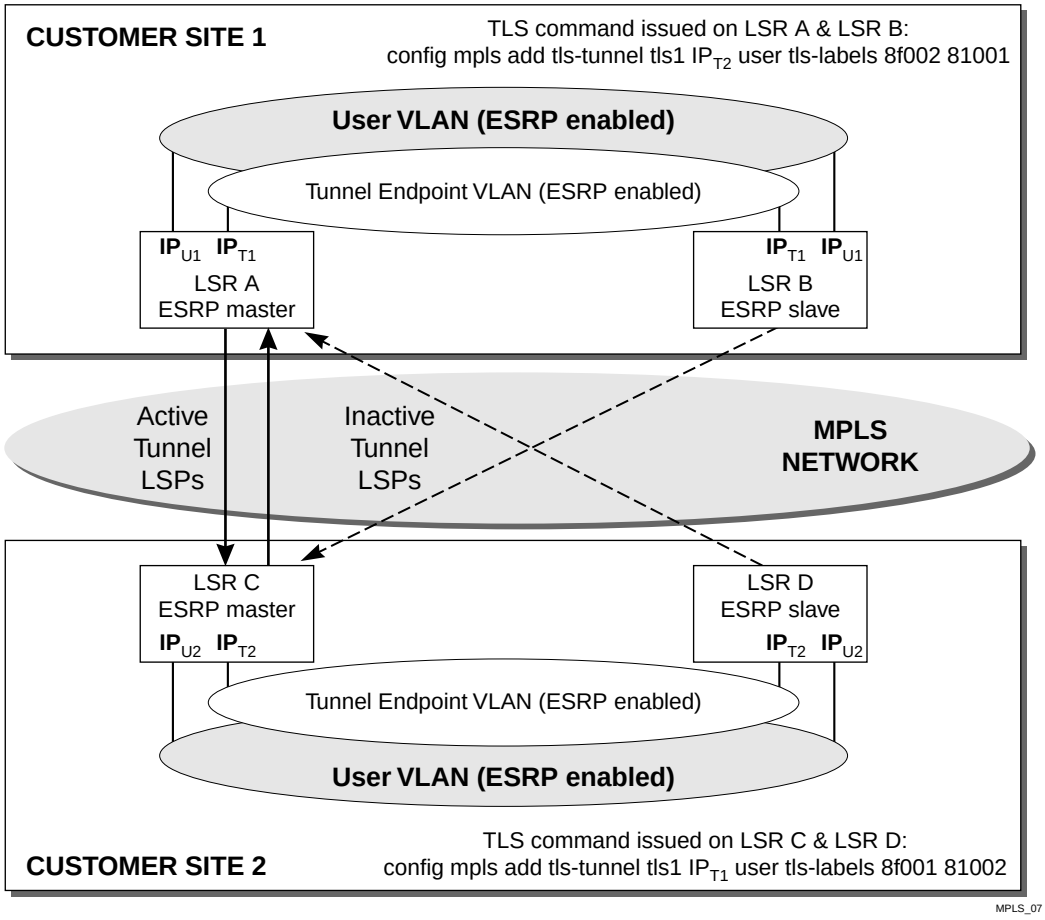
Using this configuration, the LSRs at the spoke sites automatically connect to the active hub-LSR and rapidly adapt to failures. If the master hub-LSR fails, ESRP activates the standby hub-LSR, which then responds by advertising a route and label mapping for the tunnel endpoint IP address.

The LSRs at the spoke sites receive the label mapping and begin using the new tunnel LSP. Loopback mode should not be enabled when ESRP is being used to provide redundancy and ESRP should not be enabled on a VLAN that is expected to exchange routes with other non-ESRP routers (for example, routers using RIP or OSPF).

Tunnel Endpoint VLANs

Another example of using ESRP is shown in Figure 125.

Figure 125: Tunnel endpoint VLANs



In Figure 125, redundant LSRs are installed at both ends of a TLS tunnel. This example takes advantage of the IP multinetting feature in ExtremeWare by creating an overlay *tunnel endpoint* VLAN that shares the same Ethernet ports as the user VLAN that is extended across the MPLS backbone network. A tunnel endpoint VLAN is created at both sites.

ESRP is enabled on the tunnel endpoint VLANs and the user VLANs. To ensure that the same LSR is selected as the ESRP master for both VLANs, the ESRP configuration of the user VLAN and the associated tunnel endpoint VLAN must be identical. Enabling ESRP on the user VLAN ensures that only one LSR (the ESRP master) forwards traffic for the VLAN at each site.

The redundant IP address configured on the tunnel endpoint VLAN (IP_{T1}) is also used as the tunnel endpoint address in the same manner as described for the preceding example. Therefore, it is the ESRP

master for the user VLAN that forwards traffic onto the tunnel LSP, and it is the ESRP master for the tunnel endpoint VLAN that forwards traffic received from the tunnel LSP (as a consequence of being the LSR with which the tunnel LSP is established).

The tunnel endpoint VLANs are created specifically to provide fault-tolerant tunnel endpoint IP addresses in a manner that is totally transparent to the user VLAN. ESRP is used to provide the fault-tolerant IP addresses. The tunnel endpoint IP addresses could be defined on the user VLAN instead. However, an OSPF route must be advertised for a tunnel endpoint IP address to ensure that the underlying LSP is established by LDP. By creating the tunnel endpoint VLAN the IP address defined on the user VLAN does not need to be exported into the MPLS backbone (which would expose information about the user VLAN to the MPLS backbone).

IP addresses are defined on the user VLAN (IP_{U1}) for ESRP purposes, but these addresses are only used locally at each site. In this example, IP addresses would have to be defined on a different set of VLANs to provide the connectivity to the MPLS backbone. These MPLS VLANs are not depicted in Figure 125. The MPLS VLANs contain a different set of physical ports than the user VLAN, and MPLS must be enabled on the MPLS VLANs.

ESRP standby LSRs preestablish tunnel LSPs to the ESRP master LSR at the other site. The pre-established tunnel LSPs are inactive as long as the LSR is in standby mode, but can expedite recovery from a failure. For example, if LSR A were to fail, LSR B would become the ESRP master at Site 1, and LSR B would already have an LSP established to LSR C. Upon becoming ESRP master, LSR B would advertise an OSPF route and a MPLS label mapping for IP_{T1}, and LSR C would then begin using the new tunnel LSP to LSR B.

The ESRP route table tracking feature is also useful in conjunction with TLS. ESRP route table tracking can be configured to initiate an ESRP failover when no route is available to the tunnel endpoint IP address. For example, LSR A can be configured to initiate a failover to LSR B when its route table does not have an entry for IP_{T2}. Each of the LSRs would be configured to use ESRP route table tracking in a similar manner.

LSP Tracking

LSP tracking provides MPLS with specific ESRP selection criteria for determining the ESRP status of a VLAN. LSP tracking is similar to route tracking and ping tracking in ESRP. As shown in Figure 125, ESRP can be configured to protect the user VLAN from disruptions in the MPLS network core. For example, LSR A and LSR B can be configured to track an established LSP to IP_{T2}. If a network disruption causes the LSP from LSR A to LSR C to fail, ESRP detects the condition and fails over to LSR B (provided LSR B has an established LSP to LSR C). This type of LSP protection is especially useful when providing ESRP redundant TLS L2 VPN services using Traffic Engineered LSPs that take completely different paths (for example, LSP from LSR A to LSR C and LSP from LSR B to LSR C).

Using ESRP domains, LSP tracking can be easily scaled to support several TLS VLANs that are tunneled across an L2 VPN using a single LSP. Instead of each TLS VLAN tracking the same LSP, all of the TLS VLANs are placed into an ESRP domain for which there is one non-TLS VLAN, configured to track the state of the LSP. When ESRP detects that the LSP has failed, all of the VLANs in the configured ESRP domain transition to neutral state and the backup LSR becomes the master switch for all of the TLS VLANs.

To configure LSP tracking, use the following commands:

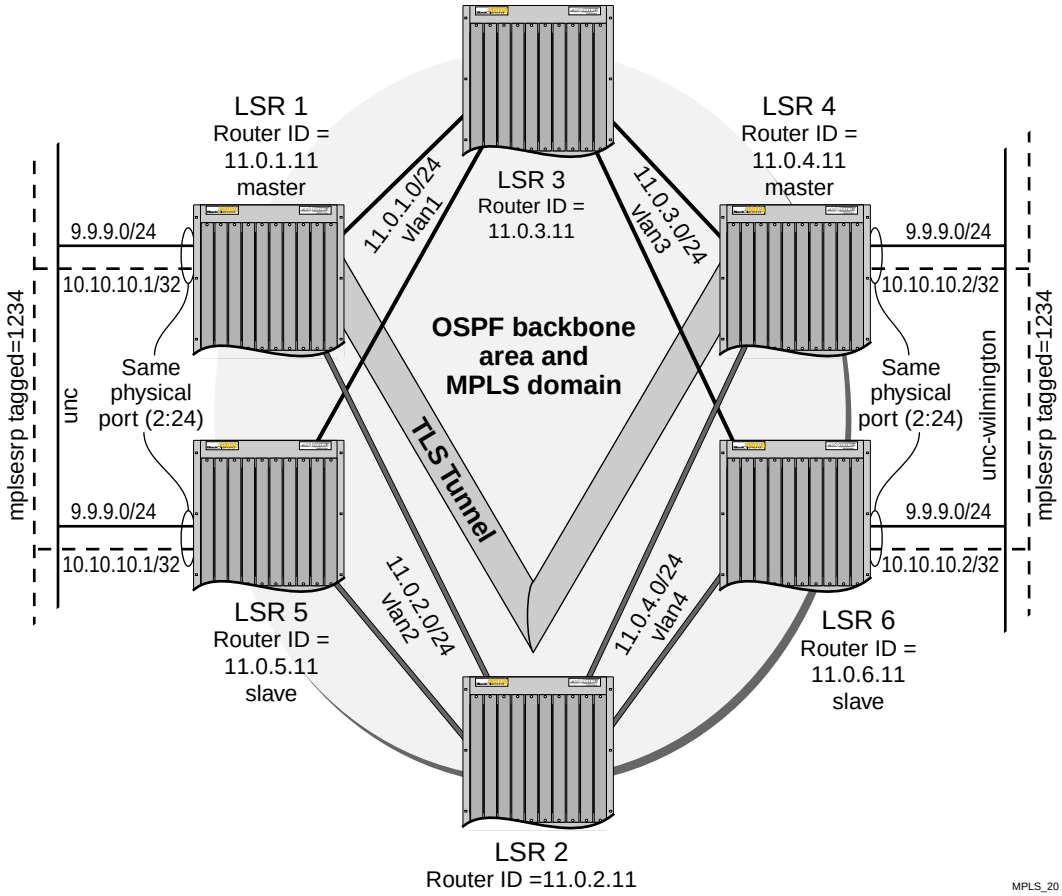
```
config vlan <vlan name> add track-lsp [<lsp_name> | ipaddress <ipaddress/masklength>]

config vlan <vlan name> delete track-lsp [<lsp_name> | ipaddress
<ipaddress/masklength> | all]
```

This command configures the LSPs tracked by ESRP in order to determine the ESRP state of the specified VLAN. The `add track-lsp` command configures ESRP to track up to eight LSPs. Fail over to the slave switch is based on the total number of established tracked LSPs. The switch with the greatest number of established tracked LSPs is elected the master switch for the specified VLAN. Specifying the parameter `<lsp_name>` instructs ESRP to track the status of an RSVP-TE LSP. Specifying the `ipaddress` keyword instructs ESRP to track the LSP status for the IP prefix as defined by the `<ipaddress/masklength>` parameter. Both types of LSPs can be tracked simultaneously. The `delete track-lsp` command removes an LSP from ESRP tracking for the specified VLAN. If you specify the `all` keyword, all configured LSPs are removed from ESRP tracking for the specified VLAN.

Configuration Example

The MPLS TLS ESRP configuration example, shown in Figure 126, illustrates how to configure a pair of BlackDiamond switches to provide redundant Layer-2 VPN services over an MPLS domain. Two additional switches have been added to the TLS MPLS network configuration example shown in Figure 120, LSR 5 and LSR 6. LSR 5 and LSR 6 provide redundant connectivity for TLS VLANs into the MPLS domain.

Figure 126: TLS configuration example using ERSP



The following sections describe how to configure LSR 1 and LSR 5.

The following commands create a tagged ESRP VLAN over which ESRP control packets flow. Tagging the VLAN separates the customer's local traffic from the ESRP control packets and prevents OSPF routes from the MPLS service provider domain from leaking into the customer's VLAN:

```
create vlan mplsesrp
config vlan mplsesrp tag 1234
config vlan mplsesrp ipaddress 10.10.10.1/32
config vlan mplsesrp add port 2:24 tagged
```

The ESRP VLAN must be OSPF-enabled so that the router interface is advertised into the MPLS domain. The ESRP router interface is used as the LSP destination for the TLS tunnel. By configuring a TLS tunnel using the ESRP VLAN router interface, the TLS tunnel can migrate between switches as switches change ESRP state:

```
config ospf add vlan mplsesrp area 0.0.0.0
config ospf vlan mplsesrp cost 10
```

The following command enables ESRP on VLAN *mplsesrp*. The ESRP VLAN and the TLS VLAN must have the same port membership. In this example, port 2:24 is a member of both VLANs:

```
enable esrp vlan mplsesrp
```

The following command creates a TLS tunnel from VLAN *unc* to the master switch providing connectivity for VLAN *unc-wilmington*:

```
config mpls add tls-tunnel rt40 10.10.10.2 unc vcid 1 from mplsesrp
```

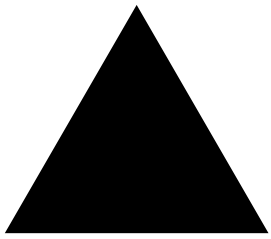
From an ESRP perspective, LSR 5 is configured identically as LSR 1.

LSR 4 and LSR 6 are configured in a very similar manner to LSR 1 and LSR 5. A tagged ESRP control VLAN is created between them and given an IP address. The ESRP VLAN is also OSPF-enabled so that the router interface is advertised into the MPLS domain.

```
create vlan mplsesrp
config vlan mplsesrp tag 1234
config vlan mplsesrp ipaddress 10.10.10.2/32
config vlan mplsesrp add port 2:24 tagged

config ospf add vlan mplsesrp area 0.0.0.0
config ospf vlan mplsesrp cost 10

enable esrp vlan mplsesrp
```

And finally, a TLS tunnel is created from VLAN *unc-wilmington* to the master switch providing connectivity for VLAN *unc*. This configuration command is issued on both LSR 4 and LSR 6.

```
config mpls add tls-tunnel rt40 10.10.10.1 unc-wilmington vcid 1 from mplsesrp
```



Part 4
Appendixes

A Software Upgrade and Boot Options

This appendix describes the following topics:

- Downloading a New Image on page 581
- Saving Configuration Changes on page 582
- Using TFTP to Download the Configuration on page 584
- Synchronizing MSMs on page 585
- Upgrading and Accessing BootROM on page 585

Downloading a New Image

The image file contains the executable code that runs on the switch. It comes preinstalled from the factory. As new versions of the image are released, you should upgrade the software running on your system.

The image is upgraded by using a download procedure from either a Trivial File Transfer Protocol (TFTP) server on the network or from a PC connected to the serial port using the XMODEM protocol. Downloading a new image involves the following steps:

- Load the new image onto a TFTP server on your network (if you will be using TFTP).
- Load the new image onto a PC (if you will be using XMODEM).
- Download the new image to the switch using the following command:

  `download image [<ipaddress> | <hostname>] <filename> {primary | secondary}`

  where the following is true:

  `ipaddress`—Is the IP address of the TFTP server.

  `hostname`—Is the hostname of the TFTP server. (You must enable DNS to use this option.)

  `filename`—Is the filename of the new image.

  `primary`—Indicates the primary image.

  `secondary`—Indicates the secondary image.

The switch can store up to two images; a primary and a secondary. When you download a new image, you must select into which image space (primary or secondary) the new image should be placed. If not indicated, the primary image space is used.

If two MSMs are installed in the BlackDiamond switch, the downloaded image is saved to the same location on each one.

You can select which image the switch will load on the next reboot by using the following command:

```
use image [primary | secondary]
```

To download an image to an individual slot on an Alpine switch, use the following command:

```
download image [<ipaddress> | <hostname>] <filename> {primary | secondary | slot <slot number>}
```

Rebooting the Switch

To reboot the switch, use the following command:

```
reboot { time <date> <time> | cancel}
```

where `date` is the date and `time` is the time (using a 24-hour clock format) when the switch will be rebooted. The values use the following format:

```
mm/dd/yyyy hh:mm:ss
```

If you do not specify a reboot time, the reboot occurs immediately following the command, and any previously schedule reboots are cancelled. To cancel a previously scheduled reboot, use the `cancel` option.

To reboot the Alpine 3802, use the following command:

```
reboot { time <date> <time> | cancel | slot <slot number>}
```

Saving Configuration Changes

The configuration is the customized set of parameters that you have selected to run on the switch. As you make configuration changes, the new settings are stored in run-time memory. Settings that are stored in run-time memory are not retained by the switch when the switch is rebooted. To retain the settings, and have them load when you reboot the switch, you must save the configuration to nonvolatile storage.

The switch can store two different configurations: a primary and a secondary. When you save configuration changes, you can select to which configuration you want the changes saved. If you do not specify, the changes are saved to the configuration area currently in use.

If you have made a mistake, or you must revert to the configuration as it was before you started making changes, you can tell the switch to use the secondary configuration on the next reboot.

To save the configuration, use the following command:

```
save {configuration} {primary | secondary}
```

To use the configuration, use the following command:

```
use configuration [primary | secondary]
```

The configuration takes effect on the next reboot.

NOTE

If the switch is rebooted while in the middle of a configuration save, the switch boots to factory default settings. The configuration that is not in the process of being saved is unaffected.

Returning to Factory Defaults

To return the switch configuration to factory defaults, use the following command:

```
unconfig switch
```

This command resets the entire configuration, with the exception of user accounts and passwords that have been configured, and the date and time.

To erase the currently selected configuration image and reset all switch parameters, use the following command:

```
unconfig switch all
```

Using TFTP to Upload the Configuration

You can upload the current configuration to a TFTP server on your network. The uploaded ASCII file retains the command-line interface (CLI) format. This allows you to:

- Modify the configuration using a text editor, and later download a copy of the file to the same switch, or to one or more different switches.
- Send a copy of the configuration file to the Extreme Networks Technical Support department for problem-solving purposes.
- Automatically upload the configuration file every day, so that the TFTP server can archive the configuration on a daily basis. Because the filename is not changed, the configured file stored in the TFTP server is overwritten every day.

To upload the configuration, use the following command:

```
upload configuration [<ipaddress> | <hostname>] <filename> {every <time>}
```

where the following is true:

- `ipaddress`—Is the IP address of the TFTP server.
- `hostname`—Is the hostname of the TFTP server. (You must enable DNS to use this option.)
- `filename`—Is the name of the ASCII file. The filename can be up to 255 characters long, and cannot include any spaces, commas, quotation marks, or special characters.
- `every <time>`—Specifies the time of day you want the configuration automatically uploaded on a daily basis. If not specified, the current configuration is immediately uploaded to the TFTP server.

To cancel a previously scheduled configuration upload, use the following command:

```
upload configuration cancel
```

Using TFTP to Download the Configuration

You can download ASCII files that contain CLI commands to the switch to modify the switch configuration. Three types of configuration scenarios that can be downloaded:

- Complete configuration
- Incremental configuration
- Scheduled incremental configuration

Configurations created in a chassis are not supported in a different model chassis. For example, a configuration from a BlackDiamond 6808 is not supported in a BlackDiamond 6804. Configurations for different models generate error messages for any line in the configuration that concerns unavailable slots.

If you load a configuration from a different model, you can safely write the correct configuration over the unsupported configuration.

Downloading a Complete Configuration

Downloading a complete configuration replicates or restores the entire configuration to the switch. You typically use this type of download in conjunction with the `upload config` command, which generates a complete switch configuration in an ASCII format. As part of the complete configuration download, the switch is automatically rebooted.

To download a complete configuration, use the following command:

```
download configuration [<hostname> | <ip_address>] <filename>
```

After the ASCII configuration is downloaded by way of TFTP, you are prompted to reboot the switch. The downloaded configuration file is stored in current switch memory during the rebooting process, and is not retained if the switch has a power failure.

When the switch completes booting, it treats the downloaded configuration file as a script of CLI commands, and automatically executes the commands. If your CLI connection is through a Telnet connection (and not the console port), your connection is terminated when the switch reboots, but the command executes normally.

Downloading an Incremental Configuration

A partial or incremental change to the switch configuration may be accomplished by downloaded ASCII files that contain CLI commands. These commands are interpreted as a script of CLI commands, and take effect at the time of the download, without requiring a reboot of the switch.

To download an incremental configuration, use the following command:

```
download configuration <hostname | ip_address> <filename> {incremental}
```

Do not download an incremental configuration when you have time-critical applications running. When you download an incremental configuration, the switch immediately processes the changes, which can affect the processing of other tasks. We recommend that you either download small incremental configurations, or schedule downloads during maintenance windows.

Scheduled Incremental Configuration Download

You can schedule the switch to download a partial or incremental configuration on a regular basis. You could use this feature to update the configuration of the switch regularly from a centrally administered TFTP server. As part of the scheduled incremental download, you can optionally configuration a backup TFTP server.

To configure the primary and/or secondary TFTP server and filename, use the following command:

```
config download server [primary | secondary] [<hostname> | <ip_address>] <filename>
```

To enable scheduled incremental downloads, use the following command:

```
download configuration every <hour:minute>
```

To display scheduled download information, use the following command:

```
show switch
```

To cancel scheduled incremental downloads, use the following command:

```
download configuration cancel
```

Remember to Save

Regardless of which download option is used, configurations are downloaded into switch runtime memory, only. The configuration is saved only when the save command is issued, or if the configuration file, itself, contains the save command.

If the configuration currently running in the switch does not match the configuration that the switch used when it originally booted, an asterisk (*) appears before the command line prompt when using the CLI.

Synchronizing MSMs

On the BlackDiamond switch, you can take the master MSM64i configurations and images and replicate them on the slave MSM64i using the following command:

```
synchronize
```

In addition to replicating the configuration settings and images, this command also replicates which configuration or image the MSM64i should use on subsequent reboots. This command does not replicate the run-time configuration. You must use the `save configuration` command to store the run-time configuration first.

Upgrading and Accessing BootROM

The BootROM of the switch initializes certain important switch variables during the boot process. If necessary, BootROM can be upgraded, after the switch has booted, using TFTP. In the event the switch does not boot properly, some boot option functions can be accessed through a special BootROM menu.

Upgrading BootROM

Upgrading BootROM is done using TFTP (from the CLI), after the switch has booted. Upgrade the BootROM only when asked to do so by an Extreme Networks technical representative. To upgrade the BootROM, use the following command:

```
download bootrom [<host_name> | <ip_addr>]
```

Accessing the BootROM Menu

Interaction with the BootROM menu is only required under special circumstances, and should be done only under the direction of Extreme Networks Customer Support. The necessity of using these functions implies a non-standard problem which requires the assistance of Extreme Networks Customer Support.

To access the BootROM menu, follow these steps:

1. Attach a serial cable to the console port of the switch.
2. Attach the other end of the serial cable to a properly configured terminal or terminal emulator, power cycle the switch while depressing the spacebar on the keyboard of the terminal.

   As soon as you see the `BootROM->` prompt, release the spacebar. You can see a simple help menu by pressing `h` . Options in the menu include

   - Selecting the image to boot from
   - Booting to factory default configuration
   - Performing a serial download of an image

For example, to change the image that the switch boots from in flash memory, press `1` for the image stored in primary or `2` for the image stored in secondary. Then, press the `f` key to boot from newly selected on-board flash memory.

To boot to factory default configuration, press the `d` key for default and the `f` key to boot from the configured on-board flash.

To perform a serial download, you can optionally change the baud rate to 38.4K using the `b` command, and then press the `s` key to prepare the switch for an image to be sent from your terminal using the XMODEM protocol. After this has completed, select the `g` command, to boot the image that is currently in RAM. The switch restores the console port to 9600 bps, and begins the boot process.

NOTE

Doing a serial download does not store an image into flash, it only allows the switch to boot an operational image so that a normal TFTP upgrade from the CLI can then be performed.

B Troubleshooting

If you encounter problems when using the switch, this appendix may be helpful. If you have a problem not listed here or in the release notes, contact your local technical support representative.

LEDs

Power LED does not light:

Check that the power cable is firmly connected to the device and to the supply outlet.

On powering-up, the MGMT LED lights yellow:

The device has failed its Power On Self Test (POST) and you should contact your supplier for advice.

A link is connected, but the Status LED does not light:

Check that:

- All connections are secure.
- Cables are free from damage.
- The devices at both ends of the link are powered-up.
- Both ends of the Gigabit link are set to the same autonegotiation state.

  The Gigabit link must be enabled or disabled on both sides. If the two sides are different, typically the side with autonegotiation disabled will have the link LED lit, and the side with autonegotiation enabled will not be lit. The default configuration for a Gigabit port is autonegotiation enabled. This can be verified by entering the following command:

  ```
  show port config
  ```

On power-on, some I/O modules do not boot:

Check if you are using 110V power input. The BlackDiamond switch powers only up to four modules if it is connected to a 110V outlet.

Error LED on the MSM64i turns amber:

Check the syslog message for a “critical” software errors.

Status LED on the I/O module turns amber:

Check the syslog message for a related I/O module error. If the error is an inserted an I/O module that conflicts with the software configuration, use one of the following commands to reset the slot configuration:

```
clear slot
```

config slot <slot> module [f32t | f32f | f48t | g4x | g6x | g8x | g12x]

Otherwise, contact Extreme Networks for further assistance.

ENV LED on the MSM64i turns amber:

Check each of the power supplies and all of the fans. Additionally, the status of these is indicated in the `show switch` display. Look for the "Temperature" and "Power Supply" entries in the display.

Switch does not power up:

All products manufactured by Extreme Networks use digital power supplies with surge protection. In the event of a power surge, the protection circuits shut down the power supply. To reset, unplug the switch for 1 minute, plug it back in, and attempt to power up the switch.

If this does not work, try using a different power source (different power strip/outlet) and power cord.

Using the Command-Line Interface

The initial welcome prompt does not display:

Check that your terminal or terminal emulator is correctly configured.

For console port access, you may need to press [Return] several times before the welcome prompt appears.

Check the settings on your terminal or terminal emulator. The settings are 9600 baud, 8 data bits, 1 stop bit, no parity, XON/OFF flow control enabled.

The SNMP Network Manager cannot access the device:

Check that the device IP address, subnet mask, and default router are correctly configured, and that the device has been reset.

Check that the device IP address is correctly recorded by the SNMP Network Manager (refer to the user documentation for the Network Manager).

Check that the community strings configured for the system and Network Manager are the same.

Check that SNMP access was not disabled for the system.

The Telnet workstation cannot access the device:

Check that the device IP address, subnet mask and default router are correctly configured, and that the device has been reset. Ensure that you enter the IP address of the switch correctly when invoking the Telnet facility. Check that Telnet access was not disabled for the switch. If you attempt to log in and the maximum number of Telnet sessions are being used, you should receive an error message indicating so.

Traps are not received by the SNMP Network Manager:

Check that the SNMP Network Manager's IP address and community string are correctly configured, and that the IP address of the Trap Receiver is configured properly on the system.

The SNMP Network Manager or Telnet workstation can no longer access the device:

Check that Telnet access or SNMP access is enabled.

Check that the port through which you are trying to access the device has not been disabled. If it is enabled, check the connections and network cabling at the port.

Check that the port through which you are trying to access the device is in a correctly configured VLAN.

Try accessing the device through a different port. If you can now access the device, a problem with the original port is indicated. Re-examine the connections and cabling.

A network problem may be preventing you accessing the device over the network. Try accessing the device through the console port.

Check that the community strings configured for the device and the Network Manager are the same.

Check that SNMP access was not disabled for the system.

Permanent entries remain in the FDB:

If you have made a permanent entry in the FDB (which requires you to specify the VLAN to which it belongs and then delete the VLAN), the FDB entry will remain. Though causing no harm, you must manually delete the entry from the FDB if you want to remove it.

Default and Static Routes:

If you have defined static or default routes, those routes will remain in the configuration independent of whether the VLAN and VLAN IP address that used them remains. You should manually delete the routes if no VLAN IP address is capable of using them.

You forget your password and cannot log in:

If you are not an administrator, another user having administrator access level can log in, delete your user name, and create a new user name for you, with a new password.

Alternatively, another user having administrator access level can log in and initialize the device. This will return all configuration information (including passwords) to the initial values.

In the case where no one knows a password for an administrator level user, contact your supplier.

Port Configuration

No link light on 10/100 Base port:

If patching from a hub or switch to another hub or switch, ensure that you are using a CAT5 cross-over cable. This is a CAT5 cable that has pins 1&2 on one end connected to pins 3&6 on the other end.

Excessive RX CRC errors:

When a device that has auto-negotiation disabled is connected to a Extreme switch that has auto-negotiation enabled, the Extreme switch links at the correct speed, but in half duplex mode. The Extreme switch 10/100 physical interface uses a method called *parallel detection* to bring up the link. Because the other network device is not participating in auto-negotiation (and does not advertise its capabilities), parallel detection on the Extreme switch is only able to sense 10Mbps versus 100Mbps speed, and not the duplex mode. Therefore, the switch establishes the link in half duplex mode using the correct speed.

The only way to establish a full duplex link is to either force it at both sides, or run auto-negotiation on both sides (using full duplex as an advertised capability, which is the default setting on the Extreme switch).

NOTE

A mismatch of duplex mode between the Extreme switch and another network device will cause poor network performance. Viewing statistics using the `show port rx` *command on the Extreme switch may display a constant increment of CRC errors. This is characteristic of a duplex mismatch between devices. This is NOT a problem with the Extreme switch.*

Always verify that the Extreme switch and the network device match in configuration for speed and duplex.

No link light on Gigabit fiber port:

Check to ensure that the transmit fiber goes to the receive fiber side of the other device, and vice-versa. All gigabit fiber cables are of the cross-over type.

The Extreme switch has auto-negotiation set to on by default for gigabit ports. These ports need to be set to auto off (using the command `config port <port #> auto off`) if you are connecting it to devices that do not support auto-negotiation.

Ensure that you are using multi-mode fiber (MMF) when using a 1000BASE-SX GBIC, and single mode fiber (SMF) when using a 1000BASE-LX GBIC. 1000BASE-SX does not work with SMF. 1000BASE-LX works with MMF, but requires the use of a mode conditioning patchcord (MCP).

VLANs

You cannot add a port to a VLAN:

If you attempt to add a port to a VLAN and get an error message similar to

```
localhost:7 # config vlan marketing add port 1:1,1:2
ERROR: Protocol conflict on port 1:5
```

you already have a VLAN using untagged traffic on a port. Only one VLAN using untagged traffic can be configured on a single physical port.

VLAN configuration can be verified by using the following command:

```
show vlan <vlan name>
```

The solution for this error is to remove ports 1 and 2 from the VLAN currently using untagged traffic on those ports. If this were the “default” VLAN, the command would be

```
localhost:23 # config vlan default del port 1:1,1:2
```

which should now allow you to re-enter the previous command without error as follows:

```
localhost:26 # config vlan red add port 1:1,1:2
```

VLAN names:

There are restrictions on VLAN names. They cannot contain whitespaces and cannot start with a numeric value unless you use quotation marks around the name. If a name contains whitespaces, starts with a number, or contains non-alphabetical characters, you must use quotation marks whenever referring to the VLAN name.

802.1Q links do not work correctly:

Remember that VLAN names are only locally significant through the command-line interface. For two switches to communicate across a 802.1Q link, the VLAN ID for the VLAN on one switch should have a corresponding VLAN ID for the VLAN on the other switch.

If you are connecting to a third-party device and have checked that the VLAN IDs are the same, the Ethertype field used to identify packets as 802.1Q packets may differ between the devices. The default value used by the switch is 8100. If the third-party device differs from this and cannot be changed, you may change the 802.1Q Ethertype used by the switch with the following command:

```
config dot1p ethertype <ethertype>
```

Changing this parameter changes how the system recognizes all tagged frames received, as well as the value it inserts in all tagged frames it transmits.

VLANs, IP Addresses and default routes:

The system can have an IP address for each configured VLAN. It is necessary to have an IP address associated with a VLAN if you intend to manage (Telnet, SNMP, ping) through that VLAN or route IP traffic. You can also configure multiple default routes for the system. The system first tries the default route with the lowest cost metric.

STP

You have connected an endstation directly to the switch and the endstation fails to boot correctly:

The switch has STP enabled, and the endstation is booting before the STP initialization process is complete. Specify that STP has been disabled for that VLAN, or turn off STP for the switch ports of the endstation and devices to which it is attempting to connect, and then reboot the endstation.

The switch keeps aging out endstation entries in the switch Forwarding Database (FDB):

Reduce the number of topology changes by disabling STP on those systems that do not use redundant paths.

Specify that the endstation entries are static or permanent.

Debug Tracing

ExtremeWare includes a debug-tracing facility for the switch. The show debug-tracing command can be applied to one or all VLANs, as follows:

```
show debug-tracing {vlan <vlan name>}
```

The debug commands should only be used under the guidance of Extreme Networks technical personnel.

To reset all debug-tracing to the factory default level, use the following command:

```
clear debug-trace
```

To change the debug tracing facility for a certain module to debug level, use the following command:

```
config debug-trace [access-list | accounting | bgp-dampening | bgp-events |
bgp-keepalive | bgp-misc | bgp-msgs | bgp-neighbor | bgp-update-in | bgp-update-out |
bridge-learning | bridging | card-state-change | e1 {multilink ports <multilink
name>}| eaps-system | esrp-system | fdb-replacement | fdb-system | flow-redirect |
flowstats | health-check | ipforwarding | ipfdb | ipmcfdb | iproute | ipxrip-route |
ipxsap-entry | isis-cli | isis-event | isis-lsp | isis-snp | isis-spf | lcp {multilink
ports <multilink name>}| nat | ncp {multilink ports <multilink name>}| npcard | npdiag
| ospf-lsa | ospf-spf | pim-cache | pim-rp-mgmt | pppauth {multilink ports <multilink
name>}| ppphexdump {multilink ports <multilink name>}| slb-connection | slb-failover |
slb-3dns | snmp-trace | stp-in-pdu | stp-out-pdu | stp-system | t1 {multilink ports
<multilink name>}| t3 {multilink ports <multilink name>}| xp ] <debug level>
```

To change the debug tracing level for a certain module to a particular level for one or more VLANs, use the following command:

```
config debug-trace [bootprelay | dvmrp-cache | dvmrp-hello | dvmrp-message |
dvmrp-neighbor | dvmrp-route | dvmrp-timer | esrp-message | esrp-state-change | fdb |
igmp-snooping | iparp | ipxgns-messages | ipxrip-message | ipxsap-message | isis-hello
| ospf-hello | ospf-neighbor | pim-hello | pim-neighbor | pim-message | rip-message |
rip-route-change | rip-triggered-update | udp-forwarding | vrrp | vrrp-hello] <debug
level> vlan <vlan name>
```

To display the debug tracing configuration, use the following command:

```
show debug-trace [[access-list | accounting | bgp-dampening | bgp-events |
bgp-keepalive | bgp-misc | bgp-msgs | bgp-neighbor | bgp-update-in | bgp-update-out |
bridge-learning | bridging | card-state-change | e1 {multilink ports <multilink
name>}| eaps-system | esrp-system | fdb-replacement | fdb-system | flow-redirect |
flowstats | health-check | ipforwarding | ipfdb | ipmcfdb | iproute | ipxrip-route |
ipxsap-entry | isis-cli | isis-event | isis-lsp | isis-snp | isis-spf | lcp {multilink
ports <multilink name>}| nat | ncp {multilink ports <multilink name>}| npcard | npdiag
| ospf-lsa | ospf-spf | pim-cache | pim-rp-mgmt | pppauth {multilink ports <multilink
name>}| ppphexdump {multilink ports <multilink name>}| slb-connection | slb-failover |
slb-3dns | snmp-trace | stp-in-pdu | stp-out-pdu | stp-system | t1 {multilink ports
<multilink name>}| t3 {multilink ports <multilink name>}| xp ]]
```

To display the debug tracing configuration for one or more VLANs, use the following command:

```
show debug-trace [bootprelay | dvmrp-cache | dvmrp-hello | dvmrp-message |
dvmrp-neighbor | dvmrp-route | dvmrp-timer | esrp-message | esrp-state-change | fdb |
igmp-snooping | iparp | ipxgns-messages | ipxrip-message | ipxsap-message | isis-hello
| ospf-hello | ospf-neighbor | pim-hello | pim-neighbor | pim-message | rip-message |
rip-route-change | rip-triggered-update | udp-forwarding | vrrp | vrrp-hello] vlan
<vlan name>
```

TOP Command

The top command is a utility that indicates CPU utilization by process.

System Health Check

The system health check tests both the backplane and the CPU by periodically forwarding packets and checking for the validity of these packets. All error messages are logged in the syslog and the diagnostics CLI show output. A “CRIT” message will be posted to the log if any of the packet tests fail. If you observe a failure, please contact Extreme Technical Support.

To enable system health check, use the following command:

```
enable sys-health-check
```

System health check is enabled by default.

To disable the system health checker, use the following command:

```
disable sys-health-check
```

To configure the system health checker, use the following command:

```
configure sys-health-check alarm-level [card-down | default | log | system-down |
traps]
```

This command allows you to configure the switch’s reaction to a failed health check, and provides the following options:

- `log`—posts a CRIT message to the log
- `traps`—posts a CRIT message to the log and sends a trap
- `card-down`—posts a CRIT message to the log, sends a trap, and brings the module down
- `system-down`—posts a CRIT message to the log, sends a trap, and brings the system down

The default option is log.

To view the status of the system health checker, use this command:

```
show diag
```

NOTE

You cannot use both mirroring and the system health checker at the same time. If you configure mirroring with the system health checker enabled, the health checker will indicate that it has been disabled by sending a message to the syslog.

System Memory Dump

You can download the entire contents of memory through the Ethernet management port. This is used only for troubleshooting, and should not be used without assistance from Extreme Networks technical support.

To transfer the dump, use the following command:

```
upload system-dump [<ip address>]
```

If you do not specify an IP address, the configured system-dump server IP address is used.

To specify the IP address to which to transfer a dump if the `system-dump` option is specified in the configuration, use the following command:

```
config system-dump server <ip address>
```

This address is also used if no address is provided in the `upload system-dump` command. The default is 0 or “no IP”.

To set an optional timeout for the dump transfer, use the following command:

```
config system-dump timeout <seconds>
```

The default is 0. The minimum non-zero value is 120 seconds. The minimum recommended value is 480 seconds.

To return the system-dump configuration to the defaults, use the following command:

```
unconfig system-dump
```

To display the system-dump server IP and dump-timeout, use the following command:

```
show system-dump
```

To specify a memory dump if a task generates a software exception, use the following command:

```
config sys-recovery-level [all | critical] system-dump [maintenance-mode |
msm-failover | reboot | shutdown]
```

The four options specify the action taken when the dump transfer is complete. The actions occur whether or not the dump was successful. The `maintenance-mode` option leaves the switch in whatever state it was in before the dump.

System Odometer

Each field replaceable component contains a system odometer counter in EEPROM. You can use the `show switch` command to see how long an individual component has been in service since it was manufactured. The odometer is supported on the following components:

Alpine

- SMMi
- Baseboard
- All modules
- PSU

BlackDiamond

- Master MSM64i and slave MSM64i
- Backplane
- All modules

Summit7i

- CPU
- Baseboard
- I/O boards

Summit48i

- CPU
- Daughter card

Summit5i

- CPU
- Daughter card

Summit1i

- CPU

Memory Scanning and Memory Mapping

Memory scanning and memory mapping identify and correct fabric checksum issues. Sometimes referred to as EDP checksums, today Extreme Networks recognizes all these issues under the general category of checksum errors.

Hard drives use disk scanning tools to map out bad sectors in order to allow the drive to remain operational with no adverse effect on performance, capacity, or reliability. Memory scanning and memory mapping function similarly.

Memory scanning is designed to help isolate one of the major root causes for checksum errors. Memory scanning detects with a high probability all current single bit permanent failures in the switch memory that would result in checksum errors.

Memory mapping can correct up to 8 of these detected permanent single bit errors by reconfiguring the memory maps around the problem areas. Memory scanning and memory mapping are two separate functions. Scanning detects the faulted portion of the memory. Mapping re-maps the memory to remove the faulted memory section.

Modes of Operation

The memory scanning feature has two modes of operation: manual mode, which is the default and recommended mode; and automatic mode, which is only used in redundant networks.

Memory scanning is supported on the following modules and platforms:

- BlackDiamond 6816, BlackDiamond 6808, and BlackDiamond 6804
- BlackDiamond modules - MSM64i, F96Ti, F48Ti, G8Xi, G8Ti, G12SXi
- Alpine 3808, Alpine 3804, and Alpine 3802
- Summit48i, Summit7i, Summit5i, Summit1i, and Summit48si

Manual Mode

Manual mode is initiated by the following command:

```
run diagnostics packet-memory
```

NOTE

This command is available on ExtremeWare 6.2.1 for BlackDiamond I/O modules, and ExtremeWare 6.2.2 and higher for BlackDiamond MSM64i, Alpine, and stackables. The command is only executed on one module at a time, although you can queue up two run diagnostics commands at a time.

Automatic Mode (Auto Scan)

Automatic mode for initiating memory scanning is set up after the auto-recovery option is enabled under the system health check configuration. This is done using the following commands:

For stackable and Alpine switches:

```
configure sys-health-check alarm-level [ log | system-down | traps | auto-recovery [
<cr> | offline | online ] ]
```

For BlackDiamond switches:

```
configure sys-health-check auto-recovery [ <number of tries> ] [ <cr> | offline |
online ]
```

Automatic mode status is listed in the `show switch` output sys-health-check field.

Once auto-recovery mode is enabled, an automated background polling task checks every 20 seconds to see if any checksums have occurred. Three consecutive samples must be corrupted for any module to invoke autoscan. If autoscan is invoked, regardless of platform type or number of errors, there is an initial period where the device is taken offline so the scan can be run.

Memory Scanning and Memory Mapping Functions

Once initiated (either automatically or by manual control) the memory scanning feature takes the selected module offline, and initiates a thorough memory write-read operation to detect any permanent single bit errors within the module's memory. This takes approximately 90 seconds and the module remains offline for the duration of the scan.

Memory scanning and memory mapping behavior differs based on the platform, the mode you configure (online or offline), and whether you configure auto-recovery or run the diagnostics manually.

Table 72 describes the behavior of the switch if you configure auto-recovery using the `config sys-health-check` command. The behavior differs based on the hardware configuration, the mode selected (online or offline), and the number of errors detected.

Table 72: Auto-recovery memory scanning and memory mapping behavior

Platform	Online	Offline	New Errors Detected	Behavior
Alpine	✓		0	Switch kept online.
	✓		1-7	Errors mapped, switch kept online.
	✓		>7	Errors not mapped, switch kept online.
		✓	0	Switch enters limited commands mode.
		✓	1-7	Errors mapped, switch kept online.
		✓	>7	Errors not mapped, switch enters limited commands mode.
Summit	✓		0	Switch kept online.
	✓		1-7	Errors mapped, switch kept online.
	✓		>7	Errors not mapped, switch kept online.
		✓	0	Switch enters limited commands mode.
		✓	1-7	Errors mapped, switch kept online.
		✓	>7	Errors not mapped, switch enters limited commands mode.
BlackDiamond with one MSM64i (or slave MSM64i is offline)	✓		0	Switch kept online.
	✓		1-7	Errors mapped, switch kept online.
	✓		>7	Errors not mapped, switch kept online.
		✓	0	Switch enters limited commands mode.
		✓	1-7	Errors mapped, switch kept online.
		✓	>7	Errors not mapped, switch enters limited commands mode.

Table 72: Auto-recovery memory scanning and memory mapping behavior (continued)

Platform	Online	Offline	New Errors Detected	Behavior
BlackDiamond with two MSM64i's, errors on Master	✓		0	MSM64i kept online.
	✓		1-7	Errors mapped, MSM64i kept online.
	✓		>7	Errors not mapped, MSM64i kept online.
		✓	0	Master MSM64i fails over.
		✓	1-7	Errors mapped, MSM64i kept online.
		✓	>7	Errors not mapped, Master MSM64i fails over.
BlackDiamond with two MSM64i's, errors on Slave	✓		0	MSM64i kept online.
	✓		1-7	Errors mapped, MSM64i kept online.
	✓		>7	Errors not mapped, MSM64i kept online.
		✓	0	Slave MSM64i taken offline.
		✓	1-7	Errors mapped, MSM64i kept online.
		✓	>7	Errors not mapped, Slave MSM64i taken offline.
BlackDiamond with two MSM64i's, errors on both	✓		0	Both kept online.
	✓		1-7	Errors mapped, both kept online.
	✓		>7	Errors not mapped, both kept online.
		✓	0	Both enter limited commands mode.
		✓	1-7	Errors mapped, both kept online.
		✓	>7	Errors not mapped, both enter limited commands mode.
BlackDiamond 6816 MSM64i's in slots C and D	✓		0	MSM64i kept online.
	✓		1-7	Errors mapped, MSM64i kept online.
	✓		>7	Errors not mapped, MSM64i kept online.
		✓	0	MSM64i taken offline
		✓	1-7	Errors mapped, MSM64i kept online.
		✓	>7	Errors not mapped, MSM64i taken offline.
Alpine and BlackDiamond "*i*" series I/O modules	✓		0	Module kept online.
	✓		1-7	Errors mapped, module kept online.
	✓		>7	Errors not mapped, module kept online.
		✓	0	Module taken offline
		✓	1-7	Errors mapped, module kept online.
		✓	>7	Errors not mapped, module taken offline.

Table 73 describes the behavior of the switch if you run diagnostics manually using the `run diagnostics` command with the `normal` option. The behavior differs based on the hardware configuration, the mode selected (online or offline) using the `config sys-health-check` command, and the number of errors detected.

Table 73: Manual diagnostics memory scanning and memory mapping behavior, normal

Platform	Online	Offline	New Errors Detected	Behavior
Alpine	✓		0	Switch kept online.
	✓		1-7	Errors mapped, switch kept online.
	✓		>7	Errors not mapped, switch kept online.
		✓	0	Switch kept online.
		✓	1-7	Errors mapped, switch kept online.
		✓	>7	Errors not mapped, switch enters limited commands mode.
Summit	✓		0	Switch kept online.
	✓		1-7	Errors mapped, switch kept online.
	✓		>7	Errors not mapped, switch kept online.
		✓	0	Switch kept online.
		✓	1-7	Errors mapped, switch kept online.
		✓	>7	Errors not mapped, switch enters limited commands mode.
BlackDiamond with one MSM64i (or slave MSM64i is offline)	✓		0	Switch kept online.
	✓		1-7	Errors mapped, switch kept online.
	✓		>7	Errors not mapped, switch kept online.
		✓	0	Switch kept online.
		✓	1-7	Errors mapped, switch kept online.
		✓	>7	Errors not mapped, switch enters limited commands mode.
BlackDiamond with two MSM64i's, errors on Master	✓		0	MSM64i kept online.
	✓		1-7	Errors mapped, MSM64i kept online.
	✓		>7	Errors not mapped, MSM64i kept online.
		✓	0	MSM64i kept online.
		✓	1-7	Errors mapped, MSM64i kept online.
		✓	>7	Errors not mapped, Master MSM64i fails over.
BlackDiamond with two MSM64i's, errors on Slave	✓		0	MSM64i kept online.
	✓		1-7	Errors mapped, MSM64i kept online.
	✓		>7	Errors not mapped, MSM64i kept online.
		✓	0	MSM64i kept online.
		✓	1-7	Errors mapped, MSM64i kept online.
		✓	>7	Errors not mapped, Slave MSM64i enters limited commands mode.

Table 73: Manual diagnostics memory scanning and memory mapping behavior, normal (continued)

Platform	Online	Offline	New Errors Detected	Behavior
BlackDiamond 6816 MSM64i's in slots C and D	✓		0	MSM64i kept online.
	✓		1-7	Errors mapped, MSM64i kept online.
	✓		>7	Errors not mapped, MSM64i kept online.
		✓	0	MSM64i kept online.
		✓	1-7	Errors mapped, MSM64i kept online.
		✓	>7	Errors not mapped, MSM64i taken offline.
Alpine and BlackDiamond "*i*" series I/O modules	✓		0	Module kept online.
	✓		1-7	Errors mapped, module kept online.
	✓		>7	Errors not mapped, module kept online.
		✓	0	Module kept online.
		✓	1-7	Errors mapped, module kept online.
		✓	>7	Errors not mapped, module taken offline.

Table 74 describes the behavior of the switch if you run diagnostics manually using the `run diagnostics` command with the `extended` option. The behavior differs based on the hardware configuration and whether errors are detected (the mode selected has no effect).

Table 74: Manual diagnostics memory scanning and memory mapping behavior, extended

Platform	Errors Detected?	Behavior
Alpine	Y	Switch enters limited commands mode.
	N	Switch kept online.
Summit	Y	Switch enters limited commands mode.
	N	Switch kept online.
BlackDiamond with one MSM64i (or slave MSM64i is offline)	Y	Switch enters limited commands mode.
	N	Switch kept online.
BlackDiamond with two MSM64i's, errors on Master	Y	Master MSM64i fails over.
	N	MSM64i kept online.
BlackDiamond with two MSM64i's, errors on Slave	Y	MSM64i taken offline.
	N	MSM64i kept online.
BlackDiamond 6816 MSM64i's in slots C and D	Y	Module taken offline.
	N	Module kept online.
Alpine and BlackDiamond "*i*" series I/O modules	Y	Module taken offline.
	N	Module kept online.
BlackDiamond non-"*i*" series I/O modules	Y	Module taken offline.
	N	Module kept online.

Limited Commands Mode

Both manual and automatic diagnostics results can put the switch into limited commands mode. In limited commands mode, all tasks are suspended, I/O modules are powered down, and a limited set of commands are available for troublshooting or corrective action. The available commands are:

- clear log
- config diagnostics
- config iparp
- config iproute add default
- config vlan ipaddress
- download boootrom
- download configuration
- download image
- ping
- reboot
- show iparp
- show iproute
- show log
- show version
- show vlan
- unconfig switch
- use configuration
- use image
- show diagnostics

Effects of Running Memory Scanning on the Switch

During the scanning period, the module is taken offline. Expect a minimum offline time of 90 seconds. Up to eight correctable single bit errors are corrected, with minimal loss to the total memory buffers.

In extremely rare cases, non-correctable errors are detected by memory scanning. In these circumstances the condition is noted, but no corrective action is possible. In manual mode the module is returned to online service after all possible corrective actions have been taken.

During the memory scan the CPU utilization is high and mostly dedicated to executing the diagnostics as is normal for running any diagnostic on the modules. During this time other network activities where this system is expected to be a timely participant could be adversely affected, for example, STP, OSPF.

Using Memory Scanning

If the system has checksum error messages occurring consistently over any period of time, manually initiate a memory scan within a network maintenance window that allows for total unavailability of the entire system.

The targeted I/O module is offline for the duration of the manually initiated scan, and the entire system can be adversely affected due to the CPU utilization being almost totally dedicated to the diagnostic

memory scan. Memory scanning can also be run during a stage in process for new modules and or systems.

It is extremely unlikely that more than 8 detectable errors are ever detected on any module; however if this does occur the module may be permanently marked down (if offline option is enabled). With the offline option enabled, it is left in a non-operational state and cannot be used in a system running ExtremeWare 6.2.2 version or higher software. If that happens, the module needs to be replaced.

Online options can bring the module online even with 8 or more detectable errors, but the module must still be replaced.

Recommended Mode

Extreme Networks strongly recommends that only manual mode memory scanning be used and that appropriate maintenance windows be arranged for the entire system, not just the intended I/O module paths. In addition to packet memory scan, extended diagnostics must also be run during this window as together these tests can detect not only problems with the packet memory but any other problems with the module. Further, the BlackDiamond chassis must be isolated either physically or logically from the network during the diagnostics run. This ensures that various network features converge properly.

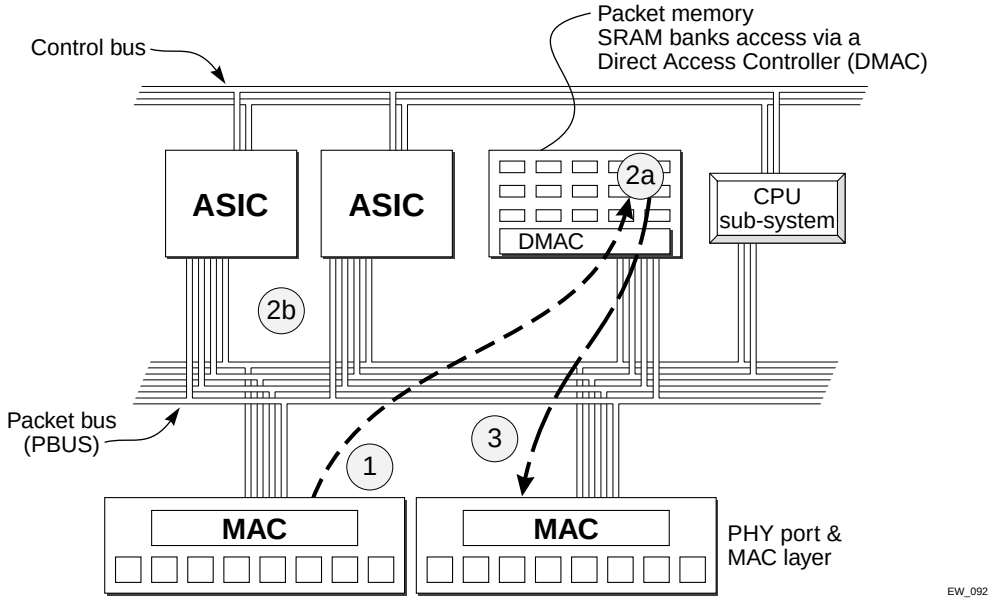
We also recommend that, if possible, ,memory scanning be performed while actual fabric checksums are being reported in the log. Although this is not an absolute requirement, and in fact is not a factor in the actual memory scan, by executing manual memory scanning while there are checksums occurring provides the best correlation between this diagnostic and the actual event.

Memory Scanning and Fabric Checksums

Memory scanning can only address fabric checksum attributed to errors in the memory area of the switching fabric. In this specific regard it can detect several error conditions in the memory, however it only corrects a maximum of eight of these single bit error instances.

Other types of checksum can occur and are signaled under the general checksum log message. These are not detected or corrected by memory scanning. Within an Extreme Networks switch, the following high-level diagram represents the basic data path for packets ingressing and egressing the switch fabric.

Figure 127: Switch Fabric



A switch fabric is essentially an extremely high-speed data path between multiple ports, which has a certain degree of flexibility through a forwarding database, to examine and switch packets intelligently between their ingress ports and their egress ports.

Data typically enters the switch fabric after passing through the PHY ports and the MAC device layers. From the ingress point of the MAC the data is moved to temporary storage in the packet memory. Checksums are applied at the point of entry to the switch fabric, and these checksums are validated upon exit of the switch fabric. If the checksum does not evaluate correctly to the contents of the packet then some corruption has occurred to that packet.

Corruption can occur anywhere along the data path and storage. These corruptions are extremely rare but with a high traffic switch fabric even a temporary PBUS or memory problem can lead to a large amount of individual packet corruptions.

If packet corruption occurs in the switch fabric it must occur frequently or consistently to be considered a problem. Nonetheless, log messages are generated to signal when any fabric checksums occur. Consistent checksum log messages indicate a problem. ExtremeWare also protects the CPU from corrupted packets by evaluating the checksums placed by the MAC devices whenever these packets are sent up to the CPU for processing.

Using Memory Scanning to Screen I/O Modules

Memory scanning is available in ExtremeWare 6.2.2 or higher. To check modules supported by the memory scanning feature you can screen existing or new modules without having to upgrade or certify this new build on your networks. No particular configuration or traffic load is needed to execute memory scanning on the supported modules. Simply load ExtremeWare 6.2.2 onto a spare chassis with a default configuration and scan the modules as needed

If your environment does not support a spare chassis or it would be impractical to rotate through the installed modules, then consider temporarily loading ExtremeWare 6.2.2 onto your existing systems during an extended maintenance window to perform memory scanning on modules in the field.

To do this, schedule an extended maintenance window and prepare the system for a temporary upgrade to ExtremeWare 6.2.2. Do not convert or save the configuration on the switch. It is not possible to correctly run an ExtremeWare 6.2.2 configuration on an older version of ExtremeWare.

In temporarily upgrading your systems, plan to roll back the systems to the original working code image and configuration. This means you need the original ExtremeWare code version in hand and accessible by TFTP server from the switch. In addition you also need the latest saved configuration uploaded and also accessible to download back to the switch from a TFTP server.

No particular configuration is needed to support running memory scanning, in fact a default configuration is just as effective. The ExtremeWare 6.2.2 release notes outline the recommended steps to upgrade your system to ExtremeWare 6.2.2 and BootROM 7.6. Follow the release notes carefully. Since this upgrade is only a temporary step to perform memory scanning, there is no need to re-download the saved configuration. The existing default configuration can be used to scan the supported modules and then the system can be restored to the original ExtremeWare code version and configuration.

If you must support a large campus environment with several BlackDiamond or Alpine systems for this screening operation, you can temporarily dedicate a single MSM64i to ExtemeWare 6.2.2 for the exercise and manually move this around all the systems with a default configuration to perform the scanning of the modules. For stackable platforms, you must load ExtemeWare 6.2.2 on every switch to run this test.

Be aware that any memory defect found and mapped out under this exercise does not remain mapped out when those modules are returned to a pervious version of ExtremeWare. ExtremeWare does not have the capability to use the mapped out information located in the detected module's EEPROM. The validity of this temporary screening exercise is limited to identifying modules with memory defects.

Reboot Loop Protection

If the system reboots due to a failure that remains after the reboot, it reboots when it detects the failure again. To protect against continuous reboot loops, you can configure reboot loop protection using the following command:

```
config reboot-loop-protection threshold <time-interval> <count>
```

If the switch reboots the specified number of times within the specified time interval, it stops rebooting and comes up in minimal mode. If you reboot the switch manually or use the `run msm-failover` or `run diagnostics` commands, the time interval and count are both reset to 0.

Minimal Mode

In minimal mode, only the CPU, NVRAM, management port, and minimal tasks are active. The following commands are supported in minimal mode:

- Reboot
- Unconfig switch all
- Unconfig switch
- Use image
- Use configuration
- Download boootrom
- Download image

- Download configuration
- Config iparp
- Config vlan ipaddress
- Config iproute add default
- Config diagnostics
- Show iproute
- Show iparp
- Show vlan
- Show version
- Show log
- Ping
- Clear log
- Clear log diag-status

Contacting Extreme Technical Support

If you have a network issue that you are unable to resolve, contact Extreme Networks technical support. Extreme Networks maintains several Technical Assistance Centers (TACs) around the world to answer networking questions and resolve network problems. You can contact technical support by phone at:

- (800) 998-2408
- (408) 579-2826

or by email at:

- support@extremenetworks.com

You can also visit the support website at:

http://www.extremenetworks.com/services/resources/

to download software updates (requires a service contract) and documentation (including a .pdf version of this manual).

C Supported Protocols, MIBs, and Standards

The following is a list of software standards and protocols supported by ExtremeWare.

General Routing and Switching	
RFC 1812 Requirements for IP Version 4 Routers	RFC 793 Transmission Control Protocol
RFC 1519 An Architecture for IP Address Allocation with CIDR	RFC 826 Ethernet Address Resolution Protocol: Or converting network protocol addresses to 48.bit Ethernet address for transmission on Ethernet hardware
RFC 1256 ICMP Router Discovery Messages	RFC 2338 Virtual Router Redundancy Protocol
RFC 783 TFTP Protocol (revision 2)	Extreme Standby Router Protocol (ESRP)
RFC 951 Bootstrap Protocol	IPX RIP/SAP Router specification
RFC 1542 Clarifications and Extensions for the Bootstrap Protocol	IEEE 802.1D-1998 Spanning Tree Protocol
RFC 2131 Dynamic Host Configuration Protocol	IEEE 802.1Q - 1998 Virtual Bridged Local Area Networks
RFC 1591 Domain Name System Structure and Delegation	Ethernet Automatic Protection Switching (EAPS)
RFC 1122 Requirements for Internet Hosts - Communication Layers	Multiple Instances of Spanning Tree (PVST, 802.1Q interoperable)
RFC 768 User Datagram Protocol	Software controlled redundant PHYs
RFC 791 Internet Protocol	
RFC 792 Internet Control Message Protocol	

VLANs	
IEEE 802.1Q VLAN Tagging	Multiple STP domains per VLAN
IEEE 802.3ad Static ConfigPort-based VLANs	RFC 3069 VLAN Aggregation for Efficient IP Address Allocation
MAC-based VLANs	Virtual MANs
Protocol-sensitive VLANs	

Quality of Service	
IEEE 802.1D -1998 (802.1p) Packet Priority	RFC 2475 An Architecture for Differentiated Service
RFC 2474 Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers	Layer 1-4, Layer 7 (user name) Policy-Based Mapping
RFC 2598 An Expedited Forwarding PHB	Policy-Based Mapping/Overwriting of DiffServ code points, .1p priority
RFC 2597 Assured Forwarding PHB Group	
Bi-directional Rate Shaping	

RIP	
RFC 1058 Routing Information Protocol	RFC 2453 RIP Version 2

OSPF	
RFC 2328 OSPF Version 2	RFC 1765 OSPF Database Overflow
RFC 1587 The OSPF NSSA Option	RFC 2370 The OSPF Opaque LSA Option

IS-IS	
RFC 1195 Use of OSI IS-IS for Routing in TCP/IP and Dual Environments	ISO 10589 OSI IS-IS Intra-Domain Routing Protocol (Replicated as RFC 1142)

BGP4	
RFC 1771 A Border Gateway Protocol 4 (BGP-4)	RFC 1997 BGP Communities Attribute
RFC 1965 Autonomous System Confederations for BGP	RFC 1745 BGP4/IDRP for IP---OSPF Interaction
RFC 2796 BGP Route Reflection - An Alternative to Full Mesh IBGP	RFC 2385 Protection of BGP Sessions via the TCP MD5 Signature Option
	RFC 2439 BGP Route Flap Dampening

IP Multicast	
RFC 2362 Protocol Independent Multicast-Sparse Mode (PIM-SM): Protocol Specification	RFC 2236 Internet Group Management Protocol, Version 2
PIM-DM Draft IETF PIM Dense Mode v2-dm-03)DVMRP v3 draft IETF DVMRP v3-07	IGMP Snooping with Configurable Router Registration Forwarding
RFC 1112 Host extensions for IP multicasting	

Management - SNMP & MIBs	
RFC 1155 Structure and identification of management information for TCP/IP-based internets	RFC 2021 Remote Network Monitoring Management Information Base Version 2 using SMIv2
RFC 1157 Simple Network Management Protocol (SNMP)	RFC 2613 Remote Network Monitoring MIB Extensions for Switched Networks Version 1.0
RFC-1212 Concise MIB definitions	RFC 2668 Definitions of Managed Objects for IEEE 802.3 Medium Attachment Units (MAUs)
RFC-1213 Management Information Base for Network Management of TCP/IP-based internets: MIB-II	RFC 1643 Definitions of Managed Objects for the Ethernet-like Interface Types
RFC-1215 Convention for defining traps for use with the SNMP	RFC 1650 Definitions of Managed Objects for the Ethernet-like Interface Types using SMIv2
RFC 1901 Introduction to Community-based SNMPv2	RFC 1573 Evolution of the Interfaces Group of MIB-II
RFC 1902 Structure of Management Information for Version 2 of the Simple Network Management Protocol (SNMPv2)	RFC 1493 Definitions of Managed Objects for Bridges
RFC 1903 Textual Conventions for Version 2 of the Simple Network Management Protocol (SNMPv2)	RFC 1354 IP Forwarding Table MIB
RFC 1904 Conformance Statements for Version 2 of the Simple Network Management Protocol (SNMPv2)	RFC 2037 Entity MIB using SMIv2
RFC 1905 Protocol Operations for Version 2 of the Simple Network Management Protocol (SNMPv2)	RFC 2096 IP Forwarding Table MIB
RFC 1906 Transport Mappings for Version 2 of the Simple Network Management Protocol (SNMPv2)	RFC 1724 RIP Version 2 MIB Extension
RFC 1907 Management Information Base for Version 2 of the Simple Network Management Protocol (SNMPv2)	RFC 1850 OSPF Version 2 Management Information Base
RFC 1908 Coexistence between Version 1 and Version 2 of the Internet-standard Network Management Framework	RFC 1657 Definitions of Managed Objects for the Fourth Version of the Border Gateway Protocol (BGP-4) using SMIv2
RFC 1757 Remote Network Monitoring Management Information Base	RFC 2787 Definitions of Managed Objects for the Virtual Router Redundancy Protocol
	RFC 2925 Definitions of Managed Objects for Remote Ping, Traceroute, and Lookup Operations
	ExtremeWare vendor MIB (includes ACL, MAC FDB, IP FDB, QoS policy and VLAN config and statistics, STP and others)

Management - Other:	
RFC 1866 Hypertext Markup Language - 2.0	NetFlow version 1 export
RFC 2068 Hypertext Transfer Protocol -- HTTP/1.1	Configuration logging
RFC 854 Telnet Protocol Specification	Multiple Images, Multiple Configs
HTML/ HTTP management	BSD System Logging Protocol (SYSLOG), with Multiple Syslog Servers
Secure Shell (SSHv2) and Telnet management,	999 Local Messages (criticals stored across reboots)
Telnet and SSHv2 clients	RFC 2030 Simple Network Time Protocol (SNTP) Version 4 for IPv4, IPv6 and OSI
Secure Copy (SCPv2)	

Security	
Routing protocol authentication (see above)	RADIUS Per-command Authentication
Secure Shell (SSHv2) & Secure Copy (SCPv2) with encryption/authentication	Access Profiles on All Routing Protocols
RFC 1492 An Access Control Protocol, Sometimes Called TACACS	Access Profiles on All Management Methods
RFC 2138 Remote Authentication Dial In User Service (RADIUS)	Network Login (including DHCP / RADIUS integration)
RFC 2139 RADIUS Accounting	MAC Address Security / Lockdown
	Network Address Translation (NAT)
	Layer 2/3/4/7 Access Control Lists (ACLs)

Denial of Service Protection	
RFC 2267 Network Ingress Filtering: Defeating Denial of Service Attacks which employ IP Source Address Spoofing	IP Broadcast Forwarding Control
RPF (Unicast Reverse Path Forwarding) Control	ICMP and IP-Option Response Control
Wire-speed ACLs	Server Load Balancing with Layer 3,4 Protection of Servers
Rate Limiting by ACLs	SYN attack protection
	Uni-directional Session Control

Robust Against Common Network Attacks	
CERT (http://www.cert.org)	Host Attacks (http://www.rootshell.com)
• CA--97.28.Teardrop_Land -Teardrop and “LAND” attack	• Syndrop
• IP Options Attack	• Nestea
• CA--98-13-tcp-denial-of-service	• Latierra
• CA--98.01.smurf	• Newtear
• CA--96.26.ping	• Bonk
• CA--96.21.tcp_syn_flooding	• Winnuke
• CA--96.01.UDP_service_denial	• Raped
• CA--95.01.IP_Spoofing_Attacks_and_Hijacked_ Terminal_Connections	• Simping
• CA-2002-03: SNMP vulnerabilities	• Sping
	• Ascend
	• Stream

MPLS - Standards and MIBs	
RFC 2212 Specification of Guaranteed Quality of Service RFC 2961 RSVP Overhead Refresh Reduction Extensions RFC 3032 MPLS Label Stack Encoding RFC 3031 Multiprotocol Label Switching Architecture RFC 3036 LDP Specification Martini drafts: draft-martini-circuit-encap-mpls-04.txt and draft-martini-l2circuit-trans-mpls-08.txt RSVP-TE LSP tunnel draft: draft-ietf-mpls-rsvp-lsp-tunnel-09.txt Traffic Engineering Extensions to OSPF: draft-katz-yeung-ospf-traffic-06.txt	The Extreme MPLS implementation provides read-only (GET but not SET) support for a subset of the MPLS LSR MIB, as defined in the Internet Draft *draft-ietf-mpls-lsr-mib-07.txt*, and a subset of the MPLS LDP MIB, as defined in the Internet Draft *draft-ietf-mpls-ldp-mib-07.txt*.

ATM - Standards and MIBs	
The interface counters in MIB-II (RFC 1213) are supported for ATM. Support for read-only operations (GET operations, but not SET operations) is provided for selected objects in the standard ATM MIB (RFC 2515). Additional MIB objects to support ATM have also been added to the Extreme Networks private MIB.	

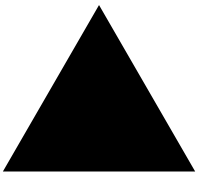
SONET/SDH - Standards and MIBs	
GR-253-CORE, Synchronous Optical Network (SONET) Transport Systems: Common Generic Criteria, Bellcore, Issue 2, Revision 2, January 1999. ANSI T1.105.02-1995, Synchronous Optical Network (SONET)—Payload Mappings, American National Standards Institute, 1995. ITU-T G.707 (03/96), Network Node Interfaces for the Synchronous Digital Hierarchy (SDH), March 1996.	A subset of RFC 2558, *Definitions of Managed Objects for the SONET/SDH Interface Type*, has been implemented. The Virtual Tributary (VT) group and the Section/Line/Path interval tables were not implemented. Read-only support (GET operations, but not SET operations) has been implemented for the remainder of the MIB.

DiffServ - Standards and MIBs	
RFC 2474 Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers RFC 2475 An Architecture for Differentiated Services RFC 2597 Assured Forwarding PHB Group RFC 2598 An Expedited Forwarding PHB	The Extreme Networks implementation of RED is based on the well-known paper *Random Early Detection Gateways for Congestion Avoidance*, by Sally Floyd and Van Jacobson. The Extreme Networks implementation of RED also complies with the recommendations published in RFC 2309, *Recommendations on Queue Management and Congestion Avoidance in the Internet*.

PPP - Standards and MIBs	
RFC 1661 The Point-to-Point Protocol (PPP) RFC 1662 PPP in HDLC-like Framing RFC 2615 PPP over SONET/SDH RFC 1334 PPP Authentication Protocols RFC 1994 PPP Challenge Handshake Authentication Protocol (CHAP) RFC 1989 An Application of the BGP Community Attribute in Multi-home Routing RFC 1332 The PPP Internet Protocol Control Protocol (IPCP) RFC 2878 PPP Bridging Control Protocol (BCP) RFC 1191 Path MTU Discovery RFC 3032 MPLS Label Stack Encoding	The interface counters in MIB-II (RFC 1213) are supported for PPP. Support for read-only operations (GET operations, but not SET operations) is provided for the following PPP MIBs: • RFC 1471 The Definitions of Managed Objects for the Link Control Protocol of the Point-to-Point Protocol • RFC 1472 The Definitions of Managed Objects for the Security Protocols of the Point-to-Point Protocol • RFC 1474 The Definitions of Managed Objects for the Bridge Network Control Protocol of the Point-to-Point Protocol • RFC 1473 The Definitions of Managed Objects for the IP Network Control Protocol of the Point-to-Point Protocol

Flow Statistics- Standards and MIBs	
Because no standard MIBs are defined for managing the NetFlow function, Extreme Networks has defined and implemented an enterprise MIB that provides read-only support (GET but not SET operations) for NetFlow configuration parameters and status information. Any of the parameters that can be set with the `config flowstats` commands can be accessed through using the MIB, and any of the status information displayed by the `show flowstats` command can also be read using the MIB. You can download the NetFlow enterprise MIB from the Extreme Network World Wide Web site at the following URL: http://www.extremenetworks.com/support/documentation.asp	

APS - Standards and MIBs	
GR-253-CORE, Synchronous Optical Network (SONET) Transport Systems: Common Generic Criteria, Bellcore, Issue 2, Revision 2, January 1999. ANSI T1.105.01-1998, Synchronous Optical Networks (SONET)—Automatic Protection Switching, American National Standards Institute, 1998. ITU-T G.783 (04/97), Characteristics of Synchronous Digital Hierarchy (SDH) Equipment Functional Blocks, April 1997.	Because no standard MIBs are defined for managing the APS function, Extreme Networks has defined and implemented an enterprise MIB that provides read-only support (GET but not SET operations) for APS configuration parameters and status information. Any of the parameters that can be set with the config aps commands can be accessed through using the MIB, and any of the status information displayed by the show aps command can also be read using the MIB. You can download the APS enterprise MIB from the Extreme Network World Wide Web site at the following URL: http://www.extremenetworks.com/support/documentation.asp



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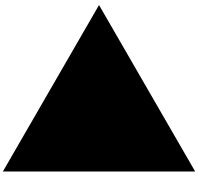

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