



# RackSwitch™ G8000 Application Guide

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**BLADE**  
NETWORK TECHNOLOGIES

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# Preface

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The RackSwitch G8000 *Application Guide* describes how to configure and use the software on the RackSwitch G8000 switch. For documentation about installing the switch physically, see the *Installation Guide* for your switch.

## Who Should Use This Guide

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This *Application Guide* is intended for network installers and system administrators engaged in configuring and maintaining a network. The administrator should be familiar with Ethernet concepts, IP addressing, Spanning Tree Protocol, and SNMP configuration parameters.

## What You'll Find in This Guide

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This guide will help you plan, implement, and administer RS G8000 software. Where possible, each section provides feature overviews, usage examples, and configuration instructions.

- [Chapter 1, “Accessing the Switch,”](#) describes how to access the switch to perform administration tasks. This chapter also discusses different methods to manage the switch for remote administrators using specific IP addresses, authentication, and Secure Shell (SSH).
- [Chapter 2, “Port-based Network Access Control,”](#) describes how to authenticate devices attached to a LAN port that has point-to-point connection characteristics. It prevents access to ports that fail authentication and authorization. This feature provides security for switch ports.
- [Chapter 3, “VLANs,”](#) describes how to configure Virtual Local Area Networks (VLANs) for creating separate network segments, including how to use VLAN tagging for devices that use multiple VLANs. This chapter also describes Private VLANs.
- [Chapter 4, “Ports and Trunking,”](#) describes how to group multiple physical ports together to aggregate the bandwidth between large-scale network devices.
- [Chapter 5, “Spanning Tree,”](#) discusses how Spanning Trees configure the network so that the switch uses the most efficient path when multiple paths exist.
- [Chapter 6, “Quality of Service,”](#) discusses Quality of Service features, including IP filtering using Access Control Lists, Differentiated Services, and IEEE 802.1p priority values.
- [Chapter 7, “Remote Monitoring,”](#) discusses how to configure and use the Remote Monitoring (RMON) agent on the switch.
- [Chapter 8, “Basic IP Routing,”](#) describes how to configure the switch for IP routing using IP subnets, and DHCP.
- [Chapter 9, “IGMP,”](#) describes how the RS G8000 software implements IGMP Snooping to handle multicast traffic efficiently.
- [Chapter 10, “High Availability,”](#) describes how to use the Uplink Failure Detection (UFD) to ensure that network resources remain available if one switch is removed for service.
- [Appendix A, “Troubleshooting,”](#) discusses the main tool for troubleshooting your switch—monitoring ports.

# Typographic Conventions

The following table describes the typographic styles used in this book.

**Table 1** Typographic Conventions

Typeface or Symbol	Meaning	Example
AaBbCc123	This type is used for names of commands, files, and directories used within the text.  It also depicts on-screen computer output and prompts.	View the <code>readme.txt</code> file.  Main#
<b>AaBbCc123</b>	This bold type appears in command examples. It shows text that must be typed in exactly as shown.	Main# <b>sys</b>
<AaBbCc123>	This italicized type appears in command examples as a parameter placeholder. Replace the indicated text with the appropriate real name or value when using the command. Do not type the brackets.  This also shows book titles, special terms, or words to be emphasized.	To establish a Telnet session, enter: host# <b>telnet</b> <IP address>  Read your <i>User's Guide</i> thoroughly.
[ ]	Command items shown inside brackets are optional and can be used or excluded as the situation demands. Do not type the brackets.	host# <b>ls</b> [-a]

## How to Get Help

---

If you need help, service, or technical assistance, call Blade Network Technologies Technical Support:

US toll free calls: 1-800-414-5268

International calls: 1-408-834-7871

You also can visit our website at the following address:

<http://www.bladenetwork.net>

Click the **Support** tab.

The warranty card received with your product provides details for contacting a customer support representative. If you are unable to locate this information, please contact your reseller. Before you call, prepare the following information:

- Serial number of the switch unit
- Software release version number
- Brief description of the problem and the steps you have already taken
- Technical support dump information (`# show tech-support`)

## CHAPTER 1

# Accessing the Switch

---

The Blade OS software provides means for accessing, configuring, and viewing information and statistics about the RackSwitch G8000. This chapter discusses different methods of accessing the switch and ways to secure the switch for remote administrators:

- “Configuring an IP Interface” on page 16
- “Using Telnet” on page 17
- “Using the Browser-Based Interface” on page 18
- “Using SNMP” on page 20
- “Securing Access to the Switch” on page 25
  - “RADIUS Authentication and Authorization” on page 26
  - “TACACS+ Authentication” on page 30
  - “End User Access Control” on page 36

## Configuring an IP Interface

---

To manage the switch using Telnet, SNMP, or a Web browser, you must configure an IP interface. Configure the following IP parameters:

- IP address
- Subnet mask
- Default gateway address

1. **Log on to the switch.**
2. **Enter IP interface mode.**

```
RS G8000> enable
RS G8000# configure terminal
RS G8000 (config)# interface ip 1
```

3. **Configure an IP interface, subnet mask, and VLAN assignment. Enable the interface.**

```
RS G8000 (config-ip-if)# ip address 10.10.10.2           (example IP address)
RS G8000 (config-ip-if)# ip netmask 255.255.255.0
RS G8000 (config-ip-if)# ipvlan 1
RS G8000 (config-ip-if)# enable
RS G8000 (config-ip-if)# exit
```

4. **Configure the default gateway. Enable the gateway.**

```
RS G8000 (config)# ip gateway address 10.10.10.1      (example gateway address)
RS G8000 (config)# ip gateway enable
```

Once you configure the IP address for your switch and you have an existing network connection, you can use the Telnet program from an external management station to access and control the switch.

The G8000 supports a command-line interface (CLI) that you can use to configure and control the switch over the network using the Telnet program. You can use the CLI to perform many basic network management functions. In addition, you can configure the switch for management using an SNMP-based network management system or a Web browser.

For more information about using the CLI, refer to the RackSwitch G8000 *Command Reference*.



## Using Telnet

---

A Telnet connection offers the convenience of accessing the switch from any workstation connected to the network. Telnet access provides the same options for user access and administrator access as those available through the console port.

To configure the switch for Telnet access, the switch must have an IP address. The switch can get its IP address in one of two ways:

- Dynamically, from a DHCP server on your network
- Manually, when you configure the switch IP address

Once you have configured the switch with an IP address and gateway, you can access the switch from any workstation connected to the management network. Telnet access provides the same options for user and administrator access as those available through the console port.

By default, Telnet access is enabled. Use the following command to disable/enable Telnet access:

```
RS G8000 (config)# [no] access telnet enable
```

To establish a Telnet connection to the switch, you can run the Telnet program on your workstation and issue the Telnet command, followed by the switch IP address:

```
telnet <switch IP address>
```

## Using the Browser-Based Interface

---

The Browser-Based Interface (BBI) is a Web-based management interface for interactive switch access through your Web browser.

The BBI provides access to the common configuration, management and operation features of the switch through your Web browser. For more information, refer to the RackSwitch G8000 *BBI Quick Guide*.

### Configuring BBI access via HTTP

By default, BBI access via HTTP is enabled. Use the following command to disable/enable BBI access on the switch via HTTP:

```
RS G8000 (config)# access http enable
```

The default HTTP web server port to access the BBI is port 80. However, you can change the default Web server port with the following command:

```
RS G8000 (config)# access http port <TCP port number>
```

For workstation access to your switch via the BBI, open a Web browser window and type in the URL using the IP interface address of the switch, such as:

```
http://10.10.10.1
```

### Configuring BBI access via HTTPS

The BBI can be accessed via a secure HTTPS connection over management and data ports. By default, BBI access via HTTPS is enabled.

To enable BBI Access on the switch via HTTPS, use the following command:

```
RS G8000 (config)# access https enable
```

To change the HTTPS Web server port number from the default port 443, use the following command:

```
RS G8000 (config)# access https port <TCP port number>
```

Accessing the BBI via HTTPS requires a SSL certificate to be used during the key exchange. A default certificate is created the first time HTTPS is enabled, but you can import a new certificate that defines the information you want to be used. Use the following command to import the SSL certificate:

```
RS G8000 (config)# access https import-certificate
```

The certificate is saved to Flash memory for use once the switch is rebooted.

When a client (e.g. web browser) connects to the switch, the client is asked to accept the certificate and verify that the fields match what is expected. Once BBI access is granted to the client, the BBI can be used as described in the RackSwitch G8000 *BBI Quick Guide*.

The BBI is organized at a high level as follows:

**Context buttons** – These buttons allow you to select the type of action you wish to perform. The *Configuration* button provides access to the configuration elements for the entire switch. The *Statistics* button provides access to the switch statistics and state information. The *Dashboard* button allows you to display settings and operating status of a variety of switch features.

**Navigation Window** – This window provides a menu list of switch features and functions, as follows:

- **System** – This folder provides access to the configuration elements for the entire switch.
- **Switch Ports** – Configure each of the physical ports on the switch.
- **Port-Based Port Mirroring** – Configure port mirroring and mirror port.
- **Layer 2 Management** – Configure Layer 2 features, such as VLANs and Spanning Tree
- **RMON Menu**– Configure Remote Monitoring (RMON).
- **Layer 3 Management** – Configure Layer 3 features, such as IP interfaces and gateway.
- **QoS** – Configure Quality of Service (QoS) features for the switch.
- **Access Control** – Configure Access Control Lists to filter IP packets.
- **Uplink Failure Detection** – Configure Uplink Failure Detection to provide link redundancy.

## Using SNMP

---

Blade OS provides SNMP v1.0 and SNMP v3.0 support for access through any network management software, such as IBM Director or HP-OpenView.

### SNMP v1, v2

To access the SNMP agent on the G8000, the read and write community strings on the SNMP manager should be configured to match those on the switch. The default read community string on the switch is `public` and the default write community string is `private`.

The read and write community strings on the switch can be changed using the following commands on the CLI:

```
RS G8000 (config)# snmp-server read-community <1-32 characters>
```

and

```
RS G8000 (config)# snmp-server write-community <1-32 characters>
```

The SNMP manager should be able to reach any one of the IP interfaces on the switch.

### SNMP v3.0

SNMPv3 is an enhanced version of the Simple Network Management Protocol, approved by the Internet Engineering Steering Group in March, 2002. SNMP v3.0 contains additional security and authentication features that provide data origin authentication, data integrity checks, timeliness indicators and encryption to protect against threats such as masquerade, modification of information, message stream modification and disclosure.

SNMPv3 ensures that the client can use SNMPv3 to query the MIBs, mainly for security.

For more information on SNMP MIBs and the commands used to configure SNMP on the switch, see the RackSwitch G8000 *Command Reference*.

### Default configuration

The G8000 has two SNMP v3 users by default. Both of the following users have access to all the MIBs supported by the switch:

- 1) username 1: **adminmd5** (password `adminmd5`). Authentication used is MD5.
- 2) username 2: **adminsha** (password `adminsha`). Authentication used is SHA.

To configure an SNMP user name, enter the following command:

```
RS G8000 (config)# snmp-server user <1-16> name <1-32>
```

### User configuration:

Users can be configured to use the authentication/privacy options. The G8000 supports two authentication algorithms: MD5 and SHA, as specified in the following command:

```
snmp-server user <1-16> authentication-protocol md5|sha
```

1. **To configure a user with name 'admin,' authentication type MD5, and authentication password of 'admin,' privacy option DES with privacy password of 'admin,' use the following CLI commands.**

```
RS G8000 (config)# snmp-server user 5 name admin
RS G8000 (config)# snmp-server user 5 authentication-protocol md5
                    authentication-password
Changing authentication password; validation required:
Enter current admin password:                <admin. password>
Enter new authentication password:           <auth. password>
Re-enter new authentication password:        <auth. password>
New authentication password accepted.

RS G8000 (config)# snmp-server user 5 privacy-protocol des
                    privacy-password
Changing privacy password; validation required:
Enter current admin password:                <admin. password>
Enter new privacy password:                  <privacy password>
Re-enter new privacy password:               <privacy password>
New privacy password accepted.
```

2. **Configure a user access group, along with the views the group may access. Use the access table to configure the group's access level.**

```
RS G8000 (config)# snmp-server access 5 name admingrp
RS G8000 (config)# snmp-server access 5 level authpriv
RS G8000 (config)# snmp-server access 5 read-view iso
RS G8000 (config)# snmp-server access 5 write-view iso
RS G8000 (config)# snmp-server access 5 notify-view iso
```

Because the read view, write view, and notify view are all set to "iso," the user type has access to all private and public MIBs.

3. **Assign the user to the user group. Use the group table to link the user to a particular access group.**

```
RS G8000 (config)# snmp-server group 5 user-name admin  
RS G8000 (config)# snmp-server group 5 group-name admingrp
```

## Configuring SNMP Trap Hosts

### SNMPv1 trap host

1. Configure an entry in the notify table.

```
RS G8000 (config)# snmp-server notify 10 name public
RS G8000 (config)# snmp-server notify 10 tag v1trap
```

2. Specify the IP address and other trap parameters in the targetAddr and targetParam tables. Use the following command to specify the user name used with this targetParam table:

**snmp-server target-parameters <1-16> user-name**

```
RS G8000 (config)# snmp-server target-address 10 name v1trap
                    address 10.70.70.190
RS G8000 (config)# snmp-server target-address 10
                    parameters-name v1param
RS G8000 (config)# snmp-server target-address 10 taglist v1param
RS G8000 (config)# snmp-server target-parameters 10 name v1param
RS G8000 (config)# snmp-server target-parameters 10 user-name v1only
RS G8000 (config)# snmp-server target-parameters 10 message snmpv1
```

### SNMPv2 trap host configuration

The SNMPv2 trap host configuration is similar to the SNMPv1 trap host configuration. Wherever you specify the model, use `snmpv2` instead of `snmpv1`.

```
RS G8000 (config)# snmp-server read-community public
RS G8000 (config)# snmp-server target-address 1 name v2trap2
                    address 10.70.70.190
RS G8000 (config)# snmp-server target-address 1
                    parameters-name v2param2
RS G8000 (config)# snmp-server target-address 1 taglist v2param2
RS G8000 (config)# snmp-server target-parameters 1 name v2param2
RS G8000 (config)# snmp-server target-parameters 1 user-name v2only
RS G8000 (config)# snmp-server target-parameters 1 message snmpv2
RS G8000 (config)# snmp-server notify 1 name public
RS G8000 (config)# snmp-server notify 1 tag v2param2
```

## SNMPv3 trap host configuration

To configure a user for SNMPv3 traps, you can choose to send the traps with both privacy and authentication, with authentication only, or without privacy or authentication.

This is configured in the access table using the following commands:

```
RS G8000 (config)# snmp-server access <1-32> level
```

```
RS G8000 (config)# snmp-server target-parameters <1-16>
```

Configure the user in the user table accordingly.

It is not necessary to configure the community table for SNMPv3 traps because the community string is not used by SNMPv3.

The following example shows how to configure a SNMPv3 user v3trap with authentication only:

```
RS G8000 (config)# snmp-server user 11 name v3trap
RS G8000 (config)# snmp-server user 11 authentication-protocol md5
                    authentication-password
Changing authentication password; validation required:
Enter current admin password: <admin. password>
Enter new authentication password: <auth. password>
Re-enter new authentication password: <auth. password>
New authentication password accepted.
RS G8000 (config)# snmp-server access 11 notify-view iso
RS G8000 (config)# snmp-server access 11 level authnopriv
RS G8000 (config)# snmp-server group 11 user-name v3trap
RS G8000 (config)# snmp-server group 11 tag v3trap
RS G8000 (config)# snmp-server notify 11 name v3trap
RS G8000 (config)# snmp-server notify 11 tag v3trap
RS G8000 (config)# snmp-server target-address 11 name v3trap
                    address 47.81.25.66
RS G8000 (config)# snmp-server target-address 11 taglist v3trap
RS G8000 (config)# snmp-server target-address 11
                    parameters-name v3param
RS G8000 (config)# snmp-server target-parameters 11 name v3param
RS G8000 (config)# snmp-server target-parameters 11 user-name v3trap
RS G8000 (config)# snmp-server target-parameters 11 level authNoPriv
RS G8000 (config)# snmp-server target-parameters 11 message snmpv3
```



# Securing Access to the Switch

---

Secure switch management is needed for environments that perform significant management functions across the Internet.

The following features are addressed in this section:

- [“RADIUS Authentication and Authorization” on page 26](#)
- [“TACACS+ Authentication” on page 30](#)
- [“End User Access Control” on page 36](#)

## RADIUS Authentication and Authorization

Blade OS supports the RADIUS (Remote Authentication Dial-in User Service) method to authenticate and authorize remote administrators for managing the switch. This method is based on a client/server model. The Remote Access Server (RAS)—the switch—is a client to the back-end database server. A remote user (the remote administrator) interacts only with the RAS, not the back-end server and database.

RADIUS authentication consists of the following components:

- A protocol with a frame format that utilizes UDP over IP (based on RFC 2138 and 2866)
- A centralized server that stores all the user authorization information
- A client, in this case, the switch

The G8000—acting as the RADIUS client—communicates to the RADIUS server to authenticate and authorize a remote administrator using the protocol definitions specified in RFC 2138 and 2866. Transactions between the client and the RADIUS server are authenticated using a shared key that is not sent over the network. In addition, the remote administrator passwords are sent encrypted between the RADIUS client (the switch) and the back-end RADIUS server.

### How RADIUS authentication works

1. **Remote administrator connects to the switch and provides user name and password.**
2. **Using Authentication/Authorization protocol, the switch sends request to authentication server.**
3. **Authentication server checks the request against the user ID database.**
4. **Using RADIUS protocol, the authentication server instructs the switch to grant or deny administrative access.**

## Configuring RADIUS

Use the following procedure to configure RADIUS authentication on your switch.

1. **Configure the Primary and Secondary RADIUS servers, and enable RADIUS authentication.**

```
RS G8000 (config)# radius-server primary-host 10.10.1.1
RS G8000 (config)# radius-server secondary-host 10.10.1.2
RS G8000 (config)# radius-server enable
```

2. **Configure the RADIUS secret and enable the feature.**

```
RS G8000 (config)# radius-server primary-host 10.10.1.1
                    key <1-32 character secret>
RS G8000 (config)# radius-server secondary-host 10.10.1.2
                    key <1-32 character secret>
```

3. **If desired, you may change the default UDP port number used to listen to RADIUS.**

The well-known port for RADIUS is 1812.

```
RS G8000 (config)# radius-server port <UDP port number>
```

4. **Configure the number retry attempts for contacting the RADIUS server, and the timeout period.**

```
RS G8000 (config)# radius-server retransmit 3
RS G8000 (config)# radius-server timeout 5
```

## RADIUS authentication features in Blade OS

Blade OS supports the following RADIUS authentication features:

- Supports RADIUS client on the switch, based on the protocol definitions in RFC 2138 and RFC 2866.
- Allows RADIUS secret password up to 32 bytes and less than 16 octets.
- Supports *secondary authentication server* so that when the primary authentication server is unreachable, the switch can send client authentication requests to the secondary authentication server. Use the following command to show the currently active RADIUS authentication server:

```
RS G8000 (config)# show radius-server
```

- Supports user-configurable RADIUS server retry and time-out values:

- Time-out value = 1-10 seconds
- Retries = 1-3

The switch will time out if it does not receive a response from the RADIUS server in 1-3 retries. The switch will also automatically retry connecting to the RADIUS server before it declares the server down.

- Supports user-configurable RADIUS application port.  
The default is 1812/UDP-based on RFC 2138. Port 1645 is also supported.
- Allows network administrator to define privileges for one or more specific users to access the switch at the RADIUS user database.

## Switch User Accounts

The user accounts listed in [Table 1-1](#) can be defined in the RADIUS server dictionary file.

**Table 1-1** User Access Levels

User Account	Description and Tasks Performed	Password
User	The User has no direct responsibility for switch management. He/she can view all switch status information and statistics but cannot make any configuration changes to the switch.	user
Operator	The Operator manages all functions of the switch. The Operator can reset ports.	oper
Administrator	The super-user Administrator has complete access to all commands, information, and configuration commands on the switch, including the ability to change both the user and operator passwords.	admin

## RADIUS Attributes for G8000 user privileges

When the user logs in, the switch authenticates his/her level of access by sending the RADIUS access request, that is, the client authentication request, to the RADIUS authentication server.

If the remote user is successfully authenticated by the authentication server, the switch will verify the *privileges* of the remote user and authorize the appropriate access. The administrator has an option to allow *secure backdoor* access via Telnet/SSH. Secure backdoor provides switch access when the RADIUS servers cannot be reached.

---

**NOTE** – To obtain the RADIUS backdoor password for your G8000, contact Technical Support.

---

All user privileges, other than those assigned to the Administrator, have to be defined in the RADIUS dictionary. RADIUS attribute 6 which is built into all RADIUS servers defines the administrator. The file name of the dictionary is RADIUS vendor-dependent. The following RADIUS attributes are defined for G8000 user privileges levels:

**Table 1-2** Blade OS-proprietary Attributes for RADIUS

User Name/Access	User-Service-Type	Value
User	<i>Vendor-supplied</i>	255
Operator	<i>Vendor-supplied</i>	252
Admin	<i>Vendor-supplied</i>	6

## TACACS+ Authentication

Blade OS supports authentication and authorization with networks using the Cisco Systems TACACS+ protocol. The G8000 functions as the Network Access Server (NAS) by interacting with the remote client and initiating authentication and authorization sessions with the TACACS+ access server. The remote user is defined as someone requiring management access to the G8000 through a data port.

TACACS+ offers the following advantages over RADIUS:

- TACACS+ uses TCP-based connection-oriented transport; whereas RADIUS is UDP-based. TCP offers a connection-oriented transport, while UDP offers best-effort delivery. RADIUS requires additional programmable variables such as re-transmit attempts and time-outs to compensate for best-effort transport, but it lacks the level of built-in support that a TCP transport offers.
- TACACS+ offers full packet encryption whereas RADIUS offers password-only encryption in authentication requests.
- TACACS+ separates authentication, authorization and accounting.

### How TACACS+ authentication works

TACACS+ works much in the same way as RADIUS authentication as described on [page 26](#).

1. **Remote administrator connects to the switch and provides user name and password.**
2. **Using Authentication/Authorization protocol, the switch sends request to authentication server.**
3. **Authentication server checks the request against the user ID database.**
4. **Using TACACS+ protocol, the authentication server instructs the switch to grant or deny administrative access.**

During a session, if additional authorization checking is needed, the switch checks with a TACACS+ server to determine if the user is granted permission to use a particular command.

## TACACS+ authentication features in Blade OS

Authentication is the action of determining the identity of a user, and is generally done when the user first attempts to log in to a device or gain access to its services. Blade OS supports ASCII inbound login to the device. PAP, CHAP and ARAP login methods, TACACS+ change password requests, and one-time password authentication are not supported.

### Authorization

Authorization is the action of determining a user's privileges on the device, and usually takes place after authentication.

The default mapping between TACACS+ authorization levels and Blade OS management access levels is shown in [Table 1-3](#). The authorization levels must be defined on the TACACS+ server.

**Table 1-3** Default TACACS+ Authorization Levels

Blade OS User Access Level	TACACS+ level
user	0
oper	3
admin	6

Alternate mapping between TACACS+ authorization levels and Blade OS management access levels is shown in [Table 1-4](#). Use the following command to set the alternate TACACS+ authorization levels.

```
RS G8000 (config)# tacacs-server privilege-mapping
```

**Table 1-4** Alternate TACACS+ Authorization Levels

Blade OS User Access Level	TACACS+ level
user	0 - 1
oper	6 - 8
admin	14 - 15

If the remote user is successfully authenticated by the authentication server, the switch verifies the *privileges* of the remote user and authorizes the appropriate access. The administrator has an option to allow *secure backdoor* access via Telnet/SSH. Secure backdoor provide switch access when the TACACS+ servers cannot be reached.

---

**NOTE** – To obtain the TACACS+ backdoor password for your G8000, contact Technical Support.

---

### Accounting

Accounting is the action of recording a user's activities on the device for the purposes of billing and/or security. It follows the authentication and authorization actions. If the authentication and authorization is not performed via TACACS+, there are no TACACS+ accounting messages sent out.

You can use TACACS+ to record and track software logins, configuration changes, and interactive commands.

The G8000 supports the following TACACS+ accounting attributes:

- protocol (console/Telnet/SSH/HTTP/HTTPS)
- start\_time
- stop\_time
- elapsed\_time
- disc\_cause

---

**NOTE** – When using the Browser-Based Interface, the TACACS+ Accounting Stop records are sent only if the **Logout** button on the browser is clicked.

---

### Command authorization and logging

When TACACS+ Command Authorization is enabled, Blade OS configuration commands are sent to the TACACS+ server for authorization. Use the following command to enable TACACS+ Command Authorization:

```
RS G8000 (config)# tacacs-server command-authorization
```



When TACACS+ Command Logging is enabled, Blade OS configuration commands are logged on the TACACS+ server. Use the following command to enable TACACS+ Command Logging:

```
RS G8000 (config)# tacacs-server command-logging
```

The following examples illustrate the format of Blade OS commands sent to the TACACS+ server:

```
authorization request, cmd=shell, cmd-arg=interface ip
accounting request, cmd=shell, cmd-arg=interface ip
authorization request, cmd=shell, cmd-arg=enable
accounting request, cmd=shell, cmd-arg=enable
```

## Configuring TACACS+ Authentication

1. **Configure the Primary and Secondary TACACS+ servers, and enable TACACS authentication.**

```
RS G8000 (config)# tacacs-server primary-host 10.10.1.1
RS G8000 (config)# tacacs-server secondary-host 10.10.1.2
RS G8000 (config)# tacacs-server enable
```

2. **Configure the TACACS+ secret and second secret.**

```
RS G8000 (config)# tacacs-server primary-host 10.10.1.1
key <1-32 character secret>
RS G8000 (config)# tacacs-server secondary-host 10.10.1.2
key <1-32 character secret>
```

3. **If desired, you may change the default TCP port number used to listen to TACACS+.**

The well-known port for TACACS+ is 49.

```
RS G8000 (config)# tacacs-server port <TCP port number>
```

4. **Configure the number of retry attempts, and the timeout period.**

```
RS G8000 (config)# tacacs-server retransmit 3
RS G8000 (config)# tacacs-server timeout 5
```

## Secure Shell

Secure Shell (SSH) use secure tunnels to encrypt and secure messages between a remote administrator and the switch. Telnet does not provide this level of security. The Telnet method of managing a G8000 does not provide a secure connection.

**SSH** is a protocol that enables remote administrators to log securely into the G8000 over a network to execute management commands.

The benefits of using SSH are listed below:

- Authentication of remote administrators
- Identifying the administrator using Name/Password
- Authorization of remote administrators
- Determining the permitted actions and customizing service for individual administrators
- Encryption of management messages
- Encrypting messages between the remote administrator and switch
- Secure copy support

The Blade OS implementation of SSH supports both versions 1.0 and 2.0 and supports SSH client versions 1.5 - 2.x.

### Configuring SSH features on the switch

Before you can use SSH commands, use the following commands to turn on SSH. SSH is disabled by default.

Use the following command to enable SSH:

```
RS G8000 (config)# ssh enable
```

### SSH encryption of management messages

The following encryption and authentication methods are supported for SSH:

Server Host Authentication:	Client RSA authenticates the switch at the beginning of every connection
Key Exchange:	RSA
Encryption:	3DES-CBC, DES
User Authentication:	Local password authentication

## Generating RSA Host and Server Keys for SSH access

To support the SSH server feature, two sets of RSA keys (host and server keys) are required. The host key is 1024 bits and is used to identify the G8000. The server key is 768 bits and is used to make it impossible to decipher a captured session by breaking into the G8000 at a later time.

When the SSH server is first enabled and applied, the switch automatically generates the RSA host and server keys and is stored in the Flash memory. To configure RSA host and server keys, enter the following commands to generate them manually.

```
RS G8000 (config)# ssh generate-host-key
RS G8000 (config)# ssh generate-server-key
```

When the switch reboots, it will retrieve the host and server keys from the Flash memory. If these two keys are not available in the flash and if the SSH server feature is enabled, the switch automatically generates them during the system reboot. This process may take several minutes to complete.

The switch can automatically regenerate the RSA server key. To set the interval of RSA server key autogeneration, use the following command:

```
RS G8000 (config)# ssh interval <number of hours (0-24)>
```

A value of 0 (zero) denotes that RSA server key autogeneration is disabled. When greater than 0, the switch will autogenerate the RSA server key every specified interval; however, RSA server key generation is skipped if the switch is busy doing other key or cipher generation when the timer expires.

---

**NOTE** – The switch will perform only one session of key/cipher generation at a time. Thus, an SSH client will not be able to log in if the switch is performing key generation at that time, or if another client has logged in immediately prior. Also, key generation will fail if an SSH client is logging in at that time.

---

## SSH Integration with RADIUS/TACACS+ Authentication

SSH is integrated with RADIUS authentication. After the RADIUS server is enabled on the switch, all subsequent SSH authentication requests will be redirected to the specified RADIUS servers for authentication. The redirection is transparent to the SSH clients.

SSH is integrated with TACACS+ authentication. After the TACACS+ server is enabled on the switch, all subsequent SSH authentication requests will be redirected to the specified TACACS+ servers for authentication. The redirection is transparent to the SSH clients.

## End User Access Control

Blade OS allows an administrator to define end user accounts that permit end users to perform operation tasks via the switch CLI commands. Once end user accounts are configured and enabled, the switch requires username/password authentication.

For example, an administrator can assign a user, who can then log into the switch and perform operational commands (effective only until the next switch reboot).

### Considerations for configuring End User Accounts

- A maximum of 10 user IDs are supported on the switch.
- Blade OS supports end user support for console, Telnet, BBI, and SSHv1/v2 access to the switch. As a result, only very limited access will be granted to the Primary Administrator under the BBI/SSH1 mode of access.
- If RADIUS authentication is used, the user password on the Radius server will override the user password on the G8000. Also note that the password change command on the switch only modifies the use switch password and has no effect on the user password on the Radius server. Radius authentication and user password cannot be used concurrently to access the switch.
- Passwords for end users can be up to 128 characters in length.

### User Access Control

The end user access control commands allow you to configure end user accounts.

#### Setting up User IDs

Up to 10 user IDs can be configured. Use the following commands to define user names and passwords:

```
RS G8000 (config)# access user 1 name <1-8 characters>
RS G8000 (config)# access user 1 password

Changing user1 password; validation required:
Enter current admin password: <current administrator password>
Enter new user1 password: <new user password>
Re-enter new user1 password: <new user password>
New user1 password accepted.
```

### Defining a User's access level

The end user is by default assigned to the user access level (also known as class of service, or COS). COS for all user accounts have global access to all resources except for User COS, which has access to view only resources that the user owns. For more information, see [Table 1-1 “User Access Levels” on page 29](#).

To change the user's level, select one of the following options:

```
RS G8000 (config)# access user 1 level {user|operator|administrator}
```

### Enabling or Disabling a User

An end user account must be enabled before the switch recognizes and permits login under the account. Once enabled, the switch requires any user to enter both username and password.

```
RS G8000 (config)# access user 1 enable
RS G8000 (config)# no access user 1 enable
```

### Listing current Users

The following command displays defined user accounts and whether or not each user is currently logged into the switch.

```
RS G8000# show access user

Usernames:
  user      - Enabled - offline
  oper      - Disabled - offline
  admin     - Always Enabled - online 1 session

Current User ID table:
1: name jane      , ena, cos user      , password valid, online 1 session
2: name john      , ena, cos user      , password valid, online 2 sessions
```

### Logging into an End User account

Once an end user account is configured and enabled, the user can login to the switch using the username/password combination. The level of switch access is determined by the COS established for the end user account.



## CHAPTER 2

# Port-based Network Access Control

---

Port-Based Network Access control provides a means of authenticating and authorizing devices attached to a LAN port that has point-to-point connection characteristics. It prevents access to ports that fail authentication and authorization. This feature provides security to ports of the G8000 that connect to servers.

The following topics are discussed in this section:

- “Extensible Authentication Protocol over LAN” on page 40
- “802.1X authentication process” on page 41
- “802.1X port states” on page 43
- “Supported RADIUS attributes” on page 44
- “Configuration guidelines” on page 45

## Extensible Authentication Protocol over LAN

---

The G8000 can provide user-level security for its ports using the IEEE 802.1X protocol, which is a more secure alternative to other methods of port-based network access control. Any device attached to an 802.1X-enabled port that fails authentication is prevented access to the network and denied services offered through that port.

The 802.1X standard describes port-based network access control using Extensible Authentication Protocol over LAN (EAPoL). EAPoL provides a means of authenticating and authorizing devices attached to a LAN port that has point-to-point connection characteristics and of preventing access to that port in cases of authentication and authorization failures.

EAPoL is a client-server protocol that has the following components:

- **Supplicant or Client**  
The Supplicant is a device that requests network access and provides the required credentials (user name and password) to the Authenticator and the Authentication Server.
- **Authenticator**  
The Authenticator enforces authentication and controls access to the network. The Authenticator grants network access based on the information provided by the Supplicant and the response from the Authentication Server. The Authenticator acts as an intermediary between the Supplicant and the Authentication Server: requesting identity information from the client, forwarding that information to the Authentication Server for validation, relaying the server's responses to the client, and authorizing network access based on the results of the authentication exchange. The G8000 acts as an Authenticator.
- **Authentication Server,**  
The Authentication Server validates the credentials provided by the Supplicant to determine if the Authenticator should grant access to the network. The Authentication Server may be co-located with the Authenticator. The G8000 relies on external RADIUS servers for authentication.

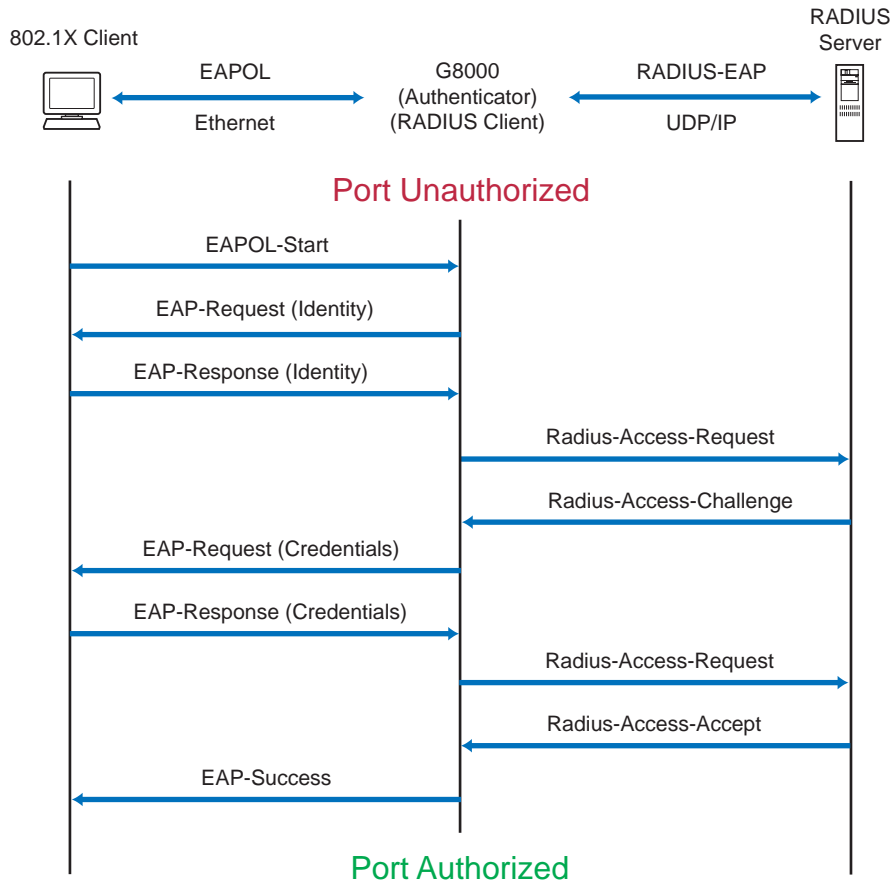
Upon a successful authentication of the client by the server, the 802.1X-controlled port transitions from unauthorized to authorized state, and the client is allowed full access to services through the port. When the client sends an EAP-Logoff message to the authenticator, the port will transition from authorized to unauthorized state.



## 802.1X authentication process

The clients and authenticators communicate using Extensible Authentication Protocol (EAP), which was originally designed to run over PPP, and for which the IEEE 802.1X Standard has defined an encapsulation method over Ethernet frames, called EAP over LAN (EAPOL).

Figure 2-1 shows a typical message exchange initiated by the client.



**Figure 2-1** Authenticating a Port Using EAPoL

## EAPoL message exchange

During authentication, EAPoL messages are exchanged between the client and the G8000 authenticator, while RADIUS-EAP messages are exchanged between the G8000 authenticator and the RADIUS server.

Authentication is initiated by one of the following methods:

- The G8000 authenticator sends an EAP-Request/Identity packet to the client
- Client sends an EAPoL-Start frame to the G8000 authenticator, which responds with an EAP-Request/Identity frame.

The client confirms its identity by sending an EAP-Response/Identity frame to the G8000 authenticator, which forwards the frame encapsulated in a RADIUS packet to the server.

The RADIUS authentication server chooses an EAP-supported authentication algorithm to verify the client's identity, and sends an EAP-Request packet to the client via the G8000 authenticator. The client then replies to the RADIUS server with an EAP-Response containing its credentials.

Upon a successful authentication of the client by the server, the 802.1X-controlled port transitions from unauthorized to authorized state, and the client is allowed full access to services through the controlled port. When the client later sends an EAPoL-Logoff message to the G8000 authenticator, the port transitions from authorized to unauthorized state.

If a client that does not support 802.1X connects to an 802.1X-controlled port, the G8000 authenticator requests the client's identity when it detects a change in the operational state of the port. The client does not respond to the request, and the port remains in the unauthorized state.

---

**NOTE** – When an 802.1X-enabled client connects to a port that is not 802.1X-controlled, the client initiates the authentication process by sending an EAPoL-Start frame. When no response is received, the client retransmits the request for a fixed number of times. If no response is received, the client assumes the port is in authorized state, and begins sending frames, even if the port is unauthorized.

---

## 802.1X port states

The state of the port determines whether the client is granted access to the network, as follows:

- **Unauthorized**

While in this state the port discards all ingress and egress traffic except EAP packets.

- **Authorized**

When the client is successfully authenticated, the port transitions to the authorized state allowing all traffic to and from the client to flow normally.

- **Force Unauthorized**

You can configure this state that denies all access to the port.

- **Force Authorized**

You can configure this state that allows full access to the port.

Use the 802.1X global configuration commands (`dot1x`) to configure 802.1X authentication for all ports in the switch. Use the 802.1X port commands to configure a single port.

## Supported RADIUS attributes

The G8000 802.1X Authenticator relies on external RADIUS servers for authentication with EAP. Table 2 lists the RADIUS attributes that are supported as part of RADIUS-EAP authentication based on the guidelines specified in Annex D of the 802.1X standard and RFC 3580.

**Table 2** Support for RADIUS Attributes

#	Attribute	Attribute Value	A-R	A-A	A-C	A-R
1	User-Name	The value of the Type-Data field from the supplicant's EAP-Response/Identity message. If the Identity is unknown (i.e. Type-Data field is zero bytes in length), this attribute will have the same value as the Calling-Station-Id.	1	0-1	0	0
4	NAS-IP-Address	IP address of the authenticator used for Radius communication.	1	0	0	0
5	NAS-Port	Port number of the authenticator port to which the supplicant is attached.	1	0	0	0
24	State	Server-specific value. This is sent unmodified back to the server in an Access-Request that is in response to an Access-Challenge.	0-1	0-1	0-1	0
30	Called-Station-ID	The MAC address of the authenticator encoded as an ASCII string in canonical format, e.g. 000D5622E3 9F.	1	0	0	0
31	Calling-Station-ID	The MAC address of the supplicant encoded as an ASCII string in canonical format, e.g. 00034B436206.	1	0	0	0
79	EAP-Message	Encapsulated EAP packets from the supplicant to the authentication server (Radius) and vice-versa. The authenticator relays the decoded packet to both devices.	1+	1+	1+	1+
80	Message-Authenticator	Always present whenever an EAP-Message attribute is also included. Used to integrity-protect a packet.	1	1	1	1
87	NAS-Port-ID	Name assigned to the authenticator port, e.g. Server1_Port3	1	0	0	0

### Legend:

RADIUS Packet Types: A-R (Access-Request), A-A (Access-Accept), A-C (Access-Challenge), A-R (Access-Reject)

RADIUS Attribute Support:

- 0 This attribute MUST NOT be present in a packet.
- 0+ Zero or more instances of this attribute MAY be present in a packet.
- 0-1 Zero or one instance of this attribute MAY be present in a packet.
- 1 Exactly one instance of this attribute MUST be present in a packet.
- 1+ One or more of these attributes MUST be present.

## Configuration guidelines

When configuring EAPoL, consider the following guidelines:

- The 802.1X port-based authentication is currently supported only in point-to-point configurations, that is, with a single supplicant connected to an 802.1X-enabled switch port.
- When 802.1X is enabled, a port has to be in the authorized state before any other Layer 2 feature can be operationally enabled. For example, the STG state of a port is operationally disabled while the port is in the unauthorized state.
- The 802.1X supplicant capability is not supported. Therefore, none of its ports can successfully connect to an 802.1X-enabled port of another device, such as another switch, that acts as an authenticator, unless access control on the remote port is disabled or is configured in forced-authorized mode. For example, if a G8000 is connected to another G8000, and if 802.1X is enabled on both switches, the two connected ports must be configured in force-authorized mode.
- The 802.1X standard has optional provisions for supporting dynamic virtual LAN assignment via RADIUS tunnelling attributes, for example, Tunnel-Type (=VLAN), Tunnel-Medium-Type (=802), and Tunnel-Private-Group-ID (=VLAN id). These attributes are not supported and might affect 802.1X operations. Other unsupported attributes include Service-Type, Session-Timeout, and Termination-Action.
- RADIUS accounting service for 802.1X-authenticated devices or users is not supported.
- Configuration changes performed using SNMP and the standard 802.1X MIB will take effect immediately.



## CHAPTER 3

# VLANs

---

This chapter describes network design and topology considerations for using Virtual Local Area Networks (VLANs). VLANs commonly are used to split up groups of network users into manageable broadcast domains, to create logical segmentation of workgroups, and to enforce security policies among logical segments. The following topics are discussed in this chapter:

- [“VLANs and Port VLAN ID Numbers” on page 49](#)
- [“VLAN Tagging” on page 51](#)
- [“VLAN Topologies and Design Considerations” on page 55](#)  
This section discusses how you can connect users and segments to a host that supports many logical segments or subnets by using the flexibility of the multiple VLAN system.
- [“Private VLANs” on page 59](#)

---

**NOTE** – VLANs can be configured from the Command Line Interface (see “VLAN Configuration” as well as “Port Configuration” in the *Command Reference*).

---

## Overview

---

Setting up virtual LANs (VLANs) is a way to segment networks to increase network flexibility without changing the physical network topology. With network segmentation, each switch port connects to a segment that is a single broadcast domain. When a switch port is configured to be a member of a VLAN, it is added to a group of ports (workgroup) that belong to one broadcast domain.

Ports are grouped into broadcast domains by assigning them to the same VLAN. Frames received in one VLAN can only be forwarded within that VLAN, and multicast, broadcast, and unknown unicast frames are flooded only to ports in the same VLAN. The G8000 supports jumbo frames up to 9,216 bytes.



# VLANs and Port VLAN ID Numbers

---

## VLAN numbers

The G8000 supports up to 1024 VLANs per switch. Even though the maximum number of VLANs supported at any given time is 1024, each can be identified with any number between 1 and 4094. VLAN 1 is the default VLAN for all ports.

## Viewing VLANs

- VLAN information:

```
RS G8000 (config)# show vlan
```

VLAN	Name	Status	Ports
1	VLAN 1	ena	1-48, XGE2-XGE4 pol-pol04
2	VLAN 2	dis	empty

## PVID numbers

Each port in the switch has a configurable default VLAN number, known as its *PVID*. By default, the PVID for all ports is set to 1, which correlates to the default VLAN ID. The PVID for each port can be configured to any VLAN number between 1 and 4094.

### Viewing and Configuring PVIDs

Use the following CLI commands to view PVIDs:

- Port information:

```
RS G8000# show interface information
```

Alias	Port	Tag	Edge	Lrn	Fld	PVID	NAME	VLAN(s)
1	1	y	n	e	e	1	1	1
2	2	y	n	e	e	1	2	1
3	3	y	n	e	e	1	3	1
4	4	y	n	e	e	1	4	1
5	5	y	n	e	e	1	5	1
6	6	y	n	e	e	1	6	1
...	...					...		...
44	44	n	n	e	e	1	44	1
45	45	n	n	e	e	1	45	1
46	46	n	n	e	e	1	46	1
47	47	n	n	e	e	1	47	1
48	48	n	n	e	e	1	48	1
XGE1	49	n	n	e	e	1	49	1
XGE2	50	n	n	e	e	1	50	1
XGE3	51	n	n	e	e	1	51	1
XGE4	52	n	n	e	e	1	52	1

\* = PVID is tagged.

- Port Configuration:

```
RS G8000 (config)# interface port 7
RS G8000 (config-if)# pvid 7
```

Each port on the switch can belong to one or more VLANs, and each VLAN can have any number of switch ports in its membership. Any port that belongs to multiple VLANs, however, must have VLAN *tagging* enabled (see “[VLAN Tagging](#)” on page 51).

# VLAN Tagging

---

Blade OS software supports IEEE 802.1Q VLAN *tagging*, providing standards-based VLAN support for Ethernet systems.

Tagging places the VLAN identifier in the frame header of a packet, allowing each port to belong to multiple VLANs. When you add a port to multiple VLANs, you also must enable tagging on that port.

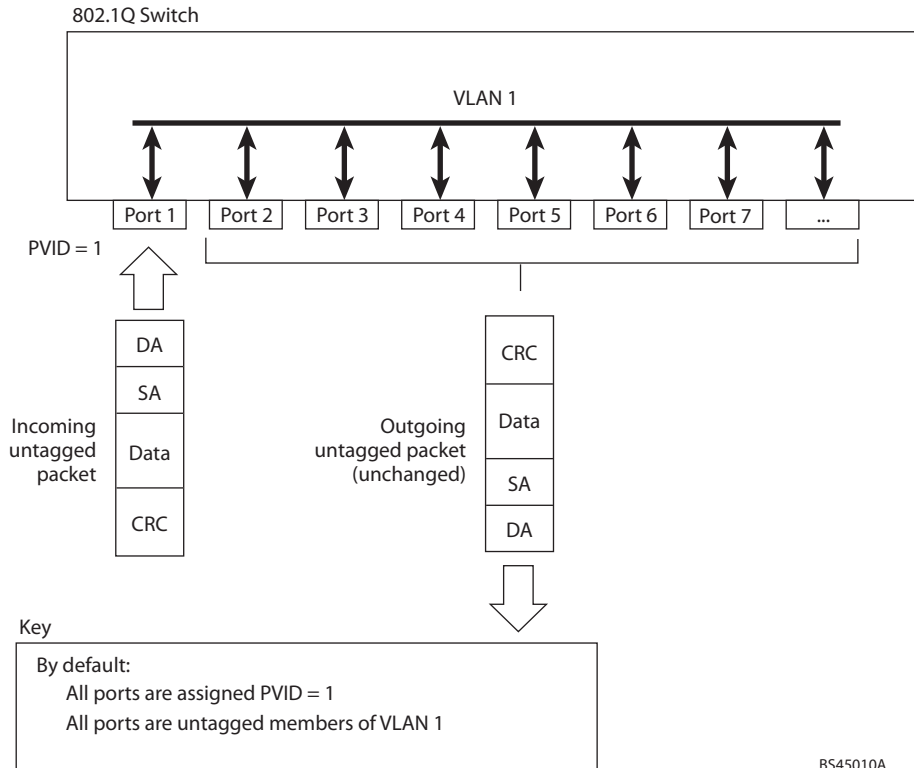
Since tagging fundamentally changes the format of frames transmitted on a tagged port, you must carefully plan network designs to prevent tagged frames from being transmitted to devices that do not support 802.1Q VLAN tags, or devices where tagging is not enabled.

Important terms used with the 802.1Q tagging feature are:

- **VLAN identifier (VID)**—the 12-bit portion of the VLAN tag in the frame header that identifies an explicit VLAN.
- **Port VLAN identifier (PVID)**—a classification mechanism that associates a port with a specific VLAN. For example, a port with a PVID of 3 (PVID =3) assigns all untagged frames received on this port to VLAN 3. Any untagged frames received by the switch are classified with the PVID of the receiving port.
- **Tagged frame**—a frame that carries VLAN tagging information in the header. This VLAN tagging information is a 32-bit field (VLAN tag) in the frame header that identifies the frame as belonging to a specific VLAN. Untagged frames are marked (tagged) with this classification as they leave the switch through a port that is configured as a tagged port.
- **Untagged frame**— a frame that does not carry any VLAN tagging information in the frame header.
- **Untagged member**—a port that has been configured as an untagged member of a specific VLAN. When an untagged frame exits the switch through an untagged member port, the frame header remains unchanged. When a tagged frame exits the switch through an untagged member port, the tag is stripped and the tagged frame is changed to an untagged frame.
- **Tagged member**—a port that has been configured as a tagged member of a specific VLAN. When an untagged frame exits the switch through a tagged member port, the frame header is modified to include the 32-bit tag associated with the PVID. When a tagged frame exits the switch through a tagged member port, the frame header remains unchanged (original VID remains).

**NOTE** – If a 802.1Q tagged frame is received by a port that has VLAN-tagging disabled and the port VLAN ID (PVID) is different than the VLAN ID of the packet, then the frame is dropped at the ingress port.

**Figure 3-1** Default VLAN settings



**NOTE** – The port numbers specified in these illustrations may not directly correspond to the physical port configuration of your switch model.

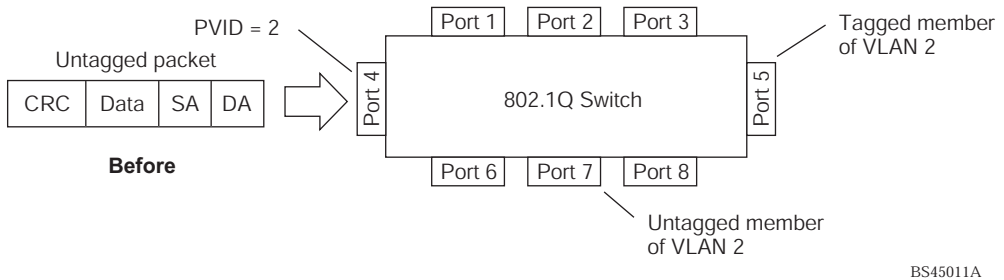
When a VLAN is configured, ports are added as members of the VLAN, and the ports are defined as either *tagged* or *untagged* (see [Figure 3-2](#) through [Figure 3-5](#)).

The default configuration settings for the G8000 has all ports set as untagged members of VLAN 1 with all ports configured as PVID = 1. In the default configuration example shown in [Figure 3-1](#), all incoming packets are assigned to VLAN 1 by the default port VLAN identifier (PVID = 1).

Figure 3-2 through Figure 3-5 illustrate generic examples of VLAN tagging. In Figure 3-2, untagged incoming packets are assigned directly to VLAN 2 (PVID = 2). Port 5 is configured as a *tagged* member of VLAN 2, and port 7 is configured as an *untagged* member of VLAN 2.

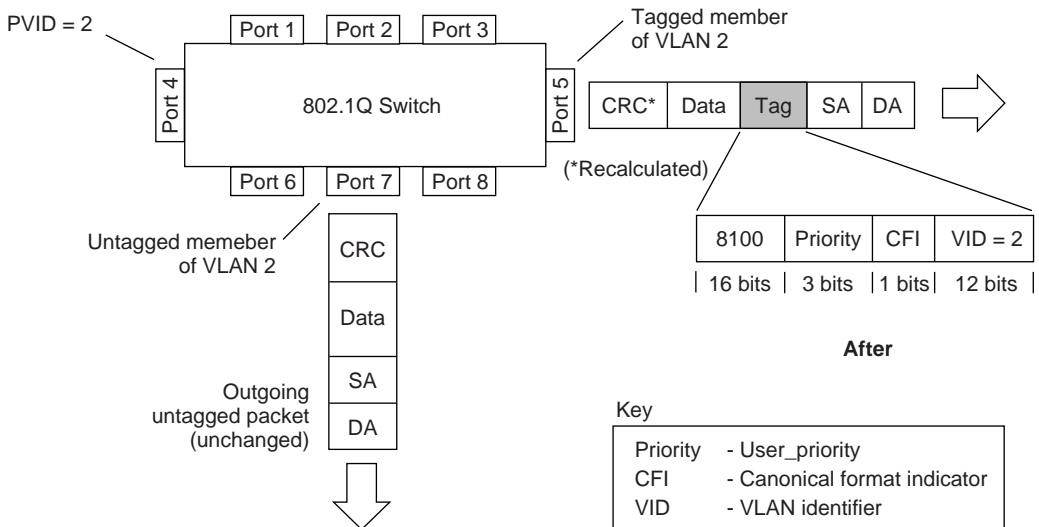
**NOTE** – The port assignments in the following figures are not meant to match the G8000.

**Figure 3-2** Port-based VLAN assignment



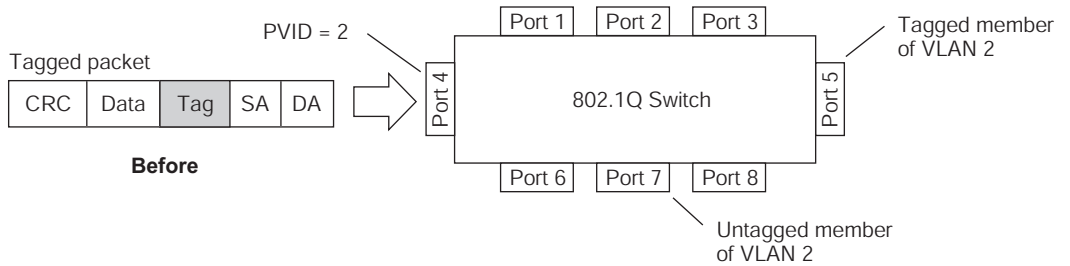
As shown in Figure 3-3, the untagged packet is marked (tagged) as it leaves the switch through port 5, which is configured as a tagged member of VLAN 2. The untagged packet remains unchanged as it leaves the switch through port 7, which is configured as an untagged member of VLAN 2.

**Figure 3-3** 802.1Q tagging (after port-based VLAN assignment)



In [Figure 3-4](#), tagged incoming packets are assigned directly to VLAN 2 because of the tag assignment in the packet. Port 5 is configured as a *tagged* member of VLAN 2, and port 7 is configured as an *untagged* member of VLAN 2.

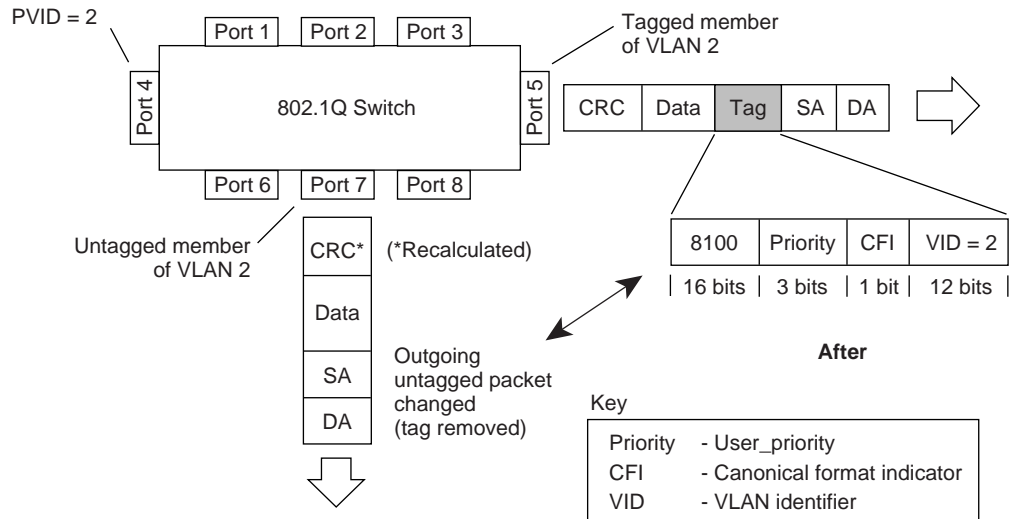
**Figure 3-4** 802.1Q tag assignment



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As shown in [Figure 3-5](#), the tagged packet remains unchanged as it leaves the switch through port 5, which is configured as a tagged member of VLAN 2. However, the tagged packet is stripped (untagged) as it leaves the switch through port 7, which is configured as an untagged member of VLAN 2.

**Figure 3-5** 802.1Q tagging (after 802.1Q tag assignment)



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## VLAN Topologies and Design Considerations

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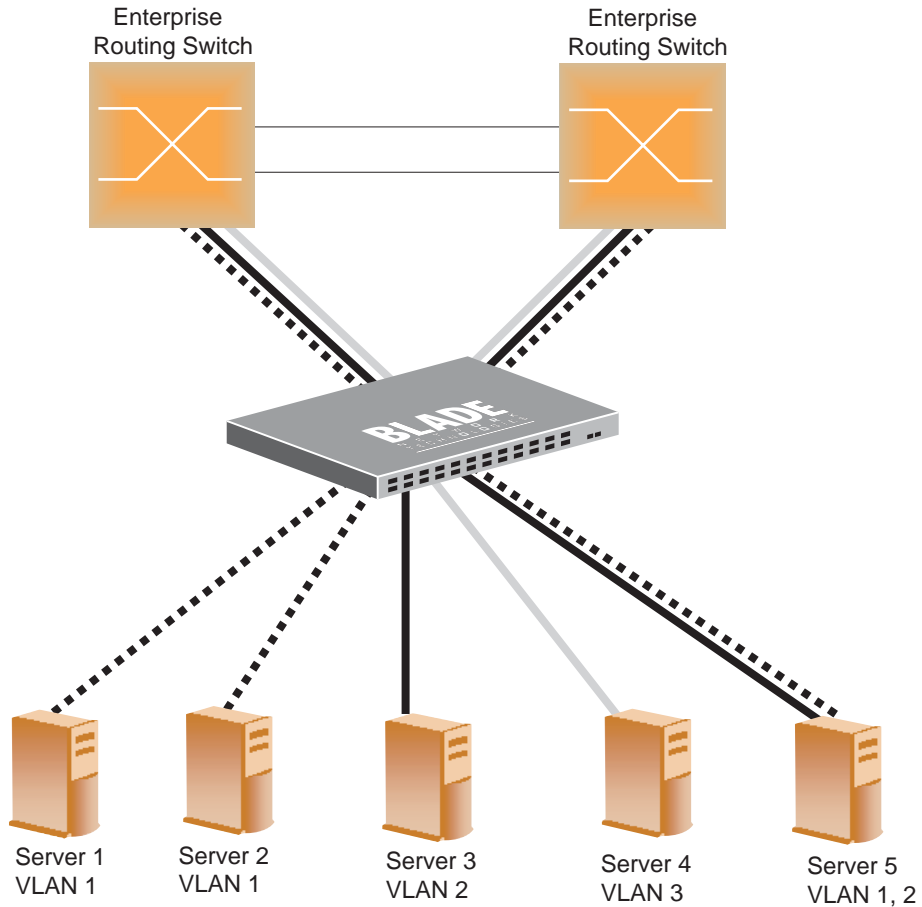
- By default, the G8000 software is configured so that tagging is disabled on all ports.
- By default, the G8000 software is configured so that all ports are members of VLAN 1.
- If you configure Spanning Tree, note that Spanning Tree Groups 2-128 may contain only one VLAN.

### VLAN configuration rules

VLANs operate according to specific configuration rules. When creating VLANs, consider the following rules that determine how the configured VLAN reacts in any network topology:

- All ports involved in trunking and port mirroring must have the same VLAN configuration. If a port is on a trunk with a mirroring port, the VLAN configuration cannot be changed. For more information trunk groups, see [“Port Trunking Example” on page 67](#).
- All ports that are involved in port mirroring must have memberships in the same VLANs. If a port is configured for port mirroring, the port’s VLAN membership cannot be changed. For more information on configuring port mirroring, see [“Monitoring Ports” on page 140](#).

## Multiple VLANs with Tagging Adapters



**Figure 3-6** Example 1: Multiple VLANs with VLAN-Tagged Gigabit Adapters

The features of this VLAN are described below:

Component	Description
G8000 switch	This switch is configured with three VLANs that represent three different IP subnets. Five ports are connected downstream to servers. Two ports are connected upstream to routing switches. Uplink ports are members of all three VLANs, with VLAN tagging enabled.



<b>Component</b>	<b>Description</b>
Server 1	This server is a member of VLAN 1 and has presence in only one IP subnet. The associated switch port is only a member of VLAN 1, so tagging is disabled.
Server 2	This server is a member of VLAN 1 and has presence in only one IP subnet. The associated switch port is only a member of VLAN 1, so tagging is disabled.
Server 3	This server belongs to VLAN 2, and it is logically in the same IP subnet as Server 5. The associated switch port has tagging disabled.
Server 4	A member of VLAN 3, this server can communicate only with other servers via a router. The associated switch port has tagging disabled.
Server 5	A member of VLAN 1 and VLAN 2, this server can communicate only with Server 1, Server 2, and Server 3. The associated switch port has tagging enabled.
Enterprise Routing switches	These switches must have all three VLANs (VLAN 1, 2, 3) configured. They can communicate with Server 1, Server 2, and Server 5 via VLAN 1. They can communicate with Server 3 and Server 5 via VLAN 2. They can communicate with Server 4 via VLAN 3. Tagging on switch ports is enabled.

**NOTE** – VLAN tagging is required only on ports that are connected to other switches or on ports that connect to tag-capable end-stations, such as servers with VLAN-tagging adapters.

## VLAN configuration example

Use the following procedure to configure the example network shown in [Figure 3-6](#).

### 1. Enable VLAN tagging on server ports that support multiple VLANs.

```
RS G8000 (config)# interface port 5
RS G8000 (config-if)# tagging
RS G8000 (config-if)# exit
```

### 2. Enable tagging on uplink ports that support multiple VLANs.

```
RS G8000 (config)# interface port 47
RS G8000 (config-if)# tagging
RS G8000 (config-if)# exit
RS G8000 (config)# interface port 48
RS G8000 (config-if)# tagging
RS G8000 (config-if)# exit
```

### 3. Configure the VLANs and their member ports.

```
RS G8000 (config)# vlan 2
RS G8000 (config-vlan)# enable
RS G8000 (config-vlan)# member 3
RS G8000 (config-vlan)# member 5
RS G8000 (config-vlan)# member 47
RS G8000 (config-vlan)# member 48
RS G8000 (config-vlan)# exit
RS G8000 (config)# vlan 3
RS G8000 (config-vlan)# enable
RS G8000 (config-vlan)# member 4,47,48
RS G8000 (config-vlan)# exit
```

By default, all ports are members of VLAN 1, so configure only those ports that belong to other VLANs.

## Private VLANs

---

Private VLANs provide Layer 2 isolation between the ports within the same broadcast domain. Private VLANs can control traffic within a VLAN domain, and provide port-based security for host servers.

Use Private VLANs to partition a VLAN domain into sub-domains. Each sub-domain is comprised of one primary VLAN and one or more secondary VLANs, as follows:

- **Primary VLAN**—carries unidirectional traffic downstream from promiscuous ports. Each Private VLAN has only one primary VLAN. All ports in the Private VLAN are members of the primary VLAN.
- **Secondary VLAN**—Secondary VLANs are internal to a private VLAN domain, and are defined as follows:
  - **Isolated VLAN**—carries unidirectional traffic upstream from the host servers toward ports in the primary VLAN and the gateway. Each Private VLAN can contain only one Isolated VLAN.
  - **Community VLAN**—carries upstream traffic from ports in the community VLAN to other ports in the same community, and to ports in the primary VLAN and the gateway. Each Private VLAN can contain multiple community VLANs.

After you define the primary VLAN and one or more secondary VLANs, you map the secondary VLAN(s) to the primary VLAN.

### Private VLAN ports

Private VLAN ports are defined as follows:

- **Promiscuous**—A promiscuous port is a port that belongs to the primary VLAN. The promiscuous port can communicate with all the interfaces, including ports in the secondary VLANs (Isolated VLAN and Community VLANs). Each promiscuous port can belong to only one Private VLAN.
- **Isolated**—An isolated port is a host port that belongs to an isolated VLAN. Each isolated port has complete layer 2 separation from other ports within the same private VLAN (including other isolated ports), except for the promiscuous ports.
  - Traffic sent to an isolated port is blocked by the Private VLAN, except the traffic from promiscuous ports.
  - Traffic received from an isolated port is forwarded only to promiscuous ports.

- **Community**—A community port is a host port that belongs to a community VLAN. Community ports can communicate with other ports in the same community VLAN, and with promiscuous ports. These interfaces are isolated at layer 2 from all other interfaces in other communities and from isolated ports within the Private VLAN.

## Configuration guidelines

The following guidelines apply when configuring Private VLANs:

- The default VLAN 1 cannot be a Private VLAN.
- IGMP Snooping must be disabled on isolated VLANs.
- Each secondary port's (isolated port and community ports) PVID must match its corresponding secondary VLAN ID.
- Private VLAN ports cannot be members of a trunk group. Link Aggregation Control Protocol (LACP) must be turned off on ports within a Private VLAN.
- Ports within a secondary VLAN cannot be members of other VLANs.
- All VLANs that comprise the Private VLAN must belong to the same Spanning Tree Group.

## Configuration example

Follow this procedure to configure a Private VLAN.

1. **Select a VLAN and define the Private VLAN type as primary.**

```
RS G8000 (config)# vlan 100
RS G8000 (config-vlan)# enable
RS G8000 (config-vlan)# member 2
RS G8000 (config-vlan)# private-vlan type primary
RS G8000 (config-vlan)# private-vlan enable
RS G8000 (config-vlan)# exit
```

## 2. Configure a secondary VLAN and map it to the primary VLAN.

```

RS G8000 (config)# vlan 110
RS G8000 (config-vlan)# enable
RS G8000 (config-vlan)# member 3
RS G8000 (config-vlan)# member 4
RS G8000 (config-vlan)# private-vlan type isolated
RS G8000 (config-vlan)# private-vlan map 100
RS G8000 (config-vlan)# private-vlan enable
RS G8000 (config-vlan)# exit

```

## 3. Verify the configuration.

```

RS G8000 (config)# show private-vlan

```

Private-VLAN	Type	Mapped-To	Status	Ports
100	primary	110	ena	2
110	isolated	100	ena	3-4



## CHAPTER 4

# Ports and Trunking

---

Trunk groups can provide super-bandwidth, multi-link connections between switches or other trunk-capable devices. A trunk group is a group of ports that act together, combining their bandwidth to create a single, larger virtual link. This chapter provides configuration background and examples for trunking multiple ports together:

- [““Overview” on page 64”](#)
- [“Port Trunking Example” on page 67](#)
- [“Configurable Trunk Hash Algorithm” on page 69](#)
- [“Link Aggregation Control Protocol” on page 70](#)

## Overview

---

When using port trunk groups between two switches, as shown in [Figure 4-1](#), you can create a virtual link between the switches, operating up to 40 Gb per second, depending on how many physical ports are combined. Each G8000 supports up to 52 static trunk groups (portchannels) and up to 52 LACP trunk groups, consisting of 1-8 ports in each group.

Trunk groups are also useful for connecting a G8000 to third-party devices that support link aggregation, such as Cisco routers and switches with EtherChannel technology (*not* ISL trunking technology) and Sun's Quad Fast Ethernet Adapter. Trunk Group technology is compatible with these devices when they are configured manually.

### Statistical load distribution

Network traffic is distributed statistically between the ports in a trunk group. The switch can use a combination of Layer 2 MAC and Layer 3 IP address information, present in each transmitted frame, to determine load distribution.

Each packet's particular MAC or IP address information results in selecting one line in the trunk group for data transmission. The more data streams feeding the trunk lines, the more evenly traffic distribution becomes.

### Built-In fault tolerance

Since each trunk group is comprised of multiple physical links, the trunk group is inherently fault tolerant. As long as one connection between the switches is available, the trunk remains active.

Statistical load balancing is maintained whenever a port in a trunk group is lost or returned to service.



## Before you configure static trunks

When you create and enable a static trunk, the trunk members (switch ports) take on certain settings necessary for correct operation of the trunking feature.

Before you configure your trunk, you must consider these settings, along with specific configuration rules, as follows:

1. **Read the configuration rules provided in the section, “[Static trunk group configuration rules](#)” on page 65.**
2. **Determine which switch ports (up to eight) are to become *trunk members* (the specific ports making up the trunk).**

Ensure that the chosen switch ports are set to `enabled`. Trunk member ports must have the same VLAN and Spanning Tree configuration.

3. **Consider how the existing Spanning Tree will react to the new trunk configuration. See [Chapter 4, “Spanning Tree Protocol”](#) for Spanning Tree Group configuration guidelines.**
4. **Consider how existing VLANs will be affected by the addition of a trunk.**

## Static trunk group configuration rules

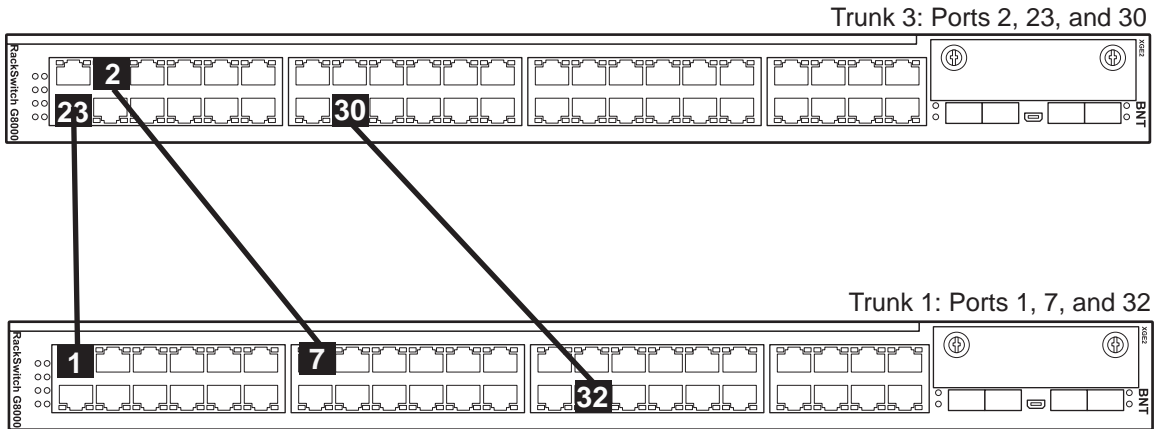
The trunking (portchannel) feature operates according to specific configuration rules. When creating trunks, consider the following rules that determine how a trunk group reacts in any network topology:

- All trunks must originate from one device, and lead to one destination device.
- Any physical switch port can belong to only one trunk group.
- Trunking from third-party devices must comply with Cisco® EtherChannel® technology.
- When ports become members of a trunk, configuration parameters (except ACL and QoS) are applied per trunk. When a trunk group is formed, these parameters are configured for the trunk ID, which overrides the port-level parameters.
- All trunk member ports must be assigned to the same VLAN configuration before the trunk can be enabled.
- You cannot change the VLAN membership for a trunk group’s member port. You can change the VLAN membership of the trunk group.
- When an active port is configured in a trunk, the port becomes a *trunk member* when you enable the trunk. The Spanning Tree parameters for the port then change to reflect the new trunk settings.

- All trunk members must be in the same Spanning Tree Group (STG) and can belong to only one Spanning Tree Group (STG). However if all ports are *tagged*, then all trunk ports can belong to multiple STGs.
- When a trunk is enabled, the trunk's Spanning Tree participation setting takes precedence over that of any trunk member.
- You cannot configure a trunk member as a monitor port in a port-mirroring configuration.
- Trunks cannot be monitored by a monitor port; however, trunk members can be monitored.
- All ports in static trunks must be have the same link configuration (speed, duplex, flow control).

## Port Trunking Example

In the example below, three ports are trunked between two switches.



**Figure 4-1** Port Trunk Group Configuration Example

Prior to configuring each switch in the above example, you must connect to the appropriate switch's Command Line Interface (CLI) as the administrator.

**NOTE** – For details about accessing and using any of the menu commands described in this example, see the *Command Reference*.

### 1. Follow these steps on the G8000:

- (a) Define a trunk group.

```
RS G8000 (config)# portchannel 3 member 2,23,30
RS G8000 (config)# portchannel 3 enable
```

- (b) Verify the configuration.

```
# show portchannel
```

Examine the resulting information. If any settings are incorrect, make appropriate changes.

## 2. Repeat the process on the other switch.

```
RS G8000 (config)# portchannel 1 member 1,7,32
RS G8000 (config)# portchannel 1 enable

# show portchannel
```

## 3. Connect the switch ports that will be members in the trunk group.

Trunk group 3 (on the G8000) is now connected to trunk group 1 (on the other switch).

---

**NOTE** – In this example, two G8000 switches are used. If a third-party device supporting link aggregation is used (such as Cisco routers and switches with EtherChannel technology or Sun's Quad Fast Ethernet Adapter), trunk groups on the third-party device should be configured manually. Connection problems could arise when using automatic trunk group negotiation on the third-party device.

---

## 4. Examine the trunking information on each switch.

```
# show portchannel information
PortChannel 3: Enabled
port state:
  2: STG 1 forwarding
 23: STG 1 forwarding
 30: STG 1 forwarding
```

Information about each port in each configured trunk group is displayed. Make sure that trunk groups consist of the expected ports and that each port is in the expected state.

The following restrictions apply:

- Any physical switch port can belong to only one trunk group.
- Up to eight ports can belong to the same trunk group.
- All ports in static trunks must have the same link configuration (speed, duplex, flow control).
- Trunking from third-party devices must comply with Cisco® EtherChannel® technology.

## Configurable Trunk Hash Algorithm

---

This feature allows you to configure parameters for the trunk hash algorithm, instead of using the default values.

Use the IP Trunk Hash commands to configure new default behavior for Layer 2 traffic and Layer 3 traffic. The trunk hash settings affect both static trunks and LACP trunks.

You can select a minimum of one or a maximum of two parameters to create one of the following configurations:

- Source MAC (SMAC):

```
RS G8000 (config)# portchannel hash source-mac-address
```

- Destination MAC (DMAC):

```
RS G8000 (config)# portchannel hash destination-mac-address
```

- Source MAC (SMAC) + Destination MAC (DMAC):

```
RS G8000 (config)# portchannel hash source-destination-mac
```

- Source IP (SIP):

```
RS G8000 (config)# portchannel hash source-ip-address
```

- Destination IP (DIP):

```
RS G8000 (config)# portchannel hash destination-ip-address
```

- Source IP (SIP) + Destination IP (DIP):

```
RS G8000 (config)# portchannel hash source-destination-ip
```

# Link Aggregation Control Protocol

---

Link Aggregation Control Protocol (LACP) is an IEEE 802.3ad standard for grouping several physical ports into one logical port (known as a dynamic trunk group or Link Aggregation group) with any device that supports the standard. Please refer to IEEE 802.3ad-2002 for a full description of the standard.

The 802.3ad standard allows standard Ethernet links to form a single Layer 2 link using the Link Aggregation Control Protocol (LACP). Link aggregation is a method of grouping physical link segments of the same media type and speed in full duplex, and treating them as if they were part of a single, logical link segment. If a link in a LACP trunk group fails, traffic is reasigned dynamically to the remaining link(s) of the dynamic trunk group.

---

**NOTE** – LACP implementation in the Blade OS does not support the Churn machine, an option used to detect if the port is operable within a bounded time period between the actor and the partner. Only the Marker Responder is implemented, and there is no marker protocol generator.

---

A port's Link Aggregation Identifier (LAG ID) determines how the port can be aggregated. The Link Aggregation ID (LAG ID) is constructed mainly from the *system ID* and the port's *admin key*, as follows:

**System ID** is an integer value based on the switch's MAC address and the system priority assigned in the CLI.

### Admin key

A port's Admin key is an integer value (53-65535) that you can configure in the CLI. Each switch port that participates in the same LACP trunk group must have the same *admin key* value. The Admin key is *local significant*, which means the partner switch does not need to use the same Admin key value.

For example, consider two switches, an Actor (the G8000) and a Partner (another switch), as shown in [Table 4-1](#).

**Table 4-1** Actor vs. Partner LACP configuration

Actor Switch	Partner Switch 1
Port 7 (admin key = 100)	Port 1 (admin key = 50)
Port 8 (admin key = 100)	Port 2 (admin key = 50)

In the configuration shown in [Table 4-1](#), Actor switch port 7 and port 8 aggregate to form an LACP trunk group with Partner switch port 1 and port 2.

LACP automatically determines which member links can be aggregated and then aggregates them. It provides for the controlled addition and removal of physical links for the link aggregation.

Each port on the switch can have one of the following LACP modes.

- **off (default)**  
The user can configure this port in to a regular static trunk group.
- **active**  
The port is capable of forming an LACP trunk. This port sends LACPDU packets to partner system ports.
- **passive**  
The port is capable of forming an LACP trunk. This port only responds to the LACPDU packets sent from an LACP *active* port.

Each active LACP port transmits LACP data units (LACPDUs), while each passive LACP port listens for LACPDUs. During LACP negotiation, the admin key is exchanged. The LACP trunk group is enabled as long as the information matches at both ends of the link. If the admin key value changes for a port at either end of the link, that port's association with the LACP trunk group is lost.

When the system is initialized, all ports by default are in LACP *off* mode and are assigned unique *admin keys*. To make a group of ports aggregatable, you assign them all the same *admin key*. You must set the port's LACP mode to *active* to activate LACP negotiation. You can set other port's LACP mode to *passive*, to reduce the amount of LACPDU traffic at the initial trunk-forming stage.

Use the following command to check whether the ports are trunked:

```
RS G8000 # show lacp information
```

---

**NOTE** – If you configure LACP on ports with 802.1X network access control, make sure the ports on both sides of the connection are properly configured for both LACP and 802.1X.

---

## LACP configuration guidelines

Consider the following guidelines when you configure LACP trunks:

- When ports become members of a trunk, configuration parameters (except ACL and QoS) are applied per trunk. When a trunk group is formed, these parameters are configured for the trunk ID, which overrides the port-level parameters.
- The range of potential LACP trunk IDs is 53-104.
- When a LACP trunk forms, the trunk ID is determined by the lowest port number in the trunk. For example, if the lowest port number is 1, then the LACP trunk ID is 53.
- The LACP trunk ID can change if the link is lost on the lowest port in the group. When the trunk ID changes, trunk-level parameters are cleared. To avoid losing configuration parameters, configure LACP trunk-level parameters for all possible trunk IDs. Use the port range configuration mode to set parameters for all of the ports that might participate in LACP.
- When a port becomes a member of a LACP trunk, LACP overrides the individual port configuration.
- If the port leaves the LACP trunk, you must reconfigure the port settings.
- Each port that is configured to participate in LACP must be set to full duplex.

## Configuring LACP

Use the following procedure to configure LACP on ports 2-6 to participate in link aggregation.

1. **Configure port parameters. All ports that participate in the LACP trunk group must have the same settings, including VLAN membership.**
2. **Select a range of ports and define the admin key. Only ports with the same admin key can form a LACP trunk group.**

```
RS G8000 (config)# interface port 2-6
RS G8000 (config-if)# lacp key 100
```

3. **Set the LACP mode.**

```
RS G8000 (config-if)# lacp mode active
RS G8000 (config-if)# exit
```



## CHAPTER 5

# Spanning Tree

---

When multiple paths exist on a network, Spanning Tree Protocol configures the network so that a switch uses only the most efficient path.

The following topics are discussed in this chapter:

- “Overview” on page 74
- “Rapid Spanning Tree Protocol” on page 80
- “Per VLAN Rapid Spanning Tree” on page 83
- “Multiple Spanning Tree Protocol” on page 86
- “Fast Uplink Convergence” on page 91

## Overview

---

Spanning Tree Protocol detects and eliminates logical loops in a bridged or switched network. When multiple paths exist, Spanning Tree configures the network so that a switch uses only the most efficient path. If that path fails, Spanning Tree automatically sets up another active path on the network to sustain network operations.

The G8000 supports the following Spanning Tree Protocols:

- IEEE 802.1D (2004) Rapid Spanning Tree Protocol (RSTP). RSTP enhances the Spanning Tree Protocol to provide rapid convergence on Spanning Tree Group 1.
- IEEE 802.1Q (2003) Multiple Spanning Tree Protocol, which extends RSTP to multiple Spanning Tree Groups. MSTP provides both rapid convergence and load balancing in a VLAN environment, using multiple VLANs in each Spanning-Tree Group (STG).
- Per VLAN Rapid Spanning Tree Plus Protocol (PVRST+), which enhances the RSTP protocol by adding the ability to have multiple spanning tree groups. PVRST+ is based on IEEE 802.1w Rapid Spanning Tree Protocol.

The relationship between port, trunk groups, VLANs, and Spanning Trees is shown in [Table 5-1](#).

**Table 5-1** Ports, Trunk Groups, and VLANs

Switch Element	Belongs to
Port	Trunk group or One or more VLANs
Trunk group	One or more VLANs
VLAN (non-default)	RSTP: One VLAN per Spanning Tree group PVRST+: One VLAN per Spanning Tree Group MSTP: Multiple VLANs per Spanning Tree group

---

**NOTE** – Due to Spanning Tree’s sequence of discarding, learning, and forwarding, lengthy delays may occur.

You can use a port’s **spanning-tree edge** command to permit a port that participates in Spanning Tree to bypass the Discarding and Learning states, and enter directly into the Forwarding state.

---

## Bridge Protocol Data Units (BPDUs)

To create a Spanning Tree, the switch generates a configuration Bridge Protocol Data Unit (BPDU), which it then forwards out of its ports. All switches in the Layer 2 network participating in the Spanning Tree gather information about other switches in the network through an exchange of BPDUs.

A BPDU is a 64-byte packet that is sent out at a configurable interval, which is typically set for two seconds. The BPDU is used to establish a path, much like a “hello” packet in IP routing. BPDUs contain information about the transmitting bridge and its ports, including bridge MAC address, bridge priority, port priority, and path cost.

The generic action of a switch upon receiving a BPDU is to compare the received BPDU to its own BPDU that it will transmit. If the received BPDU is better than its own BPDU, it will replace its BPDU with the received BPDU. Then, the switch uses this information to block any necessary ports.

### Determining the Path for Forwarding BPDUs

When determining which port to use for forwarding and which port to block, the G8000 uses information in the BPDU, including each bridge ID. A technique based on the “lowest root cost” is then computed to determine the most efficient path for forwarding.

#### *Bridge Priority*

The bridge priority parameter controls which bridge on the network is the STG root bridge. To make one switch become the root bridge, configure the bridge priority lower than all other switches and bridges on your network. The lower the value, the higher the bridge priority. Use the following command to configure the spanning-tree bridge priority:

```
RS G8000 (config)# spanning-tree stp 1 bridge  
                    priority <0-61440, in steps of 4096>
```

### Port Priority

The port priority helps determine which bridge port becomes the root/designated port. The case for the root port is when 2 switches are connected using a minimum of two links with the same path-cost. The case for the designated port is in a network topology that has multiple bridge ports with the same path-cost connected to a single segment—the port with the lowest port priority becomes the designated port for the segment. Use the following command to configure the spanning-tree port priority (Interface Port mode):

```
RS G8000 (config-if)# spanning-tree stp 1  
                        priority <0-240, in steps of 16>
```

### Port Path Cost

The port path cost assigns lower values to high-bandwidth ports, such as 10 Gigabit Ethernet, to encourage their use. The objective is to use the fastest links so that the route with the lowest cost is chosen. A value of 0 indicates that the default cost will be computed for an auto-negotiated link speed.

Use the following command to modify the port path cost:

```
RS G8000 (config-if)# spanning-tree stp 1 path-cost <0-200000000>
```

## Spanning Tree Group configuration guidelines

This section provides important information on configuring Spanning Tree Groups (STGs):

### Changing the Spanning Tree mode

When the spanning-tree mode is changed (for example, RSTP to MSTP),

- You must reconfigure spanning-tree parameters for each STG, including VLAN assignment.
- If a STG in RSTP mode is disabled and then re-enabled, the STP topology does not converge rapidly.

## Assigning a VLAN to a Spanning Tree Group

- If no VLANs exist beyond the default VLAN 1 see [“Creating a VLAN” on page 78](#) for information on adding ports to VLANs.
- Assign the VLAN to the STG using the following command:

```
RS G8000 (config-if)# spanning-tree stp 1 vlan <1-4094>
```

- If the association between the spanning-tree group and a VLAN is broken, the spanning-tree parameters are cleared. Reconfigure all of the parameters for the STG.
- Each STG must have a VLAN assigned to it before it becomes functional. You cannot configure other STG settings until the VLAN is assigned. If the STG VLAN is unassigned, other configuration settings are cleared. Assign a VLAN and reconfigure the STG settings.

---

**NOTE** – To ensure proper operation with switches that use Cisco Per VLAN Spanning Tree (PVST+), you must either:  
create a separate STG for each VLAN, or  
manually add all associated VLANs into a single STG.

---

## Creating a VLAN

When you create a VLAN, that VLAN automatically belongs to STG 1, the default STG. You can assign the VLAN to another STG.

- Move a newly created VLAN to an existing STG by following this order:
  - Create the VLAN.
  - Enable the VLAN.
  - Add the VLAN to an existing STG.
- VLANs must be contained *within* a single STG; a VLAN cannot span multiple STGs. By confining VLANs within a single STG, you avoid problems with spanning tree blocking ports and causing a loss of connectivity within the VLAN. When a VLAN spans multiple switches, it is recommended that the VLAN remain within the same Spanning Tree Group (have the same STG ID) across all the switches.
- If ports are tagged, all tagged ports can belong to multiple STGs.
- A port cannot be added directly to an STG. First add the port to a VLAN, then add the VLAN to the STG.

## Rules for VLAN Tagged ports

- Tagged ports can belong to more than one STG.
- Untagged ports can belong to only one STG.

## Adding and removing ports from STGs

- When you add a port to a VLAN that belongs to an STG, the VLAN's member port is added to the STG. However, if the port you are adding is an untagged port and is already a member of an STG, that port will be removed from this STG and added to the new STG. An untagged port cannot belong to more than one STG.

For example, assume that VLAN 2 belongs to STG 2. You add an untagged port (port 5) that belongs to STG 2 to VLAN 2. The port becomes a member of STG 2, and the switch displays a message to inform you that the PVID changed from 1 to 2:

```
"Port 5 is an UNTAGGED port and its PVID changed from 1 to 2."
```

- When you remove a port from a VLAN that belongs to an STG, that port is removed from the STG. However, if that port belongs to another VLAN in the same STG, the port remains in the STG.

As an example, assume that port 1 belongs to VLAN 2, and VLAN 2 belongs to STG 2. When you remove port 1 from VLAN 2, port 1 is also removed from STG 2. The port moves to the default VLAN 1.

However, if port 1 belongs to both VLAN 1 and VLAN 2 and both VLANs belong to STG 1, removing port 1 from VLAN 2 does not remove port 1 from STG 1 because VLAN 1 is still a member of STG 1.

- An STG cannot be deleted, only disabled. If you disable the STG while it still contains VLAN members, Spanning Tree will be off on all ports belonging to that VLAN.

The relationship between port, trunk groups, VLANs, and Spanning Trees is shown in [Table 5-1](#).

## Rapid Spanning Tree Protocol

---

Rapid Spanning Tree Protocol (RSTP) provides rapid convergence of the spanning tree and provides for fast re-configuration critical for networks carrying delay-sensitive traffic such as voice and video. RSTP significantly reduces the time to reconfigure the active topology of the network when changes occur to the physical topology or its configuration parameters. RSTP reduces the bridged-LAN topology to a single Spanning Tree.

RSTP parameters are configured in Spanning Tree Group 1. STP Groups 2-128 do not apply to RSTP. There are new STP parameters to support RSTP, and some values to existing parameters are different.

RSTP is compatible with devices that run 802.1D (1998) Spanning Tree Protocol. If the switch detects 802.1D (1998) BPDUs, it responds with 802.1D (1998)-compatible data units. RSTP is not compatible with Per VLAN Spanning Tree (PVST+) protocol.

### Port state changes

The port state controls the forwarding and learning processes of Spanning Tree. In RSTP, the port state has been consolidated to the following: discarding, learning, and forwarding. [Table 3](#) compares the port states between 802.1D (1998) Spanning Tree and 802.1D (2004) Rapid Spanning Tree.

**Table 3** RSTP vs. STP Port states

Operational status	STP Port State	RSTP Port State
Enabled	Blocking	Discarding
Enabled	Listening	Discarding
Enabled	Learning	Learning
Enabled	Forwarding	Forwarding
Disabled	Disabled	Discarding



## Port Type and Link Type

Spanning Tree configuration includes the following parameters to support RSTP and MSTP: edge port and link type.

### Edge Port

A port that does not connect to a bridge is called an *edge port*. Edge ports can start forwarding as soon as the link is up.

Edge ports do not take part in Spanning Tree, and should not receive BPDUs. A port with Edge enabled is intended to be connected directly to a host. If a port with edge enabled does receive a BPDU, it immediately begins working as a normal port, and participates in Spanning Tree.

### Link Type

The link type determines how the port behaves in regard to Rapid Spanning Tree. The link type corresponds to the duplex mode of the port. A full-duplex link is point-to-point (**p2p**), while a half-duplex link should be configured as **shared**. If you select **auto** as the link type, the port dynamically configures the link type.

## RSTP configuration guidelines

This section provides important information about configuring Rapid Spanning Tree Groups:

- When RSTP is turned on, STP parameters apply only to STP Group 1.
- When RSTP is turned on, STG 2-128 are turned off.
- When RSTP is turned on, all VLANs are moved to Spanning Tree Group 1.

## RSTP configuration example

This section provides steps to configure Rapid Spanning Tree on the G8000, using the Command-Line Interface (ISCLI).

Rapid Spanning Tree Protocol is the default setting on the G8000.

### Configure Rapid Spanning Tree

Rapid Spanning Tree is the default Spanning Tree mode on the G8000.

1. **Configure port and VLAN membership on the switch.**
2. **Set the Spanning Tree mode to Rapid Spanning Tree.**

```
RS G8000 (config)# spanning-tree mode rstp
```

## Per VLAN Rapid Spanning Tree

---

Per VLAN Rapid Spanning Tree Plus Protocol (PVRST+) enhances the RSTP protocol by adding the ability to have multiple spanning tree groups. PVRST+ is based on IEEE 802.1w Rapid Spanning Tree Protocol.

In PVRST mode, the G8000 supports a maximum of 128 Spanning Tree Groups (STGs). Multiple STGs provide multiple data paths, which can be used for load-balancing and redundancy.

To enable load balancing between two G8000s using multiple STGs, configure each path with a different VLAN and then assign each VLAN to a separate STG. Each STG is independent. Each STG sends its own Bridge Protocol Data Units (BPDUs), and each STG must be configured independently.

The STG, or bridge group, forms a loop-free topology that includes one or more virtual LANs (VLANs). The switch supports 128 STGs running simultaneously. The default STG 1 may contain multiple VLANs. STGs 2-128 each may contain only one VLAN.

### Default Spanning Tree configuration

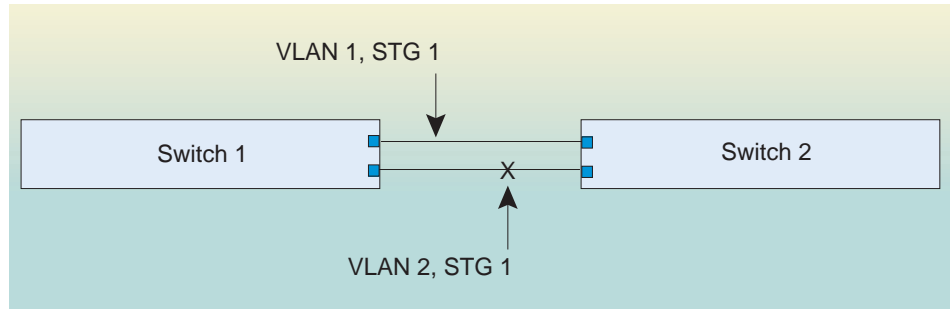
In the default configuration, a single STG (STG 1) includes all ports on the switch. This is called the default STG. Although ports can be added to or deleted from the default STG, the default STG cannot be deleted from the system.

All other STGs, except the default STG 1, are empty and you must assign a VLAN to the STG. However, you cannot assign ports directly to an STG. Add ports to a VLAN and add the VLAN to the STG. Each STG is enabled by default, and assigned an ID number from 2 to 128.

## Why do we need multiple Spanning Trees?

The following examples describe why we need multiple spanning trees.

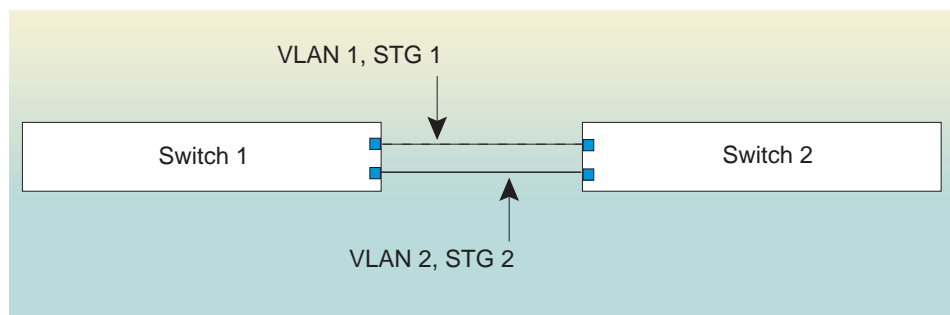
In [Figure 5-1](#), VLAN 1 and VLAN 2 pass traffic between switch 1 and switch 2. If you have a single Spanning Tree Group, the switches see an apparent physical loop, and one VLAN may become blocked, affecting connectivity, even though no logical loop exists. VLAN 2 traffic is blocked unnecessarily.



VLAN 2 traffic blocked by STG 1

**Figure 5-1** Two VLANs on one Spanning Tree Group

In [Figure 5-2](#), VLAN 1 and VLAN 2 belong to different Spanning Tree Groups. The two instances of Spanning Tree separate the topology without forming a loop. Both VLANs can forward packets between the switches without losing connectivity.



VLAN 1 passes traffic on STG 1  
VLAN 2 passes traffic on STG 2

**Figure 5-2** Two VLANs, each on a different Spanning Tree Group

## PVRST configuration guidelines

This section provides important information about configuring Per VLAN Rapid Spanning Tree Groups:

- By default, STGs 2-128 are empty, and STG 1 contains all configured VLANs until individual VLANs are assigned to other STGs. The G8000 allows only one VLAN per STG, except for STG 1.
- If the ports are tagged, each port sends out a special BPDU containing the tagged information.
- When a tagged port belongs to more than one STG, the egress BPDUs are tagged to distinguish the BPDUs of one STG from those of another STG.

## Configuring PVRST

This configuration shows how to configure PVRST+ on the switch.

### 1. Set the Spanning-tree mode to PVRST+.

```
RS G8000 (config)# spanning-tree mode pvrst
```

### 2. Configure port membership for VLAN 1 and VLAN 2. Define the STGs for each VLAN.

By default, port 1 is a member of VLAN 1, and VLAN 1 is assigned to STG 1. Add port 2 to VLAN 2, and assign VLAN 2 to STG 2.

```
RS G8000 (config)# vlan 2
RS G8000 (config-vlan)# enable
RS G8000 (config-vlan)# member 2
RS G8000 (config-vlan)# stg 2
RS G8000 (config-vlan)# exit
```

# Multiple Spanning Tree Protocol

---

Multiple Spanning Tree extends Rapid Spanning Tree Protocol through multiple Spanning Tree Groups, using multiple VLANs in each STG. MSTP supports up to 32 Spanning-Tree instances, that correspond to STP Groups 1-32.

For more information about Spanning Tree Protocol, see [Chapter 5, “Spanning Tree.”](#)

In Multiple Spanning Tree Protocol (MSTP), several VLANs can be mapped to each Spanning-Tree instance. Each Spanning-Tree instance is independent of other instances. MSTP allows frames assigned to different VLANs to follow separate paths, each path based on an independent Spanning-Tree instance. This approach provides multiple forwarding paths for data traffic, enabling load-balancing, and reducing the number of Spanning-Tree instances required to support a large number of VLANs.

## MSTP Region

A group of interconnected bridges that share the same attributes is called an MST region. Each bridge within the region must share the following attributes:

- Alphanumeric name
- Revision number
- VLAN-to STG mapping scheme

MSTP provides rapid re-configuration, scalability and control due to the support of regions, and multiple Spanning-Tree instances support within each region.

## Common Internal Spanning Tree

The Common Internal Spanning Tree (CIST) provides a common form of Spanning Tree Protocol, with one Spanning-Tree instance that can be used throughout the MSTP region. CIST allows the switch to interoperate with legacy equipment, including devices that run IEEE 802.1D (1998).

CIST allows the MSTP region to act as a virtual bridge to other bridges outside of the region, and provides a single Spanning-Tree instance to interact with them.

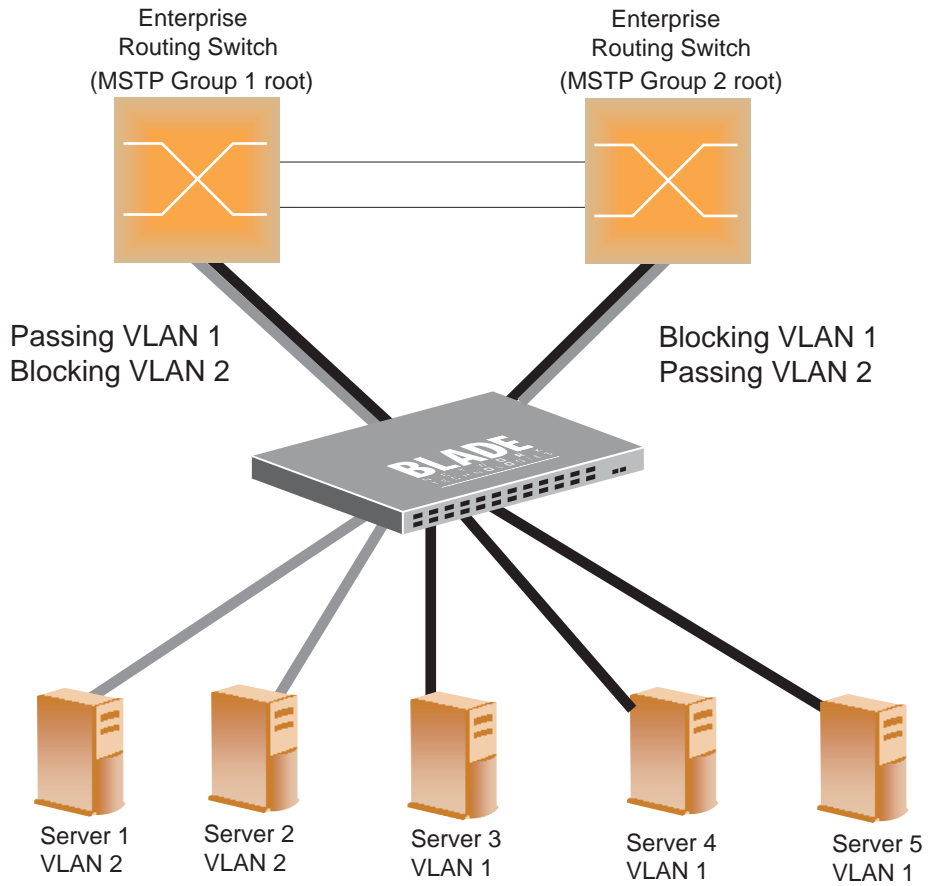
CIST port configuration includes Hello time, path-cost, and interface priority. These parameters do not affect Spanning Tree Groups 1-32. They apply only when the CIST is used.

## MSTP configuration guidelines

This section provides important information about configuring Multiple Spanning Tree Groups:

- When MSTP is turned on, the switch automatically moves all VLANs to the CIST. When MSTP is turned off, the switch moves all VLANs from the CIST to STG 1.
- When enabling MSTP, Region Name must be configured, and a default version number of 0 (zero) is configured automatically. Each bridge in the region must have the same name, version number, and VLAN mapping.

Figure 5-3 shows how multiple Spanning Trees can provide redundancy without wasting any uplink ports. In this example, the server ports are split between two separate VLANs. Both VLANs belong to two different Multiple Spanning Tree (MSTP) groups. The Spanning Tree *priority* values are configured so that each routing switch is the root for a different MSTP instance. All of the uplinks are active, with each uplink port backing up the other.



**Figure 5-3** Implementing Multiple Spanning Tree Groups



## Configuring Multiple Spanning Tree Groups

This configuration shows how to configure MSTP Groups on the switch, as shown in [Figure 5-3](#).

### 1. Configure port membership and define the Spanning Tree groups for VLAN 1.

Enable tagging on uplink ports that share VLANs. Port 51 and port 52 connect to the Enterprise Routing switches.

```
RS G8000 (config)# interface port 51
RS G8000 (config-if)# tagging
RS G8000 (config-if)# exit
RS G8000 (config)# interface port 52
RS G8000 (config-if)# tagging
RS G8000 (config-if)# exit
```

Add server ports 1 and 2 to VLAN 1. Add uplink ports 51 and 52 to VLAN 1.

```
RS G8000 (config)# vlan 1
RS G8000 (config-vlan)# enable
RS G8000 (config-vlan)# member 3
RS G8000 (config-vlan)# member 4
RS G8000 (config-vlan)# member 5
RS G8000 (config-vlan)# member 51
RS G8000 (config-vlan)# member 52
RS G8000 (config-vlan)# stg 1
RS G8000 (config-vlan)# exit
```

### 2. Configure Multiple Spanning Tree Protocol.

Configure the MSTP region name, set the Spanning-tree mode to **mst**, and configure the version.

```
RS G8000 (config)# spanning-tree mstp name MyRegion
RS G8000 (config)# spanning-tree mode mst
RS G8000 (config)# spanning-tree mstp version 100
```

### 3. Configure port membership and define the Spanning Tree groups for VLAN 2.

Add server ports 3, 4, and 5 to VLAN 2. Add uplink ports 51 and 52 to VLAN 2. Assign VLAN 2 to Spanning Tree Group 2.

```
RS G8000 (config)# vlan 2
RS G8000 (config-vlan)# enable
RS G8000 (config-vlan)# member 1
RS G8000 (config-vlan)# member 2
RS G8000 (config-vlan)# member 51
RS G8000 (config-vlan)# member 52
RS G8000 (config-vlan)# stg 2
RS G8000 (config-vlan)# exit
```

---

**NOTE** – Each Spanning Tree Group (STG) is enabled by default.

---

## Fast Uplink Convergence

---

Fast Uplink Convergence enables the G8000 to recover quickly from the failure of the primary link or trunk group in a Layer 2 network using Spanning Tree Protocol. Normal recovery can take as long as 50 seconds, while the backup link transitions from Blocking to Listening to Learning and then Forwarding states. With Fast Uplink Convergence enabled, the G8000 immediately places the secondary path into Forwarding state, and sends multicasts of addresses in the forwarding database (FDB) and ARP table over the secondary link so that upstream switches can learn the new path.

---

**NOTE** – In order for Fast Uplink Convergence to be functional, the switch must be running in PVRST+ mode and must be linked to switches running STP/PVST.

---

### Configuration Guidelines

When you enable Fast Uplink Convergence, the G8000 automatically makes the following configuration changes:

- Sets the bridge priority to 61440 so that it does not become the root switch.
- Increases the cost of all ports by 30000, across all VLANs and Spanning Tree Groups. This ensures that traffic never flows through the G8000 to get to another switch unless there is no other path.

These changes are reversed if the feature is disabled.

### Configuring Fast Uplink Convergence

Use the following CLI commands to enable Fast Uplink Convergence on all ports.

```
RS G8000 (config)# spanning-tree uplinkfast
```



## CHAPTER 6

# Quality of Service

---

Quality of Service features allow you to allocate network resources to mission-critical applications at the expense of applications that are less sensitive to such factors as time delays or network congestion. You can configure your network to prioritize specific types of traffic, ensuring that each type receives the appropriate Quality of Service (QoS) level.

The following topics are discussed in this section:

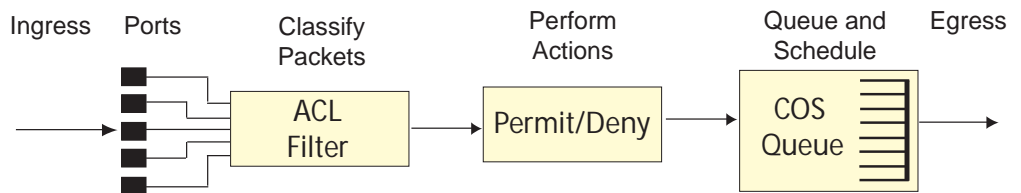
- [“Overview” on page 94](#)
- [“Using ACL Filters” on page 95](#)
- [“Using Storm Control Filters” on page 105](#)
- [“Using DSCP Values to Provide QoS” on page 106](#)
- [“Using 802.1p Priority to Provide QoS” on page 111](#)
- [“Queuing and Scheduling” on page 112](#)

## Overview

QoS helps you allocate guaranteed bandwidth to the critical applications, and limit bandwidth for less critical applications. Applications such as video and voice must have a certain amount of bandwidth to work correctly; using QoS, you can provide that bandwidth when necessary. Also, you can put a high priority on applications that are sensitive to timing out or that cannot tolerate delay, by assigning their traffic to a high-priority queue.

By assigning QoS levels to traffic flows on your network, you can ensure that network resources are allocated where they are needed most. QoS features allow you to prioritize network traffic, thereby providing better service for selected applications.

Figure 6-1 shows the basic QoS model used by the switch.



**Figure 6-1** QoS Model

The basic QoS model works as follows:

- Classify traffic:
  - Read DSCP value.
  - Read 802.1p priority value.
  - Match ACL filter parameters.
- Perform actions:
  - Permit packets.
  - Deny packets.
  - Map 802.1p Priority to COS queue.
  - Map DSCP to COS queue.
  - Set the number of COS queues (1-8).
- Queue and schedule traffic:
  - Place packets in one of the COS queues.
  - Schedule transmission based on the COS queue.

## Using ACL Filters

---

Access Control Lists are filters that allow you to classify data packets according to a particular content in the packet header, such as the source address, destination address, source port number, destination port number, and others. Packet classifiers identify flows for more processing. Each filter defines the conditions that must match for inclusion in the filter, and also the actions that are performed when a match is made.

ACLs are used to control whether packets are forwarded or blocked at the switch ports. ACLs can provide basic security for access to the network. For example, you can use an ACL to permit one host to access a part of the network, and deny another host access to the same area.

Each ACL contains rules that define the matching criteria for data packets. The ACL checks each packet against its rules, to determine if there is a match. If the packet matches the ACL's rules, the ACL performs its configured action: either permit or deny the packet.

The G8000 supports the following ACL types:

- MAC Extended ACLs
- IP Standard ACLs
- IP Extended ACLs

### MAC Extended ACLs

The switch supports up to 127 MAC extended ACLs, numbered from 1-65535. Use MAC Extended ACLs to filter traffic using the following criteria:

- Source/destination MAC address
- VLAN
- Ethernet protocol
- User priority criteria

To create a MAC Extended ACL:

```
RS G8000 (config)# access-list mac extended 1
RS G8000 (config-ext-macl)#
```

To delete a MAC Extended ACL:

```
RS G8000 (config)# no access-list mac extended 1
RS G8000 (config)#
```

## IP Standard ACLs

The switch supports up to 127 IP ACLs (standard and extended). IP Standard ACLs are numbered from 1-1000. Use IP Standard ACLs to filter traffic using source IP address/network mask and destination IP address/network/mask.

To create an IP Standard ACL:

```
RS G8000 (config)# access-list ip standard 1
RS G8000 (config-std-nacl)#
```

To delete an IP Standard ACL:

```
RS G8000 (config)# no access-list ip standard 1
RS G8000 (config)#
```

## IP Extended ACLs

The switch supports up to 127 IP ACLs (standard and extended). IP Extended ACLs are numbered from 1001-65535. Use IP Extended ACLs to filter traffic using the following criteria:

- Source IP address/network mask
- Destination IP address/network mask
- IP protocol number or name as shown in [Table 6-1](#)
- TCP/UDP application ports, as shown in [Table 6-2 on page 97](#)
- TCP flags
- ICMP message code and type
- Type of Service (TOS) value
- DSCP value



**Table 6-1** Well-known protocol types

Number	Protocol Name
1	icmp
4	ip
6	tcp
17	udp
89	ospf
103	pim

**Table 6-2** Well-known application ports

Number	TCP/UDP Application	Number	TCP/UDP Application	Number	TCP/UDP Application
20	ftp-data	79	finger	179	bgp
21	ftp	80	http	194	irc
22	ssh	109	pop2	220	imap3
23	telnet	110	pop3	389	ldap
25	smtp	111	sunrpc	443	https
37	time	119	nntp	520	rip
42	name	123	ntp	554	rtsp
43	whois	143	imap	1645, 1812	Radius
53	domain	144	news	1813	Radius Accounting
69	tftp	161	snmp	1985	hsrp
70	gopher	162	snmptrap		

To create an IP Extended ACL:

```
RS G8000 (config)# access-list ip extended 1001
RS G8000 (config-ext-nacl)#
```

To delete an IP Extended ACL:

```
RS G8000 (config)# no access-list ip extended 1001
RS G8000 (config)#
```

## Understanding ACL priority

Each ACL has a unique priority, based on its number. The higher the ACL number, the higher the priority, so ACL 1 has the lowest priority.

The priority is used to decide which ACL rule to apply when a packet matches one or more ACLs. When an incoming packet matches the highest priority ACL, the ACL's configured action takes place. The other assigned ACLs are considered in numeric order, from highest to lowest.

In the following example, the switch considers ACL 1003 before ACL 1001 because ACL 1003 has a higher priority. The order in which the ACLs are assigned to a port does not affect their priority.

### **Port 1 access group**

#### **ACL IP Extended 1001:**

TCP

Port number = 80

Action = permit

#### **ACL IP Extended 1002:**

TCP

Port number = 23

Action = deny

#### **ACL IP Extended 1003:**

TCP

Port number = less than 100

Action = permit

IP ACLs have precedence over MAC ACLs.

## Assigning ACLs to a port

Once you configure an ACL, you must assign the ACL to a port. Each port can accept up to 127 ACLs. Note that higher priority ACLs are considered first, and their action takes precedence over lower-priority ACLs.

When you assign an ACL to a port, you must specify the filtering direction for traffic on the port by including one of the following parameters:

- in: ingress traffic
- out: egress traffic

---

**NOTE** – To ensure your ACLs function properly, do not assign the same ACL to different ports using different filtering directions. It is recommended that you create two ACLs, one for ingress traffic, and one for egress traffic.

---

To assign an ACL to a port:

```
RS G8000 (config)# interface port 1
RS G8000 (config-if)# ip access-group 1001 in
RS G8000 (config-if)# exit
```

To delete an ACL from a port:

```
RS G8000 (config)# interface port 1
RS G8000 (config-if)# no ip access-group 1001 in
RS G8000 (config-if)# exit
```

Each port retains its assigned ACLs, even if the port becomes a member of a trunk group (portchannel).

## Viewing ACL statistics

ACL statistics display how many packets hit (matched) each ACL. Use ACL statistics to check filter performance, and debug the ACL filters. You must enable statistics for each ACL that you want to monitor. Use the following command to enable statistics for the ACL:

```
RS G8000 (config)# access-list ip standard 1 statistics
```

Use the following command to view ACL statistics:

```
RS G8000 (config)# show access-list counters
```

## ACL configuration examples

### Example 1

Use this configuration to block traffic to a specific host. All traffic that ingresses port 1 is denied if it is destined for the host at IP address 100.10.1.1

#### 1. Configure an Access Control List.

```
RS G8000 (config)# access-list ip standard 1  
RS G8000 (config-std-nacl)# deny any host 100.10.1.1  
RS G8000 (config-std-nacl)# exit
```

#### 2. Assign the ACL to port 1.

```
RS G8000 (config)# interface port 1  
RS G8000 (config-if)# ip access-group 1 in  
RS G8000 (config-if)# exit
```

#### 3. Verify the configuration.

```
RS G8000# show access-list 1  
  
Standard IP Access List 1  
-----  
Source IP address           : 0.0.0.0  
Source IP address mask     : 0.0.0.0  
Destination IP address     : 100.10.1.1  
Destination IP address mask : 255.255.255.255  
In Port List                : 1  
Out Port List               : NULL  
Filter Action                : Deny  
User Priority                : Nil  
Statistics                  : Disabled  
Status                      : Active
```

## Example 2

Use this configuration to block traffic from a network destined for a specific host address. All traffic that ingresses port 10 with source IP from the class 100.10.1.0/24 and destination IP 200.20.2.2 is denied.

### 1. Configure an Access Control List.

```
RS G8000 (config)# access-list ip standard 2  
RS G8000 (config-std-nacl)# deny 100.10.1.0 255.255.255.0  
                        host 200.20.2.2  
RS G8000 (config-std-nacl)# exit
```

### 2. Assign the ACL to port 10.

```
RS G8000 (config)# interface port 10  
RS G8000 (config-if)# ip access-group 2 in  
RS G8000 (config-if)# exit
```

### Example 3

Use this configuration to block traffic from a network that is destined for a specific egress port. All traffic that egresses port 6 from the network 100.10.1.0/24 is denied.

#### 1. Configure an Access Control List.

```
RS G8000 (config)# ip access-list ip extended 1001
RS G8000 (config-ext-nacl)# deny ip 100.10.1.0 255.255.255.0 any
RS G8000 (config-ext-nacl)# exit
```

#### 2. Add the ACL to port 6.

```
RS G8000 (config)# interface port 6
RS G8000 (config-if)# ip access-group 1001 out
RS G8000 (config-if)# exit
```

### Example 4

Use this configuration to block HTTP traffic on a port.

#### 1. Configure an Access Control List.

```
RS G8000 (config)# access-list ip extended 1002
RS G8000 (config-ext-nacl)# deny tcp any any eq 80
RS G8000 (config-ext-nacl)# exit
```

#### 2. Add the ACL to a port.

```
RS G8000 (config)# interface port 12
RS G8000 (config-if)# ip access-group 1002 in
RS G8000 (config-if)# exit
```

## Example 5

Use this configuration to block all traffic except traffic of certain types. HTTP/HTTPS, DHCP, and ARP packets are permitted on the port. All other traffic is denied.

### 1. Configure one IP ACL for each type of traffic that you want to permit.

```
RS G8000 (config)# access-list ip extended 1103
RS G8000 (config-ext-nacl)# permit tcp any any eq 80
RS G8000 (config-ext-nacl)# exit
RS G8000 (config)# access-list ip extended 1104
RS G8000 (config-ext-nacl)# permit tcp any any eq 443
RS G8000 (config-ext-nacl)# exit
RS G8000 (config)# access-list ip extended 1105
RS G8000 (config-ext-nacl)# permit udp any any eq 67
RS G8000 (config-ext-nacl)# exit
RS G8000 (config)# access-list ip extended 1106
RS G8000 (config-ext-nacl)# permit udp any any eq 68
RS G8000 (config-ext-nacl)# exit
```

### 2. Configure IP ACLs to deny all other traffic.

```
RS G8000 (config)# access-list ip extended 1007
RS G8000 (config-ext-nacl)# deny tcp any any
RS G8000 (config-ext-nacl)# exit
RS G8000 (config)# access-list ip extended 1008
RS G8000 (config-ext-nacl)# deny udp any any
RS G8000 (config-ext-nacl)# exit
```

The ACLs that allow traffic must have a higher index number, and therefore higher priority, than the ACL that denies all traffic.

### 3. Configure one MAC ACL for each type of traffic that you want to permit (ARP).

```
RS G8000 (config)# access-list mac extended 200
RS G8000 (config-ext-macl)# permit any any 806
RS G8000 (config-ext-macl)# exit
```

### 4. Configure a MAC ACL to deny all other traffic.

```
RS G8000 (config)# access-list mac extended 10
RS G8000 (config-ext-macl)# deny any any
RS G8000 (config-ext-macl)# exit
```

## 5. Assign the ACLs to a port.

```
RS G8000 (config)# interface port 7
RS G8000 (config-if)# ip access-group 1103 in
RS G8000 (config-if)# ip access-group 1104 in
RS G8000 (config-if)# ip access-group 1105 in
RS G8000 (config-if)# ip access-group 1106 in
RS G8000 (config-if)# ip access-group 1007 in
RS G8000 (config-if)# ip access-group 1008 in
RS G8000 (config-if)# mac access-group 200 in
RS G8000 (config-if)# mac access-group 10 in
```



## Using Storm Control Filters

The G8000 provides filters that can limit the number of the following packet types transmitted by switch ports:

- Broadcast packets
- Multicast packets
- Unknown unicast packets (destination lookup failure)

### Broadcast storms

Excessive transmission of broadcast or multicast traffic can result in a broadcast storm. A broadcast storm can overwhelm your network with constant broadcast or multicast traffic, and degrade network performance. Common symptoms of a broadcast storm are slow network response times and network operations timing out.

Unicast packets whose destination MAC address is not in the Forwarding Database are *unknown unicasts*. When an unknown unicast is encountered, the switch handles it like a broadcast packet and floods it to all other ports in the VLAN (broadcast domain). A high rate of unknown unicast traffic can have the same negative effects as a broadcast storm.

### Configuring storm control

Configure broadcast filters on each port that requires broadcast storm control. Set a threshold that defines the total number of broadcast packets transmitted, in Megabits per second. When the threshold is reached, no more packets of the specified type are transmitted.

To filter broadcast packets on a port, use the following commands:

```
RS G8000 (config)# interface port 1
RS G8000 (config-if)# broadcast-threshold <packet rate (1-33554431)>
RS G8000 (config-if)# exit
```

To filter multicast packets on a port, use the following commands:

```
RS G8000 (config)# interface port 1
RS G8000 (config-if)# multicast-threshold <packet rate (1-33554431)>
RS G8000 (config-if)# exit
```

To filter unknown unicast packets on a port, use the following commands:

```
RS G8000 (config)# interface port 1
RS G8000 (config-if)# dest-lookup-threshold <packet rate (1-33554431)>
RS G8000 (config-if)# exit
```

## Using DSCP Values to Provide QoS

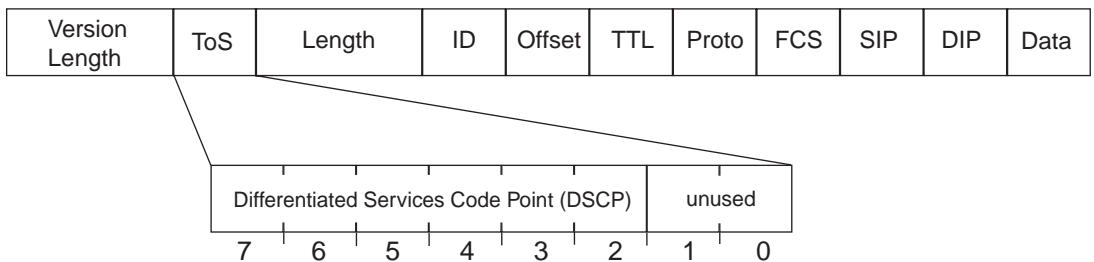
The switch uses the Differentiated Services (DiffServ) architecture to provide QoS functions. DiffServ is described in IETF RFCs 2474 and 2475.

The six most significant bits in the TOS byte of the IP header are defined as DiffServ Code Points (DSCP). Packets are marked with a certain value depending on the type of treatment the packet must receive in the network device. DSCP is a measure of the Quality of Service (QoS) level of the packet.

The switch can classify traffic by reading the DiffServ Code Point (DSCP) or IEEE 802.1p priority value, or by using filters to match specific criteria. When network traffic attributes match those specified in a traffic pattern, the policy instructs the switch to perform specified actions on each packet that passes through it. The packets are assigned to different Class of Service (COS) queues and scheduled for transmission.

### Differentiated Services Concepts

To differentiate between traffic flows, packets can be classified by their DSCP value. The Differentiated Services (DS) field in the IP header is an octet, and the first six bits, called the DS Code Point (DSCP), can provide QoS functions. Each packet carries its own QoS state in the DSCP. There are 64 possible DSCP values (0-63).



**Figure 6-2** Layer 3 IPv4 packet

The switch can perform the following actions to the DSCP:

- Read the DSCP value of ingress packets.
- Map the DSCP value to an 802.1p priority.

The switch can use the DSCP value to direct traffic prioritization.

With DiffServ, you can establish policies to direct traffic. A policy is a traffic-controlling mechanism that monitors the characteristics of the traffic, (for example, its source, destination, and protocol) and performs a controlling action on the traffic when certain characteristics are matched.

## Per Hop Behavior

The DSCP value determines the Per Hop Behavior (PHB) of each packet. The PHB is the forwarding treatment given to packets at each hop. QoS policies are built by applying a set of rules to packets, based on the DSCP value, as they hop through the network.

The default settings are based on the following standard PHBs, as defined in the IEEE standards:

- Expedited Forwarding (EF)—This PHB has the highest egress priority and lowest drop precedence level. EF traffic is forwarded ahead of all other traffic. EF PHB is described in RFC 2598.
- Assured Forwarding (AF)—This PHB contains four service levels, each with a different drop precedence, as shown below. Routers use drop precedence to determine which packets to discard last when the network becomes congested. AF PHB is described in RFC 2597.

Drop Precedence	Class 1	Class 2	Class 3	Class 4
Low	AF11 (DSCP 10)	AF21 (DSCP 18)	AF31 (DSCP 26)	AF41 (DSCP 34)
Medium	AF12 (DSCP 12)	AF22 (DSCP 20)	AF32 (DSCP 28)	AF42 (DSCP 36)
High	AF13 (DSCP 14)	AF23 (DSCP 22)	AF33 (DSCP 30)	AF43 (DSCP 38)

- Class Selector (CS)—This PHB has eight priority classes, with CS7 representing the highest priority, and CS0 representing the lowest priority, as shown below. CS PHB is described in RFC 2474.

Priority	Class Selector	DSCP
Highest	CS7	56
	CS6	48
	CS5	40
	CS4	32
	CS3	24
	CS2	16
	CS1	8
Lowest	CS0	0

## QoS Levels

**Table 6-3** shows the default service levels provided by the switch, listed from highest to lowest importance:

**Table 6-3** Default QoS Service Levels

<b>Service Level</b>	<b>Default PHB</b>	<b>802.1p Priority</b>
Critical	CS7	7
Network Control	CS6	6
Premium	EF, CS5	5
Platinum	AF41, AF42, AF43, CS4	4
Gold	AF31, AF32, AF33, CS3	3
Silver	AF21, AF22, AF23, CS2	2
Bronze	AF11, AF12, AF13, CS1	1
Standard	DF, CS0	0

## DSCP-to-802.1p mapping

The switch can use the DSCP value of ingress packets to set the 802.1p priority value. Use the following command to view the default settings.

```
RS G8000 (config)# show qos dscp
Current DSCP Remarking Configuration: OFF
  DSCP      New 802.1p Prio
-----
    0         0
    1         0
    2         0
    3         0
    4         0
    5         0
    6         0
    7         0
    8         1
    9         0
   10         1
   ...
   51         0
   52         0
   53         0
   54         0
   55         0
   56         7
   57         0
   58         0
   59         0
   60         0
   61         0
   62         0
   63         0
```

Use the following command to turn on DSCP mapping globally:

```
RS G8000# qos dscp enable
```

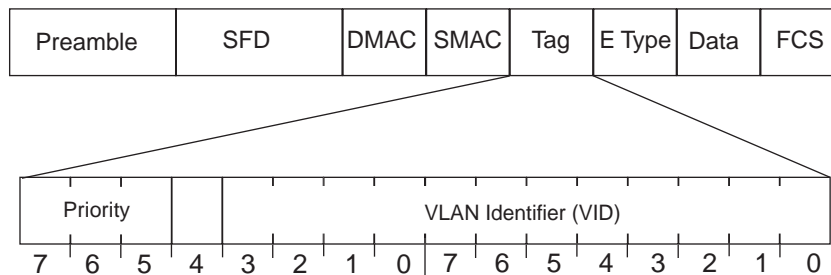
Use the following command to perform DSCP-to-802.1p mapping:

```
RS G8000# qos dscp dot1p-mapping <DSCP value (0-63)> <802.1p priority value (0-7)>
```

## Using 802.1p Priority to Provide QoS

The G8000 provides Quality of Service functions based on the priority bits in a packet's VLAN header. (The priority bits are defined by the 802.1p standard within the IEEE 802.1Q VLAN header.) The 802.1p bits, if present in the packet, specify the priority that should be given to packets during forwarding. Packets with a numerically higher (non-zero) priority are given forwarding preference over packets with lower priority value.

The IEEE 802.1p standard uses eight levels of priority (0-7). Priority 7 is assigned to highest priority network traffic, such as OSPF or RIP routing table updates, priorities 5-6 are assigned to delay-sensitive applications such as voice and video, and lower priorities are assigned to standard applications. A value of 0 (zero) indicates a "best effort" traffic prioritization, and this is the default when traffic priority has not been configured on your network. The switch can filter packets based on the 802.1p values.



**Figure 6-3** Layer 2 802.1p/802.1Q VLAN tagged packet

Ingress packets receive a priority value, as follows:

- **Tagged packets**—switch reads the 802.1p priority in the VLAN tag.
- **Untagged packets**—switch tags the packet and assigns an 802.1p priority value, based on the port's default 802.1p priority.

Egress packets are placed in a COS queue based on the priority value, and scheduled for transmission based on the scheduling weight of the COS queue.

## 802.1p configuration example

### 1. Configure a port's default 802.1p priority value to 2.

```
RS G8000 (config)# interface port 1
RS G8000 (config-if)# dot1p 2
RS G8000 (config-if)# exit
```

### 2. Map the 802.1p priority value to a COS queue and set the COS queue scheduling weight.

```
RS G8000 (config)# qos transmit-queue mapping 1 0
RS G8000 (config)# qos transmit-queue weight-cos 10
```

## Queuing and Scheduling

---

The G8000 has up to eight output Class of Service (COS) queues per port, into which each packet is placed. Each packet's 802.1p priority determines its COS queue.

Each COS queue uses Weighted Round Robin (WRR) scheduling, with user configurable weight from 1 to 15. The weight of 0 (zero) indicates strict priority, which might starve the low priority queues.

You can configure the following attributes for COS queues:

- Map 802.1p priority value to a COS queue, as follows:

```
RS G8000 (config)# qos transmit-queue mapping <802.1p priority
value (0-7)> <COS queue (0-7)>
```

- Define the number of COS queues, as follows:

```
RS G8000 (config)# qos transmit-queue number-cos <1-8>
```

- Define the scheduling weight of each COS queue, as follows:

```
RS G8000 (config)# qos transmit-queue weight-cos
<COS queue (0-7)> <scheduling weight (0-15)>
```



## CHAPTER 7

# Remote Monitoring

---

Remote Monitoring (RMON) allows network devices to exchange network monitoring data.

RMON allows the switch to perform the following functions:

- Track events and trigger alarms when a threshold is reached.
- Notify administrators by issuing a syslog message or SNMP trap.

### Overview

The RMON MIB provides an interface between the RMON agent on the switch and an RMON management application. The RMON MIB is described in RFC 1757.

The RMON standard defines objects that are suitable for the management of Ethernet networks. The RMON agent continuously collects statistics and proactively monitors switch performance. RMON allows you to monitor traffic flowing through the switch.

The switch supports the following RMON Groups, as described in RFC 1757:

- Group 1: Statistics
- Group 2: History
- Group 3: Alarms
- Group 9: Events

## RMON group 1—Statistics

The switch supports collection of Ethernet statistics as outlined in the RMON statistics MIB, in reference to etherStatsTable. You can configure RMON statistics on a per-port basis.

RMON statistics are sampled every second, and new data overwrites any old data on a given port.

---

**NOTE** – You must configure RMON statistics for the port before you can view RMON statistics.

---

### Configuring RMON statistics

#### 1. Enable RMON on a port.

```
RS G8000 (config)# interface port 1
RS G8000 (config-if)# rmon enable
```

#### 2. Configure the RMON statistics on a port.

```
RS G8000 (config)# interface port 1
RS G8000 (config-if)# rmon collection-stats 1
RS G8000 (config-if)# rmon collection-stats owner "port 1 rmon"
```

This configuration enables RMON statistics on port 1.

#### 3. View RMON statistics for the port.

```
RS G8000 (config)# show rmon statistics
RMON is enabled
Collection 1 on 7 is active, and owned by port 1 rmon
Monitors ifEntry.1.7 which has
Received 0 octets, 0 packets,
0 broadcast and 0 multicast packets,
0 undersized and 0 oversized packets,
0 fragments and 0 jabbers,
0 CRC alignment errors and 0 collisions.
# of packets received/transmitted of length (in octets):
64: 0, 65-127: 0, 128-255: 0,
256-511: 0, 512-1023: 0, 1024-1518: 0
```

## RMON group 2—History

The RMON History group allows you to sample and archive Ethernet statistics for a specific interface during a specific time interval. History sampling is done per port.

---

**NOTE** – RMON port statistics must be enabled for the port before an RMON history group can monitor the port.

---

Data is stored in *buckets*, which store data gathered during discreet sampling intervals. At each configured interval, the History index takes a sample of the current Ethernet statistics, and places them into a bucket. History data buckets reside in dynamic memory. When the switch is re-booted, the buckets are emptied.

Requested buckets are the number of buckets, or data slots, requested by the user for each History Group. Granted buckets are the number of buckets granted by the system, based on the amount of system memory available. The system grants a maximum of 50 buckets.

You can use an SNMP browser to view History samples, or use the following command:

```
RS G8000# show rmon history
```

### History MIB Object ID

The type of data that can be sampled must be of an `ifIndex` object type, as described in RFC1213 and RFC1573. The most common data type for the History sample is as follows:

1.3.6.1.2.1.2.2.1.1.x

The last digit (*x*) represents the number of the port to monitor. In the CLI, you do not need to enter the History MIB Object ID, because the port is specified when you enter Interface Port mode.

## Configuring RMON History

Perform the following steps to configure RMON History on a port.

### 1. Enable RMON on a port.

```
RS G8000 (config)# interface port 1
RS G8000 (config)# rmon enable
```

### 2. Configure the RMON History parameters for a port.

```
RS G8000 (config-if)# rmon collection-history 1 buckets 30
RS G8000 (config-if)# rmon collection-history 1 interval 120
RS G8000 (config-if)# rmon collection-history 1
                        owner "rmon port 1 history"
```

This configuration enables RMON history collection on port 1.

### 3. View RMON History for the port.

```
RS G8000 (config)# show rmon history
RMON is enabled
```

Index	IFOID	Interval	Rbnum	Gbnum
1	ifEntry.1.7	120	30	30

```
History Ether table is empty
```

## RMON group 3—Alarms

The RMON Alarm group allows you to define a set of thresholds used to determine network performance. When a configured threshold is crossed, an alarm is generated. For example, you can configure the switch to issue an alarm if more than 1,000 CRC errors occur during a 10-minute time interval.

Each Alarm index consists of a variable to monitor, a sampling time interval, and parameters for rising and falling thresholds. The Alarm Group can be used to track rising or falling values for a MIB object. The object must be a counter, gauge, integer, or time interval.

Use one of the following commands to correlate an Alarm index to an Event index:

```
RS G8000 (config)# rmon alarm <alarm number> rise-event <event number>
RS G8000 (config)# rmon alarm <alarm number> fall-event <event number>
```

When the alarm threshold is reached, the corresponding event is triggered.

## Alarm MIB objects

The most common data types used for alarm monitoring are `ifStats`: errors, drops, bad CRCs, and so on. These MIB Object Identifiers (OIDs) correlate to the ones tracked by the History Group. The following are examples of RMON statistics:

1.3.6.1.2.1.5.1.0 – `mgmt.icmp.icmpInMsgs`

1.3.6.1.2.1.2.2.1.10.x – `ifInOctets`

The last digit (*x*) represents the interface on which to monitor, which corresponds to the interface number, or port number, as follows:

```
1-128 = IF 1-128
129 = port 1
130 = port 2
...
172 = port 44
```

This value represents the alarm's MIB OID, as a string. Note that for non-tables, you must supply a .0 to specify end node.

## Configuring RMON Alarms

### Example 1

1. **Configure the RMON Alarm parameters to track the number of packets received on port 1.**

```
RS G8000 (config)# rmon alarm 1 oid 1.3.6.1.2.1.2.2.1.10.129
                    alarm-type rising rise-event 100
RS G8000 (config)# rmon alarm 1 interval-time 3600
RS G8000 (config)# rmon alarm 1 rising-threshold 2000000000
RS G8000 (config)# rmon alarm 1 owner "Alarm for ifInOctets"
```

This configuration creates an RMON alarm that checks `ifInOctets` on port 1 once every hour. If the statistic exceeds two billion, an alarm is generated that triggers event index 100.

## Example 2

### 1. Configure the RMON Alarm parameters to track ICMP messages.

```

RS G8000 (config)# rmon alarm 1 oid 1.3.6.1.2.1.5.8.0
                    alarm-type rising rise-event 110
RS G8000 (config)# rmon alarm 1 interval-time 60
RS G8000 (config)# rmon alarm 1 rising-threshold 200
RS G8000 (config)# rmon alarm 1 sample-type delta
RS G8000 (config)# rmon alarm 1 owner "Alarm for icmpInEchos"

```

This configuration creates an RMON alarm that checks `icmpInEchos` on the switch once every minute. If the statistic exceeds 200 within a 60 second interval, an alarm is generated that triggers event index 110.

## RMON group 9—Events

The RMON Event Group allows you to define events that are triggered by alarms. An event can be a log message, an SNMP trap, or both.

When an alarm is generated, it triggers a corresponding event notification. Use the following commands to correlate an Event index to an alarm:

```

RS G8000 (config)# rmon alarm <alarm number> rise-event <event number>
RS G8000 (config)# rmon alarm <alarm number> fall-event <event number>

```

RMON events use SNMP and syslog to send notifications. Therefore, an SNMP trap host must be configured for trap event notification to work properly.

RMON uses a syslog host to send syslog messages. Therefore, an existing syslog host must be configured for event log notification to work properly. Each log event generates a syslog of type RMON that corresponds to the event.

## Configure RMON events

### 1. Configure the RMON event parameters.

```

RS G8000 (config)# rmon event 110 type log-only
RS G8000 (config)# rmon event 110 description "SYSLOG_this_alarm"
RS G8000 (config)# rmon event 110 owner "log icmpInEchos alarm"

```

This configuration creates an RMON event that sends a syslog message each time it is triggered by an alarm.

## CHAPTER 8

# Basic IP Routing

---

This chapter provides configuration background and examples for using the G8000 to perform IP routing functions. The following topics are addressed in this chapter:

- “IP Routing Benefits” on page 120
- “Routing Between IP Subnets” on page 121
- “Example of Subnet Routing” on page 123
- “Dynamic Host Configuration Protocol” on page 127

## IP Routing Benefits

---

The switch uses a combination of configurable IP switch interfaces and IP routing options. The switch IP routing capabilities provide the following benefits:

- Connects the server IP subnets to the rest of the backbone network.
- Provides the ability to route IP traffic between multiple Virtual Local Area Networks (VLANs) configured on the switch.

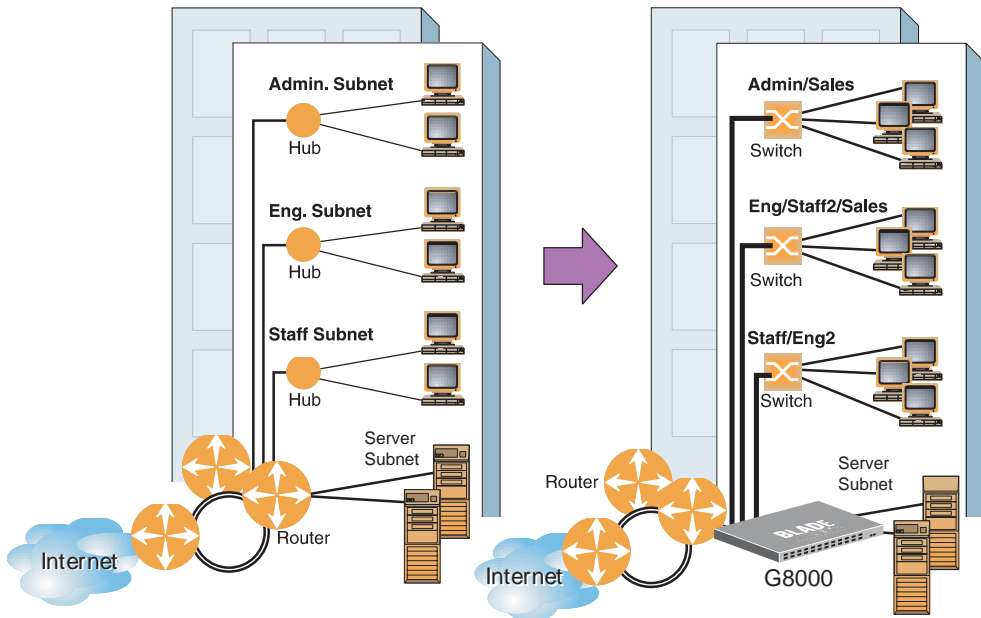


## Routing Between IP Subnets

The physical layout of most corporate networks has evolved over time. Classic hub/router topologies have given way to faster switched topologies, particularly now that switches are increasingly intelligent. The G8000 is intelligent and fast enough to perform routing functions on a par with wire speed Layer 2 switching.

The combination of faster routing and switching in a single device provides another service—it allows you to build versatile topologies that account for legacy configurations.

For example, consider the following topology migration:



**Figure 8-1** The Router Legacy Network

In this example, a corporate campus has migrated from a router-centric topology to a faster, more powerful, switch-based topology. As is often the case, the legacy of network growth and redesign has left the system with a mix of illogically distributed subnets.

This is a situation that switching alone cannot cure. Instead, the router is flooded with cross-subnet communication. This compromises efficiency in two ways:

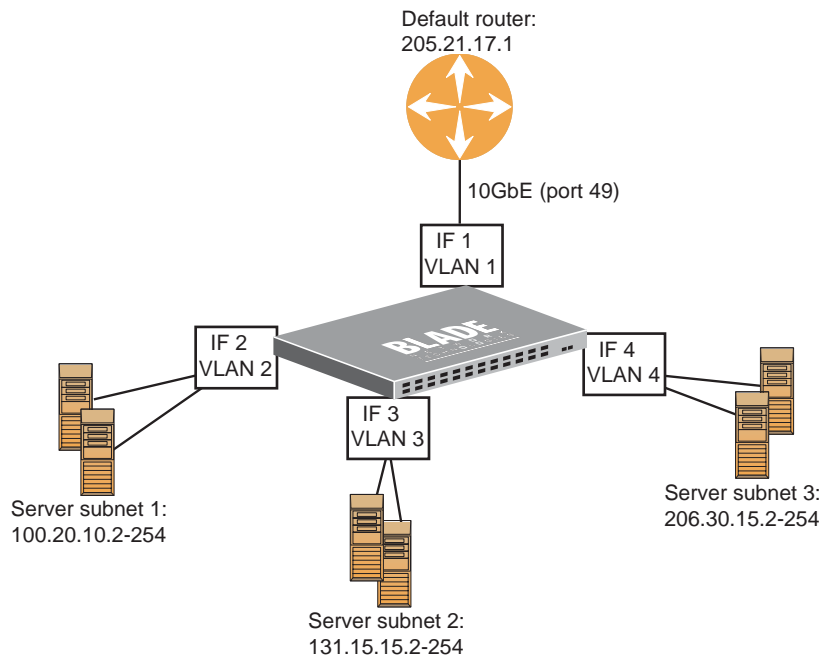
- Routers can be slower than switches. The cross-subnet side trip from the switch to the router and back again adds two hops for the data, slowing throughput considerably.
- Traffic to the router increases, increasing congestion.

Even if every end-station could be moved to better logical subnets (a daunting task), competition for access to common server pools on different subnets still burdens the routers.

This problem is solved by using switches with built-in IP routing capabilities. Cross-subnet LAN traffic can now be routed within the switches with wire speed Layer 2 switching performance. This not only eases the load on the router but saves the network administrators from reconfiguring each and every end-station with new IP addresses.

## Example of Subnet Routing

Consider the role of the G8000 in the following configuration example:



**Figure 8-2** Switch-Based Routing Topology

The switch connects the Gigabit Ethernet and Fast Ethernet trunks from various switched subnets throughout one building. Common servers are placed on another subnet attached to the switch. A primary and backup router are attached to the switch on yet another subnet.

Without Layer 3 IP routing on the switch, cross-subnet communication is relayed to the default gateway (in this case, the router) for the next level of routing intelligence. The router fills in the necessary address information and sends the data back to the switch, which then relays the packet to the proper destination subnet using Layer 2 switching.

With Layer 3 IP routing in place on the switch, routing between different IP subnets can be accomplished entirely within the switch. This leaves the routers free to handle inbound and outbound traffic for this group of subnets.

## Using VLANs to segregate Broadcast Domains

If you want to control the broadcasts on your network, use VLANs to create distinct broadcast domains. Create one VLAN for each server subnet, and one for the router.

### Configuration example

This section describes the steps used to configure the example topology shown in [Figure 8-2 on page 123](#).

- 1. Assign an IP address (or document the existing one) for each router and each server.**

The following IP addresses are used:

**Table 8-1** Subnet Routing Example: IP Address Assignments

Subnet	Devices	IP Addresses
1	Default router	205.21.17.1
2	Web servers	100.20.10.2-254
3	Database servers	131.15.15.2-254
4	Terminal Servers	206.30.15.2-254

- 2. Assign an IP interface for each subnet attached to the switch.**

Since there are four IP subnets connected to the switch, four IP interfaces are needed:

**Table 8-2** Subnet Routing Example: IP Interface Assignments

Interface	Devices	IP Interface Address
IF 1	Default router	205.21.17.3
IF 2	Web servers	100.20.10.1
IF 3	Database servers	131.15.15.1
IF 4	Terminal Servers	206.30.15.1

### 3. Determine which switch ports and IP interfaces belong to which VLANs.

The following table adds port and VLAN information:

**Table 8-3** Subnet Routing Example: Optional VLAN Ports

Devices	IP Interface	Switch Ports	VLAN #
Default router	1	49	1
Web servers	2	1 and 2	2
Database servers	3	3 and 4	3
Terminal Servers	4	5 and 6	4

**NOTE** – To perform this configuration, you must be connected to the switch Command Line Interface (CLI) as the administrator.

### 4. Add the switch ports to their respective VLANs.

The VLANs shown in [Table 8-3](#) are configured as follows:

```

RS G8000 (config)# vlan 1
RS G8000 (config-vlan)# enable
RS G8000 (config-vlan)# member 49           (Add ports to VLAN 1)
RS G8000 (config-vlan)# exit
RS G8000 (config)# vlan 2
RS G8000 (config-vlan)# enable
RS G8000 (config-vlan)# member 1,2         (Add ports to VLAN 2)
RS G8000 (config-vlan)# exit
RS G8000 (config)# vlan 3
RS G8000 (config-vlan)# enable
RS G8000 (config-vlan)# member 3,4         (Add ports to VLAN 3)
RS G8000 (config-vlan)# exit
RS G8000 (config)# vlan 4
RS G8000 (config-vlan)# enable
RS G8000 (config-vlan)# member 5,6         (Add ports to VLAN 4)
RS G8000 (config-vlan)# exit

```

Each time you add a port to a VLAN, you may get the following prompt:

```
Port 4 is an untagged port and its PVID is changed from 1 to 3.
```

## 5. Assign a VLAN to each IP interface.

Now that the ports are separated into VLANs, the VLANs are assigned to the appropriate IP interface for each subnet. From [Table 8-3 on page 125](#), the settings are made as follows:

```

RS G8000 (config)# interface ip 1                (Select IP interface 1)
RS G8000 (config-ip-if)# ip address 205.21.17.3
RS G8000 (config-ip-if)# ipvlan 1              (Add VLAN 1)
RS G8000 (config-ip-if)# enable
RS G8000 (config-vlan)# exit
RS G8000 (config)# interface ip 2              (Select IP interface 2)
RS G8000 (config-ip-if)# ip address 100.20.10.1
RS G8000 (config-ip-if)# ipvlan 2              (Add VLAN 2)
RS G8000 (config-ip-if)# enable
RS G8000 (config-ip-if)# exit
RS G8000 (config)# interface ip 3              (Select IP interface 3)
RS G8000 (config-ip-if)# ip address 131.15.15.1
RS G8000 (config-ip-if)# ipvlan 3              (Add VLAN 3)
RS G8000 (config-ip-if)# enable
RS G8000 (config-ip-if)# exit
RS G8000 (config)# interface ip 4              (Select IP interface 4)
RS G8000 (config-ip-if)# ip address 206.30.15.1
RS G8000 (config-ip-if)# ipvlan 4              (Add VLAN 4)
RS G8000 (config-ip-if)# enable
RS G8000 (config-ip-if)# exit

```

## 6. Configure the default gateway to the routers' addresses.

The default gateway allows the switch to send outbound traffic to the router:

```

RS G8000 (config)# ip gateway address 205.21.17.1
RS G8000 (config)# ip gateway enable

```

## 7. Enable IP routing.

```

RS G8000 (config)# ip routing

```

## 8. Verify the configuration.

```

RS G8000 (config)# show vlan
RS G8000 (config)# show interface information
RS G8000 (config)# show interface ip

```

Examine the resulting information. If any settings are incorrect, make the appropriate changes.

# Dynamic Host Configuration Protocol

---

Dynamic Host Configuration Protocol (DHCP) is a transport protocol that provides a framework for automatically assigning IP addresses and configuration information to other IP hosts or clients in a large TCP/IP network. Without DHCP, the IP address must be entered manually for each network device. DHCP allows a network administrator to distribute IP addresses from a central point and automatically send a new IP address when a device is connected to a different place in the network.

The switch accepts gateway configuration parameters if they have not been configured manually. The switch ignores DHCP gateway parameters if the gateway is configured.

DHCP is an extension of another network IP management protocol, Bootstrap Protocol (BOOTP), with an additional capability of being able to allocate reusable network addresses and configuration parameters for client operation.

Built on the client/server model, DHCP allows hosts or clients on an IP network to obtain their configurations from a DHCP server, thereby reducing network administration. The most significant configuration the client receives from the server is its required IP address; (other optional parameters include the “generic” file name to be booted, the address of the default gateway, and so forth).

To enable DHCP on an IP interface, use the following commands:

```
RS G8000 (config)# interface ip 2  
RS G8000 (config-ip-if)# dhcp enable  
RS G8000 (config-ip-if)# exit
```





## CHAPTER 9

# IGMP

---

Internet Group Management Protocol (IGMP) is used by IP Multicast routers to learn about the existence of host group members on their directly attached subnet (see RFC 2236). The IP Multicast routers get this information by broadcasting IGMP Membership Queries and listening for IP hosts reporting their host group memberships. This process is used to set up a client/server relationship between an IP Multicast source that provides the data streams and the clients that want to receive the data.

The G8000 can perform IGMP Snooping, and connect to static multicast routers (Mrouters).

The following topics are discussed in this chapter:

- [“IGMP Snooping” on page 130](#)
- [“IGMPv3 Snooping” on page 131](#)
- [“Static Multicast Router” on page 134](#)

## IGMP Snooping

---

IGMP Snooping allows the switch to forward multicast traffic only to those ports that request it. IGMP Snooping prevents multicast traffic from being flooded to all ports. The switch learns which server hosts are interested in receiving multicast traffic, and forwards it only to ports connected to those servers.

IGMP Snooping conserves bandwidth. With IGMP Snooping, the switch learns which ports are interested in receiving multicast data, and forwards multicast data only to those ports. In this way, other ports are not burdened with unwanted multicast traffic.

The switch can sense IGMP Membership Reports from attached clients and act as a proxy to set up a dedicated path between the requesting host and a local IP Multicast router. After the pathway is established, the switch blocks the IP Multicast stream from flowing through any port that does not connect to a host member, thus conserving bandwidth.

The client-server path is set up as follows:

- An IP Multicast Router (Mrouter) sends *Membership Queries* to the switch, which forwards them to all ports in a given VLAN.
- Hosts that want to receive the multicast data stream send *Membership Reports* to the switch, which sends a proxy Membership Report to the Mrouter.
- The switch sets up a path between the Mrouter and the host, and blocks all other ports from receiving the multicast.
- Periodically, the Mrouter sends Membership Queries to ensure that the host wants to continue receiving the multicast. If a host fails to respond with a Membership Report, the Mrouter stops sending the multicast to that path.
- The host can send a *Leave Report* to the switch, which sends a proxy Leave Report to the Mrouter. The multicast path is terminated immediately.

The G8000 supports the following IGMP capacities:

- IGMP version 1, 2, and 3
- 1024 VLANs
- 128 Mrouters
- 512 multicast groups

---

**NOTE** – Unknown multicast traffic is sent to an Mrouter port only if the flood option is disabled. To enable or disable IGMP flood, use the following command:

```
RS G8000 (config)# [no] ip igmp flood
```

---

## FastLeave

In normal IGMP operation, when the switch receives an IGMPv2 Leave message, it sends a Group-Specific Query to determine if any other devices in the same group (and on the same port) are still interested in the specified multicast group traffic. The switch removes the affiliated port from that particular group, if the following conditions apply:

- If the switch does not receive an IGMP Membership Report within the query-response-interval.
- If no multicast routers have been learned on that port.

With FastLeave enabled on the VLAN, a port can be removed immediately from the port list of the group entry when the IGMP Leave message is received, unless a multicast router was learned on the port.

Enable FastLeave only on VLANs that have only one host connected to each physical port. To enable FastLeave, use the following command:

```
RS G8000 (config)# ip igmp fastleave <VLAN number (1-4094)>
```

## IGMPv3 Snooping

IGMPv3 includes new membership report messages to extend IGMP functionality. The switch provides snooping capability for all types of IGMP version 3 (IGMPv3) Membership Reports.

IGMPv3 supports Source-Specific Multicast (SSM). SSM identifies session traffic by both source and group addresses.

The IGMPv3 implementation keeps records on the multicast hosts present in the network. If a host is already registered, when it sends an IS\_INC/TO\_INC/IS\_EXC/TO\_EXC report, the switch overwrites the existing (port-host-group) registration with the new registration; the registrations of other hosts on the same group, same port are not changed. IS\_INCLUDE/TO\_INCLUDE reports with no source are not registered.

The switch supports the following IGMPv3 filter modes:

- **INCLUDE mode:** The host requests membership to a multicast group and provides a list of IP addresses from which it wants to receive traffic.
- **EXCLUDE mode:** The host requests membership to a multicast group and provides a list of IP addresses from which it *does not* want to receive traffic. This indicates that the host wants to receive traffic only from sources that are not part of the Exclude list. To disable snooping on EXCLUDE mode reports, use the following command:

```
RS G8000 (config)# no ip igmp snoop igmpv3 exclude
```

By default, the switch snoops the first eight sources listed in the IGMPv3 Group Record. Use the following command to change the number of snooping sources:

```
RS G8000 (config)# ip igmp snoop igmpv3 sources <1-64>
```

IGMPv3 Snooping is compatible with IGMPv1 and IGMPv2 Snooping. You can disable snooping on version 1 and version 2 reports, using the following command:

```
RS G8000 (config)# no ip igmp snoop igmpv3 v1v2
```

## IGMP Snooping configuration example

This section provides steps to configure IGMP Snooping on the switch.

### Configure IGMP Snooping

1. **Configure port and VLAN membership on the switch.**
2. **Enable IGMP Snooping.**

```
RS G8000 (config)# ip igmp snoop enable
```

3. **Add VLANs to IGMP Snooping.**

```
RS G8000 (config)# ip igmp snoop vlan 1
```

4. **Enable IGMPv3 Snooping (optional).**

```
RS G8000 (config)# ip igmp snoop igmpv3 enable
```

## 5. View dynamic IGMP information.

```

RS G8000# show ip igmp groups

Note: Local groups (224.0.0.x) are not snooped/relayed and will not appear.

```

Source	Group	VLAN	Port	Version	Mode	Expires	Fwd
10.1.1.1	232.1.1.1	2	4	V3	INC	4:16	Yes
10.1.1.5	232.1.1.1	2	4	V3	INC	4:16	Yes
*	232.1.1.1	2	4	V3	INC	-	No
10.10.10.43	235.0.0.1	9	1	V3	INC	2:26	Yes
*	236.0.0.1	9	1	V3	EXC	-	Yes

```

RS G8000# show ip igmp mrouter

```

VLAN	Port	Version	Expires	Max Query Resp. Time	QRV	QQIC
1	4	V2	static	unknown	-	-
2	3	V3	4:09	128	2	125

These commands display information about IGMP Groups and Mrouters learned by the switch.

## Static Multicast Router

A static multicast router (Mrouter) can be configured for a particular port on a particular VLAN. A static Mrouter does not have to be learned through IGMP Snooping. Any data port can accept a static Mrouter.

When you configure a static Mrouter on a VLAN, it replaces any dynamic Mrouters learned through IGMP Snooping.

### Configure a Static Multicast Router

1. **For each MRouter, configure a port or trunk group (1-52, po1-po104), VLAN (1-4094) and version (1-3).**

```
RS G8000 (config)# ip igmp mrouter 5 1 2
```

The IGMP version is set for each VLAN, and cannot be configured separately for each Mrouter.

2. **Verify the configuration.**

```
RS G8000# show ip igmp mrouter
```

## CHAPTER 10

# High Availability

---

The RackSwitch G8000 supports high-availability network topologies.

The following topics are discussed in this chapter:

- [“Uplink Failure Detection” on page 136.](#)

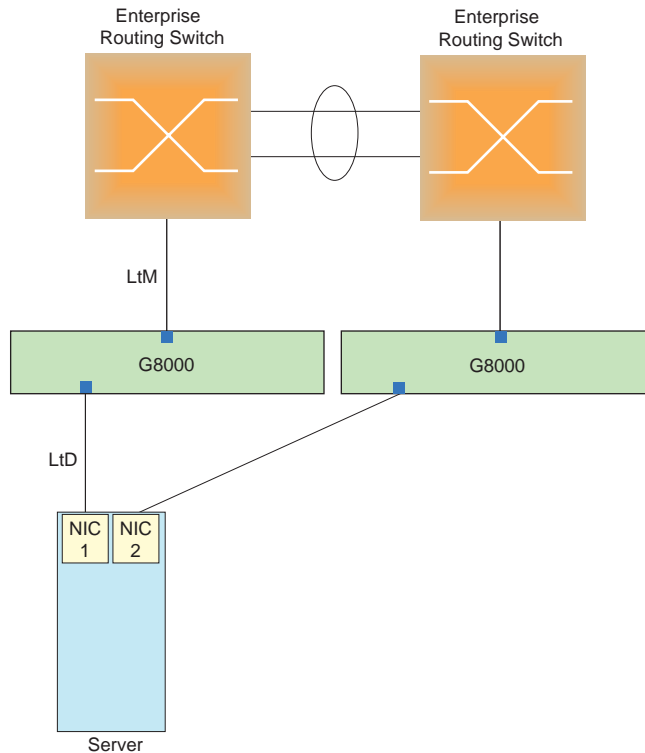
## Uplink Failure Detection

Uplink Failure Detection (UFD) is designed to support Network Adapter Teaming. Network Adapter Teaming allows all the NICs on each server to share the same IP address. The NICs are configured into a team. One NIC is the primary link, and the other is a standby link.

UFD allows the switch to monitor specific ports (Link to Monitor ports) to detect link failures. When the switch detects a link failure, it automatically disables specific ports (Link to Disable ports). Each corresponding server's network adapter can detect the disabled port, and trigger a network-adapter failover to another port on the switch.

The switch automatically enables the control ports when the monitor ports return to service.

The following figure shows a basic UFD configuration, with a Failure Detection Pair (FDP) that consists of one LtM (Link to Monitor) and one LtD (Link to Disable). When the switch detects a link failure in the LtM, it disables the ports in the LtD. The servers detect the disabled ports, which triggers a NIC failover.



**Figure 10-1** Uplink Failure Detection example



## Failure Detection Pair

To use UFD, you must configure a Failure Detection Pair and then turn UFD on. A Failure Detection Pair consists of the following groups of ports:

- **Link to Monitor (LtM)**  
The Link to Monitor group consists of one port or one trunk group. The switch monitors the LtM for link failure.
- **Link to Disable (LtD)**  
The Link to Disable group consists of one or more ports and trunk groups. When the switch detects a link failure on the LtM, it automatically disables all ports in the LtD. When the LtM returns to service, the switch automatically enables all ports in the LtD.

## Spanning Tree Protocol with UFD

If Spanning Tree Protocol (STP) is enabled on ports in the LtM, then the switch monitors the STP state and the link status on ports in the LtM. The switch automatically disables the ports in the LtD when it detects a link failure or STP BLOCKING state.

When the switch determines that ports in the LtM are in the FORWARDING State, then it automatically enables the ports in the LtD, to fall back to normal operation.

## Configuration guidelines

This section provides important information about configuring UFD.

- Only one Failure Detection pair (one group of Links to Monitor and one group of Links to Disable) is supported on the switch (all VLANs and Spanning Tree Groups).
- A LtM may contain either one port or one Multi-Link trunk group.
- Ports that are already members of a trunk group are not allowed to be assigned to a LtM.
- A port cannot be added to a trunk group if it already belongs to a LtM.
- A LtD can contain one or more ports, and/or one or more trunks.

Use the following command to find out how many times link failure was detected on the LtM, how many times Spanning Tree blocking state was detected on the LtM, and how many times UFD disabled ports in the LtD:

```
RS G8000 (config)# show ufd counters
```

## Configuring UFD

Figure 10-1 shows a basic UFD configuration. In this example, NIC 1 is the primary network adapter; NIC 2 is a non-primary adapter. NIC 1 is connected to port 16 and NIC 2 is connected to port 17. Port 2 is connected to a Layer 2/3 routing switch.

The following procedure pertains to the example shown in Figure 10-1.

1. **Configure Network Adapter Teaming on the servers.**
2. **Assign the Link to Monitor (LtM) ports.**

```
RS G8000 (config)# ufd fdp ltm port 2
```

3. **Assign the Link to Disable (LtD) ports.**

```
RS G8000 (config)# ufd fdp ltd port 16
```

4. **Turn on Uplink Failure Detection (UFD).**

```
RS G8000 (config)# ufd fdp enable  
RS G8000 (config)# ufd enable
```

## Monitoring UFD

The UFD information menu displays the current status of the LtM and LtD, and their member ports or trunks. For example:

```
RS G8000# show ufd
```

## APPENDIX A

# Troubleshooting

---

This section discusses some tools to help you troubleshoot common problems on the RackSwitch G8000:

- [“Monitoring Ports” on page 140](#)

## Monitoring Ports

The port mirroring feature in the G8000 allows you to attach a sniffer to a monitoring port that is configured to receive a copy of all packets that are forwarded from the mirrored port. The G8000 enables you to mirror port traffic for all layer 2 and layer 3. Port mirroring can be used as a troubleshooting tool or to enhance the security of your network. For example, an IDS server can be connected to the monitor port to detect intruders attacking the network.

As shown in [Figure A-1](#), port 13 is monitoring *ingress* traffic (traffic entering the switch) on port 2 and *egress* traffic (traffic leaving the switch) on port 12. You can attach a device to port 13 to monitor the traffic on ports 2 and port 12.



**Figure A-1** Monitoring Ports

[Figure A-1](#) shows two mirrored ports monitored by a single port. Similarly, you can have a single or groups of:

- one mirrored port to one monitored port
- more than two mirrored ports to one monitored port

The G8000 supports four monitor ports. The G8000 does not support a single port being monitored by multiple ports.

Ingress and egress traffic is duplicated and sent to the monitor port after processing.

## Port Mirroring behavior

This section describes the composition of monitored packets in the switch, based on the configuration of the ports.

The following port-mirroring cases apply to the G8000:

- Ingress mirrored packets are not modified.
- Egress mirrored packets are tagged with the PVID of the egress port.

## Configuring Port Mirroring

To configure port mirroring for the example shown in [Figure A-1](#):

1. **Specify the monitoring port, the mirroring port(s), and the port-mirror direction.**

```
RS G8000 (config)# port-mirroring monitor-port 3 mirroring-port 2 in
RS G8000 (config)# port-mirroring monitor-port 3
                    mirroring-port 12 out
```

2. **Enable port mirroring.**

```
RS G8000 (config)# port-mirroring enable
```

3. **View the current configuration.**

```
RS G8000# show port-mirroring
Port mirroring is enabled
Monitoring Ports      Mirrored Ports
1                     none
2                     none
3                     (3, in) (12, out)
4                     none
5                     none
...
```



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