ExtremeWare Software User Guide

Software Version 7.3.0

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Contents

Preface

Introduction **29**
Terminology 30

Conventions **30**

Related Publications **30**
Using ExtremeWare Publications Online 31

Part 1 Using ExtremeWare

Chapter 1 ExtremeWare Overview

Summary of Features **35**
Virtual LANs (VLANs) 36
Spanning Tree Protocol 37
Quality of Service 37
Unicast Routing 37
IP Multicast Routing 38
Load Sharing 38

Software Licensing **38**
Router Licensing 38
Security Licensing 40

Software Factory Defaults **40**

Chapter 2 Accessing the Switch

Understanding the Command Syntax **43**
Syntax Helper 44
Command Shortcuts 44
Modular Switch Numerical Ranges 45
Stand-alone Switch Numerical Ranges 45
Names 45

Symbols 46
Limits 46

Line-Editing Keys 46

Command History 47

Common Commands 47

Configuring Management Access 49
User Account 49
Administrator Account 50
Default Accounts 50
Creating a Management Account 51

Domain Name Service Client Services 52

Checking Basic Connectivity 52
Ping 53
Traceroute 53

Chapter 3 Managing the Switch

Overview 55

Using the Console Interface 56

Using the 10/100 Ethernet Management Port 56

Using Telnet 57
Connecting to Another Host Using Telnet 57
Configuring Switch IP Parameters 57
Disconnecting a Telnet Session 59
Controlling Telnet Access 59

Using Secure Shell 2 (SSH2) 60

Using ExtremeWare Vista 60
Controlling Web Access 61
Setting Up Your Browser 61
Accessing ExtremeWare Vista 62
Navigating ExtremeWare Vista 62
Saving Changes 64
Filtering Information 64
Do a GET When Configuring a VLAN 64
Sending Screen Output to Extreme Networks 65

Using SNMP 65
Enabling and Disabling SNMPv1/v2c and SNMPv3 65
Accessing Switch Agents 66
Supported MIBs 66
Configuring SNMPv1/v2c Settings 66
Displaying SNMP Settings 67
SNMP Trap Groups 68

SNMPv3 70
SNMPv3 Overview 70
Message Processing 71
SNMPv3 Security 71
MIB Access Control 73
Notification 74

Authenticating Users 77
RADIUS Client 77
TACACS+ 77
Configuring RADIUS Client and TACACS+ 77

Using Network Login 77

Using the Simple Network Time Protocol 78
Configuring and Using SNTP 78
SNTP Example 81

Using Alternative Queue Management 81
Default Queue Management Behavior 81
Enabling Alt-Queue Management 82

Chapter 4 Configuring Slots and Ports on a Switch

Configuring a Slot on a Modular Switch 85
Mode of Operation (Alpine 3802) 86

Configuring Ports on a Switch 87
Enabling and Disabling Switch Ports 87
Configuring Switch Port Speed and Duplex Setting 87
Configuring Link Detection 89
Configuring Interpacket Gap for 10 Gigabit Ethernet Ports 89

Jumbo Frames 90
Enabling Jumbo Frames 90
Path MTU Discovery 91
IP Fragmentation with Jumbo Frames 91
IP Fragmentation within a VLAN 92

Load Sharing on the Switch 92
Dynamic Versus Static Load Sharing 92
Load-Sharing Algorithms 93
Configuring Switch Load Sharing 94
Load-Sharing Examples 95
Verifying the Load-Sharing Configuration 96
Performance Enhancements for Load Sharing 96

Switch Port-Mirroring 97
Modular Switch Port-Mirroring Example 97
Stand-alone Switch Port-Mirroring Example 98

Extreme Discovery Protocol 98

Software-Controlled Redundant Port and Smart Redundancy **98**
Software-Controlled Redundant Load-Shared Port Groups 100
Limitations of Software-Controlled Redundant Ports and Port Groups 100
Configuring Software-Controlled Redundant Ports 101
Configuring Software-Controlled Redundant Load-Shared Port Groups 101

Port Aggregate Bandwidth Control **102**
Configuring Port Aggregate Control Bandwidth 103
Displaying Port Aggregate Control Bandwidth Configuration 103

Chapter 5 Hitless Failover and Hitless Upgrade

Causes and Behaviors of MSM Failover **106**

Summary of Supported Features **107**

Overview of Hitless Failover **108**
Hitless Failover Concepts 108

Configuring Hitless Failover **109**
Enabling Hitless Failover 109
Configuring Timers 111
Disabling Hitless Failover 111
Displaying Hitless Failover Statistics 111

Configuring ESRP for Hitless Failover **112**
ESRP Domain Behavior 113
Displaying ESRP Hitless Failover Statistics 114

Overview of Hitless Upgrade **114**
Standard Upgrade 115
Conservative Upgrade 115

Performing a Hitless Upgrade **115**
Standard Software Upgrade 115
Conservative Software Upgrade 117
Troubleshooting 118

Chapter 6 Virtual LANs (VLANs)

Overview of Virtual LANs **121**
Benefits 121

Types of VLANs **122**
Port-Based VLANs 122
Tagged VLANs 124
Protocol-Based VLANs 127
Precedence of Tagged Packets Over Protocol Filters 129

VLAN Names **130**
Default VLAN 130
Renaming a VLAN 130

Configuring VLANs on the Switch **131**
VLAN Configuration Examples 131

Displaying VLAN Settings **132**
Displaying VLAN Statistics 133
Displaying VLAN Statistics Per Port 133
Displaying Protocol Information 134

VLAN Tunneling (VMANs) **134**

MAC-Based VLANs **136**
MAC-Based VLAN Guidelines 136
MAC-Based VLAN Limitations 137
MAC-Based VLAN Example 137
Timed Configuration Download for MAC-Based VLANs 137

VLAN Translation **139**
VLAN Translation Behavior 140
VLAN Translation Limitations and Notes 140
VLAN Translation Configuration Examples 141

Chapter 7 Forwarding Database (FDB)

Overview of the FDB **147**
FDB Contents 147
How FDB Entries Get Added 147
FDB Entry Types 148
Disabling MAC Address Learning 149

Associating QoS Profiles with an FDB Entry **150**

Scanning the FDB **151**
Enabling FDB Scanning 151
Disabling FDB Scanning 151
Configuring the FDB Scan Interval 152
Displaying FDB Scan Statistics 152

FDB Configuration Examples **153**

MAC-Based Security **153**

Displaying FDB Entries **154**

Chapter 8 Quality of Service (QoS)

Overview of Policy-Based Quality of Service **156**

Applications and Types of QoS **156**
Voice Applications 157
Video Applications 157
Critical Database Applications 157
Web Browsing Applications 157
File Server Applications 158

Configuring QoS **158**

QoS Profiles **159**

Traffic Groupings **160**
IP-Based Traffic Groupings 160
MAC-Based Traffic Groupings 161
Explicit Class of Service (802.1p and DiffServ) Traffic Groupings 162
Configuring DiffServ 164
Physical and Logical Groupings 167

Configuring QoS Traffic Grouping Priorities **168**
Verifying and Resetting QoS Traffic Grouping Priorities 169

Verifying Configuration and Performance **169**
QoS Monitor 169
Displaying QoS Profile Information 170

Modifying a QoS Configuration **170**

Bi-Directional Rate Shaping **170**
Configuring Bi-Directional Rate Shaping 171
Bandwidth Settings 171
Bi-Directional Rate Shaping Limitations 173

Dynamic Link Context System **173**
DLCS Guidelines 173
DLCS Limitations 174

Chapter 9 Network Address Translation (NAT)

Overview **175**

Internet IP Addressing **176**

Configuring VLANs for NAT **176**
NAT Modes 177

Configuring NAT **178**

Creating NAT Rules **178**
Creating Static and Dynamic NAT Rules 178
Creating Portmap NAT Rules 179
Creating Auto-Constrain NAT Rules 179
Advanced Rule Matching 180
Configuring Time-outs 180

Displaying NAT Settings **180**

Disabling NAT **181**

Chapter 10 Server Load Balancing (SLB)

Overview **183**

SLB Components **184**

Nodes 184
Pools 185
Virtual Servers 185
Node, Pool, and Virtual Server Relationships 186

SLB Traffic Types 187

Forwarding Modes 188
Transparent Mode 188
Translation Mode 190
Port Translation Mode 191
GoGo Mode 192

Load-Balancing Methods 193
Round-Robin 193
Ratio 193
Least Connections 194
Priority 194

Advanced SLB Application Example 194

Using Persistence 197
Persistence Methods 197
Persistence Levels 198
Persistence Types 199

Using High Availability System Features 200
Server Load Balancing with ESRP 200
Active-Active Operation 202

Health Checking 205
Ping-Check 206
TCP-Port-Check 206
Service-Check 206
3DNS Health Checking 207
Maintenance Mode 207
Health Checking in GoGo Mode 207

Flow Redirection 208
Web Cache Redirection 209
Policy-Based Routing 211

Chapter 11 Status Monitoring and Statistics

Status Monitoring 213

Slot Diagnostics 214
Runtime Diagnostics (BlackDiamond Switches) 214
Packet Memory Scanning (BlackDiamond Switches) 215

Port Statistics 216

Port Errors 217

Port Monitoring Display Keys **218**

System Temperature **218**

System Health Checking **219**
Checking the Integrity of the FDB 221
Testing the Transceivers 221

Setting the System Recovery Level **224**

Event Management System/Logging **225**
Sending Event Messages to Log Targets 225
Filtering Events Sent to Targets 226
Formatting Event Messages 232
Displaying Real-Time Log Messages 233
Displaying Events Logs 233
Uploading Events Logs 234
Displaying Counts of Event Occurrences 234
Displaying Debug Information 235
Compatibility with previous ExtremeWare commands 236
Logging Configuration Changes 237

Configuring and Monitoring Flow Statistics **237**
Flow Statistics Background Information 237
Collection Port and Filtering Options 240
Collection Architecture Scalability and Reliability 240
Export Criteria 241

Using sFlow® **246**
Configuring sFlow 246

RMON **249**
About RMON 249
RMON Features of the Switch 249
Configuring RMON 250
Event Actions 251

Chapter 12 Security

Security Overview **253**

Network Access Security **253**

MAC-Based VLANs **254**

IP Access Lists (ACLs) **254**
Using IP Access Lists 254
How IP Access Lists Work 255
Precedence Numbers 255
IP Access Rules 255
The permit-established Keyword 257
Adding and Deleting Access List Entries 257
Verifying Access List Configurations 257

IP Access List Examples 258

MAC Address Security 261

Limiting Dynamic MAC Addresses 261

MAC Address Lock Down 263

Network Login 264

Web-Based and 802.1x Authentication 264

Campus and ISP Modes 266

Interoperability Requirements 267

Multiple Supplicant Support 268

Exclusions and Limitations 268

Configuring Wired Network Login 269

Configuring Wireless Network Login 270

Web-Based Authentication User Login Using Campus Mode 272

DHCP Server on the Switch 273

Displaying DHCP Information 274

Network Login Configuration Commands 274

Displaying Network Login Settings 274

Disabling Network Login 275

Wireless Network Login Considerations 275

Additional Configuration Details 275

Trusted Organizational Unique Identifier 277

Unified Access Security 279

Wireless User Access Security 280

Network Security Policies for Wireless Interfaces 282

Security Profiles 284

Secure Web Login Access 287

Unified Access MAC RADIUS 290

Managing Wireless Clients 290

Example Wireless Configuration Processes 291

Switch Protection 308

Routing Access Profiles 308

Using Routing Access Profiles 308

Creating an Access Profile 308

Configuring an Access Profile Mode 309

Adding an Access Profile Entry 309

Deleting an Access Profile Entry 311

Applying Access Profiles 311

Routing Profiles for RIP 312

Routing Access Profiles for IPX 313

Routing Access Profiles for OSPF 313

Routing Access Profiles for DVMRP 315

Routing Access Profiles for PIM 316

Routing Access Profiles for BGP 317

Making Changes to a Routing Access Policy 317

Removing a Routing Access Policy 318

Route Maps 318

Using Route Maps 318
Creating a Route Map 318
Add Entries to the Route Map 318
Add Statements to the Route Map Entries 319
Route Map Operation 321
Changes to Route Maps 322
Route Maps in BGP 322

Denial of Service Protection 323
Configuring Denial of Service Protection 323
Enabling Denial of Service Protection 324
Disabling Denial of Service Protection 324
Displaying Denial of Service Settings 324
How to Deploy DoS Protection 324
Blocking SQL Slammer DoS Attacks 325
Improving Performance with Enhanced DoS Protection 326

Duplicate IP Protection 329
Host Lookup 330
Network Lookup 330
Duplicate IP Address Protection Commands 331

Management Access Security 332

Authenticating Users Using RADIUS or TACACS+ 332
RADIUS Client 332
Configuring TACACS+ 338
RADIUS Authentication Decoupling 339

Secure Shell 2 (SSH2) 342
Enabling SSH2 for Inbound Switch Access 343
Using SCP2 from an External SSH2 Client 344
SSH2 Client Functions on the Switch 345

Part 2 Using Switching and Routing Protocols

Chapter 13 Ethernet Automatic Protection Switching

Overview of the EAPS Protocol 349
EAPS Terms 351

Fault Detection and Recovery 352
Link Down Message Sent by a Transit Node 353
Ring Port Down Event Sent by Hardware Layer 353
Polling 353
Restoration Operations 353

Multiple EAPS Domains Per Switch **354**

Multiple EAPS Rings Sharing Common Links **355**

Configuring EAPS on a Switch **356**
Creating and Deleting an EAPS Domain 356
Defining the EAPS Mode of the Switch 356
Configuring EAPS Polling Timers 356
Configuring the Primary and Secondary Ports 358
Configuring the EAPS Control VLAN 358
Configuring the EAPS Protected VLANs 359
Enabling and Disabling an EAPS Domain 359
Enabling and Disabling EAPS 359
Unconfiguring an EAPS Ring Port 360
Displaying EAPS Status Information 360

Configuring EAPS Shared Ports **363**
Steady State 364
Common Link Failures 364
Creating and Deleting a Shared Port 365
Defining the Mode of the Shared Port 365
Configuring the Link ID of the Shared Port 366
Unconfiguring an EAPS Shared Port 366
Displaying EAPS Shared-Port Status Information 366

EAPS Shared Port Configuration Rules **369**

EAPS Shared Port Configuration Examples **369**
Basic Configuration 369
Basic Core Configuration 370
Right Angle Configuration 370
Combined Basic Core and Right Angle Configuration 371
Large Core and Access Rings Configuration 371
Advanced Configuration 372

Chapter 14 Spanning Tree Protocol (STP)

Overview of the Spanning Tree Protocol **373**

Spanning Tree Domains **374**
STPD Modes 374
Port Modes 375
STPD BPDU Tunneling 375
Rapid Root Failover 375

STP Configurations **376**
Basic STP Configuration 376
Multiple STPDs on a Port 379
VLAN Spanning Multiple STPDs 379
EMISTP Deployment Constraints 380

Per-VLAN Spanning Tree **382**

STPD VLAN Mapping 382
Native VLAN 382

Rapid Spanning Tree Protocol 382
RSTP Terms 383
RSTP Concepts 383
RSTP Operation 386

STP Rules and Restrictions 393

Configuring STP on the Switch 393
STP Configuration Examples 394

Displaying STP Settings 397

Chapter 15 Extreme Standby Router Protocol

Overview of ESRP 399
Reasons to Use ESRP 400
ESRP Terms 400

ESRP Concepts 401
ESRP-Aware Switches 402
Linking ESRP Switches 402

Determining the ESRP Master 403
Master Switch Behavior 403
Pre-Master Switch Behavior 403
Slave Switch Behavior 403
Electing the Master Switch 404
Failover Time 404
ESRP Election Algorithms 404

Advanced ESRP Features 405
ESRP Tracking 405
ESRP Port Restart 410
ESRP and VLAN Aggregation 410
ESRP Host Attach 411
ESRP Don’t Count 412
ESRP Domains 412
ESRP Groups 413
Selective Forwarding 414

Displaying ESRP Information 415

Using ELRP with ESRP 416
ELRP Terms 416
Using ELRP with ESRP to Recover Loops 417
Configuring ELRP 417
Displaying ELRP Information 419

Using Standalone ELRP to Enable Loop Tests 419
About Standalone ELRP 420

Configuring Standalone ELRP 420

ESRP Examples 421

Single VLAN Using Layer 2 and Layer 3 Redundancy 421

Multiple VLANs Using Layer 2 Redundancy 423

ESRP Cautions 424

Configuring ESRP and Multinetting 424

ESRP and Spanning Tree 424

Extreme Link Status Monitoring (ELSM) 425

Enabling ELSM 425

Disabling ELSM 425

Configuring ELSM 425

ELSM Timers 426

ELSM Receive Port 426

ELSM Transmit Port 427

Using ELSM With ESRP 428

Monitoring ELSM 428

Configuring ELSM Debug Tracing 429

Chapter 16 Virtual Router Redundancy Protocol

Overview 431

Determining the VRRP Master 432

VRRP Tracking 432

Electing the Master Router 435

Additional VRRP Highlights 435

VRRP Port Restart 436

VRRP Operation 436

Simple VRRP Network Configuration 436

Fully-Redundant VRRP Network 437

VRRP Configuration Parameters 439

VRRP Examples 440

Configuring the Simple VRRP Network 440

Configuring the Fully-Redundant VRRP Network 441

Chapter 17 IP Unicast Routing

Overview of IP Unicast Routing 443

Router Interfaces 444

Populating the Routing Table 444

Subnet-Directed Broadcast Forwarding 446

Proxy ARP 447

ARP-Incapable Devices 447

Proxy ARP Between Subnets 447

Relative Route Priorities **448**

Configuring IP Unicast Routing **449**
Verifying the IP Unicast Routing Configuration 449

Routing Configuration Example **449**

IP Multinetting **451**
IP Standard Multinetting 451
Proprietary IP Multinetting 456
IP Multinetting Operation 457
IP Multinetting Examples 458

Configuring DHCP/BOOTP Relay **459**
Configuring the DHCP Relay Agent Option (Option 82) 459
Verifying the DHCP/BOOTP Relay Configuration 460

UDP-Forwarding **460**
Configuring UDP-Forwarding 461
UDP-Forwarding Example 461
ICMP Packet Processing 461
UDP Echo Server 461

VLAN Aggregation **462**
VLAN Aggregation Properties 463
VLAN Aggregation Limitations 464
VLAN Aggregation SubVLAN Address Range Checking 464
Isolation Option for Communication Between Sub-VLANs 464
VLAN Aggregation Example 464
Verifying the VLAN Aggregation Configuration 465

Chapter 18 Interior Gateway Protocols

Overview **468**
RIP Versus Either OSPF or IS-IS 468

Overview of RIP **469**
Routing Table 469
Split Horizon 469
Poison Reverse 469
Triggered Updates 469
Route Advertisement of VLANs 470
RIP Version 1 Versus RIP Version 2 470

Overview of OSPF **470**
Link-State Database 470
Areas 472
Point-to-Point Support 475

Route Re-Distribution **475**
Configuring Route Re-Distribution 476
OSPF Timers and Authentication 478

RIP Configuration Example **478**

Configuring OSPF **480**
Configuring OSPF Wait Interval 480

OSPF Configuration Example **481**
Configuration for ABR1 482
Configuration for IR1 482

Displaying OSPF Settings **483**
OSPF LSDB Display 483

Overview of IS-IS **484**
Overview of Integrated IS-IS 484

Implementing IS-IS Routing **485**
Authentication 486
Summarizing Level 1 IP Routing Information 487
Filtering Level 1 IP Routing Information 487
External Route Redistribution 487
Originating Default Route 487
Overload Bit 487
Metric Size 488
Default Routes to Nearest Level 1/2 Switch for Level 1 Only Switches 488

Chapter 19 Exterior Gateway Routing Protocols

Overview **491**

BGP Attributes **492**

BGP Communities **492**

BGP Features **492**
Route Reflectors 493
Route Confederations 493
Route Aggregation 496
IGP Synchronization 497
Using the Loopback Interface 497
BGP Peer Groups 497
BGP Route Flap Dampening 498
BGP Route Selection 501
Stripping Out Private AS Numbers from Route Updates 501

Route Re-Distribution **501**
Configuring Route Re-Distribution 502

Chapter 20 IP Multicast Routing

Overview **503**
DVMRP Overview 504
PIM Overview 504
IGMP Overview 508

Multicast Tools 509
Performance Enhancements for the BlackDiamond Switch 510

Configuring IP Multicasting Routing 510

Configuration Examples 512
PIM-DM Configuration Example 512
Configuration for IR1 513
Configuration for ABR1 514

Configuring Static Multicasting Routing 514

Chapter 21 IPX Routing

Overview of IPX 515
Router Interfaces 515
IPX Routing Performance 516
IPX Load Sharing 517
IPX Encapsulation Types 517
Tagged IPX VLANs 517
Populating the Routing Table 518

IPX/RIP Routing 518
Routing SAP Advertisements 519

Configuring IPX 519
Verifying IPX Router Configuration 520
Protocol-Based VLANs for IPX 520

IPX Configuration Example 521

Part 3 Configuring Modules

Chapter 22 Accounting and Routing Module (ARM)

Summary of Features 525
ARM Module Limitations 526
About IP Unicast Forwarding 526
About Selective Longest Prefix Match 526
About Destination-Sensitive Accounting 528

Configuring the ARM 529
Basic Accounting Configuration Information 529
Basic SLPM Configuration Information 531
Configuring Access Profiles 533
Using Route Maps 533

ARM Configuration Examples 535
Configuring Destination-Sensitive Accounting Based on Destination IP Subnets 535
Configuring Destination-Sensitive Accounting Based on BGP Community Strings 539
Configuring Routing Using SLPM 541

Retrieving Accounting Statistics **544**
Using the CLI to Retrieve Accounting Statistics 544
Using SNMP to Retrieve Accounting Statistics 545

Diagnostics Commands **545**

Layer 2 and Layer 3 Switching Attributes **546**

Debug Trace Commands **546**

547

Chapter 23 Asynchronous Transfer Mode (ATM) Module

About the ATM Module **549**
Feature Summary 550
Function Summary 550

Configuring the ATM Module **552**
Basic ATM Module Configuration Information 552

Configuring and Monitoring ATM Ports **557**
Configuring PVCs 557
Deleting PVCs 557
Displaying ATM Port Status Information 558
Displaying PVC Status Information 559
Configuring ATM Scrambling 559

Configuring and Monitoring SONET **560**
SONET Parameters and Values 560
Configuring SONET Framing 561
Configuring SONET Clocking 561
Configuring the Signal Fail Threshold 561
Configuring the Signal Degrade Threshold 562
Configuring the Section Trace Identifier 562
Configuring the Path Trace Identifier 563
Configuring the Signal Label 563
Resetting SONET Configuration Parameter Values 564
Displaying SONET Status Information on ATM ports 564
SONET Events on ATM Ports 565

Configuring VLAN-Related Attributes **566**
Configuring Tagged VLAN 802.1p and 802.1Q Functions 567
Generic VLAN Registration Protocol Functions 569

Configuring Forwarding Database Attributes **569**

Configuring Spanning Tree Attributes **569**

Configuring QoS Functions **569**
Configuring a QoS Profile 570
Classification and Replacement Policies 571
Configuring DiffServ 572
Enhanced RED Support 574

QoS Monitor 580
Intra-Subnet QoS 580

Limitations and Unsupported Features 581
Configuring Port Attributes 581
Jumbo Frame Support 581
Configuring IGMP Attributes 582
Configuring Layer 2 and 3 Switching Attributes 582
Configuring Access List Attributes 582
Changing Image and Configuration Attributes 582

Chapter 24 Packet Over SONET (PoS) Modules

About the PoS Modules 583
Summary of Features 584
Function Summary 585
Service Provider Features 586

Configuring the PoS Module 588

Basic PoS Module Configuration Information 589
Default PoS Module Configurations 589
PoS Port Configuration and Default VLAN Assignments 589
Default Configuration: Bridging Over PoS Ports 590
Routing Over PoS Ports 591
Automatic Protection Switching 593

Configuring and Monitoring SONET Ports 596
Configuring SONET Framing 596
Configuring SONET Loopback (OC12) 596
Configuring SONET Clocking 597
Configuring the Signal Fail Threshold 597
Configuring the Signal Degrade Threshold 597
Configuring the Section Trace Identifier 598
Configuring the Path Trace Identifier 598
Configuring the Signal Label 599
Resetting SONET Configuration Parameter Values 599
Displaying SONET Port Status Information 599
SONET Events 600

Configuring and Monitoring PPP Functions 602
PPP Overview 602
Creating a PPP User Account 606
Configuring the PoS Checksum 606
Configuring PoS Scrambling 606
Configuring Link Maintenance 607
Configuring PPP Link Quality Monitoring 607
Configuring PPP Authentication 608
Configuring the Name and Password for the Port 608
Creating an Authentication Database Entry 609

Configuring the Network Control Protocol 610
Configuring the MPLS Control Protocol 611
Configuring the OSI Network Layer Control Protocol 611
Configuring the Delayed-Down-Time Interval 612
Displaying PPP Information 612
Resetting PPP Configuration Parameter Values 614

Configuring VLAN-Related Attributes 614
Configuring Tagged VLAN 802.1p and 802.1Q Functions 615
Generic VLAN Registration Protocol Functions 617

Configuring Forwarding Database Attributes 617

Configuring Spanning Tree Attributes 617

Configuring QoS Functions 617
Configuring a QoS Profile 618
Classification and Replacement Policies 618
Configuring DiffServ 620
Enhanced RED Support 622
QoS Monitor 629
Intra-Subnet QoS 629

Configuring and Monitoring Flow Statistics 629
Flow Statistics Background Information 630
Collection Port and Filtering Options 632
Collection Architecture Scalability and Reliability 632
Export Criteria 633
MIB Support for Flow Statistics 639

Configuring and Monitoring APS Functions 639
APS Network Configuration Options 641
Sample Line-Switching Scenario 643
APS Benefits 646
Enabling and Disabling APS 649
Creating and Deleting an APS Group 649
Adding a Port to an APS Group 649
Deleting a Port from an APS Group 650
Configuring APS Authentication 650
Configuring Nonrevertive or Revertive Mode 651
Configuring APS Timers 652
Configuring APS Lockout 652
Configuring Forced Switch Mode 653
Configuring Manual Switch Mode 654
Resetting APS Group Configuration Parameters 654
Displaying APS Group Status Information 655
MIB Support for APS 656

Configuring Port Tunneling 656
Configuring the PoS Port Tunnel 657
Configuring the Ethernet Module 658

Configuring the MPLS tls-Tunnel 658

Limitations and Unsupported Commands 658

Configuring General Switch Attributes 659

PoS Module Limitations 659

Configuring Port Attributes 659

Jumbo Frame Support 659

Configuring Access List Attributes 661

Changing Image and Configuration Attributes 661

Chapter 25 T1, E1, and T3 WAN Modules

Overview 663

Red, Blue, and Yellow Alarms 664

Configuring WAN Physical Links 664

Cable Length 665

Clock Source 665

Facility Data Link 665

Framing 666

Inband Loopback Detection 666

Linecoding 666

Receiver Gain 667

SNMP Alerts 667

Timeslots 667

Yellow Alarms 667

Monitoring WAN Physical Links 668

Loopback 668

Configuring PPP and MLPPP 671

Multilink PPP and Multilink Groups 672

Configuring a PPP/MLPPP Link 672

WAN Multilink Configuration Examples 675

Configuring a Bridged PPP/MLPPP Link Example 675

Configuring a Routed PPP/MLPPP Link Example 676

VLAN Tunneling (VMANs) 676

VMAN Transport by WAN Links 677

VMAN Termination at WAN ports 678

Chapter 26 MultiProtocol Label Switching (MPLS) Module

About MPLS 681

Overview of MPLS 682

MPLS Layer 686

About MPLS Layer-2 VPNs 689

About IP Unicast Forwarding 690

About Destination-Sensitive Accounting 690

About the MPLS Module **691**
Summary of Features 691

Configuring the MPLS Module **692**
Configuring MPLS Interfaces 692
Configuring the Propagation of IP TTL 693
Configuring Penultimate Hop Popping 693
Configuring QoS Mappings 694
Resetting MPLS Configuration Parameter Values 695
Displaying MPLS Configuration Information 695

Configuring the Label Distribution Protocol (LDP) **697**
Overview of LDP 698
Configuring LDP 698

MPLS and IP Routing **702**
Routing Using LSPs 702
LSPs and IBGP Next Hops 705
Optimized Forwarding of Non-MPLS IP Traffic 705

Configuration Example **706**

MPLS Configuration Constraints **708**

Chapter 27 Configuring RSVP-TE

RSVP Elements **710**
Message Types 710
Reservation Styles 712
Bandwidth Reservation 712

Traffic Engineering **714**
RSVP Tunneling 714
RSVP Objects 714

RSVP Features **715**
Route Recording 715
Explicit Route Path LSPs 716
Redundant LSPs 716
Improving LSP Scaling 717

Configuring RSVP-TE **718**
Configuring RSVP-TE on a VLAN 718
Configuring RSVP-TE Protocol Parameters 718
Configuring an RSVP-TE Path 719
Configuring an Explicit Route 720
Configuring an RSVP-TE Profile 721
Configuring an Existing RSVP-TE Profile 722
Configuring an RSVP-TE LSP 722
Adding a Path to an RSVP-TE LSP 723
Displaying RSVP-TE LSP Configuration Information 723
Displaying the RSVP-TE Routed Path 724

Displaying the RSVP-TE Path Profile 724
Displaying the RSVP-TE LSP 724

Configuration Example 724

Chapter 28 Configuring MPLS Layer-2 VPNs

Overview of MPLS Layer-2 VPNs 729
Layer-2 VPN Services 729
MPLS VC Tunnels 730
Layer-2 VPN Domains 731
MAC Learning 731
Spanning Tree Protocols 731

TLS VPN Characteristics 732

Configuring MPLS Layer-2 VPNs 732
Adding a TLS Tunnel 732
Deleting a TLS Tunnel 734
Displaying TLS Configuration Information 734

TLS VPN Configuration Examples 736
Basic MPLS TLS Configuration Example 736
Full Mesh TLS Configuration 737
Hub and Spoke TLS Configuration 738
Configuration Example Using PPP Transparent Mode 739

Using ESRP with MPLS TLS 740
Tunnel Endpoint VLANs 741
LSP Tracking 742
Configuration Example 743

Chapter 29 High Density Gigabit Ethernet Module

About the High Density Gigabit Ethernet Module 747
Alpine High Density Gigabit Ethernet Modules 749
BlackDiamond High Density Gigabit Ethernet Modules 749
Summary of Features 750
Summary of Functions 751

Configuring the High Density Gigabit Ethernet Module 752
Configuring Flow Control 752
Configuring VLANs 752
Configuring Ingress QoS Functions 753
Configuring DiffServ 757
Configuring Rate Limiting on Egress Ports 759
Displaying Statistics 760

Configuration Examples 761
Configuring Ingress Rate Limiting 761
Configuring Bandwidth Requirements for Multiple Types of Traffic 761

Performing Cable Diagnostics **762**
Running Cable Diagnostics 762
Viewing Cable Diagnostics Data 763

Chapter 30 Power Over Ethernet

Summary of PoE Features **765**

Port Power Management **765**
Port Power Operator Limit 766
Power Budget Management 766
Port Power Events 767
Alpine Power Checking for PoE Modules 768

Configuring Power Over Ethernet **768**
Controlling and Monitoring System and Slot Power 769
Controlling and Monitoring Port Power 772

Chapter 31 H-VPLS

VPLS Overview **781**
Increasing the Number of Supported VPNs 783
Eliminating VLAN ID Coordination Between Customers 783
VPLS Network Failure Recovery without Requiring STP 783
Reducing the number of MAC Addresses cached in the Core 784
Reducing the Number of Tunnel LSPs 784
Eliminating Packet Replication by the MTU 784
Simplifying Customer Service Provisioning 784
Minimizing Tunnel LSP Fail-over Times 785
Operational Manageability 785
H-VPLS Support 785
Signaling H-VPLS VC LSPs 785
H-VPLS Interfaces 786
MPLS LDP Peer Access Authentication 786

Configuring H-VPLS **786**
VPLS Configuration 786
VPLS Peers 787
LDP ACLs 787
Health Check Configuration 787
Ping and traceroute 788
Show Commands 788
Reset Command 789

Chapter 32 Wireless Networking

Overview of Wireless Networking **791**
Summary of Wireless Features 792

Wireless Devices **792**

Altitude 300-2d Detachable Antenna 793

Bridging 793

Managing the Altitude 300 793

Wireless Show Commands 794

Configuring RF Properties 795

Creating an RF Profile 795

Deleting an RF Profile 795

Configuring an RF Profile 796

Viewing RF Profile Properties 797

Configuring RF Monitoring 798

AP Detection 798

Performing Client Scanning 801

Enabling and Disabling Client Scanning 801

Configuring Client Scanning 802

Viewing Client Scanning Properties and Results 802

Collecting Client History Statistics 804

Client Current State 804

Client History Information 805

Client Aging 806

Configuring Wireless Switch Properties 807

Configuring Country Codes 807

Configuring the Default Gateway 808

Configuring the Management VLAN 808

Configuring Wireless Ports 808

Enabling and Disabling Wireless Ports 808

Configuring Wireless Port Properties 809

Configuring Wireless Interfaces 809

Enabling and Disabling Wireless Interfaces 810

Configuring Wireless Interfaces 810

Configuring Inter-Access Point Protocol (IAPP) 811

Event Logging and Reporting 812

Enabling SVP to Support Voice Over IP 812

Part 4 Appendixes

Appendix A Software Upgrade and Boot Options

Downloading a New Image 815

Selecting a Primary or a Secondary Image 816

Downloading Images to Slots and Modules 816

Understanding the Image Version String 817

Software Signatures 818
Rebooting the Switch 818
Rebooting a Module 819
Saving Configuration Changes 819
Returning to Factory Defaults 820
Using TFTP to Upload the Configuration 820
Using TFTP to Download the Configuration 821
Downloading a Complete Configuration 821
Downloading an Incremental Configuration 821
Scheduled Incremental Configuration Download 822
Remember to Save 822
Synchronizing MSMs 822
Upgrading and Accessing BootROM 823
Upgrading BootROM 823
Accessing the BootROM Menu 823
Configuring Dual-Mode Default Configuration 824
Appendix B Troubleshooting
LEDs 825
Using the Command-Line Interface 826
Port Configuration 828
VLANs 828
STP 829
Debug Tracing/Debug Mode 830
TOP Command 830
System Health Check 831
System Memory Dump 831
System Odometer 832
Memory Scanning and Memory Mapping 833
Modes of Operation 833
Memory Scanning and Memory Mapping Functions 834
Using Memory Scanning to Screen I/O Modules 840
Reboot Loop Protection 841
Minimal Mode 841
Contacting Extreme Technical Support 842
Appendix C Supported Protocols, MIBs, and Standards
Index

Index of Commands

Preface

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

Introduction

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

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

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

NOTE

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

Terminology

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

Conventions

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

Table 1: Notice Icons

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

Table 2: Text Conventions

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

Related Publications

The publications related to this one are:

- ExtremeWare release notes
- *ExtremeWare 7.3.0 Software Command Reference Guide*
- *Extreme Networks Consolidated “i” Series Hardware Installation Guide*

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

http://www.extremenetworks.com/

Using ExtremeWare Publications Online

You can access ExtremeWare publications by downloading them from the Extreme Networks World Wide Web location or from your ExtremeWare product CD. Publications are provided in Adobe® Portable Document Format (PDF). Displaying or printing PDF files requires that your computer be equipped with Adobe® Reader® software, which is available free of charge from Adobe Systems Incorporated.

NOTE

If you are using Adobe Reader or Adobe Acrobat® Version 6.0 or later to view PDF files, see "Using Adobe Reader Version 6.0" in this section for important information on making a configuration adjustment to ensure proper viewing and linking of PDF files.

The following two ExtremeWare publications are available as PDF files that are designed to be used online together:

- *ExtremeWare Software User Guide*
- *ExtremeWare Software Command Reference Guide*

The user guide PDF file provides links that connect you directly to relevant command information in the command reference guide PDF file. This quick-referencing capability enables you to easily find detailed information in the command reference guide for any command mentioned in the user guide.

To ensure that the quick-referencing feature functions properly, follow these steps:

1. Download both the user guide PDF file and the command reference guide PDF file to the *same* destination directory on your computer.
2. You may open one or both PDF files to enable cross-referenced linking between the user guide and command reference guide; however, it is recommended that for ease of use, you keep both files open concurrently on your computer desktop. To keep both PDF files open when you activate a cross-reference link, open both PDF files before using the link.

Handling PDF Display Problems

To avoid PDF display problems that can complicate effective cross-referenced linking between the *ExtremeWare Software User Guide* and the *ExtremeWare Software Command Reference Guide*, follow the PDF guidelines in this section.

Opening Both PDF Files Before Using the Links. If you activate a cross-referencing link from the *ExtremeWare Software User Guide* PDF file to the *ExtremeWare Software Command Reference* PDF file when the command reference PDF file is closed (that is, not currently open on your computer desktop), the system will first close the user guide PDF file and then open the command reference PDF file. To keep both PDF files open when you activate a cross-reference link, open both PDF files *before* using the link.

Using Adobe Reader Version 6.0. If you are using Adobe Reader version 6.0 or later, or if you are using Reader embedded in Adobe Acrobat version 6.0 or later, follow these steps to ensure proper concurrent viewing and linking of both the user guide and command reference guide PDF files:

1 Double-click a PDF icon to open the Adobe Reader or Adobe Acrobat window.

You can also open the Adobe Reader or Acrobat window by double-clicking the Reader or Acrobat icon on your desktop or by using the Windows *Start* menu and navigating to the appropriate Adobe program.

2 In the *Edit* pull-down menu, select *Preferences*. The Preferences window will be displayed.

3 In the Preferences window, select the *General* option displayed in the left-hand column in the list of preference options. The General options will be displayed in the Preferences window.

4 In the Miscellaneous area of the Preferences window (shown in the lower section of the Preferences window), deselect the following option:

```
Open cross-document links in same window
```

To deselect this option, make sure that the check box next to it is *unchecked*.

5 Click *OK*.

Part 1

Using ExtremeWare

1 ExtremeWare Overview

This chapter covers the following topics:

- Summary of Features on page 35
- Software Licensing on page 38
- Software Factory Defaults on page 40

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

NOTE

ExtremeWare 7.3.0 only supports Extreme Networks products that contain the "i" or "t" series chipset. This includes the BlackDiamond, Alpine, and Summit "i" series platforms, but does not include the Summit 24e3 and Summit 200 series platforms.

Summary of Features

The features of ExtremeWare include:

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

- Diffserv support
- Access-policy support for routing protocols
- Access list support for packet filtering
- Internet Group Management Protocol (IGMP) snooping to control IP multicast traffic
- Distance Vector Multicast Routing Protocol (DVMRP)
- Protocol Independent Multicast-Dense Mode (PIM-DM)
- Protocol Independent Multicast-Sparse Mode (PIM-SM)
- Wire-speed IPX, IPX/RIP, and IPX/SAP support
- Server Load Balancing (SLB) support
- Load sharing on multiple ports, across all blades (modular switches only)
- Remote Authentication Dial In User Service (RADIUS) client and per-command authentication support
- Terminal Access Controller Access Control System Plus (TACACS+) support
- Console command line interface (CLI) connection
- Telnet CLI connection
- Secure Shell Version 2 (SSH2) connection
- ExtremeWare Vista Web-based management interface
- Simple Network Management Protocol (SNMP) support
- Remote Monitoring (RMON)
- Switch Network Monitoring (SMON)
- Traffic mirroring
- Network Login support
- Accounting and Routing Module (ARM) support
- Asynchronous Transfer Mode Module (ATM) support
- Packet over Synchronous Optical Network (SONET) (PoS) Module support
- WAN Module support
- MultiProtocol Label Switching (MPLS) support
- Digital Signal Algorithm (DSA) support

NOTE

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

Virtual LANs (VLANs)

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

Implementing VLANs on your network has the following three advantages:

- VLANs help to control broadcast traffic. If a device in VLAN *Marketing* transmits a broadcast frame, only VLAN *Marketing* devices receive the frame.
- VLANs provide extra security. Devices in VLAN *Marketing* can only communicate with devices on VLAN *Sales* using routing services.
- VLANs ease the change and movement of devices on networks.

NOTE

For more information on VLANs, see Chapter 6.

Spanning Tree Protocol

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

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

A single spanning tree can span multiple VLANs.

NOTE

For more information on STP, see Chapter 14.

Quality of Service

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

NOTE

For more information on Quality of Service, see Chapter 8.

Unicast Routing

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

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

NOTE

For more information on IP unicast routing, see Chapter 17. For more information on IPX/RIP, see Chapter 21.

IP Multicast Routing

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

NOTE

For more information on IP multicast routing, see Chapter 20.

Load Sharing

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

NOTE

For information on load sharing, see Chapter 4.

Software Licensing

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

Router Licensing

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

Basic Functionality

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

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

- Network Login
- VRRP
- EAPS
- VLAN Translation

Full L3 Functionality

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

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

Product Support

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

Verifying the Router License

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

Obtaining a Router License

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

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

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

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

or by phoning Extreme Networks Technical Support at:

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

Security Licensing

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

Obtaining a Security License

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

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

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

Security Features Under License Control

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

Software Factory Defaults

Table 3 shows factory defaults for global ExtremeWare features.

Table 3: ExtremeWare Global Factory Defaults

Item	Default Setting
Serial or Telnet user account	*admin* with no password and *user* with no password
Web network management	Enabled
Telnet	Enabled
SSH2	Disabled
SNMP	Enabled
SNMP read community string	*public*
SNMP write community string	*private*
RMON	Disabled

Table 3: ExtremeWare Global Factory Defaults (Continued)

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

NOTE

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

2 Accessing the Switch

This chapter covers the following topics:

- Understanding the Command Syntax on page 43
- Line-Editing Keys on page 46
- Command History on page 47
- Common Commands on page 47
- Configuring Management Access on page 49
- Domain Name Service Client Services on page 52
- Checking Basic Connectivity on page 52

Understanding the Command Syntax

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

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

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

1 Enter the command name.

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

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

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

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

NOTE

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

Syntax Helper

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

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

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

Abbreviated Syntax

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

NOTE

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

Command Shortcuts

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

```
create vlan engineering
```

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

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

you could enter the following shortcut:

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

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

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

you could enter the following shortcut:

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

Modular Switch Numerical Ranges

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

```
port 3:1
```

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

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

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

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

You can specify all ports on a particular slot by using an asterisk (*). For example,

```
port 3:*
```

indicates all ports on slot 3.

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

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

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

Stand-alone Switch Numerical Ranges

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

```
port 1-3
```

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

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

Names

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

Symbols

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

Table 4: Command Syntax Symbols

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

Limits

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

Line-Editing Keys

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

Table 5: Line-Editing Keys

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

Table 5: Line-Editing Keys (Continued)

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

Command History

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

```
history
```

Common Commands

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

Table 6: Common Commands

Command	Description
clear session <number>	Terminates a Telnet session from the switch.
configure account <user account> {encrypted} {<password>}	Configures a user account password. The switch will interactively prompt for a new password, and for reentry of the password to verify it. Passwords must have a minimum of 1 character and can have a maximum of 30 characters. Passwords are case-sensitive; user names are not case sensitive.
configure banner	Configures the banner string. You can enter up to 24 rows of 79-column text that is displayed before the login prompt of each session. Press [Return] at the beginning of a line to terminate the command and apply the banner. To clear the banner, press [Return] at the beginning of the first line.
configure banner netlogin	Configures the network login banner string. You can enter up to 1024 characters to be displayed before the login prompt of each session.
configure ports [<portlist> | all | mgmt] auto off {speed [10 | 100 | 1000]} duplex [half | full]	Manually configures the port speed and duplex setting of one or more ports on a switch.

Table 6: Common Commands (Continued)

Command	Description
configure slot <slot> module <module name>	Configures a slot for a particular I/O module card.
configure ssh2 key {pregenerated}	Generates the SSH2 host key.
configure sys-recovery-level [none | [all | critical] [msm-failover | reboot | shutdown | system-dump [maintenance-mode | msm-failover | reboot | shutdown]]]	Configures a recovery option for instances where an exception occurs in ExtremeWare. The `msm-failover` option is available on BlackDiamond® switches only. If `msm-failover` is specified, a software exception triggers a slave Management Switch Fabric Module (MSM) failover to master.
configure time <date> <time>	Configures the system date and time. The format is as follows: `mm/dd/yyyy hh:mm:ss` The time uses a 24-hour clock format. You cannot set the year past 2036.
configure timezone {name <std_timezone_ID>} <GMT_offset> {autodst {name <dst_timezone_ID>} {<dst_offset>} {begins [every <floatingday> | on <absoluteday>] {at <time_of_day>} {ends [every <floatingday> | on <absoluteday>] {at <time_of_day>}}} | noautodst}	Configures the time zone information to the configured offset from GMT time. The format of `gmt_offset` is +/- minutes from GMT time. The `autodst` and `noautodst` options enable and disable automatic Daylight Saving Time change based on the North American standard. Additional options are described in the *ExtremeWare Software Command Reference Guide*.
configure vlan <vlan name> ipaddress <ipaddress> {<netmask> | <mask length>}	Configures an IP address and subnet mask for a VLAN.
create account [admin | user] <username> {encrypted} {<password>}	Creates a user account. This command is available to admin-level users and to users with RADIUS command authorization. The username is between 1 and 30 characters, the password is between 0 and 30 characters.
create vlan <vlan name>	Creates a VLAN.
delete account <username>	Deletes a user account.
delete vlan <vlan name>	Deletes a VLAN.
disable bootp vlan [<vlan name> | all]	Disables BOOTP for one or more VLANs.
disable cli-config-logging	Disables logging of CLI commands to the Syslog.
disable clipaging	Disables pausing of the screen display when a show command output reaches the end of the page.
disable idletimeouts	Disables the timer that disconnects all sessions. Once disabled, console sessions remain open until the switch is rebooted or you logoff. Telnet sessions remain open until you close the Telnet client.
disable ports [<portlist> | all]	Disables a port on the switch.
disable ssh2	Disables SSH2 Telnet access to the switch.
disable telnet	Disables Telnet access to the switch.
disable web	Disables web access to the switch.
enable bootp vlan [<vlan name> | all]	Enables BOOTP for one or more VLANs.
enable cli-config-logging	Enables the logging of CLI configuration commands to the Syslog for auditing purposes. The default setting is enabled.
enable clipaging	Enables pausing of the screen display when `show`command output reaches the end of the page. The default setting is enabled.

Table 6: Common Commands (Continued)

Command	Description
enable idletimeouts	Enables a timer that disconnects all sessions (both Telnet and console) after 20 minutes of inactivity. The default setting is disabled.
enable license [basic_L3 | advanced_L3 | full_L3] <license_key>	Enables a particular software feature license. Specify `<license_key>` as an integer. The command `unconfigure switch {all} {enhanced}` does not clear licensing information. This license cannot be disabled once it is enabled on the switch.
enable ssh2 {access-profile [<access profile> | none]} {port <tcp_port_number>}	Enables SSH2 sessions. By default, SSH2 is enabled with no access profile, and uses TCP port number 22. To cancel a previously configured access-profile, use the `none` option.
enable telnet {access-profile [<access_profile> | none]} {port <tcp_port_number>}	Enables Telnet access to the switch. By default, Telnet is enabled with no access profile, and uses TCP port number 23. To cancel a previously configured access-profile, use the `none` option.
enable web {access-profile [<access_profile> | none]} {port <tcp_port_number>}	Enables ExtremeWare Vista™ web access to the switch. By default, web access is enabled with no access profile, using TCP port number 80. Use the `none` option to cancel a previously configured access-profile.
history	Displays the previous 49 commands entered on the switch.
show banner	Displays the user-configured banner.
unconfigure switch {all} {enhanced}	Resets all switch parameters (with the exception of defined user accounts, and date and time information) to the factory defaults. If you specify the keyword `all`, the switch erases the currently selected configuration image in flash memory and reboots. As a result, all parameters are reset to default settings.

Configuring Management Access

ExtremeWare supports the following two levels of management:

- User
- Administrator

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

User Account

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

- User account database.
- SNMP community strings.

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

```
Summit1:2>
```

Administrator Account

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

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

```
Summit1:18#
```

Prompt Text

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

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

```
*Summit1:19#
```

Default Accounts

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

Table 7: Default Accounts

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

Changing the Default Password

Default accounts do not have passwords assigned to them. Passwords can have a minimum of zero characters and can have a maximum of 30 characters.

NOTE

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

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

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

2 At the password prompt, press [Return].

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

```
configure account admin
```

4 Enter the new password at the prompt.

5 Re-enter the new password at the prompt.

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

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

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

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

```
configure account user
```

4 Enter the new password at the prompt.

5 Re-enter the new password at the prompt.

NOTE

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

Creating a Management Account

The switch can have a total of 16 management accounts. You can use the default names (*admin* and *user*), or you can create new names and passwords for the accounts. Passwords can have a minimum of 0 characters and can have a maximum of 30 characters.

To create a new account, follow these steps:

1 Log in to the switch as *admin*.

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

3 Add a new user by using the following command:

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

4 Enter the password at the prompt.

5 Re-enter the password at the prompt.

Viewing Accounts

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

```
show accounts
```

Deleting an Account

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

```
delete account <username>
```

NOTE

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

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

Domain Name Service Client Services

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

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

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

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

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

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

```
configure dns-client default-domain <domain_name>
```

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

Checking Basic Connectivity

The switch offers the following commands for checking basic connectivity:

- `ping`
- `traceroute`

Ping

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

The ping command syntax is:

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

Options for the ping command are described in Table 8.

Table 8: Ping Command Parameters

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

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

Traceroute

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

```
traceroute <host name/ip> {from <source IP address>} {ttl <number>} {port <port
number>}
```

where:

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

3 Managing the Switch

This chapter covers the following topics:

- Overview on page 55
- Using the Console Interface on page 56
- Using the 10/100 Ethernet Management Port on page 56
- Using Telnet on page 57
- Using Secure Shell 2 (SSH2) on page 60
- Using ExtremeWare Vista on page 60
- Using SNMP on page 65
- Authenticating Users on page 77
- Using Network Login on page 77
- Using the Simple Network Time Protocol on page 78

Overview

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

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

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

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

Using the Console Interface

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

NOTE

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

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

Using the 10/100 Ethernet Management Port

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

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

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

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

```
configure vlan <vlan name> ipaddress <ipaddress> {<netmask> | <mask length>}
configure iproute add default <gateway> {<metric>}
```

Using Telnet

Any workstation with a Telnet facility should be able to communicate with the switch over a TCP/IP network using VT-100 terminal emulation.

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

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

NOTE

Maximize the Telnet screen so that automatically updating screens display correctly.

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

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

Connecting to Another Host Using Telnet

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

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

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

Configuring Switch IP Parameters

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

Using a BOOTP Server

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

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

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

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

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

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

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

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

NOTE

For more information on DHCP/BOOTP relay, see Chapter 17.

Manually Configuring the IP Settings

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

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

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

NOTE

For information on creating and configuring VLANs, see Chapter 6.

To manually configure the IP settings, follow these steps:

1. Connect a terminal or workstation running terminal-emulation software to the console port, as detailed in "Using the Console Interface" on page 56.
2. At your terminal, press [Return] one or more times until you see the login prompt.
3. At the login prompt, enter your user name and password. Note that they are both case-sensitive. Ensure that you have entered a user name and password with administrator privileges.
   - If you are logging in for the first time, use the default user name *admin* to log in with administrator privileges. For example:

     ```
     login: admin
     ```

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

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

   ```
   configure vlan <vlan name> ipaddress <ipaddress> {<netmask> | <mask length>}
   ```

For example:

```
configure vlan default ipaddress 123.45.67.8 255.255.255.0
```

Your changes take effect immediately.

NOTE

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

```
configure vlan default ipaddress 123.45.67.8 / 24
```

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

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

For example:

```
configure iproute add default 123.45.67.1
```

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

```
save configuration {primary | secondary}
```

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

`logout` or `quit`

Disconnecting a Telnet Session

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

To terminate a Telnet session, follow these steps:

1 Log in to the switch with administrator privileges.

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

```
show session
```

3 Terminate the session by using the following command:

```
clear session <number>
```

Controlling Telnet Access

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

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

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

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

```
show management
```

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

```
disable telnet
```

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

```
enable telnet
```

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

NOTE

For more information on Access Profiles, see Chapter 12.

Using Secure Shell 2 (SSH2)

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

For detailed information about SSH2 and SCP2, see Chapter 12, "Security".

Using ExtremeWare Vista

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

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

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

NOTE

For more information on assigning an IP address, see "Configuring Switch IP Parameters" on page 57.

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

http://<ipaddress>

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

Controlling Web Access

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

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

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

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

```
show management
```

To disable ExtremeWare Vista, use the following command:

```
disable web
```

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

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

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

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

By default this timeout is set to 30 seconds.

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

NOTE

For more information on rebooting, see Appendix A.

Setting Up Your Browser

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

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

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

  If you are using Microsoft Internet Explorer, configure the Temporary Internet Files setting to check for newer versions of stored pages by selecting “Every visit to the page.”
- Images must be auto-loaded.
- Use a high-resolution monitor to maximize the amount of information displayed in the content frame. The recommended resolution is 1024 x 768 pixels. You can also use 800 x 600 pixels.

- Turn off one or more of the browser toolbars to maximize the viewing space of the ExtremeWare Vista content screen.
- If you will be using ExtremeWare Vista to send an email to the Extreme Networks Technical Support department, configure the email settings in your browser.
- Configure the browser to use the following recommended fonts:
  - Proportional font—Times New Roman
  - Fixed-width font—Courier New

Accessing ExtremeWare Vista

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

http://<ip_address>

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

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

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

```
Web:server busy
```

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

Navigating ExtremeWare Vista

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

ExtremeWare Vista divides the browser screen into the following sections:

- Task frame
- Content frame
- Standalone buttons

Task Frame

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

- Configuration
- Statistics
- Support
- Logout

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

NOTE

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

Content Frame

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

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

Table 9: Multiselect List Box Key Definitions

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

Status Messages

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

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

Standalone Buttons

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

Saving Changes

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

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

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

- Click the Logout button.

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

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

Filtering Information

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

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

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

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

Do a GET When Configuring a VLAN

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

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

Sending Screen Output to Extreme Networks

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

1 Click on the content frame of the screen that you must send.

2 From Netscape Navigator, select Save Frame As from the File menu, and enter a name for the file.

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

From Microsoft Internet Explorer 4.0, right-click in the content frame, select View Source, and save the HTML text by copying it and pasting it into a text editor.

3 Attach the file to the email message that you are sending to Extreme Networks.

Using SNMP

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

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

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

Enabling and Disabling SNMPv1/v2c and SNMPv3

ExtremeWare versions since 7.1.0 can concurrently support SNMPv1/v2c and SNMPv3. The default for the switch is to have both types of SNMP enabled. Network managers can access the device with either SNMPv1/v2c methods or SNMPv3. To enable concurrent support, use the following command:

```
enable snmp access
```

To prevent any type of SNMP access, use the following command:

```
disable snmp access
```

To prevent access using SNMPv1/v2c methods and allow access using SNMPv3 methods only, use the following commands:

```
enable snmp access
disable snmp access {snmp-v1v2c}
```

There is no way to configure the switch to allow SNMPv1/v2c access and prevent SNMPv3 access.

Most of the commands that support SNMPv1/v2c use the keyword `snmp`, most of the commands that support SNMPv3 use the keyword `snmpv3`.

Accessing Switch Agents

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

By default, SNMP access and SNMPv1/v2c traps are enabled. SNMP access and SNMP traps can be disabled and enabled independently—you can disable SNMP access but still allow SNMP traps to be sent, or vice versa.

Supported MIBs

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

NOTE

The SNMP ifAdminStatus MIB value is not saved after a reboot. Ports set to down in the SNMP ifAdminStatus MIB come back after rebooting. However, if you save the configuration using the CLI or SNMP after changing the port status to down in the ifAdminStatus MIB, then the change is saved after a reboot.

Configuring SNMPv1/v2c Settings

The following SNMPv1/v2c parameters can be configured on the switch:

- **Authorized trap receivers**—An authorized trap receiver can be one or more network management stations on your network. The switch sends SNMPv1/v2c traps to all trap receivers. You can have a maximum of 16 trap receivers configured for each switch, and you can specify a community string and UDP port individually for each trap receiver. All community strings must also be added to the switch using the `configure snmp add community` command.

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

  ```
  configure snmp add trapreceiver <ip address> {port <number>} community {hex}
  <community string> {from <source ip address>} {mode [enhanced | standard]}
  trap-group {auth-traps{,}} {bgp-traps{,}} {extreme-traps{,}}
  {link-up-down-traps{,}} {ospf-traps{,} {ping-traceroute-traps{,}} {rmon-traps{,}}
  {security-traps{,}} {smart-traps{,}} {stp-traps{,}} {system-traps{,}}
  {vrrp-traps{,}}
  ```

  See the Command Reference for a listing of the available traps.

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

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

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

  To configure SNMPv1/v2c read access to use an access profile, use the following command:

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

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

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

  To configure SNMPv1/v2c read/write access to use an access profile, use the following command:

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

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

- **Community strings**—The community strings allow a simple method of authentication between the switch and the remote Network Manager. There are two types of community strings on the switch. Read community strings provide read-only access to the switch. The default read-only community string is *public*. Read-write community strings provide read and write access to the switch. The default read-write community string is *private*.
- **System contact** (optional)—The system contact is a text field that enables you to enter the name of the person(s) responsible for managing the switch.
- **System name**—The system name is the name that you have assigned to this switch. The default name is the model name of the switch (for example, Summit1 switch).
- **System location** (optional)—Using the system location field, you can enter an optional location for this switch.
- **Enabling/disabling link up and link down traps** (optional)—By default, link up and link down traps (also called port-up-down traps) are enabled on the switch for all ports. SNMPv1 traps for link up and link down are not supported; ExtremeWare uses SNMPv2 traps.

  You can disable or re-enable the sending of these traps on a per port basis, by using the following commands:

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

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

  The mgmt option will only appear on platforms having a management port.
- **Enabling/disabling exceed-committed-rate traps**—By default these traps are disabled on the switch for all ports. This command is available on “3” series I/O modules only.

  You can disable or enable the sending of these traps on a per port basis, by using the following command:

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

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

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

NOTE

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

Displaying SNMP Settings

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

```
show management
```

This command displays the following information:

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

SNMP Trap Groups

SNMP trap groups allow you to specify which SNMP traps to send to a particular trap receiver. This functionality was made possible by the underlying support for SNMPv3. Essentially, a number of predefined filters are associated with a trap receiver, so that only those traps are sent. If you have already been using SNMPv1/v2c trap receivers, trap groups are very easy to incorporate into your network. You cannot define your own trap groups. If you need to define more selectively which notifications to receive, you will need to use the notification filter capabilities available in SNMPv3.

To configure trap groups, use the following command:

```
configure snmp add trapreceiver <ip address> {port <number>} community {hex}
<community string> {from <source ip address>} {mode [enhanced | standard]} trap-group
{auth-traps{,}} {bgp-traps{,}} {extreme-traps{,}} {link-up-down-traps{,}}
{ospf-traps{,} {ping-traceroute-traps{,}} {rmon-traps{,}} {security-traps{,}}
{smart-traps{,}} {stp-traps{,}} {system-traps{,}} {vrrp-traps{,}}
```

For example, to send system and link up/link down traps to the receiver at 10.20.30.44 port 9347 with the community string *private*, use the following command:

```
configure snmp add trapreceiver 10.20.30.44 port 9347 community private trap-group
link-up-down-traps , system-traps
```

Table 10 lists the currently defined SNMP trap groups. From time to time, new trap groups may be added to this command.

Table 10: SNMP Trap Groups

Trap Group	Notifications	MIB Subtree
stp-traps	newRoot topologyChange	dot1dBridge, 1.3.6.1.2.1.17
bgp-traps	bgpEstablished bgpBackwardTransition extremeBgpPrefixReachedThreshold extremeBgpPrefixMaxExceeded	bgpTraps, 1.3.6.1.2.1.15.7 extremeBgpTrapsPrefix, 1.3.6.1.4.1.1916.4.2.0

Table 10: SNMP Trap Groups (Continued)

Trap Group	Notifications	MIB Subtree
ospf-traps	ospfIfStateChange ospfVirtIfStateChange ospfNbrStateChange ospfVirtNbrStateChange ospfIfConfigError ospfVirtIfConfigError ospfIfAuthFailure ospfVirtIfAuthFailure ospfIfRxBadPacket ospfVirtIfRxBadPacket ospfTxRetransmit ospfVirtIfTxRetransmit ospfOriginateLsa ospfMaxAgeLsa ospfLsdbOverflow ospfLsdbApproachingOverflow	ospfTraps, 1.3.6.1.2.1.14.16.2
ping-traceroute-traps	pingTestFailed pingTestCompleted tracerouteTestFailed tracerouteTestCompleted	pingNotifications, 1.3.6.1.2.1.80.0 traceRouteNotifications, 1.3.6.1.2.1.81.0
vrrp-traps	vrrpTrapNewMaster vrrpTrapAuthFailure	vrrpNotifications, 1.3.6.1.2.1.68.0
system-traps	extremeOverheat extremeFanFailed extremeFanOK extremePowerSupplyFail extremePowerSupplyGood extremeModuleStateChange extremeHealthCheckFailed extremeCpuUtilizationRisingTrap extremeCpuUtilizationFallingTrap coldStart warmStart	1.3.6.1.4.1.1916.0.6 1.3.6.1.4.1.1916.0.7 1.3.6.1.4.1.1916.0.8 1.3.6.1.4.1.1916.0.10 1.3.6.1.4.1.1916.0.11 1.3.6.1.4.1.1916.0.15 1.3.6.1.4.1.1916.4.1.0.1 1.3.6.1.4.1.1916.4.1.0.2 1.3.6.1.4.1.1916.4.1.0.3 1.3.6.1.6.3.1.1.5.1 1.3.6.1.6.3.1.1.5.2
extreme-traps	extremeEsrpStateChange extremeEdpNeighborAdded extremeEdpNeighborRemoved extremeSlbUnitAdded extremeSlbUnitRemoved	1.3.6.1.4.1.1916.0.17 1.3.6.1.4.1.1916.0.20 1.3.6.1.4.1.1916.0.21 1.3.6.1.4.1.1916.0.18 1.3.6.1.4.1.1916.0.19
smart-traps	extremeSmartTrap	1.3.6.1.4.1.1916.0.14
auth-traps	AuthenticationFailure extremeInvalidLoginAttempt	1.3.6.1.6.3.1.1.5.5 1.3.6.1.4.1.1916.0.9
link-up-down-traps	linkDown linkUp	1.3.6.1.6.3.1.1.5.3 1.3.6.1.6.3.1.1.5.4
rmon-traps	risingAlarm fallingAlarm	rmon-traps, 1.3.6.1.2.1.16.0
security-traps	extremeMacLimitExceeded extremeUnauthorizedPortForMacDetected extremeMacDetectedOnLockedPort extremeNetloginUserLogin extremeNetloginUserLogout extremeNetloginAuthFailure	1.3.6.1.4.1.1916.4.3.0.1 1.3.6.1.4.1.1916.4.3.0.2 1.3.6.1.4.1.1916.4.3.0.3 1.3.6.1.4.1.1916.4.3.0.4 1.3.6.1.4.1.1916.4.3.0.5 1.3.6.1.4.1.1916.4.3.0.6

SNMPv3

Beginning in ExtremeWare version 7.1.0, support was added for SNMPv3. SNMPv3 is an enhanced standard for SNMP that improves the security and privacy of SNMP access to managed devices, and provides sophisticated control of access to the device MIB. The prior standard versions of SNMP, SNMPv1 and SNMPv2c provided no privacy and little (or no) security.

The following six RFCs provide the foundation for Extreme Networks implementation of SNMPv3:

- RFC 2570, *Introduction to version 3 of the Internet-standard Network Management Framework*, provides an overview of SNMPv3.
- RFC 2571, *An Architecture for Describing SNMP Management Frameworks*, talks about SNMP architecture, especially the architecture for security and administration.
- RFC 2572, *Message Processing and Dispatching for the Simple Network Management Protocol (SNMP)*, talks about the message processing models and dispatching that can be a part of an SNMP engine.
- RFC 2573, *SNMPv3 Applications*, talks about the different types of applications that can be associated with an SNMPv3 engine.
- RFC 2574, *The User-Based Security Model for Version 3 of the Simple Network Management Protocol (SNMPv3)*, describes the User-Based Security Model (USM).
- RFC 2575, *View-based Access Control Model (VACM) for the Simple Network Management Protocol (SNMP)*, talks about VACM as a way to access the MIB.

SNMPv3 Overview

The SNMPv3 standards for network management were primarily driven the need for greater security and access control. The new standards use a modular design and model management information by cleanly defining a message processing subsystem, a security subsystem, and an access control subsystem.

The message processing (MP) subsystem helps identify the MP model to be used when processing a received Protocol Data Unit (PDU), the packets used by SNMP for communication. This layer helps in implementing a multi-lingual agent, so that various versions of SNMP can coexist simultaneously in the same network.

The security subsystem features the use of various authentication and privacy protocols with various timeliness checking and engine clock synchronization schemes. SNMPv3 is designed to be secure against:

- Modification of information, where an in-transit message is altered.
- Masquerades, where an unauthorized entity assumes the identity of an authorized entity.
- Message stream modification, where packets are delayed and/or replayed.
- Disclosure, where packet exchanges are sniffed (examined) and information is learned about the contents.

The access control subsystem provides the ability to configure whether access to a managed object in a local MIB is allowed for a remote principal. The access control scheme allows you to define access policies based on MIB views, groups, and multiple security levels.

In addition, the SNMPv3 target and notification MIBs provide a more procedural approach for the generation and filtering of notifications.

SNMPv3 objects are stored in non-volatile memory unless specifically assigned to volatile storage. Objects defined as permanent cannot be deleted or modified.

NOTE

In SNMPv3, many objects can be identified by a human-readable string or by a string of hex octets. In many commands, you can use either a character string, or a colon separated string of hex octets to specify objects. This is indicated by the keyword `hex` *used in the command.*

Message Processing

A particular network manager may require messages that conform to a particular version of SNMP. The choice of the SNMPv1, SNMPv2, or SNMPv3 message processing model can be configured for each network manager as its target address is configured. The selection of the message processing model is configured with the `mp-model` keyword in the following command:

```
configure snmpv3 add target-params {hex} <param name> user {hex} <user name> mp-model
[snmpv1 | snmpv2c | snmpv3] sec-model [snmpv1 | snmpv2c | usm] {sec-level [noauth |
authnopriv | priv]} {volatile}
```

SNMPv3 Security

In SNMPv3 the User-Based Security Model (USM) for SNMP was introduced. USM deals with security related aspects like authentication, encryption of SNMP messages and defining users and their various access security levels. This standard also encompass protection against message delay and message replay.

USM Timeliness Mechanisms

There is one SNMPv3 engine on an Extreme switch, identified by its *snmpEngineID*. The first four octets are fixed to 80:00:07:7C, which represents the Extreme Networks Vendor ID. By default, the additional octets for the snmpEngineID are generated from the device MAC address. Every SNMPv3 engine necessarily maintains two objects: *SNMPEngineBoots*, which is the number of reboots the agent has experienced and *SNMPEngineTime*, which is the engine local time since reboot. It has a local copy of these objects and the *latestReceivedEngineTime* for every authoritative engine it wants to communicate with. Comparing these objects with the values received in messages and then applying certain rules to decide upon the message validity accomplish protection against message delay or message replay.

In a chassis, the `snmpEngineID` will be generated using the MAC address of the MSM with which the switch boots first. For MSM hitless failover, the same `snmpEngineID` will be propagated to both of the MSMs.

The *snmpEngineID* can be configured from the command line, but once the `snmpEngineID` is changed, default users will be reverted back to their original passwords/keys, while non-default users will be reset to the security level of no authorization, no privacy. Use the following command to set the *snmpEngineID*:

```
configure snmpv3 engine-id <hex octet>
```

SNMPEngineBoots can also be configured from the command line. *SNMPEngineBoots* can be set to any desired value but will latch on its maximum, 2147483647. Use the following command to set the *SNMPEngineBoots*:

```
configure snmpv3 engine-boots <(1-2147483647)>
```

Users, Groups, and Security

SNMPv3 controls access and security using the concepts of users, groups, security models, and security levels.

Users. Users are created by specifying a user name. Depending on whether the user will be using authentication and/or privacy, you would also specify an authentication protocol (MD5 or SHA) with password or key, and/or privacy (DES) password or key. To create a user, use the following command:

```
configure snmpv3 add user {hex} <user name> {authentication [md5 | sha] [hex <hex
octet> | <password>]} {privacy [hex <hex octet> | <password>]} {volatile}
```

There are a number of default, permanent users initially available.The default user names are: *admin, initial, initialmd5, initialsha, initialmd5Priv, initialshaPriv*. The default password for *admin* is *password*. For the other default users, the default password is the user name.

To display information about a user, or all users, use the following command:

```
show snmpv3 user {{hex} <user name>}
```

To delete a user, use the following command:

```
configure snmpv3 delete user [all-non-defaults | {hex} <user name>]
```

NOTE

In the SNMPv3 specifications there is the concept of a security name. In the ExtremeWare implementation, the user name and security name are identical. In this manual we use both terms to refer to the same thing.

Groups. Groups are used to manage access for the MIB. You use groups to define the security model, the security level, and the portion of the MIB that members of the group can read or write. To underscore the access function of groups, groups are defined using the following command:

```
configure snmpv3 add access {hex} <group name> {sec-model [snmpv1 | snmpv2 | usm]}
{sec-level [noauth | authnopriv | authpriv]} {read-view {hex} <view name>} {
write-view {hex} <view name>} {notify-view {hex} <view name>} {volatile}
```

The security model and security level are discussed in the section labeled “Security Models and Levels”. The view names associated with a group define a subset of the MIB (subtree) that can be accessed by members of the group. The read view defines the subtree that can be read, write view defines the subtree that can be written to, and notify view defines the subtree that notifications can originate from. MIB views are discussed in the section “MIB Access Control”.

There are a number of default (permanent) groups already defined. These groups are: *admin, initial, initialmd5, initialsha, initialmd5Priv, initialshaPriv, v1v2c_ro, v1v2c_rw*. Use the following command to display information about the access configuration of a group or all groups:

```
show snmpv3 access {{hex} <group name>}
```

Users are associated with groups using the following command:

```
configure snmpv3 add group {hex} <group name> user {hex} <user name> {sec-model
[snmpv1| snmpv2 | usm]} {volatile}
```

To show which users are associated with a group, use the following command:

```
show snmpv3 group {{hex} <group name> {user {hex} <user name>}}
```

To delete a group, use the following command:

```
configure snmpv3 delete access [all-non-defaults | {{hex} <group name>
{sec-model [snmpv1 | snmpv2c | usm] sec-level [noauth | authnopriv |
priv]}}]
```

When you delete a group, you do not remove the association between the user and the group. To delete the association between a user and a group, use the following command:

```
configure snmpv3 delete group {{hex} <group name>} user [all-non-defaults | {{hex}
<user name> {sec-model [snmpv1|snmpv2c|usm]}}]
```

Security Models and Levels. For compatibility, SNMPv3 supports three security models:

- SNMPv1—no security
- SNMPv2c—community strings based security
- SNMPv3—USM security

The default is User-Based Security Model (USM). You can select the security model based on the network manager in your network.

The three security levels supported by USM are:

- noAuthnoPriv—No authentication, no privacy. This is the case with existing SNMPv1/v2c agents.
- AuthnoPriv—Authentication, no privacy. Messages are tested only for authentication.
- AuthPriv—Authentication, privacy. This represents the highest level of security and requires every message exchange to pass the authentication and encryption tests.

When a user is created, an authentication method is selected, and the authentication and privacy passwords or keys are entered.

When MD5 authentication is specified, HMAC-MD5-96 is used to achieve authentication with a 16-octet key, which generates an 128-bit authorization code. This code is inserted in msgAuthenticationParameters field of SNMPv3 PDUs when the security level is specified as either AuthnoPriv or AuthPriv. Specifying SHA authentication uses the HMAC-SHA protocol with a 20-octet key for authentication.

For privacy, a 16-octet key is provided as input to DES-CBS encryption protocol, which generates an encrypted PDU to be transmitted. DES uses bytes 1-7 to make a 56 bit key. This key (encrypted itself) is placed in msgPrivacyParameters of SNMPv3 PDUs when the security level is specified as AuthPriv.

MIB Access Control

SNMPv3 provides a fine-grained mechanism for defining which parts of the MIB can be accessed. This is referred to as the View-Based Access Control Model (VACM).

MIB views represent the basic building blocks of VACM. They are used to define a subset of the information in the MIB. Access to read, to write, and to generate notifications is based on the relationship between a MIB view and an access group. The users of the access group can then read, write, or receive notifications from the part of the MIB defined in the MIB view as configured in the access group.

A view name, a MIB subtree/mask, and an inclusion or exclusion define every MIB view. For example, there is a *System* group defined under the MIB-2 tree. The Object Identifier (OID) for MIB-2 is 1.3.6.1.2, and the *System* group is defined as MIB-2.1.1, or directly as 1.3.6.1.2.1.1.

To define a MIB view which includes only the *System* group, use the following subtree/mask combination:

```
1.3.6.1.2.1.1 / 1.1.1.1.1.1.1.0
```

The mask can also be expressed in hex notation (this is used for the ExtremeWare CLI):

```
1.3.6.1.2.1.1 / fe
```

To define a view that includes the entire MIB-2, use the following subtree/mask:

```
1.3.6.1.2.1.1 / 1.1.1.1.1.0.0.0
```

which, on the command line, is:

```
1.3.6.1.2.1.1 / f8
```

When you create the MIB view, you can choose to include the MIB subtree/mask, or to exclude the MIB subtree/mask. To create a MIB view, use the following command:

```
configure snmpv3 add mib-view {hex} <view name> subtree <object identifier> {/<subtree mask>} {type [included | excluded]} {volatile}
```

Once the view is created, you can repeatedly use the `configure snmpv3 add mib-view` command to include and/or exclude MIB subtree/mask combinations to precisely define the items you wish to control access to.

In addition to the user created MIB views, there are three default views. They are of storage type permanent and cannot be deleted, but they can be modified. The default views are: *defaultUserView*, *defaultAdminView*, and *defaultNotifyView*. To show MIB views, use the following command:

```
show snmpv3 mib-view {{hex} <view name> {subtree <object identifier>}}
```

To delete a MIB view, use the following command:

```
configure snmpv3 delete mib-view [all-non-defaults | {{hex} <view name> {subtree <object identifier>}}]
```

MIB views which are being used by security groups cannot be deleted.

Notification

SNMPv3 notification is an enhancement to the concept of SNMP traps. Notifications are messages sent from an agent to the network manager, typically in response to some state change on the agent system. With SNMPv3, you can define precisely which traps you want to be sent, to which receiver by defining filter profiles to use for the notification receivers.

To configure notifications, you will configure a target address for the process that receives the notification, a target parameters name, and a list of notification tags. The target parameters specify the security and message processing models to use for the notifications to the target. The target parameters name also points to the filter profile used to filter the notifications. Finally, the notification tags are added to a notification table so that any target addresses using that tag will receive notifications.

Target Addresses

A target address is similar to the earlier concept of a trap receiver. To configure a target address, use the following command:

```
configure snmpv3 add target-addr {hex} <addr name> param {hex} <param name> ipaddress
<ip address> {transport-port <port>} {from <source IP address>} {tag-list {hex} <tag>,
{hex} <tag>, ...} {volatile}
```

In configuring the target address you will supply an address name that will be used to identify the target address, a parameters name that will indicate the message processing model and security for the messages sent to the target address, and the IP address and port for the receiver. The parameters name also is used to indicate the filter profile used for notifications. The target parameters will be discussed in the section "Target Parameters".

The `from` option sets the source IP address in the notification packets.

The `tag-list` option allows you to associate a list of tags with the target address. The tag *defaultNotify* is set by default. Tags are discussed in the section "Notification Tags".

To display target addresses, use the following command:

```
show snmpv3 target-addr {{hex} <addr name>}
```

To delete a single target address or all target addresses, use the following command:

```
configure snmpv3 delete target-addr [{{hex} <addr name>} | all]
```

Target Parameters

Target parameters specify the message processing model, security model, security level, and user name (security name) used for messages sent to the target address. See the sections "Message Processing" and "Users, Groups, and Security" for more details on these topics. In addition, the target parameter name used for a target address points to a filter profile used to filter notifications. When you specify a filter profile, you will associate it with a parameter name, so you will need to create different target parameter names if you will use different filters for different target addresses.

Use the following command to create a target parameter name, and set the message processing and security settings associated with it:

```
configure snmpv3 add target-params {hex} <param name> user {hex} <user name> mp-model
[snmpv1 | snmpv2c | snmpv3] sec-model [snmpv1 | snmpv2c | usm] {sec-level [noauth |
authnopriv | priv]} {volatile}
```

To display the options associated with a target parameters name, or all target parameters names, use the following command:

```
show snmpv3 target-params {{hex} <param name>}
```

To delete one or all the target parameters, use the following command:

```
configure snmpv3 delete target-params [{{hex} <param name>} | all]
```

Filter Profiles and Filters

A filter profile is a collection of filters that specifies which notifications should be sent to a target address. A filter is defined by a MIB subtree and mask, and by whether that subtree and mask is included or excluded from notification.

When you create a filter profile, you are only associating a filter profile name with a target parameter name. The filters that make up the profile are created and associated with the profile using a different command. To create a filter profile, use the following command:

```
configure snmpv3 add filter-profile {hex} <profile name> param {hex} <param name>
{volatile}
```

Once the profile name is created, you can associate filters with it using the following command:

```
configure snmpv3 add filter {hex} <profile name> subtree <object identifier>
{/<subtree mask>} type [included | excluded] {volatile}
```

The MIB subtree and mask are discussed in the section "MIB Access Control", as filters are closely related to MIB views. You can add filters together, including and excluding different subtrees of the MIB until your filter meets your needs.

To display the association between parameter names and filter profiles, use the following command:

```
show snmpv3 filter-profile {{hex} <profile name>} {param {hex} <param name>}
```

To display the filters that belong a filter profile, use the following command:

```
show snmpv3 filter {{hex} <profile name> {{subtree} <object identifier>}
```

To delete a filter or all filters from a filter profile, use the following command:

```
configure snmpv3 delete filter [all | [{hex} <profile name> {subtree <object
identifier>}]]
```

To remove the association of a filter profile or all filter profiles with a parameter name, use the following command:

```
configure snmpv3 delete filter-profile [all |[{hex}<profile name> {param {hex}<param
name>}]]
```

Notification Tags

When you create a target address, you associate a list of notification tags with the target, or by default, the *defaultNotify* tag is associated with the target. When notifications are generated, only targets associated with tags currently in an internal structure, called *snmpNotifyTable*, will be notified. To add an entry to the table, use the following command:

```
configure snmpv3 add notify {hex} <notify name> tag {hex} <tag> {volatile}
```

Any targets associated with tags in the *snmpNotifyTable* will be notified, based on the filter profile associated with the target.

To display the notifications that are set, use the following command:

```
show snmpv3 notify {{hex} <notify name>}
```

To delete an entry from the *snmpNotifyTable*, use the following command:

```
configure snmpv3 delete notify [{{hex} <notify name>} | all-non-defaults]
```

You cannot delete the default entry from the table, so any targets configured with the *defaultNotify* tag will always receive notifications consistent with any filter profile specified.

Configuring Notifications

Since the target parameters name is used to point to a number of objects used for notifications, configure the target parameter name entry first. You can then configure the target address, filter profiles and filters, and any necessary notification tags.

Authenticating Users

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

- RADIUS client
- TACACS+

RADIUS Client

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

TACACS+

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

Configuring RADIUS Client and TACACS+

For detailed information about configuring a RADIUS client or TACACS+, see Chapter 12.

Using Network Login

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

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

For detailed information about using Network login, see Chapter 12.

Using the Simple Network Time Protocol

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

Configuring and Using SNTP

To use SNTP, follow these steps:

1 Identify the host(s) that are configured as NTP server(s). Additionally, identify the preferred method for obtaining NTP updates. The options are for the NTP server to send out broadcasts, or for switches using NTP to query the NTP server(s) directly. A combination of both methods is possible. You must identify the method that should be used for the switch being configured.

2 Configure the Greenwich Mean Time (GMT) offset and Daylight Saving Time preference. The command syntax to configure GMT offset and usage of Daylight Saving Time is as follows:

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

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

```
configure timezone <GMT_offset> autodst
```

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

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

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

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

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

Table 11 describes the command options in detail:

Table 11: Time Zone Configuration Command Options

GMT_offset	Specifies a Greenwich Mean Time (GMT) offset, in + or - minutes.
std-timezone-ID	Specifies an optional name for this timezone specification. May be up to six characters in length. The default is an empty string.
autodst	Enables automatic Daylight Savings Time.
dst-timezone-ID	Specifies an optional name for this DST specification. May be up to six characters in length. The default is an empty string.
dst_offset	Specifies an offset from standard time, in minutes. Value is in the range of 1 to 60. Default is 60 minutes.

Table 11: Time Zone Configuration Command Options (Continued)

floating_day	Specifies the day, week, and month of the year to begin or end DST each year. Format is: <week><day><month> where: • <week> is specified as [first | second | third | fourth | last] or 1-5 • <day> is specified as [sunday | monday | tuesday | wednesday | thursday | friday | saturday] or 1-7 (where 1 is Sunday) • <month> is specified as [january | february | march | april | may | june | july | august | september | october | november | december] or 1-12 Default for beginning is first sunday april; default for ending is last sunday october.
absolute_day	Specifies a specific day of a specific year on which to begin or end DST. Format is: <month>/<day>/<year> where: • <month> is specified as 1-12 • <day> is specified as 1-31 • <year> is specified as 1970 - 2035 The year must be the same for the begin and end dates.
time_of_day	Specifies the time of day to begin or end Daylight Savings Time. May be specified as an hour (0-23) or as hour:minutes. Default is 2:00.
noautodst	Disables automatic Daylight Savings Time.

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

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

3 Enable the SNTP client using the following command:

```
enable sntp-client
```

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

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

```
configure sntp-client [primary | secondary] server <host name/ip>]
```

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

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

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

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

6 You can verify the configuration using the following commands:

— `show sntp-client`

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

— `show switch`

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

NTP updates are distributed using GMT time. To properly display the local time in logs and other timestamp information, the switch should be configured with the appropriate offset to GMT based on geographical location. Table 12 describes GMT offsets.

Table 12: Greenwich Mean Time Offsets

GMT Offset in Hours	GMT Offset in Minutes	Common Time Zone References	Cities
+0:00	+0	GMT - Greenwich Mean UT or UTC - Universal (Coordinated) WET - Western European	London, England; Dublin, Ireland; Edinburgh, Scotland; Lisbon, Portugal; Reykjavik, Iceland; Casablanca, Morocco
-1:00	-60	WAT - West Africa	Azores, Cape Verde Islands
-2:00	-120	AT - Azores	
-3:00	-180		Brasilia, Brazil; Buenos Aires, Argentina; Georgetown, Guyana;
-4:00	-240	AST - Atlantic Standard	Caracas; La Paz
-5:00	-300	EST - Eastern Standard	Bogota, Columbia; Lima, Peru; New York, NY, Trevor City, MI USA
-6:00	-360	CST - Central Standard	Mexico City, Mexico
-7:00	-420	MST - Mountain Standard	Saskatchewan, Canada
-8:00	-480	PST - Pacific Standard	Los Angeles, CA, Cupertino, CA, Seattle, WA USA
-9:00	-540	YST - Yukon Standard	
-10:00	-600	AHST - Alaska-Hawaii Standard CAT - Central Alaska HST - Hawaii Standard	
-11:00	-660	NT - Nome	
-12:00	-720	IDLW - International Date Line West	
+1:00	+60	CET - Central European FWT - French Winter MET - Middle European MEWT - Middle European Winter SWT - Swedish Winter	Paris, France; Berlin, Germany; Amsterdam, The Netherlands; Brussels, Belgium; Vienna, Austria; Madrid, Spain; Rome, Italy; Bern, Switzerland; Stockholm, Sweden; Oslo, Norway
+2:00	+120	EET - Eastern European, Russia Zone 1	Athens, Greece; Helsinki, Finland; Istanbul, Turkey; Jerusalem, Israel; Harare, Zimbabwe
+3:00	+180	BT - Baghdad, Russia Zone 2	Kuwait; Nairobi, Kenya; Riyadh, Saudi Arabia; Moscow, Russia; Tehran, Iran
+4:00	+240	ZP4 - Russia Zone 3	Abu Dhabi, UAE; Muscat; Tblisi; Volgograd; Kabul
+5:00	+300	ZP5 - Russia Zone 4	
+5:30	+330	IST – India Standard Time	New Delhi, Pune, Allahabad, India
+6:00	+360	ZP6 - Russia Zone 5	

Table 12: Greenwich Mean Time Offsets (Continued)

GMT Offset in Hours	GMT Offset in Minutes	Common Time Zone References	Cities
+7:00	+420	WAST - West Australian Standard	
+8:00	+480	CCT - China Coast, Russia Zone 7	
+9:00	+540	JST - Japan Standard, Russia Zone 8	
+10:00	+600	EAST - East Australian Standard GST - Guam Standard Russia Zone 9	
+11:00	+660		
+12:00	+720	IDLE - International Date Line East NZST - New Zealand Standard NZT - New Zealand	Wellington, New Zealand; Fiji, Marshall Islands

SNTP Example

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

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

Using Alternative Queue Management

Alternative Queue Management (Alt-Queue Management) provides the ability for a system to support a high number of subVLANs configured with one tagged port under one superVLAN. This feature should be enabled on the edge devices that must support a high number of subVLANs with VLAN aggregation.

Default Queue Management Behavior

Prior to Release 7.2, ExtremeWare could support only 127 sub VLANs per tagged port (Fast Ethernet). Hardware QoS profile buffers were distributed with QP1 having 256 and QP2-QP8 having 128. All packets egressing out of CPU in Extreme switches had the high priority bit set. The switch could buffer up to 128 packets that were going through QP2-QP8. To overcome this limitation ExtremeWare 7.2 incorporated the following changes:

- Moved the broadcast packets that were egressed out of each port from QP6 to QP1
- Increased buffer QP1 from 256 to 512
- New buffer settings for all Fast Ethernet ports are as follows:

  QP1=512 , QP2=128 ,QP3= 28 , QP4=128, QP5=64 , QP6=64 , QP7=64 , QP8=64

ExtremeWare can now support 512 subVLANs per tagged port (Fast Ethernet) in case of VLAN aggregation.

Enabling Alt-Queue Management

Using following command to enable Alt-Queue Management:

```
enable alt-queue-management
```

Use this command to enable the Alt-Queue Management feature for the next boot. The system must reboot for the command to take effect. Configuring the feature does not affect the queue management of the current boot.

Use the following command to disable alternate queue management:

```
disable alt-queue-management
```

Use the `show switch` command to display the Alt-Queue Management feature status, as shown in the following example:

```
MSM64:3 # show switch
SysName:            MSM64
SysLocation:
SysContact:         support@extremenetworks.com, +1 888 257 3000
System MAC:         00:01:30:12:2A:D0

License:            Full L3
System Mode:        802.1Q EtherType is 8100 (Hex).
Diag Mode:          Fast Post

RED Probability:    0  Marked Probability: 0
DLCS:               Disabled
Backplane Ls:       port-based

SysHealth Check:    Enabled.   Alarm Level = Log
Recovery Mode:      None
Transceiver Diag:   Enabled.    Failure action:  log only
Fdb-Scan Diag:      Enabled.    Failure action:  sys-health-check
MSM Failover:       take-links-down
System Watchdog:    Enabled
Reboot Loop Prot:   Disabled
Alter Queue Mgmt:   Disabled       Next Boot: Disabled
Bus-stats:          Disabled

Current Time:       Wed Oct 29 18:58:17 2003
Timezone:           [Auto DST Enabled] GMT Offset: 0 minutes, name is GMT.
                    DST of 60 minutes is currently not in effect, name is not set.
                    DST begins every first Sunday April at 2:00
                    DST ends every last Sunday October at 2:00
Press <SPACE> to continue or <Q> to quit:
```

The basic process for testing Alt-Queue Management implementation for VLAN aggregation is as follows:

1. Enable Alt-Queue Management.
2. Configure a DUT, one superVLAN.

3 Configure IP address.

4 Create 512 subVLANs, and add one Fast Ethernet port as tagged.

5 Ping any unknown IP from the switch.

6 Look for ARP broadcast packets that have been sent out to all 512 subVLANs.

With Alt-Queue Management enabled, all 512 subVLANs should receive packets. With Alt-Queue Management disabled, only 128 subVLANs will receive packets. If Gigabit Ethernet ports are connected, you can aggregate up to 1000 subVLANs.

4 Configuring Slots and Ports on a Switch

This chapter covers the following topics:

- Configuring a Slot on a Modular Switch on page 85
- Configuring Ports on a Switch on page 87
- Jumbo Frames on page 90
- Load Sharing on the Switch on page 92
- Switch Port-Mirroring on page 97
- Extreme Discovery Protocol on page 98
- Software-Controlled Redundant Port and Smart Redundancy on page 98
- Performance Enhancements for Load Sharing on page 96
- Port Aggregate Bandwidth Control on page 102

Configuring a Slot on a Modular Switch

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

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

NOTE

For information on saving the configuration, see Appendix A.

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

```
configure slot <slot> module <module name>
```

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

If a slot is configured for one type of module, and a different type of module is inserted, the inserted module is put into a mismatch state, and is not brought online. To use the new module type in a slot, the slot configuration must be cleared or configured for the new module type. To clear the slot of a previously assigned module type, use the following command:

```
clear slot <slot>
```

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

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

```
show slot <slot number>
```

Information displayed includes:

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

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

Mode of Operation (Alpine 3802)

The Alpine 3802 has three modes of switch operation that impact the type and number of modules supported in the chassis.

To configure the mode of operation for the Alpine 3802, use the following command:

```
configure switch {auto | extended | standard}
```

The three modes of switch operation are:

- Extended—In extended mode, all slots (slots 1, 2, and 3) are enabled. Slot 1 supports all existing Alpine I/O modules: Alpine Ethernet I/O modules (modules with a green stripe on the front of the module) and Alpine Access I/O modules (modules with a silver stripe on the front of the module). Slots 2 and 3 support only Alpine Access I/O modules (silver stripe).
- Standard—In standard mode, only slots 1 and 2 are enabled. Slot 3 is disabled. Slots 1 and 2 support all existing Alpine I/O modules: Alpine Ethernet I/O modules (green stripe) and Alpine Access I/O modules (silver stripe).
- Auto—In auto mode, the switch determines if it is in standard or extended mode depending upon the type of modules installed in the chassis or the slot preconfigurations. If an Alpine I/O module with a green stripe (for example, an FM-32Ti module) is installed or preconfigured in slot 2, the switch operates in standard mode. If an Alpine I/O module with a silver stripe (for example, a WM-4Ti module) is installed or preconfigured in slots 2 or 3, the switch operates in extended mode.

By default, the Alpine 3802 operates in auto mode.

If you insert a module into the Alpine 3802 that is not allowed in a particular slot, the switch logs an error to the syslog. For example, if you insert a GM-WDMi module in slot 3, a module type not supported in slot 3, the switch logs an error.

Configuring Ports on a Switch

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

```
slot:port
```

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

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

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

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

Enabling and Disabling Switch Ports

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

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

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

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

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

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

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

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

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

Configuring Switch Port Speed and Duplex Setting

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

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

If you want the switch to recognize a single fiber failure as a port failure, configure autonegotiation on both ends of the link.

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

VDSL ports default to 10 Mbps, and their speed can be configured as 5 Mbps, 10 Mbps, or to support the European Telecommunications Standards Institute (ETSI) VDSL standard, ETSI Plan 997. To configure VDSL ports, use the following command:

```
configure ports <portlist> vdsl [5meg | 10meg | etsi]
```

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

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

```
configure ports [<portlist> | all | mgmt] auto off {speed [10 | 100 | 1000]} duplex
[half | full]
```

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

```
configure ports [<portlist> | mgmt | all] auto on
```

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

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

Turning Off Autonegotiation for a Gigabit Ethernet Port

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

NOTE

1000BASE-TX ports support only autonegotiation.

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

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

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

```
configure ports 4 auto off duplex full
```

Turning Off Autopolarity Detection for an Ethernet Port

The autopolarity feature on the Summit48si switch allows the system to detect and respond to the Ethernet cable type (straight-through vs. crossover cable) used to make the connection to the switch port. When the autopolarity feature is enabled, the system causes the Ethernet link to come up regardless of the cable type connected to the port. When the autopolarity feature is disabled, the link will come up only when a crossover cable is connected to the port. The autopolarity feature is supported only on the 10BASE-T and 100BASE-TX switch ports, and enabled by default.

To disable or enable autopolarity detection, use the following command:

```
configure ports [<portlist> | all] auto-polarity [off | on]
```

where the following is true:

- `portlist`—Specifies one or more ports on the switch
- `all`—Specifies all of the ports on the switch
- `off`—Disables the autopolarity detection feature on the specified ports
- `on`—Enables the autopolarity detection feature on the specified ports

Under certain conditions, you might opt to turn autopolarity off on one or more 10BASE-T and 100BASE-TX ports. The following example turns autopolarity off for ports 3-5 on a Summit48si switch:

```
configure ports 3-5 auto-polarity off
```

NOTE

If you attempt to invoke this command on a Gigabit Ethernet switch port, the system displays a message indicating that the specified port is not supported by this feature.

When autopolarity is disabled on one or more Ethernet ports, you can verify that status by using the command:

```
show configuration
```

This command will list the ports for which the feature has been disabled.

You can also verify the current autopolarity status by using the command:

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

Configuring Link Detection

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

```
configure ports <portlist> link-detection-level <link-detection-level>
```

Configuring Interpacket Gap for 10 Gigabit Ethernet Ports

You can configure the Interpacket Gap for 10 Gigabit Ethernet ports only. The Interpacket Gap, sometimes referred to as the Interframe Gap, is the transmit packet byte-time delay between successive data packets mandated by the IEEE for Ethernet networks. Byte-time is the amount of time it takes to transmit one byte on the link at the specified or negotiated link speed. The configured Interpacket Gap value has no effect on received packets. The default value is 16. The minimum and maximum allowed values range between 12 and 1023.

The standard effective Interpacket Gap for 10 Gigabit Ethernet interfaces ranges between 12 and 1023. Some vendors' 10 Gigabit Ethernet interfaces drop packets when packets are transmitted using a value of 12. Thus, by increasing the Interpacket Gap, packet transmission is slowed and packet loss can be minimized or prevented. The Interpacket Gap value need not be modified when interconnecting Extreme Networks switches over 10 Gigabit Ethernet links. Use the following command to modify the Interpacket Gap:

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

Jumbo Frames

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

Jumbo frames are used between endstations that support larger frame sizes for more efficient transfers of bulk data. Both endstations involved in the transfer must be capable of supporting jumbo frames. The switch only performs IP fragmentation, or participates in maximum transmission unit (MTU) negotiation on behalf of devices that support jumbo frames.

Enabling Jumbo Frames

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

```
configure jumbo-frame size <number>
```

The jumbo frame size range is 1523 to 9216. This value describes the maximum size of the frame in transit (on the wire), and includes 4 bytes of CRC plus another 4 bytes if 802.1Q tagging is being used.

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

```
configure ip-mtu <number> vlan <vlan name>
```

The IP MTU default is 1500. The range is 1500-9194.

NOTE

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

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

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

NOTE

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

Path MTU Discovery

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

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

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

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

IP Fragmentation with Jumbo Frames

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

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

NOTE

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

To configure VLANs for IP fragmentation, follow these steps:

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

   ```
   configure ip-mtu <number> vlan <vlan name>
   ```

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

NOTE

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

IP Fragmentation within a VLAN

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

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

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

Load Sharing on the Switch

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

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

NOTE

Load sharing must be enabled on both ends of the link or a network loop may result. The load-sharing types (dynamic, static) must match, but the load-sharing algorithms do not need to be the same on both ends.

Dynamic Versus Static Load Sharing

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

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

Load-Sharing Algorithms

Load-sharing algorithms allow you to select the distribution technique used by the load-sharing group to determine the output port selection. Algorithm selection is not intended for use in predictive traffic engineering. You can only choose the algorithm used in static load sharing, as dynamic load sharing exclusively uses an address-based algorithm.

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

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

NOTE

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

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

Configured IP Address-Based Load Sharing

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

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

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

```
configure sharing address-based [L2 | L2_L3 | L2_L3_L4]
```

where:

- `L2`—Indicates that the switch should examine the MAC source and destination address.
- `L3`—Indicates that the switch should examine the MAC source address and destination address, and the IP source address and destination address.
- `L4`—Indicates that the switch should examine the MAC source address and destination address, the IP source address and destination address, and the UDP or TCP well-known port number.

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

To verify your configuration, use the following command:

```
show sharing address-based
```

Configuring Switch Load Sharing

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

All the ports in a load-sharing group must have the same exact configuration, including auto negotiation, duplex setting, ESRP host attach (HA) or don't-count, and so on. All the ports in a load-sharing group must also be of the same bandwidth class.

The following rules apply:

- One group can contain up to 8 ports.
- The ports in the group do not need to be contiguous.
- If dynamic load sharing is used (LACP), the ports in the group must be on the same I/O module.
- A load share group that spans multiple modules must use ports that are all of the same maximum bandwidth capability.
- When using load sharing with the ESRP HA feature, configure all ports in the same load-sharing group as host attach ports. When using load sharing with the ESRP don't count feature, configure all ports in the same load-sharing group as don't count ports.

On BlackDiamond 6804 and 6808 chassis, the following limitation applies:

- The chassis must use the MSM-3 if you are going to configure a load share group that spans multiple modules (cross-module trunking).

On BlackDiamond 6816 chassis, the following limitation applies:

- The ports in the group must be on the same I/O module.

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

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

disable sharing [<port>]
```

NOTE

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

NOTE

BlackDiamond modules implement local switching; packets that ingress and egress on the same module are not passed to the chassis backplane but switched on the module from the ingress to the egress port. For this reason, packets arriving on a module that contains any of the configured cross-module load sharing ports will only be shared with the ports on that module, and not with the ports on any other modules.

Loopback Detection

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

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

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

disable lbdetect port <portlist>
```

Load-Sharing Examples

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

Cross-Module Load Sharing on a Modular Switch

Cross-module load sharing is available on Alpine chassis, and on BlackDiamond 6804 and 6808 chassis that use the MSM-3. The following example defines a load-sharing group that contains ports 9 through 12 on slot 3, ports 7 through 10 on slot 5, and uses the first port in the slot 3 group as the master logical port 9:

```
enable sharing 3:9 grouping 3:9-3:12, 5:7-5:10
```

In this example, logical port 3:9 represents physical ports 3:9 through 3:12 and 5:7 through 5:10.

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

For BlackDiamond chassis, packets are locally switched when possible, even with load sharing enabled. For example, in the configuration above, packets received on port 3:2 that are destined for the load-sharing group will only be shared with the ports 3:9-3:12 and not with ports 5:7-5:10. In contrast, packets received on port 2:2 that are destined for the load-sharing group will be shared with the all the ports in the load-sharing group (ports 3:9-3:12 and 5:7-5:10).

Single-Module Load Sharing on a Modular Switch

Single-module load sharing is supported on all modular switches. The BlackDiamond 6816 chassis, and the BlackDiamond 6804 and 6808 chassis without the MSM-3, support only single-module load sharing. The following example defines a load-sharing group that contains ports 9 through 12 on slot 3 and uses the first port as the master logical port 9:

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

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

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

Load Sharing on a Stand-Alone Switch

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

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

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

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

NOTE

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

Verifying the Load-Sharing Configuration

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

Performance Enhancements for Load Sharing

You can modify the backplane load-sharing policy on BlackDiamond switches to enhance performance. The default backplane load-sharing policy is port-based. Selecting a policy for a particular situation will depend on the type of traffic and network topology, however, for many situations an address-based policy will enhance performance over other policies. You must save for changes to be saved across reboots.

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

```
configure backplane-ls-policy [address-based | port-based | round-robin]
```

and specify the following:

- `address-based`—address-based load-sharing algorithm
- `port-based`—port-based load-sharing algorithm
- `round-robin`—round-robin load-sharing algorithm

For more information about the load-sharing algorithms, see "Load-Sharing Algorithms" on page 93.

Switch Port-Mirroring

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

NOTE

Port mirroring is not supported with CPU-generated traffic. In addition, port mirroring is not supported across BlackDiamond modules.

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

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

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

NOTE

Frames that contain errors are not mirrored.

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

NOTE

When a mirrored port is configured, the forwarding database for items being mirrored (e.g., ports or VLANs) is automatically cleared if the link status on the mirrored port changes. This clearing results in some temporary flooding until the normal learning process completes. Removing or inserting a probe device into the mirror port may appear to cause flooding, but this temporary condition is normal.

Modular Switch Port-Mirroring Example

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

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

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

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

Stand-alone Switch Port-Mirroring Example

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

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

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

```
configure mirroring add port 1 vlan default
```

Extreme Discovery Protocol

The Extreme Discovery Protocol (EDP) is used to gather information about neighbor Extreme Networks switches. EDP is used by the switches to exchange topology information. EDP is also used by the Extreme Standby Router Protocol (ESRP), described in Chapter 15. Information communicated using EDP includes:

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

EDP is enabled on all ports by default.

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

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

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

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

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

```
show edp
```

Software-Controlled Redundant Port and Smart Redundancy

Using the software-controlled redundant port feature you can back up a specified Ethernet port (primary) with a redundant, dedicated Ethernet port (backup). If the primary port fails, the switch will establish a link on the backup port and the backup port becomes active.

Smart Redundancy is a feature that allows control over how the failover from a backup port to the primary port is managed. If this feature is enabled, the switch will attempt to revert to the primary port as soon as it can be recovered. If the feature is disabled, the switch will only attempt to reset the primary port to active if the backup port fails.

Smart Redundancy is always enabled in a saved configuration. To work around this characteristic, disable smart redundancy after downloading a configuration.

NOTE

Smart redundancy is not supported in switches using software redundant ports and load sharing.

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

Figure 1: Dual-homed redundant link

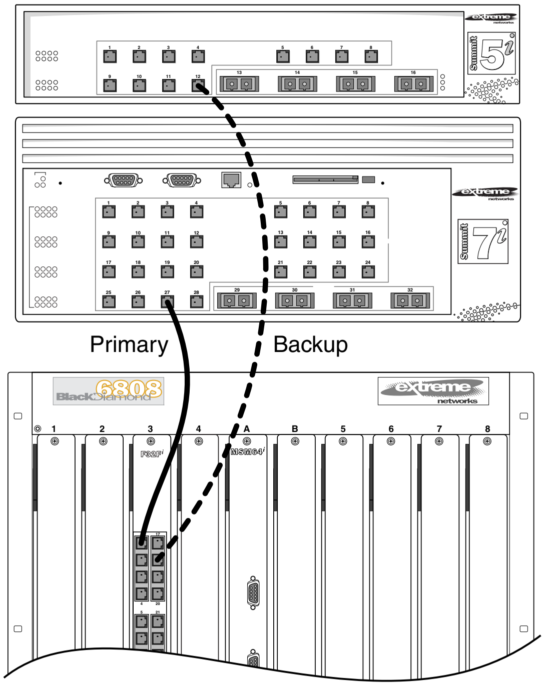
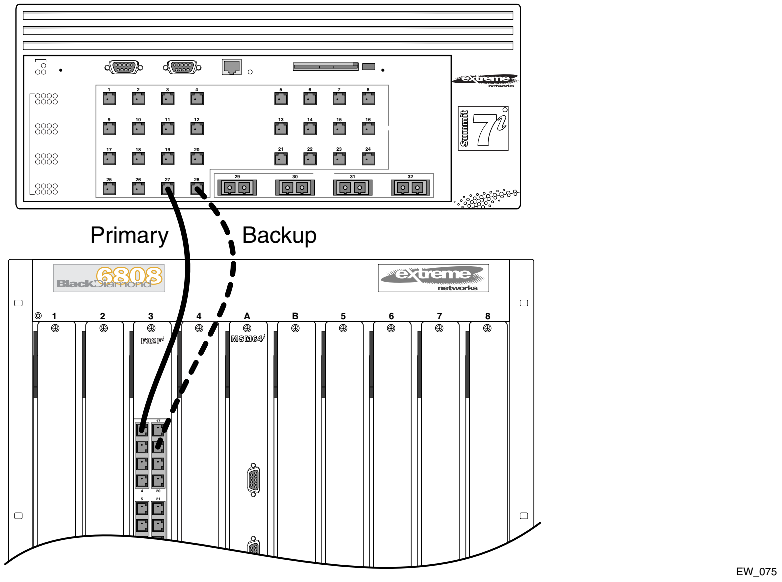


Figure 2: Redundant link between two switches



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

Software-Controlled Redundant Load-Shared Port Groups

A load-shared group of Ethernet ports (primary group) can be backed up with a set of load-shared redundant Ethernet ports (backup group) similar to configuring individual redundant ports. If the primary load-shared group is active and any link in the group fails, the entire group fails over to the backup group.

Smart Redundancy is not available for software-controlled redundant load-shared groups, so the switch will only attempt to revert to the primary group if a port in the backup group fails and the associated link in the primary group can be re-established.

Limitations of Software-Controlled Redundant Ports and Port Groups

Software-controlled redundant ports and port groups have the following limitations:

- Auto-negotiation must be enabled on all ports that are associated with the redundant links. This includes the primary and backup ports or load-shared port groups, and the associated ports on the far-end switch(es). For 10 Gigabit Ethernet ports auto-negotiation is not supported, nor is it required for this feature to work.
- Partial link loss is protected when auto-negotiation is enabled on all ports that are associated with the redundant links. For example, if only one optical fiber on either the TX or RX paths is damaged or disconnected with auto-negotiation fully enabled, the software-controlled redundant port recognizes the link loss as a port failure, and a switch to the backup port occurs. Partial link losses are not protected when auto-negotiation is *not* enabled on all ports that are associated with the redundant links. For example, if only one optical fiber is damaged or disconnected with auto-negotiation partially enabled, the software-controlled redundant port would not recognize this as a port failure, and no switch to the backup would occur.

- You cannot configure hardware redundant ports (such as ports 49 and 50 on a Summit48i) as software controlled redundant ports.
- The primary port configuration is not automatically applied to the backup port, so you must separately configure both the primary and backup ports. This includes items such as VLANs, QoS, and access control lists.
- The port speeds of software controlled redundant ports must be identical.
- You can configure only one redundant port for each primary port.
- You cannot load share two physical ports that are configured as software-controlled redundant ports.
- Members of the same load sharing trunk cannot be configured as software-controlled redundant ports.
- Dual-homing of load-shared, software-controlled redundant port groups is not supported.

Configuring Software-Controlled Redundant Ports

When provisioning software-controlled redundant ports, configure only one side of the link as redundant. In Figure 1 and Figure 2 only the ports on the lower switch would be configured as redundant.

In order to enable the software-controlled redundant port feature the primary and backup ports must be set up identically. This will include VLAN configuration, QoS settings, and any Access Control List configurations. Finally, all ports (primary, secondary, and both of the associated far-end ports) must be configured to have auto-negotiation enabled.

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

```
configure ports [<portlist> | <portid>] redundant [<portlist> | <portid>]
```

The first port specified is the primary port. The second port specified is the redundant port.

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

```
unconfigure ports [<portlist> | <port id>] redundant
```

To configure the switch for the Smart Redundancy feature, use the following command:

```
enable smartredundancy <portlist>
```

To disable the Smart Redundancy feature, use the following command:

```
disable smartredundancy [<portlist>]
```

Configuring Software-Controlled Redundant Load-Shared Port Groups

Configuring redundancy on load-shared port groups is similar to that for an individual port. Each port in the load-shared group must have a uniquely associated backup port. Each of these primary/backup port pairs must be provisioned identically. It is important to ensure that the configure command is entered for each port in the group. If a backup port is not specified for a port in a load-shared group, it will not fail over and you would end up with a split group.

In the following example, a primary load-sharing group 1:1, consisting of ports 1:1-4, is backed up by a software-controlled redundant port backup group 2:1, consisting of ports 2:1-4:

```
enable sharing 1:1 group 1:1-1:4
enable sharing 2:1 group 2:1-2:4
config ports 1:1-1:4 redundant 2:1-2:4
```

The following example is identical to the previous one, but each redundant port is configured individually:

```
enable sharing 1:1 group 1:1-1:4
enable sharing 2:1 group 2:1-2:4
config ports 1:1  redundant 2:1
config ports 1:2  redundant 2:2
config ports 1:3  redundant 2:3
config ports 1:4  redundant 2:4
```

Port Aggregate Bandwidth Control

If you use several queues for classifying traffic and you need to restrict total bandwidth for all queues to a certain amount, you can control the aggregate bandwidth of all queues for selected ports by configuring Port Aggregate Bandwidth Control. This feature allows you to limit the total bandwidth egressing a port to a defined mix of traffic.

Port Aggregate Bandwidth Control is supported in any "i" series switch. It preserves any previous egress QoS processing of queues and restricts only the amounts of egress traffic to a specific port.

For example, using standard queue bandwidth control, you might classify traffic into several categories according to various traffic characteristics such as importance, delay sensitivity, and burst. Figure 3 shows the effect on the amount of egress traffic in a scheme that involves the following traffic priority mix:

Traffic A: Priority 1, min b/w 4%, max b/w 20%
Traffic B: Priority 2, min b/w 5%, max b/w 20%
Traffic C: Priority 3, min b/w 0%, max b/w 20%

Figure 3: Standard Queue Bandwidth Control

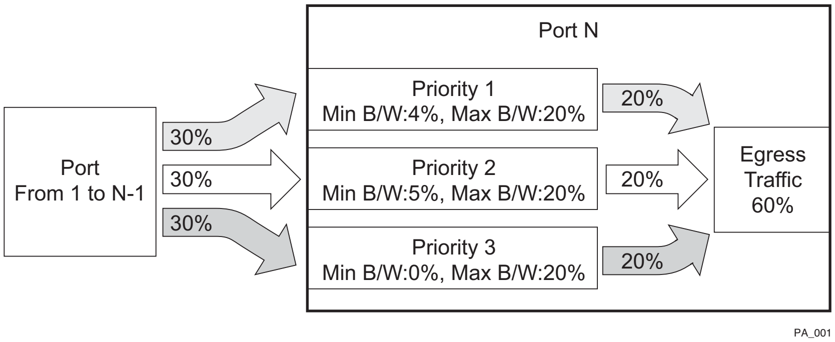
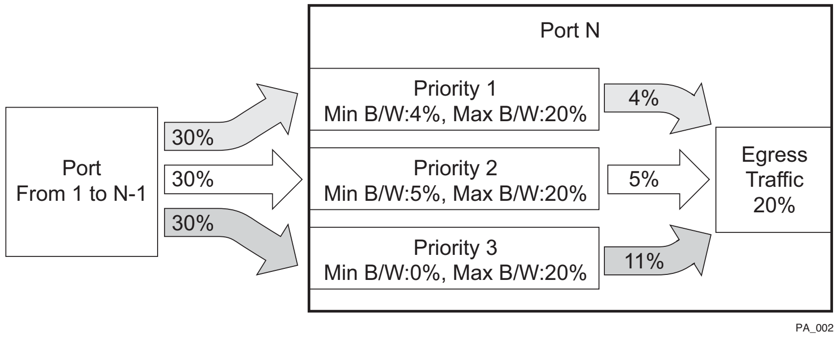


Figure 4 shows that by using Port Aggregate Bandwidth Control, you can limit the egress of traffic in a port to a specific amount, preserving the previously classified queues' configuration.

Figure 4: Port Aggregate Bandwidth Control



Configuring Port Aggregate Control Bandwidth

To configure Port Aggregate Control Bandwidth for a selected port, use the following command:

```
configure port <portnumber> aggregate-bandwidth percent <bandwidth>
```

To restore the egress bandwidth of a selected port to 100% use the following command:

```
unconfigure port <portnumber> aggregate-bandwidth
```

The real egress bandwidth is dependent on the configuration of each queue.

Displaying Port Aggregate Control Bandwidth Configuration

To display information that includes Port Aggregate Bandwidth Control information, use the `show ports {mgmt | <portlist>} info {detail}` command in the following form:

show ports <portlist> info detail

For example, the following command displays specific information for slot 2, port 6 in a modular switch:

```
show ports 2:6 info detail
```

Note that the `info detail` keywords must be used to display Port Aggregate Bandwidth Control information. Port Aggregate Bandwidth Control is not effective on the management ports, so the `mgmt` keyword is ineffective for displaying Port Aggregate Bandwidth Control information.

Following is sample output from this command. Note the Aggregate B/W data following the STP configuration information:

```
Port 2:6:
        Type:            UTP
        Diagnostic:      passed
        Random Early Drop: Disabled
        Admin state:     Enabled, with auto-duplex auto-speed sensing
        Link state:      Ready
        Link counter:   Up 0 time(s), Down 0 times(s)
        VLAN cfg:
        Default [Internal Tag=0001,Mac-Limit:Cfg=No-limit,LRN=0,BlkHole=0]

        STP cfg:
                s0(disable), Tag=(none), Mode=802.1D, State=FORWARDING

        Aggregate B/W:  Configured [ 25]%
        Trunking:       Load sharing is not enabled
        Protocol:       VLAN=Default  Vpri=0   Protocol=ANY [EtherType:ffff]
        EDP:            enabled
        DLCS:           disabled
        lbdetect:       disabled
        Learning:       enabled
        Flooding:       disabled
        Jumbo:          Disabled
        BG QoS monitor: disabled
        Ingress Rate Shaping:
        QoS profile:    None configured
        .
        .
        .
```

5 Hitless Failover and Hitless Upgrade

This chapter describes hitless failover and hitless upgrade, including:

- Causes and Behaviors of MSM Failover on page 106
- Summary of Supported Features on page 107
- Overview of Hitless Failover on page 108
- Configuring Hitless Failover on page 109
- Configuring ESRP for Hitless Failover on page 112
- Overview of Hitless Upgrade on page 114
- Performing a Hitless Upgrade on page 115

T-sync is a term used to describe the hitless failover and hitless upgrade features available on the BlackDiamond® Management Switch Module 3 (MSM-3). In simple terms, *hitless failover* transfers switch management control from the master MSM-3 to the slave MSM-3 without causing traffic to be dropped. *Hitless upgrade* allows an ExtremeWare® software upgrade on a BlackDiamond 6800 series chassis without taking it out of service or losing traffic.

NOTE

To configure hitless failover or hitless upgrade, you must install MSM-3 modules in your BlackDiamond chassis; MSM64i modules do not support hitless failover or hitless upgrade.

If you enable T-sync and normally use scripts to configure your switch, Extreme Networks recommends using the `download configuration incremental` command instead.

NOTE

To use the T-sync features available on the MSM-3 modules, you must install and run ExtremeWare 7.1.1 or later and BootROM 8.1 or later.

Causes and Behaviors of MSM Failover

This section describes the events that cause an MSM failover and the behavior of the system after failover occurs.

The following events cause an MSM failover:

- Operator command
- Software exception
- Watchdog timeout
- Keepalive failure
- Diagnostic failure
- Hot-removal of the master MSM
- Hard-reset of the master MSM

NOTE

Operator command and software exception support hitless failover.

Operator Command and Software Exception. Of the listed events, only operator command and software exception result in a hitless failover. The remaining sections of this guide describes T-sync, including:

- Supported features
- How to configure the T-sync features
- The behavior surrounding hitless failover and hitless upgrade

Watchdog Timeout and Keepalive Failure. Both the watchdog timeout and the keepalive failure are long duration events, thus they are not hitless. If one of these events occur:

- All saved operational state information is discarded
- The failed master is hard reset
- The slave uses its own flash configuration file

Diagnostic Failure, Hot-removal, or Hard-reset of the Master MSM. If the master MSM-3 experiences a diagnostic failure or you hot-remove it, a “partial” hitless failover function is performed and some traffic flows will not experience traffic hits. The switch cannot perform a completely hitless failover because it lost hardware that it uses during normal operation.

To understand how traffic is affected when MSM-3 hardware is lost, a brief explanation of the switch fabric is given. Each MSM-3 has switching logic that provides bandwidth to each I/O module. When two MSM-3s are present, both provide bandwidth so that twice the amount of bandwidth is available. For each traffic flow that requires inter-module data movement, the I/O module chooses an MSM-3 to switch the data for that flow. When an MSM-3 is lost, the remaining MSM-3 eventually instructs the I/O module that all inter-module traffic is to use the switching logic of the remaining MSM-3. In the time between the loss of an MSM-3 and the reprogramming of the I/O module, traffic destined for the lost MSM-3 switching logic is dropped.

The I/O module also switches some traffic flows directly between its own ports without MSM-3 involvement.

If you hot-remove the master MSM-3, only half of the switch fabric remains operational. The slave becomes the master and reprograms each I/O module to send all traffic through it's own switch fabric logic. In the time between the failure and the reprogramming of the I/O module, traffic destined for the removed MSM-3's switching logic is lost. After the new master recovers, it reprograms the I/O module so that all traffic uses the available MSM-3 switching logic.

If you hard-reset the master MSM-3 (using the recessed reset button on the MSM-3), all of the master's switch programming is lost. As a result, traffic that the I/O module forwards to the master is also lost. After a failover occurs, the new master reprograms the "reset" MSM-3's switch fabric and the switching logic of both MSM-3s is available again. In this case, the "Cause of last MSM failover" displayed by the `show msm-failover` command indicates "removal," and a "partial" hitless failover has occurred.

A "partial" hitless failover preserves:

- Data flows in the hardware and software, layer 2 protocol states, configurations, etc.
- All of the software states and the hardware states that are not interrupted by the diagnostic failure, hot-removal, or hard-reset.

After a failover caused by hot-removal or diagnostic failure, the I/O modules are reprogrammed to use only the switching logic of the remaining MSM-3. After a failover caused by a hard-reset of the master MSM-3, the reset MSM-3's switch fabric is reprogrammed and placed into full operation. Thus, a data hit of several seconds occurs for flows that were directed to the failed MSM-3. For flows that were directed to the currently active MSM-3, or for inter-module flows, there is no hit.

Summary of Supported Features

This section describes the features supported by T-sync. If the information in the release notes differ from the information in this guide, follow the release notes.

- Preserves unsaved configurations across a failover
- Load sharing
- Learned MAC address
- ARP
- STP
- EAPSv1
- IP FDB entries
- Access lists
- ESRP
- SNMP trap failover
- Configuration via the web, CLI, and SNMP

NOTE

T-sync does not support EAPSv2.

Overview of Hitless Failover

When you install two MSM-3 modules in a BlackDiamond chassis, one MSM-3 assumes the role of master and the other assumes the role of slave. The master executes the switch's management function, and the slave acts in a standby role. Hitless failover is a mechanism to transfer switch management control from the master to the slave.

When there is a software exception in the master, the slave may be configured to take over as the master. Without T-sync, a software exception results in a traffic "hit" because the hardware is reinitialized and all FDB information is lost. The modules require seconds to complete the initialization, but it may take minutes to relearn the forwarding information from the network. With T-sync, it is possible for this transition to occur without interrupting existing unicast traffic flows.

During failover, the master passes control of all system management functions to the slave. In addition, hitless failover preserves layer 2 data and layer 3 unicast flows for recently routed packets. When a hitless failover event occurs, the failover timer begins and all previously established traffic flows continue to function without packet loss. Hitless failover also preserves the:

- Master's active configuration (both saved and unsaved)
- Forwarding and resolution database entries (layer 2, layer 3, and ARP)
- Loop redundancy and protocol states (STP, EAPS, ESRP, and others)
- Load shared ports
- Access control lists

NOTE

Hitless failover does not preserve the full route table, routing protocol databases for OSPF, BGP, RIP, etc., or ICMP traffic.

Hitless Failover Concepts

T-sync preserves the current active configuration across a hitless failover. When you first boot up your BlackDiamond switch, it uses the master MSM-3 configuration. During the initialization of the slave, the master's active configuration is relayed to the slave. As you make configuration changes to the master, the master relays those individual changes to the slave. When a failover occurs, the slave continues to use the master's configuration. Regardless of the number of failovers, the active configuration remains in effect provided the slave can process it.

NOTE

It is important to save any switch configuration changes that you make. Configuration changes made in real-time must be saved on the master MSM-3 to guarantee hitless failover and hitless upgrade operation. Failure to save the configuration may result in an unstable environment after the hitless failover or upgrade operation is complete.

If a hitless failover occurs before you can save the changes, the changes are still in effect on the new master MSM-3. The asterisk appears in front of the command line if unsaved configuration changes are present after a hitless failover. To save your changes after a hitless failover, use the `save` command.

NOTE

If you have a BlackDiamond 6816 switch populated with four MSM-3 modules, the MSMs in slots C and D provide extra switch bandwidth; they do not participate in switch management functions.

Configuring Hitless Failover

You can configure failover so that one of the following occurs:

- All links are forced to be in a down state (nothing is preserved)
- Only the configuration is preserved
- Only the link up/down state is preserved
- The configuration and link up/down states are preserved
- The configuration, link up/down states, and layer 2 FDB and states (STP, EAPS, and ESRP) are preserved
- The configuration, link up/down states, layer 2 FDB and states, and the layer 3 FDB and ARP table are preserved

Hitless failover operation utilizes the last two options. To enable hitless failover, see the following section, "Enabling Hitless Failover."

You can also configure ESRP hitless failover behavior. See "Configuring ESRP for Hitless Failover" on page 112 for more information.

To use the hitless failover feature, you must have a BlackDiamond 6800 series chassis installed with MSM-3 modules running ExtremeWare 7.1.1 or later and BootROM 8.1 or later.

Enabling Hitless Failover

To enable hitless failover, you need to:

- Configure the system recovery level to automatically reboot after a software exception
- Enable the slave MSM-3 to "inherit" its configuration from the master MSM-3
- Configure the external ports to remain active when a failover occurs
- Enable the preservation of layer 2 and/or layer 3 state in the slave MSM-3

NOTE

If you have an active Telnet session and initiate a hitless failover on that switch, the session disconnects when failover occurs.

Configuring the System Recovery Level

You must configure the slave MSM-3 to take over control of the switch if there is a software exception on the master. To configure the slave to assume the role of master, use the following command:

```
configure sys-recovery-level [all | critical] msm-failover
```

where the following is true:

- `all`—Configures ExtremeWare to log an error into the syslog and automatically reboot the system after any task exception
- `critical`—Configures ExtremeWare to log an error into the syslog and automatically reboot the system after a critical task exception

For more information about this command, see the following chapters:

- "Status Monitoring and Statistics" in the *ExtremeWare Software User Guide*
- "Commands for Status Monitoring and Statistics" in the *ExtremeWare Command Reference Guide*

Inheriting the Master's Software Configuration

To enable the slave MSM-3 to inherit the software configuration from the master MSM-3, use the following command:

```
configure msm-failover slave-config [inherited | flash]
```

where the following is true:

- `inherited`—Specifies that the slave MSM-3 inherits the software configuration maintained by the current master MSM-3 (this supports hitless failover)
- `flash`—Specifies that the slave MSM-3 use the configuration stored in its flash memory (this is the default and does not support hitless failover)

  If you enter the `flash` keyword, you cannot use the `preserve-state` option of the `configure msm-failover link-action` command.

Configuring Port Behavior and Preserving Layer 2 and Layer 3 States

In addition to enabling the use of the inherited software configuration, you need to configure the behavior of the external ports when a failover occurs. To configure the external port response, use the following command:

```
configure msm-failover link-action [keep-links-up {preserve-state [l2 | l2_l3]} |
take-links-down]
```

where the following is true:

- `keep-links-up`—Configures the external ports to not be reset when MSM failover occurs
- `preserve-state`—Configures the preservation of the link up and down states

  NOTE

  If you do not enter the `preserve-state` *keyword, layer 2 and layer 3 states are not preserved, and the failover or upgrade is not hitless.*

  Enter one of the following options to preserver layer 2 and/or layer 3 states:

  — `l2`—Preserves layer 2 FDB and states (MAC FDB, load sharing, STP, EAPS, and ESRP)

    If you enter `l2`, additional ESRP configuration is required to preserve the ESRP state. By default, the ESRP failover action is *none*. Configuring the slave to "inherit" the master's configuration and setting the preserve state to l2 or l2_l3 is not sufficient to preserve the ESRP state.

    See "Configuring ESRP for Hitless Failover" on page 112 for more information.

  — `l2_l3`—Preserves layer 2 FDB and states plus layer 3 states (IPFDB, ARP, access lists, etc.)

  - If you enter `l2_l3`, the unicast hardware IP FDB is also preserved, but the full route table and routing protocol databases for OSPF, BGP, RIP, etc. are not preserved.

    After a hitless failover has completed, the routing protocols initialize like they do on a full reboot. The neighboring routers see that the router has restarted and the neighbors re-route IP traffic to alternate routes until the switch has reestablished it's routing databases.

    Since existing IP traffic flows are preserved in the FDB, data continues to be forwarded for these flows during the start of the hitless failover and the traffic re-route. This has the effect of shortening or eliminating traffic hits for these flows.

    The design of the neighboring router and/or the network traffic load determines whether a network re-routing operation is or is not hitless.
  - If you enter `l2_l3`, you also need to configure ESRP for hitless failover to preserve the ESRP state. See "Configuring ESRP for Hitless Failover" on page 112 for more information.
- `take-links-down`—Configures the external ports to be reset when MSM failover occurs (this is the default and does not support hitless failover)

Configuring Timers

For switch management functions to hitlessly transition between the master and the slave, timer expiration is required. When you initiate hitless failover, the failover timer begins.

The failover timer configures the time it takes from when hitless failover begins until the relearned layer 3 databases are linked to the FDB. All FDB entries that are not linked to one of the databases at the timeout are deleted.

To configure the failover timer, use the following command:

```
configure msm-failover timeout <time>
```

The `time` parameter specifies the failover time. By default, the failover time is 60 seconds, and the range is 30 to 300 seconds.

Disabling Hitless Failover

To disable hitless failover, and return to the factory defaults, use the following command:

```
unconfigure msm-failover
```

The following occurs after you execute this command:

- The external ports are reset when an MSM failover occurs
- No state is preserved when a failover occurs
- The MSM failover timeout returns to 60 seconds
- The new master uses the configuration file kept in its flash memory upon failover

Displaying Hitless Failover Statistics

To display hitless failover statistics, use the following command:

```
show msm-failover
```

The output displays the following:

- Current state of the MSM
- Software image information (primary/secondary image, version)
- Cause of the last failover
- Failover configuration (link action, preserve state, slave configuration, timeout)
- ESRP failover mode
- Failover status for the supported subsystems (configuration, layer 2 hardware, layer 3 hardware, STP, EAPS, ARP, ESRP)

  Each of the supported subsystems display one of the following states:

  — disable—Hitless failover is disabled. This is also the initial state.

  — initial—Hitless failover is enabled, but the downloading of the subsystem state has not yet started for a particular subsystem.

  — xfr—The subsystem's state is in the process of being transferred to the slave. The state transfer includes all of the state for that subsystem.

  — ready—The subsystem has received its state download. In the ready state, it may receive updates to its internal states.

  — failed—The subsystem encountered a failure. To clear the failure, reboot the slave MSM.

  — unknown—If this state is displayed, contact Extreme Networks® Technical Support.

  — <not available>—The state and reason for the current slave shows this if the slave is in the process of being rebooted or is not present in the chassis.

After a reboot or insertion of a slave MSM-3, use this command to ensure that the slave is ready before initiating a hitless failover.

Configuring ESRP for Hitless Failover

Extreme Standby Router Protocol (ESRP) operates at both the layer 2 and layer 3 levels. An ESRP instance has the following states:

- Neutral—The initial state when ESRP is enabled.
- Slave—The slave switch is available to assume the responsibilities of the master switch if the master becomes unavailable or criteria for ESRP changes. Forwarding is disabled.
- Pre-master—The ESRP pre-master switch is ready to be master but is going through possible loop detection. Forwarding is disabled.
- Master—The ESRP master switch is responsible for responding to clients for layer 3 routing and layer 2 switching for the VLAN. Forwarding is enabled.

During the initialization of hitless failover, an ESRP instance is placed in the neutral state. Therefore, a switch that is in the master state and experiences a non-hitless failover is placed in the neutral state. This may result in a loss of traffic and the election of a new master.

To prevent standby nodes from renegotiating when the master node attempts a hitless failover, the master switch sends a notification to the standby nodes indicating a hitless failover attempt. The standby nodes increase their timeout values so they do not elect a new master. After the master recovers, it resumes normal communication with the standby nodes, and the standby nodes recognize the continued presence of the master. All unicast flows are preserved, and the ports retain the same state throughout the failover.

To configure the desired operation of hitless failover when ESRP is in use, use the following command:

```
configure msm-failover esrp-failover-mode [none | rapid-reelection |
remain-esrp-master-in-l2-domains {<reelect-timeout>}]
```

where the following is true:

- none—Specifies that ESRP does not participate in hitless failover. The master switch blocks its ports during a failover and performs a full initialization of ESRP. This is the default.
- rapid-reelection—Specifies that ESRP behaves as if none was selected. In addition, if a failover occurs when the switch is the master in an ESRP domain, the switch sends a notification that the standby nodes should elect a new master as soon as possible. This facilitates a faster ESRP master reelection than none.
- remain-esrp-master-in-l2-domains—Specifies that an ESRP master notifies the standby nodes of the failover and wishes to remain the master. Along with the notification, it sends the amount of time in seconds that the standby nodes should wait before beginning reelection.
  - reelect-timeout—Specifies the amount of time the standby nodes should wait before beginning reelection. The default is 30 seconds, and the range is 15 - 180 seconds.

  When the master finishes initializing, it resumes communication with the standby nodes, and the standby nodes revert to their standard timeout value.

ESRP Domain Behavior

The configure msm-failover esrp-failover-mode command affects all ESRP domains. However, individual domains may respond differently to hitless failover depending on circumstances and configurations.

When using the remain-esrp-master-in-l2-domains option, the behavior is hitless within an ESRP domain whenever that domain is configured with layer 2 tracking options only. If you have an ESRP domain with layer 3 tracking options, or you configure an ESRP VLAN to have both layer 2 and layer 3 tracking options, the remain-esrp-master-in-l2-domains option is overridden. Rather, the ESRP domain or VLAN assumes the behavior of the rapid-reelection option.

Table 13: Hitless failover support for ESRP tracking options

Tracking Option	Hitless Support
Diagnostic	Yes
Environment	Yes
VLAN	Yes
OSPF, BGP, RIP	No
IP Route	No
Ping	No

For more information about ESRP and ESRP tracking, see the chapter “Extreme Standby Routing Protocol” in the *ExtremeWare Software User Guide*.

Displaying ESRP Hitless Failover Statistics

To display ESRP hitless failover statistics, use the following command:

```
show esrp {detail}
```

The output varies depending upon the configuration and the state of the switch:

- Standby switch—Information about the impending failover and the timeout is displayed
- Layer 3 tracking in use and the failover mode is `remain-esrp-master-in-l2-domain`—Information about rapid reelection and layer 3 tracking is displayed
- Layer 3 tracking is not in use and the failover mode is `remain-esrp-master-in-l2-domain`—Information about remaining the master is displayed
- `rapid-reelection`—Information about rapid reelection is displayed
- `none`—Information about not participating in hitless failover is displayed

Overview of Hitless Upgrade

As described previously, when you install two MSM-3 modules in a BlackDiamond chassis, one assumes the role of master and the other assumes the role of slave. The master executes the switch's management function, and the slave acts in a standby role. Hitless upgrade (a component of T-sync) is a mechanism that allows an upgrade of the ExtremeWare version running on a BlackDiamond chassis without:

- Taking the switch out of service
- Losing traffic
- Interrupting network operation

NOTE

It is important to save any switch configuration changes that you make. Configuration changes made in real-time must be saved on the master MSM-3 to guarantee hitless failover and hitless upgrade operation. Failure to save the configuration may result in an unstable environment after the hitless failover or upgrade operation is complete.

You perform a hitless upgrade by downloading the new software image, selecting it, and then forcing a hitless failover to occur. This guide describes two methods that you can use to perform a hitless upgrade:

- Standard
- Conservative

Each method results in an upgrade to the new version of ExtremeWare; the difference is which version is executed if there is another hitless failover. When you perform any upgrade, pre-established flows remain active, and new flows take additional time.

NOTE

If you have a BlackDiamond 6816 switch populated with four MSM-3 modules, the MSMs in slots C and D provide extra switch bandwidth; they do not participate in switch management functions.

To use the hitless upgrade feature, you must have a BlackDiamond 6800 series chassis installed with MSM-3 modules running ExtremeWare 7.1.1 or later and BootROM 8.1 or later.

Standard Upgrade

One method of hitless upgrade is a standard upgrade. A *standard* upgrade causes the new version of ExtremeWare to execute on any failover that occurs *after* the software upgrade. Perform a standard upgrade after you qualify the new ExtremeWare release for your network.

Use the standard approach after you test the new software release and you are ready to implement the new software across your entire network.

Conservative Upgrade

Another method of hitless upgrade is a conservative upgrade. A *conservative* upgrade causes the previous version of ExtremeWare to execute on any failover that occurs *after* the upgrade. Perform a conservative upgrade when you want to “try” a new version of ExtremeWare.

Extreme Networks recommends using the conservative approach to:

- Test a new software release before deploying it across your entire network
- Test a new software patch
- Qualify the new ExtremeWare release for your network

If you are not ready to deploy the new software, you can hitlessly restore the previous software version and network configuration. Use the conservative method to test a new ExtremeWare release. Do not use this method to run two different versions of ExtremeWare on the master and slave for an extended period of time.

Performing a Hitless Upgrade

You can perform a hitless software upgrade on an MSM-3 without interrupting network operation. This section describes two software upgrade methods and includes a troubleshooting section:

- Standard Software Upgrade on page 115
- Conservative Software Upgrade on page 117
- Troubleshooting on page 118

Standard Software Upgrade

The steps described in this section assume the following:

- MSM-3 installed in slot A is the master
- Primary image is in use
- MSM-A is the MSM-3 installed in slot A
- MSM-B is the MSM-3 installed in slot B
- You are running ExtremeWare 7.1.1 or later and BootROM 8.1 or later (see the *ExtremeWare 7.1.1 Release Notes* for more information)

- You configured the system for hitless failover operation (see “Configuring Hitless Failover” on page 109 for more information)

NOTE

If you have an active Telnet session and initiate a hitless failover on that switch, the session disconnects when failover occurs.

To failover to the same, new software image, do the following:

1 Download the new software image to the primary image space using the following command:

```
download image [<hostname> | <ip address>] <filename>
```

where the following is true:

- `hostname`—Specifies the hostname of the TFTP server from which the image should be obtained (DNS must be enabled to use this option)
- `ip address`—Specifies the IP address of the TFTP server from which the image should be obtained
- `filename`—Specifies the filename of the new software image

The primary image loads on both the master and slave MSM.

2 To use the new software image on the slave, you must reboot the slave before the failover can take place.

Reboot MSM-B using the following command:

```
reboot slot msm-b
```

where `msm-b` specifies the slave MSM-3 installed in slot B.

After you reboot the slave, the new software image begins running on the slave.

The master downloads it’s configurations, FDB entries, etc. to the slave. After the master finishes it’s download, the following message is logged:

```
Slave MSM initialized for hitless failover operation.
```

3 Verify that the correct BootROM and ExtremeWare version are loaded using the `show switch` and `show version` commands.

4 Initiate failover using the following command:

```
run msm-failover
```

MSM-B becomes the master and runs the new software image. MSM-A becomes the slave and also runs the new software image.

5 Verify the slave state using the following command:

```
show msm-failover
```

You can also verify the slave state by viewing the syslog. To view the syslog, use the following command:

```
show log
```

Conservative Software Upgrade

The steps described in this section assume the following:

- MSM-3 installed in slot A is the master
- Primary image is in use
- MSM-A is the MSM-3 installed in slot A
- MSM-B is the MSM-3 installed in slot B
- You are running ExtremeWare 7.1.1 or later and BootROM 8.1 or later (see the *ExtremeWare 7.1.1 Release Notes* for more information)
- You configured the system for hitless failover operation (see “Configuring Hitless Failover” on page 109 for more information)

NOTE

If you have an active Telnet session and initiate a hitless failover on that switch, the session disconnects when failover occurs.

To failback to the previous software image, do the following:

1. Choose the secondary image of MSM-A using the following command:

```
use image secondary
```

2. Download the new software image to the secondary image space using the following command:

```
download image [<hostname> | <ip address>] <filename>
```

   where the following is true:

   - `hostname`—Specifies the hostname of the TFTP server from which the image should be obtained (DNS must be enabled to use this option)
   - `ip address`—Specifies the IP address of the TFTP server from which the image should be obtained
   - `filename`—Specifies the filename of the new software image

3. Verify that the correct BootROM and ExtremeWare version are loaded using the `show switch` and `show version` commands.

4. Force the slave to boot up using the new software version. This must happen before failover can occur.

   Reboot MSM-B using the following command:

```
reboot slot msm-b
```

   where `msm-b` specifies the slave MSM-3 installed in slot B.

   After the slave is reset, a series of log messages are displayed:

   - The first message indicates that MSM-B has initialized as a slave
   - Another message appears for each database download (configurations, FDB entries, etc.)
   - When all of the databases are downloaded, a message indicates that the slave is fully prepared for execution of a failover

5. Select the primary image (that now contains the older software release) using the following command:

```
use image primary
```

6 Initiate failover using the following command:

```
run msm-failover
```

The failover allows MSM-B to become the master running the new software release. Because the current image selected is primary, MSM-A reboots to the old release. MSM-B then downloads the original configuration from MSM-A back to MSM-A.

NOTE

If you issue any configuration command (configuration, enable, disable, create, etc.) after a conservative upgrade, you are unable to downgrade to the previous software release.

By using the conservative method, you can upgrade or downgrade software without disrupting the network. This method allows you to test new software releases because you:

- Will not disrupt the network
- Can failback to your previous software version and configurations saved to MSM-A

If you want to failback to MSM-A after you test a software release, enter the `run msm-failover` command. MSM-A becomes the master and runs the software and configurations you had in place before the upgrade.

After you qualify the new software release and determine that you do not want to failback to the previous software release, enter the `use image secondary` command. The next time you reboot the switch, both MSM-3s run the new software image.

Troubleshooting

If you encounter problems during a hitless upgrade, this section may be helpful. If you have a problem not listed here or in the release notes, contact your Extreme Networks Technical Support representative.

MSM-3 Initialization

If the slave MSM-3 does not initialize properly, you can restart the MSM hardware, including the switch fabric, using the following command:

```
reboot slot [msm-a | msm-b] hard-reset
```

where the following is true:

- `msm-a`—Specifies the slave MSM-3 module installed in slot A.
- `msm-b`—Specifies the slave MSM-3 module installed in slot B.
- `hard-reset`—Restarts the MSM hardware, processor, and switch fabric. If you select this option, you will experience some traffic loss.

NOTE

If you enter the `hard-reset` *option, a hitless upgrade does not occur.*

After you enter the `hard-reset` option, a warning message is displayed that indicates some of the switch forwarding operations may be briefly interrupted, and you are asked to confirm the operation. If you do not want to interrupt switch forwarding, do not confirm the operation.

Unexpected Failover Results

If you experience unexpected failover results, use the following command to help determine the reason:

```
show msm-failover
```

Information about the state of the new master and the current slave is displayed:

- Old states and old reasons of the new master—Helps determine the state of the current master (former slave) before the last failover when it became the master.
- Current states and current reasons of the new slave—Helps determine the current state of the slave.

The following three sample scenarios describe how you can use the `show msm-failover` command to help troubleshoot unexpected failover results.

Scenario 1. If you perform a conservative upgrade and later configure the switch, this causes an unexpected failover result. Issuing any configuration command (configuration, enable, disable, create, etc.) after a conservative upgrade prevents you from downgrading to the previous software release on the slave.

If this happens, you can change the image of the slave to the new software release and reboot the slave. By doing this, the new software image runs on both the master and the slave. After some time, the `show msm-failover` command indicates that the slave is in the ready state and failover to the same software release is possible.

Scenario 2. If a failover occurs and there was a network hit, use the `show-msm failover` command to view the output to find out why the hit occurred.

Scenario 3. If the slave is in the failed state, hitless failover cannot occur. Use the `show-msm failover` command to view the output to display the reason for the failure.

Table 14 describes the failover reason codes displayed with the `show msm-failover` command.

Table 14: Descriptions of failover reason codes

Reason Code	Description
none	No failure occurred.
rev(M) > rev(S)	An older version slave is present, but a hitless upgrade from the slave to the master was not performed.
hotswap	A slave was removed after performing a conservative upgrade.
config command	A configuration command was entered after a conservative upgrade. This prevents you from downgrading to the pervious software release on the slave.
memory	Contact Extreme Networks Technical Support.
brkt ovflow	Contact Extreme Networks Technical Support.
invalid brkt	Contact Extreme Networks Technical Support.
invalid subtype	Each subsystem classifies its messages between the master and slave. If the slave does not recognize a message classifier, an error occurs.
comm error	This error message is currently not in use. If you see this message, contact Extreme Networks Technical Support.
no xh support	This error message is currently not in use. If you see this message, contact Extreme Networks Technical Support.
L2,L3 failed	Contact Extreme Networks Technical Support.

Table 14: Descriptions of failover reason codes (Continued)

Reason Code	Description
config failed	This error message is currently not in use. If you see this message, contact Extreme Networks Technical Support.
keepalive	Contact Extreme Networks Technical Support.
watchdog	Contact Extreme Networks Technical Support.

6 Virtual LANs (VLANs)

This chapter covers the following topics:

- Overview of Virtual LANs on page 121
- Types of VLANs on page 122
- VLAN Names on page 130
- Configuring VLANs on the Switch on page 131
- Displaying VLAN Settings on page 132
- VLAN Tunneling (VMANs) on page 134
- MAC-Based VLANs on page 136
- VLAN Translation on page 139

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

Overview of Virtual LANs

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

Benefits

Implementing VLANs on your networks has the following advantages:

- **VLANs help to control traffic—**With traditional networks, congestion can be caused by broadcast traffic that is directed to all network devices, regardless of whether they require it. VLANs increase the efficiency of your network because each VLAN can be set up to contain only those devices that must communicate with each other.
- **VLANs provide extra security—**Devices within each VLAN can only communicate with member devices in the same VLAN. If a device in VLAN *Marketing* must communicate with devices in VLAN *Sales*, the traffic must cross a routing device.

- **VLANs ease the change and movement of devices—**With traditional networks, network administrators spend much of their time dealing with moves and changes. If users move to a different subnetwork, the addresses of each endstation must be updated manually.

Types of VLANs

VLANs can be created according to the following criteria:

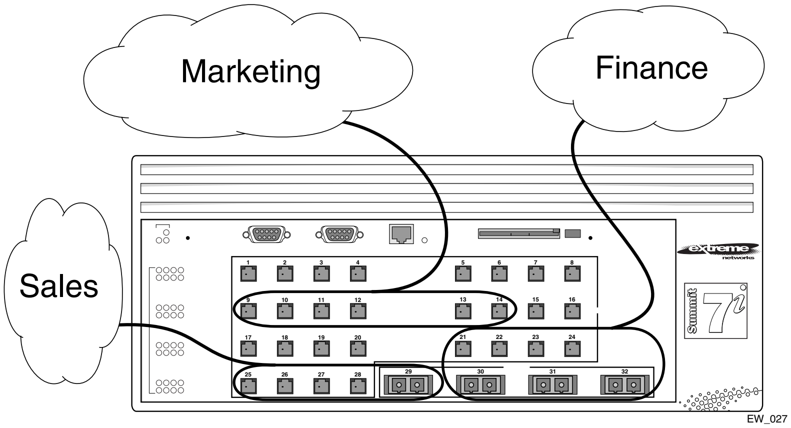
- Physical port
- 802.1Q tag
- Ethernet, LLC SAP, or LLC/SNAP Ethernet protocol type
- MAC address
- A combination of these criteria

Port-Based VLANs

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

On the Summit7i switch in Figure 5, ports 9 through 14 are part of VLAN *Marketing*; ports 25 through 29 are part of VLAN *Sales*; and ports 21 through 24 and 30 through 32 are in VLAN *Finance*.

Figure 5: Example of a port-based VLAN on the Summit7i switch



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

Spanning Switches with Port-Based VLANs

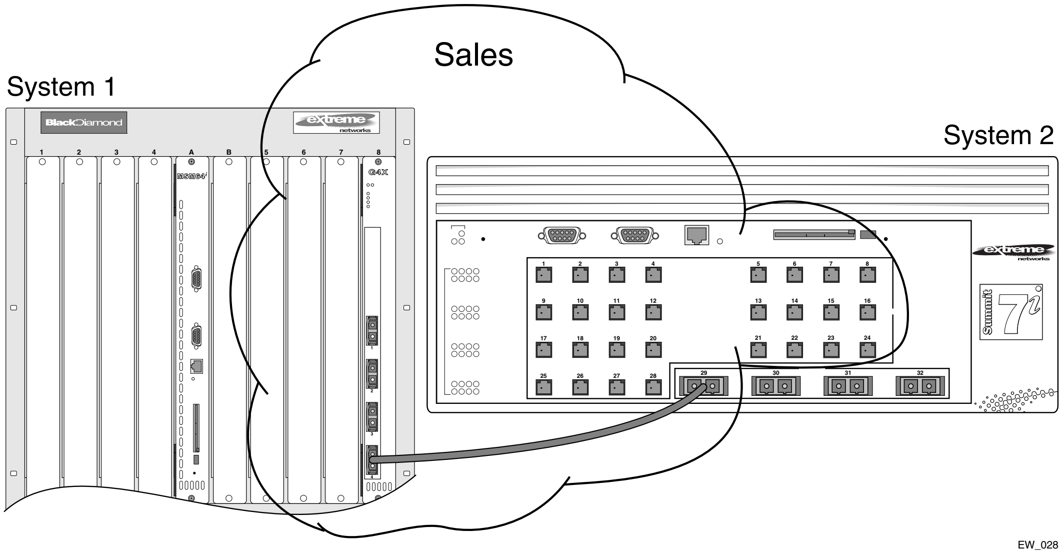
To create a port-based VLAN that spans two switches, you must do two things:

1 Assign the port on each switch to the VLAN.

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

Figure 6 illustrates a single VLAN that spans a BlackDiamond switch and a Summit7i switch. All ports on the BlackDiamond switch belong to VLAN *Sales*. Ports 1 through 29 on the Summit 7i switch also belong to VLAN *Sales*. The two switches are connected using slot 8, port 4 on system 1 (the BlackDiamond switch), and port 29 on system 2 (the Summit7i switch).

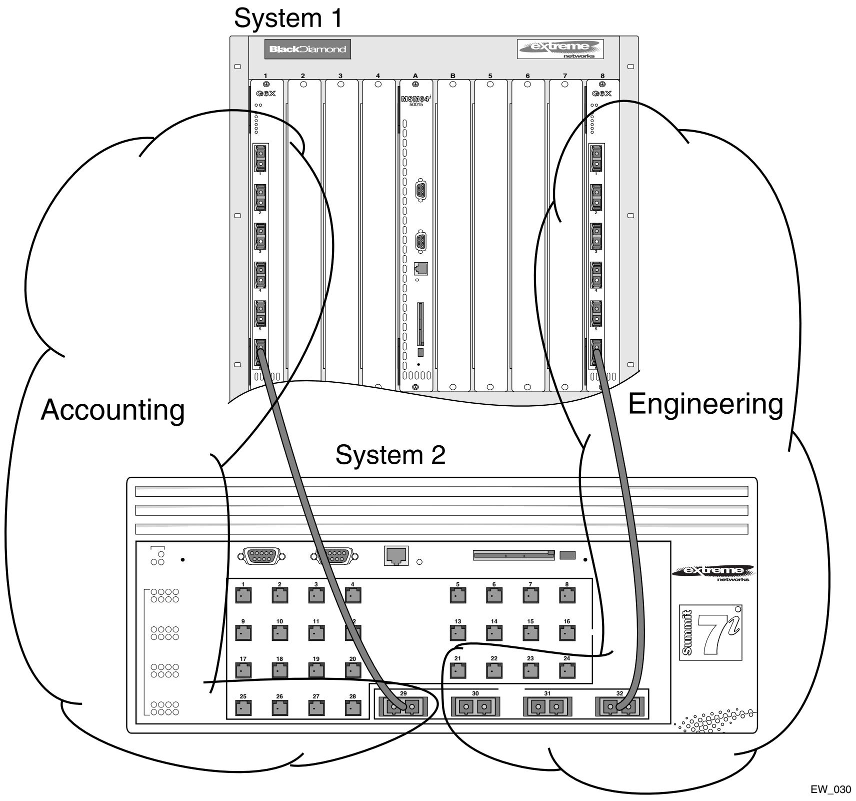
Figure 6: Single port-based VLAN spanning two switches



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

Figure 7 illustrates two VLANs spanning two switches. On system 2, ports 25 through 29 are part of VLAN *Accounting*; ports 21 through 24 and ports 30 through 32 are part of VLAN *Engineering*. On system 1, all port on slot 1 are part of VLAN *Accounting*; all ports on slot 8 are part of VLAN *Engineering*.

Figure 7: Two port-based VLANs spanning two switches



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

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

Tagged VLANs

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

NOTE

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

Uses of Tagged VLANs

Tagging is most commonly used to create VLANs that span switches. The switch-to-switch connections are typically called *trunks*. Using tags, multiple VLANs can span multiple switches using one or more trunks. In a port-based VLAN, each VLAN requires its own pair of trunk ports, as shown in Figure 7. Using tags, multiple VLANs can span two switches with a single trunk.

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

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

Assigning a VLAN Tag

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

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

NOTE

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

Figure 8 illustrates the physical view of a network that uses tagged and untagged traffic.

Figure 8: Physical diagram of tagged and untagged traffic

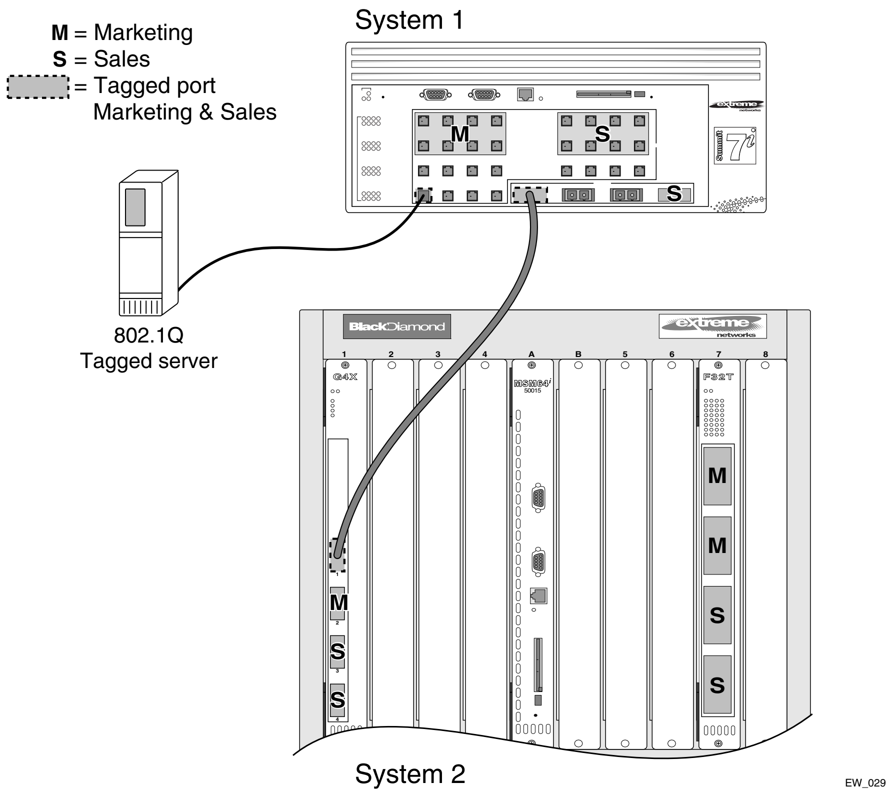
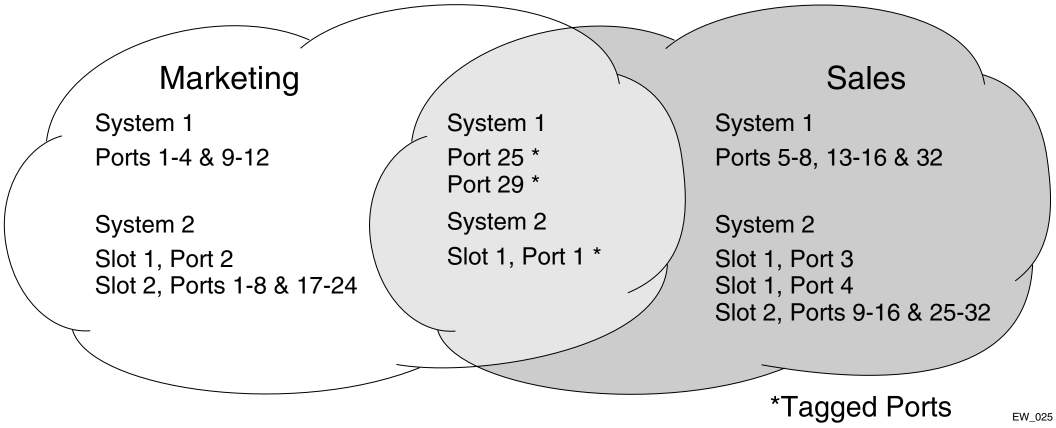


Figure 9 is a logical diagram of the same network.

Figure 9: Logical diagram of tagged and untagged traffic



In Figure 8 and Figure 9:

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

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

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

Mixing Port-Based and Tagged VLANs

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

NOTE

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

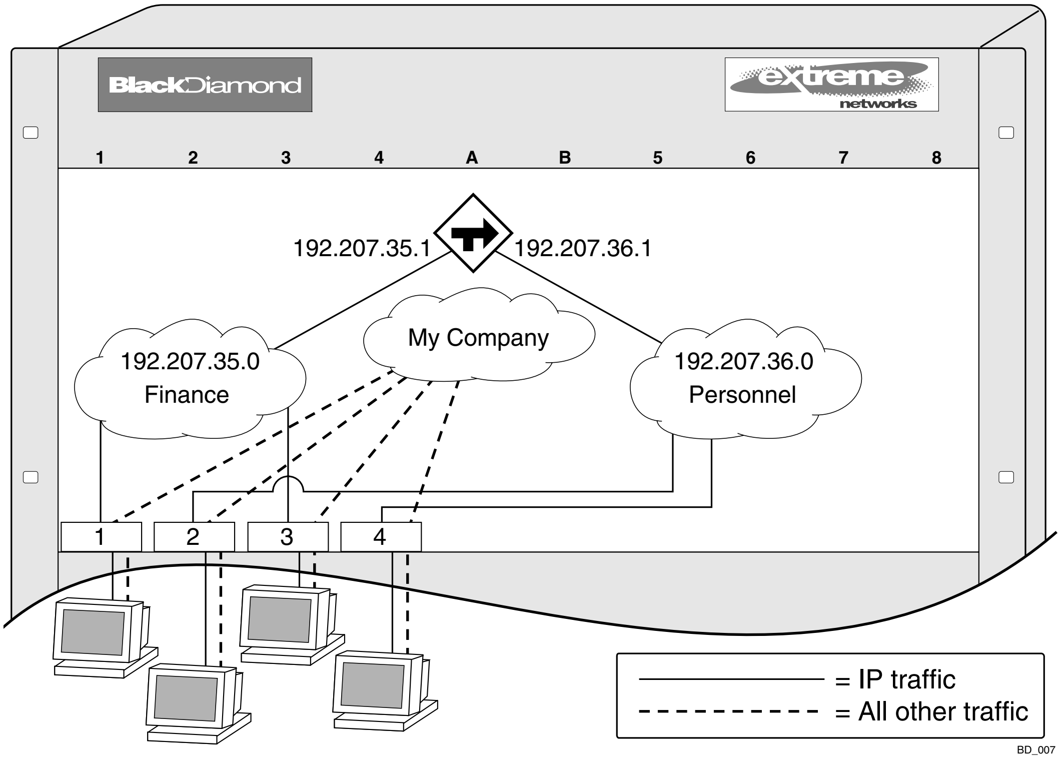
Protocol-Based VLANs

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

Protocol-based VLANs are most often used in situations where network segments contain hosts running multiple protocols. For example, in Figure 10, the hosts are running both the IP and NetBIOS protocols.

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

Figure 10: Protocol-based VLANs



Predefined Protocol Filters

The following protocol filters are predefined on the switch:

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

Defining Protocol Filters

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

1 Create a protocol using the following command:

```
create protocol <protocol_name>
```

For example:

```
create protocol fred
```

The protocol name can have a maximum of 32 characters.

2 Configure the protocol using the following command:

```
configure protocol <protocol_name> add <protocol_type> <hex_value>
{<protocol_type> <hex_value>} ...
```

Supported protocol types include:

— etype—EtherType.

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

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

— llc—LLC Service Advertising Protocol (SAP).

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

— snap—Ethertype inside an IEEE SNAP packet encapsulation.

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

For example:

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

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

NOTE

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

Deleting a Protocol Filter

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

Precedence of Tagged Packets Over Protocol Filters

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

VLAN Names

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

- Space
- Comma
- Quotation mark

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

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

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

NOTE

You should use VLAN names consistently across your entire network.

Default VLAN

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

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

Renaming a VLAN

To rename an existing VLAN, use the following command:

```
configure vlan <old_name> name <new_name>
```

The following rules apply to renaming VLANs:

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

Configuring VLANs on the Switch

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

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

NOTE

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

NOTE

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

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

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

VLAN Configuration Examples

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

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

NOTE

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

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

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

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

```
create vlan sales
configure sales tag 120
configure sales add port 1-3 tagged
configure default delete port 4,7
configure sales add port 4,7
```

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

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

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

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

Displaying VLAN Settings

To display VLAN settings, use the following command:

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

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

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

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

Displaying VLAN Statistics

To display VLAN statistics, use the following command:

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

The information displayed includes:

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

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

Displaying VLAN Statistics Per Port

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

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

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

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

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

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

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

To remove the port mask, use the following command:

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

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

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

Displaying Protocol Information

To display protocol information, use the following command:

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

This `show` command displays protocol information, which includes:

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

VLAN Tunneling (VMANs)

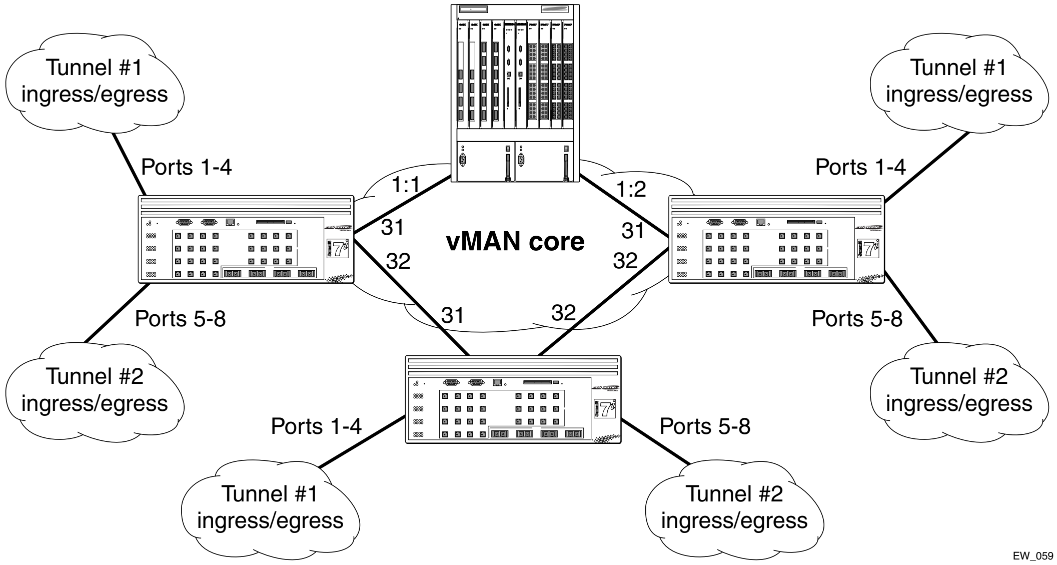
You can "tunnel" any number of 802.1Q and/or Cisco ISL VLANs into a single VLAN that can be switched through an Extreme Ethernet infrastructure. A given tunnel is completely isolated from other tunnels or VLANs. This feature is useful in building transparent private networks (VMANs) that need point-to-point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

To configure a VMAN tunnel, follow these steps:

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

Figure 11 illustrates a configuration with VMANs.

Figure 11: VMAN example



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

The configuration for the Summit7i switches shown in Figure 11 is:

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

On the BlackDiamond switch, the configuration is:

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

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

MAC-Based VLANs

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

MAC-Based VLAN Guidelines

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

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

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

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

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

MAC-Based VLAN Limitations

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

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

MAC-Based VLAN Example

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

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

Timed Configuration Download for MAC-Based VLANs

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

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

```
configure download server [primary | secondary] [<ip address> | <hostname>] <filename>
```

To enable timed interval downloads, use the following command:

```
download configuration every <time>
```

To display timed download information, use the following command:

```
show switch
```

Example

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

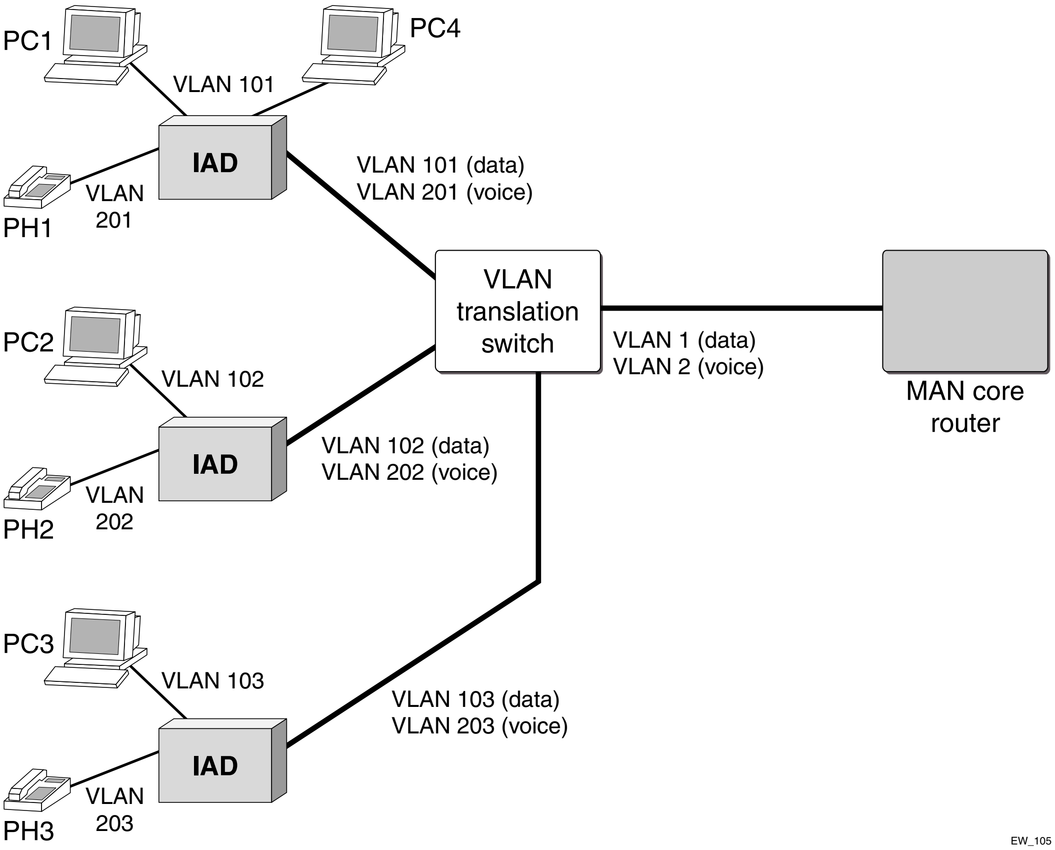
The following example shows an incremental configuration file for MAC-based VLAN information that updates the database and saves changes:

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

VLAN Translation

VLAN translation provides the ability to translate the 802.1Q tags for several VLANs into a single VLAN tag. This allows you to aggregate layer 2 VLAN traffic from multiple clients into a single uplink VLAN, improving VLAN scaling.

Figure 12: An Application of VLAN Translation



In the figure, VLANs 101, 102, and 103 carry data traffic while VLANs 201, 202, and 203 carry voice traffic. The voice and data traffic are combined on Integrated Access Devices (IAD) that connect to the VLAN translation switch. Each of the three clusters of phones and PCs use two VLANs to separate the voice and data traffic. As the traffic is combined, the six VLANs are translated into two. This simplifies administration, and scales much better for large installations.

Conceptually, this is very similar to the existing layer 3 VLAN Aggregation (super-VLANS and sub-VLANs) that currently exists in ExtremeWare. The primary differences between these two features are:

- VLAN translation is strictly a layer 2 feature.
- VLAN translation does not allow communications between the member VLANs.
- VLAN translation requires the translation VLAN (unlike a super-VLAN) to contain one or more ports.

VLAN Translation Behavior

You should be aware of the behavior of both unicast, broadcast, and multicast traffic when using VLAN translation.

Unicast Traffic

Traffic on the member VLANs may be either tagged or untagged. Traffic is switched locally between client devices on the same member VLAN as normal. Traffic cannot be switched between clients on separate member VLANs. Traffic from any member VLAN destined to the translation VLAN is switched and the VLAN tag is translated appropriately. Traffic from the translation VLAN destined to any member VLAN is switched and the VLAN tag is translated.

Broadcast Behavior

Broadcast traffic generated on a member VLAN will be replicated in every other active port of that VLAN as normal. In addition, the member VLAN traffic will be replicated to every active port in the translation VLAN and the VLAN tag will be translated appropriately. Broadcast traffic generated on the translation VLAN will be replicated to every other active port in this VLAN as usual. The caveat in this scenario is that this traffic will also be replicated to every active port in every member VLAN, with VLAN tag translation. In effect, the broadcast traffic from the translation VLAN will leak onto all member VLANs.

Multicast Behavior

IGMP snooping may be enabled on member and translation VLANs so that multicast traffic can be monitored within the network. IGMP snooping software examines all IGMP control traffic that enters the switch. IGMP control traffic received on a VLAN translation port is forwarded by the CPU to all other ports in the translation group. Software VLAN translation is performed on the packets which cross the translation boundary between member and translation VLANs. The snooping software will detect ports joining and leaving multicast streams. When a VLAN translation port joins a multicast group, an FDB entry will be created using information from the IGMP message. The FDB entry will be added for the requested multicast address and will contain a multicast PTAG. When a VLAN translation port leaves a multicast group, the port will be removed from the multicast list. The last VLAN translation port to leave a multicast group will cause the multicast FDB entry to be removed.

VLAN Translation Limitations and Notes

VLAN translation is an layer 2 function only, therefore, a limited subset of protocol support can be provided. Listed below are the limitations for VLAN translation, and some notes on usage:

- Only "*i*" series hardware is supported.
- MAC addresses must be unique for devices on all member VLANs connected to the same switch.
- IP addresses may not be configured on member or translation VLANs.
- Member VLANs cannot be configured as a translation VLAN on the same switch.
- Translation VLANs cannot be configured as a member VLAN on the same switch.
- Layer 3 VLAN aggregation cannot be enabled on member or translation VLANs.
- 802.1x authentication cannot be enabled on ports that are included in a member or translation VLAN.

- Network Login cannot be enabled on ports that are included in a member or translation VLAN.
- DHCP cannot be enabled on ports that are included in a member or translation VLAN.
- Member or translation VLANs cannot be used by TLS.
- EDP may be enabled on ports that are included in member and translation VLANs.
- ESRP cannot be enabled on member or translation VLANs.
- ESRP BPDUs will be translated through the switch (BPDU tunneling).
- ESRP redundancy may be provided by adding a translation VLAN as a member of an ESRP domain.
- STP redundancy may be provided by protecting ports that are included in member VLANs.
- EAPS control VLANs may not be either member or translation VLANs.
- EAPS protected VLANs may not be member VLANs. Only translation VLANs may be protected.
- IGMP snooping may be enabled on member and translation VLANs.
- VMAN encapsulated VLAN tags are not translated.
- VLAN translation MACs are accounted for at each port during learning, thus these MACs are used in the calculations for sending MAC security traps.

Interfaces

Use the following information for selecting and configuring VLAN translation interfaces:

- Member and translation VLANs may only contain Ethernet ports, therefore POS, ATM, and WAN (T1, E1, T3) ports are not supported.
- A single physical port may be added to multiple member VLANs, using different VLAN tags.
- Member VLANs and translation VLANs may include both tagged and untagged ports.

VLAN Translation Configuration Examples

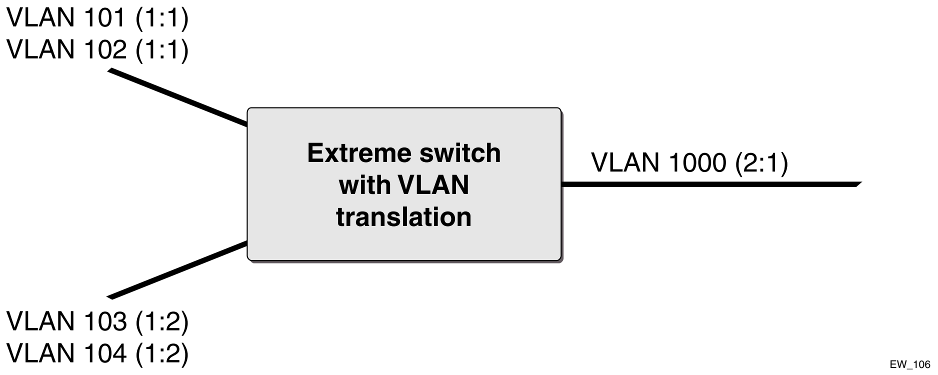
The following configuration examples show VLAN translation used in three scenarios:

- Basic VLAN Translation on page 141
- VLAN Translation with ESRP Redundancy on page 142
- VLAN Translation with STP Redundancy on page 144

Basic VLAN Translation

The following example, shown in Figure 13, configures a basic VLAN translation network. This network provides VLAN translation between four member VLANs and a single translation VLAN.

Figure 13: VLAN Translation Configuration Example



The following configuration commands create the member VLANs:

```
create vlan v101
configure v101 tag 101
configure v101 add ports 1:1 tagged
create vlan v102
configure v102 tag 102
configure v102 add ports 1:1 tagged
create vlan v103
configure v103 tag 103
configure v103 add ports 1:2 tagged
create vlan v104
configure v104 tag 104
configure v104 add ports 1:2 tagged
```

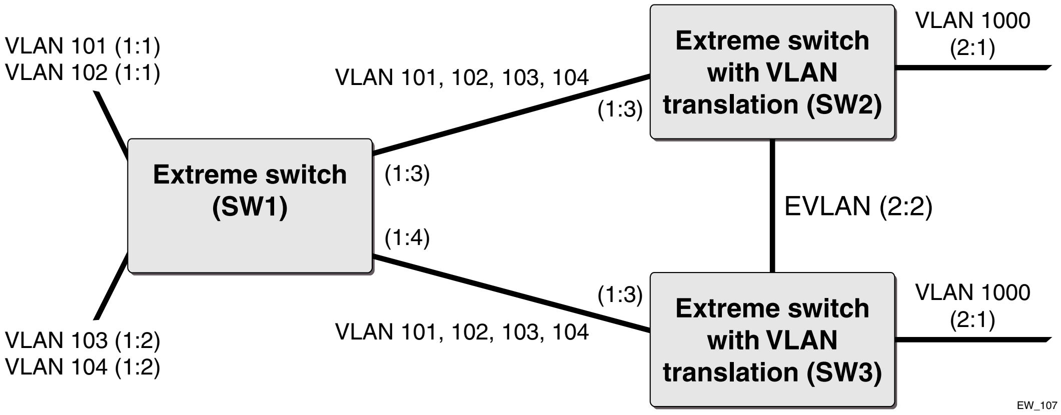
The following configuration commands create the translation VLAN and enables VLAN translation:

```
create vlan v1000
configure v1000 tag 1000
configure v1000 add ports 2:1 tagged
configure v1000 add member-vlan v101
configure v1000 add member-vlan v102
configure v1000 add member-vlan v103
configure v1000 add member-vlan v104
```

VLAN Translation with ESRP Redundancy

The following example, shown in Figure 14, configures a VLAN translation network with ESRP redundancy. The SW2 and SW3 VLAN translation switches are protected by an ESRP control VLAN. The master ESRP switch performs the translation and provides the connectivity to the backbone. When a failure occurs, the slave ESRP switch will take over and begin performing the translation.

Figure 14: ESRP Redundancy Configuration Example



The following configuration commands create the member VLANs on SW1:

```
create vlan v101
configure v101 tag 101
configure v101 add ports 1:1 tagged
configure v101 add ports 1:3 tagged
configure v101 add ports 1:4 tagged
create vlan v102
configure v102 tag 102
configure v102 add ports 1:1 tagged
configure v102 add ports 1:3 tagged
configure v102 add ports 1:4 tagged
create vlan v103
configure v103 tag 103
configure v103 add ports 1:2 tagged
configure v103 add ports 1:3 tagged
configure v103 add ports 1:4 tagged
create vlan v104
configure v104 tag 104
configure v104 add ports 1:2 tagged
configure v104 add ports 1:3 tagged
configure v104 add ports 1:4 tagged
```

The configuration for SW2 and SW3 will be identical for this example. The following configuration commands create the member VLANs on SW2:

```
create vlan v101
configure v101 tag 101
configure v101 add ports 1:3 tagged
create vlan v102
configure v102 tag 102
configure v102 add ports 1:3 tagged
create vlan v103
configure v103 tag 103
configure v103 add ports 1:3 tagged
create vlan v104
configure v104 tag 104
configure v104 add ports 1:3 tagged
```

This set of configuration commands create the translation VLANs and enables VLAN translation on SW2:

```
create vlan v1000
configure v1000 tag 1000
configure v1000 add ports 2:1 tagged
configure v1000 add member-vlan v101
configure v1000 add member-vlan v102
configure v1000 add member-vlan v103
configure v1000 add member-vlan v104
```

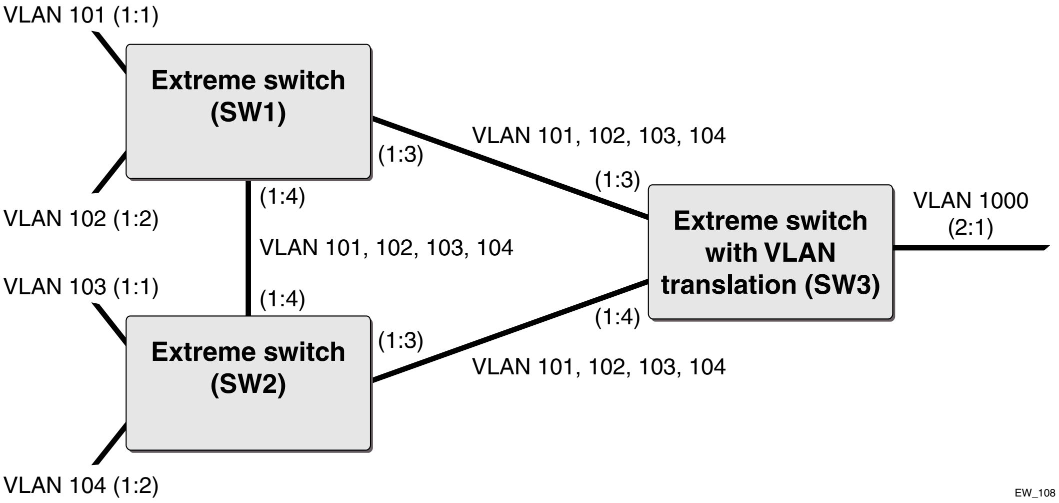
The last set of configuration commands create the ESRP control VLAN and enables ESRP protection on the translation VLAN for SW2:

```
create vlan evlan
configure evlan add ports 2:2
enable esrp evlan
configure evlan add domain-member v1000
```

VLAN Translation with STP Redundancy

The following example, shown in Figure 15, configures a VLAN translation network with redundant paths protected by STP. Parallel paths from the member VLAN portion of the network to the translation switch. STP ensures that the main path for this traffic is active and the secondary path is blocked. When a failure occurs in the main path, the secondary paths are enabled.

Figure 15: STP Redundancy Configuration Example



The following configuration commands create the member VLANs and enables STP on SW1:

```
create vlan v101
configure v101 tag 101
configure v101 add ports 1:1 tagged
configure v101 add ports 1:3 tagged
configure v101 add ports 1:4 tagged
create vlan v102
configure v102 tag 102
configure v102 add ports 1:2 tagged
configure v102 add ports 1:3 tagged
configure v102 add ports 1:4 tagged
create vlan v103
configure v103 tag 103
configure v103 add ports 1:3 tagged
configure v103 add ports 1:4 tagged
create vlan v104
configure v104 tag 104
configure v104 add ports 1:3 tagged
configure v104 add ports 1:4 tagged
create stpd stp1
configure stp1 tag 101
configure stp1 add vlan v101
configure stp1 add vlan v102
configure stp1 add vlan v103
configure stp1 add vlan v104
enable stpd stp1
```

These configuration commands create the member VLANs and enables STP on SW2:

```
create vlan v103
configure v103 tag 103
configure v103 add ports 1:1 tagged
configure v103 add ports 1:3 tagged
configure v103 add ports 1:4 tagged
create vlan v104
configure v104 tag 104
configure v104 add ports 1:2 tagged
configure v104 add ports 1:3 tagged
configure v104 add ports 1:4 tagged
create vlan v101
configure v101 tag 101
configure v101 add ports 1:3 tagged
configure v101 add ports 1:4 tagged
create vlan v102
configure v102 tag 102
configure v102 add ports 1:3 tagged
configure v102 add ports 1:4 tagged
create stpd stp1
configure stp1 tag 101
configure stp1 add vlan v101
configure stp1 add vlan v102
configure stp1 add vlan v103
configure stp1 add vlan v104
enable stpd stp1
```

This set of configuration commands create the member VLANs and enables STP on SW3:

```
create vlan v101
configure v101 tag 101
configure v101 add ports 1:3 tagged
configure v101 add ports 1:4 tagged
create vlan v102
configure v102 tag 102
configure v102 add ports 1:3 tagged
configure v102 add ports 1:4 tagged
create vlan v103
configure v103 tag 103
configure v103 add ports 1:3 tagged
configure v103 add ports 1:4 tagged
create vlan v104
configure v104 tag 104
configure v104 add ports 1:3 tagged
configure v104 add ports 1:4 tagged
create stpd stp1
configure stp1 tag 101
configure stp1 add vlan v101
configure stp1 add vlan v102
configure stp1 add vlan v103
configure stp1 add vlan v104
enable stpd stp1
```

The last set of configuration commands creates the translation VLAN and enables VLAN translation on SW3:

```
create vlan v1000
configure v1000 tag 1000
configure v1000 add ports 2:1 tagged
configure v1000 add member-vlan v101
configure v1000 add member-vlan v102
configure v1000 add member-vlan v103
configure v1000 add member-vlan v104
```

7 Forwarding Database (FDB)

This chapter describes the following topics:

- Overview of the FDB on page 147
- Associating QoS Profiles with an FDB Entry on page 150
- Scanning the FDB on page 151
- FDB Configuration Examples on page 153
- MAC-Based Security on page 153
- Displaying FDB Entries on page 154

Overview of the FDB

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

FDB Contents

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

How FDB Entries Get Added

Entries are added into the FDB in the following ways:

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

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

FDB Entry Types

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

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

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

  — A VLAN is deleted.

  — A VLAN identifier (VLANid) is changed.

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

  — A port is deleted from a VLAN.

  — A port is disabled.

  — A port enters blocking state.

  — A port QoS setting is changed.

  — A port goes down (link down).

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

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

  Both types of dynamic entries age—a dynamic entry will be removed from the FDB (aged-out) if the device does not transmit for a specified period of time (the aging time). This prevents the database from becoming full with obsolete entries by ensuring that when a device is removed from the network, its entry is deleted from the database. The aging time is configurable. For more information about setting the aging time, see "Configuring the FDB Aging Time" on page 153 later in this chapter.

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

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

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

  A *locked static entry* is an entry that was originally learned dynamically, but has been made static (locked) using the MAC address lock-down feature. It is identified by the "s" and "l" flags in `show fdb` output. See "MAC Address Lock Down" on page 263 for more information about MAC address lock-down.

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

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

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

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

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

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

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

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

Disabling MAC Address Learning

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

```
disable learning ports <portlist>
```

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

NOTE

Disabling port learning does not disable forwarding once L3 forwarding and the corresponding learning of FDB and IPFDB tables has been turned ON, Forwarding of traffic through a particular port does not stop even after port learning is disabled for that port. This characteristic is a known behavior of ExtremeWare.

If you disable MAC address learning, you can enable packet flooding on one or more ports. When flooding is enabled on a particular port, *all* frames and packets are passed on to other member ports that also have flooding enabled. This includes all broadcast, multicast, known and unknown unicast packets (including EPD). To make effective use of this feature you should have flooding enabled on more than one port.

You can enable flooding on specified ports using the following command:

```
enable flooding ports <portlist>
```

You can disable flooding on specified ports using the following command:

```
disable flooding ports <portlist>
```

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

Associating QoS Profiles with an FDB Entry

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

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

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

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

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

You can display permanent FDB entries, including their QoS profile associations by using the `permanent` option in the following command:

```
show fdb {<mac_address> | broadcast-mac | permanent | ports <portlist> | remap | vlan
<vlan name>}
```

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

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

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

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

NOTE

For more information on QoS profiles, see Chapter 8.

Scanning the FDB

You can scan the FDB on a stand-alone switch or on a slot or backplane basis on a modular switch. This setting is independent of and in addition to the system health check configuration, and the following commands do not affect the system health check configurations.

For more information about the system health checker and configuring the system health checker, see Chapter 11.

Enabling FDB Scanning

By default, FDB scanning is disabled. To enable FDB scanning on a stand-alone switch, use the following command:

```
enable fdb-scan
```

To enable FDB scanning on an Alpine switch, use the following command:

```
enable fdb-scan [all | slot {{backplane} | <slot number> | msm-a | msm-b}]
```

To enable FDB scanning on a BlackDiamond switch, use the following command:

```
enable fdb-scan [all | slot {{backplane} | <slot number> | msm-a | msm-b}]
```

where the following is true:

- `all`—Specifies all of the slots in the chassis. This is available on modular switches only.
- `backplane`—Specifies the backplane of the Alpine chassis. This is available on Alpine switches only.
- `slot number`—Specifies the slot number of the module to scan. This is available on BlackDiamond switches only.
- `msm-a`—Specifies the MSM installed in slot A. This is available on BlackDiamond switches only.
- `msm-b`—Specifies the MSM installed in slot B. This is available on BlackDiamond switches only.

Disabling FDB Scanning

To disable FDB scanning on a stand-alone switch, use the following command:

```
disable fdb-scan
```

To disable FDB scanning on an Alpine switch, use the following command:

```
disable fdb-scan [all | slot {{backplane} | <slot number> | msm-a | msm-b}]
```

To disable FDB scanning on a BlackDiamond switch, use the following command:

```
disable fdb-scan [all | slot {{backplane} | <slot number> | msm-a | msm-b}]
```

If you disable FDB scanning for a slot and the system health check is enabled, the slot is still scanned by the system health checker.

Configuring the FDB Scan Interval

You can configure the amount of time between FDB scans. To set the interval between FDB scans, use the following command:

```
configure fdb-scan period <period <1-60>>
```

The default is 30 seconds. The range is 1 - 60 seconds. If you configure a timer interval of less than 15 seconds, the following warning message is displayed and you are asked to confirm the change:

```
Setting period below (15) may starve other tasks.
Do you wish to do this? (yes, no, cancel) 06/19/2003 10:29.28 <INFO:SYST> serial
admin: configure fdb-scan period 1
n
```

NOTE

Extreme Networks recommends an interval period of at least 15 seconds.

To return the FDB scan interval to the factory default of 30 seconds, use the following command:

```
unconfigure fdb-scan period
```

If the switch detects too many failures within the specified scan period, the messages are either sent to the syslog or the configured system health check action is taken.

To configure the action the switch takes when too many failures are detected, use the following command:

```
configure fdb-scan failure-action [log | sys-health-check]
```

where the following is true:

- `log`—Messages are sent to the syslog. Only one instance of an error messages is logged at this level. This is the default configuration.
- `sys-health-check`—The configured system health check action is taken.

To return the switch to the factory default of sending messages to the syslog, use the following command:

```
unconfigure fdb-scan failure-action
```

Displaying FDB Scan Statistics

To display the FDB scan statistics, use the following command:

```
show diagnostics sys-health-check
```

The following is an example of the type of FDB scan statistics output displayed:

```
FDB Scan results:
           CardState NumFail   NumScan  Entry LastFailTime
BPLNE  : Operational       0        64
```

FDB Configuration Examples

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

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

The permanent entry has the following characteristics:

- MAC address is 00:E0:2B:12:34:56.
- VLAN name is *marketing*.
- Slot number for this device is 3.
- Port number for this device is 4.

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

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

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

This entry has the following characteristics:

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

Overriding 802.1p Priority

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

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

Configuring the FDB Aging Time

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

```
configure fdb agingtime <seconds>
```

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

MAC-Based Security

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

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

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

For detailed information about MAC-based security, see Chapter 12.

Displaying FDB Entries

To display FDB entries, use the following command:

```
show fdb {<mac_address> | broadcast-mac | permanent | ports <portlist> | remap | vlan
<vlan name>}
```

where the following is true:

- `mac_address`—Displays the entry for a particular MAC address.
- `broadcast-mac`—Specifies the broadcast MAC address. May be used as an alternate to the colon-separated byte form of the address ff:ff:ff:ff:ff:ff
- `permanent`—Displays all permanent entries, including the ingress and egress QoS profiles.
- `ports <portlist>`—Displays the entries for a set of ports or slots and ports.
- `remap`—Displays the remapped FDB entries.
- `vlan <vlan name>`—Displays the entries for a VLAN.

With no options, the command displays all FDB entries.

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

8 Quality of Service (QoS)

This chapter covers the following topics:

- Overview of Policy-Based Quality of Service on page 156
- Applications and Types of QoS on page 156
- Configuring QoS on page 158
- QoS Profiles on page 159
- Traffic Groupings on page 160
  - — IP-Based Traffic Groupings on page 160
  - — MAC-Based Traffic Groupings on page 161
  - — Explicit Class of Service (802.1p and DiffServ) Traffic Groupings on page 162
  - — Configuring DiffServ on page 164
  - — Physical and Logical Groupings on page 167
- Configuring QoS Traffic Grouping Priorities on page 168
- Verifying Configuration and Performance on page 169
- Modifying a QoS Configuration on page 170
- Bi-Directional Rate Shaping on page 170
- Dynamic Link Context System on page 173

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

This chapter does not describe the additional ingress and egress QoS capabilities available on the High Density Gigabit Ethernet “3” series I/O modules. For more information and a full description of the High Density Gigabit Ethernet module, see Chapter 29.

Overview of Policy-Based Quality of Service

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

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

NOTE

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

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

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

Applications and Types of QoS

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

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

General guidelines for each traffic type are given below and summarized in Table 15. Consider them as general guidelines and not strict recommendations. Once QoS parameters are set, you can monitor the performance of the application to determine if the actual behavior of the applications matches your expectations. It is very important to understand the needs and behavior of the particular applications you wish to protect or limit. Behavioral aspects to consider include bandwidth needs, sensitivity to latency and jitter, and sensitivity and impact of packet loss.

Voice Applications

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

Video Applications

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

Critical Database Applications

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

Web Browsing Applications

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

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

File Server Applications

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

NOTE

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

Table 15 summarizes QoS guidelines for the different types of network traffic.

Table 15: Traffic Type and QoS Guidelines

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

Configuring QoS

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

1. Configure the QoS profile.

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

2. Create traffic groupings.

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

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

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

QoS Profiles

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

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

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

The default QoS profiles cannot be deleted. Also by default, a QoS profile maps directly to a specific hardware queue across all physical ports. The settings for the default QoS parameters are summarized in Table 16.

Table 16: QoS Parameters

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

Table 16: QoS Parameters (Continued)

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

Traffic Groupings

Once a QoS profile is modified for bandwidth and priority, you assign a traffic grouping to the profile. A *traffic grouping* is a classification of traffic that has one or more attributes in common. Traffic is typically grouped based on the applications discussed starting on page 156.

Traffic groupings are separated into the following categories for discussion:

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

In the event that a given packet matches two or more grouping criteria, there is a predetermined precedence for which traffic grouping will apply. In general, the more specific traffic grouping takes precedence. By default, all traffic groupings are placed in the QoS profile Qp1. The supported traffic groupings are listed in Table 17. The groupings are listed in order of precedence (highest to lowest). The four types of traffic groupings are described in detail on the following pages.

Table 17: Traffic Groupings by Precedence

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

IP-Based Traffic Groupings

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

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

IP-based traffic groupings are defined using access lists. Access lists are discussed in detail in Chapter 12. By supplying a named QoS profile at the end of the access list command syntax, you can prescribe the bandwidth management and priority handling for that traffic grouping. This level of packet filtering has no impact on performance.

MAC-Based Traffic Groupings

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

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

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

Permanent MAC addresses

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

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

For example:

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

Dynamic MAC Addresses

Dynamic MAC addresses can be assigned a QoS profile whenever traffic is destined to the MAC address. This is done using the following command:

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

For any port on which the specified MAC address is learned in the specified VLAN, the port is assigned the specified QoS profile. For example:

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

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

```
clear fdb
```

Blackhole MAC Address

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

```
create fdbentry <mac_address> vlan <vlan name> blackhole {source-mac | dest-mac |
both}
```

For example:

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

Broadcast/Unknown Rate Limiting MAC Address

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

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

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

NOTE

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

Verifying MAC-Based QoS Settings

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

```
show fdb permanent
```

or the command

```
show qosprofile {<qosprofile>} {port <portlist>}
```

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

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

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

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

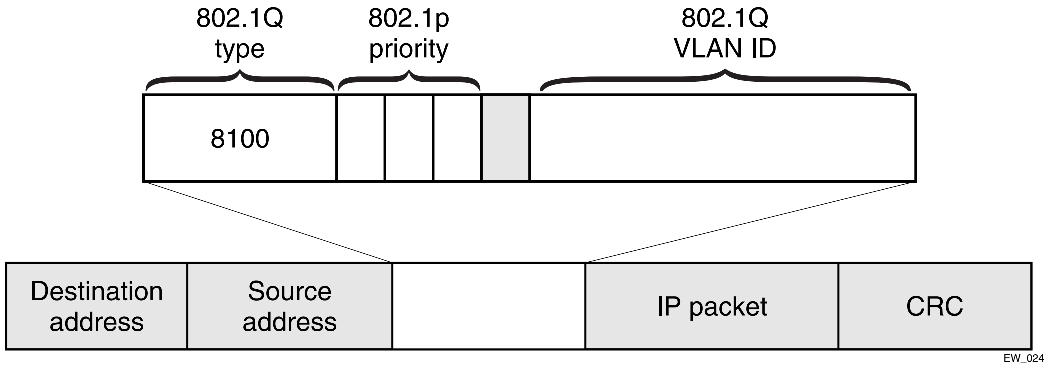
The documented capabilities for 802.1p priority markings or DiffServ capabilities (if supported) are not impacted by the switching or routing configuration of the switch. For example, 802.1p information can be preserved across a routed switch boundary and DiffServ code points can be observed or overwritten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

Configuring 802.1p Priority

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

When a packet arrives at the switch, the switch examines the 802.1p priority field and maps it to a specific hardware queue when subsequently transmitting the packet. The 802.1p priority field is located directly following the 802.1Q type field, and preceding the 802.1Q VLAN ID, as shown in Figure 16.

Figure 16: Ethernet packet encapsulation



Observing 802.1p Information

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

To control the mapping of 802.1p prioritization values to hardware queues, 802.1p prioritization values can be mapped to a QoS profile. The default mapping of each 802.1p priority value to QoS profile is shown in Table 18.

Table 18: 802.1p Priority Value-to-QoS Profile Default Mapping

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

Changing the Default 802.1p Mapping

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

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

```
configure dot1p type <dot1p_priority> qosprofile <qosprofile>
```

Configuring 802.1p Priority For Slow Path Traffic

Some traffic can originate on the switch, for example Ping or Telnet packets. This traffic comes from the switch CPU and is referred to as slow path traffic. This traffic is internally tagged with an 802.1p priority of 7, by default, and egresses the VLAN through the highest queue. If you want to set a different tag (and priority) use the following command to set the priority to a number between 0 and 7:

```
configure vlan <vlan name> priority <priority>
```

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

Replacing 802.1p Priority Information

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

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

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

802.1p priority information is replaced according to the hardware queue that is used when transmitting from the switch. The mapping is described in Table 19. This mapping cannot be changed.

Table 19: Queue to 802.1p Priority Replacement Value

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

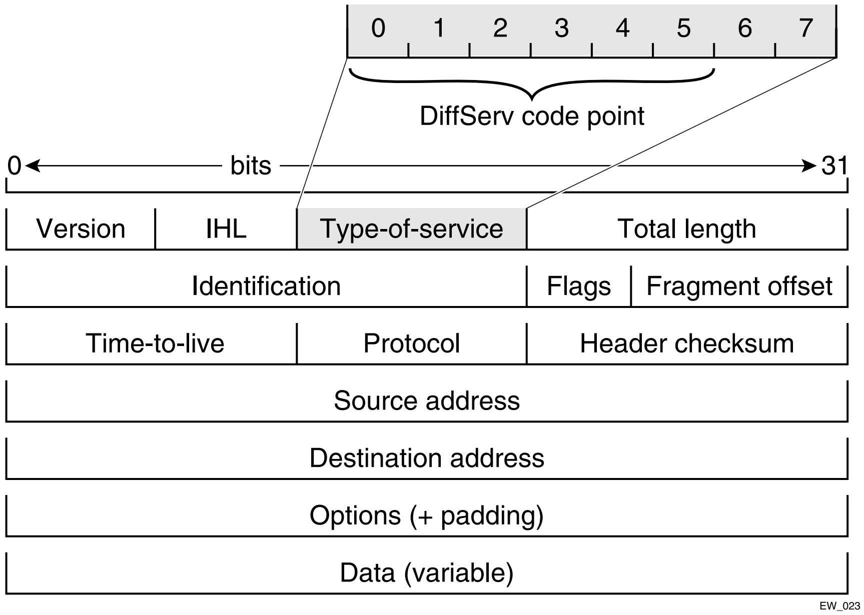
Configuring DiffServ

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

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

Figure 17 shows the encapsulation of an IP packet header.

Figure 17: IP packet header encapsulation



Observing DiffServ Information

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

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

Changing DiffServ Code point assignments in the Q0S Profile

Because the code point uses six bits, it has 64 possible values ($2^6 = 64$). Be default, the values are grouped and assigned to the default QoS profiles listed in Table 20.

Table 20: Default Code Point-to-QoS Profile Mapping

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

Table 20: Default Code Point-to-QoS Profile Mapping (Continued)

Code Point	QoS Profile
56-63	Qp8

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

```
configure diffserv examination code-point <code_point> qosprofile <qosprofile> ports
[<portlist> | all] {low-drop-probability | high-drop-probability}
```

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

Replacing DiffServ Code Points

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

The DiffServ code point value used in overwriting a packet is determined by the 802.1p priority value. The 802.1p priority value is, in turn, determined by the hardware queue used when transmitting a packet, as described in “Replacing 802.1p Priority Information” on page 164.

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

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

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

The default 802.1p priority value to code point mapping is described in Table 21.

Table 21: Default 802.1p Priority Value-to-Code Point Mapping

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

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

```
configure diffserv replacement priority <value> code-point <code_point> ports
[<portlist> | all]
```

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

To verify the DiffServ configuration, use the following command:

```
show ports {mgmt | <portlist>} [t1 | e1 | t3] info
```

DiffServ Example

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

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

1. Configure parameters of the QoS profile QP3:

   ```
   configure qp3 min 10 max 100
   ```

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

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

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

   ```
   enable dot1p replacement
   ```

   ```
   enable diffserv replacement
   ```

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

   ```
   enable diffserv examination
   ```

Table 16 indicates that qp3 is tied to hardware queue Q2. We also know that when replacement is enabled all traffic sent out Q2 will contain code point value 16 (according to Table 21). If this is the desired code point to use, all traffic from 10.1.2.x will be sent out QP3 (at 10% minimum and 100% maximum) with a code point value of 16.

Physical and Logical Groupings

Two traffic groupings exist in this category:

- Source port
- VLAN

Source port

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

```
configure ports <portlist> qosprofile <qosprofile>
```

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

```
configure ports 5:7 qosprofile qp3
```

VLAN

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

```
configure vlan <vlan name> qosprofile <qosprofile>
```

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

```
configure vlan servnet qosprofile qp4
```

Verifying Physical and Logical Groupings

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

```
show qosprofile
```

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

```
show ports {mgmt | <portlist>} [t1 | e1 | t3] info
```

or

```
show vlan
```

Configuring QoS Traffic Grouping Priorities

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

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

The valid priority values are 0 - 15. The default values are shown in Table 22.

Table 22: Traffic Grouping Priority Default Values

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

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

```
configure qostype priority source-mac 9
```

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

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

Verifying and Resetting QoS Traffic Grouping Priorities

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

```
show qostype priority
```

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

```
unconfigure qostype priority
```

Verifying Configuration and Performance

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

QoS Monitor

The QoS monitor is a utility that monitors the eight hardware queues (QP1-QP8) associated with any port(s). The QoS monitor keeps track of the number of frames and the frames per second that a specific queue is responsible for transmitting on a physical port. Two options are available: a real-time display, and a separate option for retrieving information in the background and writing it to the log.

Real-Time Performance Monitoring

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

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

```
show ports {mgmt | <portlist>} qosmonitor {egress | ingress} {discards}
```

QoS monitor sampling is configured as follows:

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

Background Performance Monitoring

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

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

Displaying QoS Profile Information

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

```
show qosprofile {<qosprofile>} {port <portlist>}
```

Displayed information includes:

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

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

- `show fdb permanent`—Displays destination MAC entries and their QoS profiles.
- `show switch`—Displays information including PACE enable/disable information.
- `show vlan`—Displays the QoS profile assignments to the VLAN.
- `show ports {mgmt | <portlist>} [t1 | e1 | t3] info`—Displays information including QoS information for the port.

Modifying a QoS Configuration

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

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

Bi-Directional Rate Shaping

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

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

Configuring Bi-Directional Rate Shaping

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

Use the following guidelines for bi-directional rate shaping:

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

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

Bandwidth Settings

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

Maximum Bandwidth Settings

The maximum bandwidth settings determine the port bandwidth available to each queue. Use Table 23 to determine the bandwidth associated with each bandwidth setting at different port speeds.

Table 23: Maximum Bandwidth Settings

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

Table 23: Maximum Bandwidth Settings (Continued)

Bandwidth Setting (%)	Bandwidth at 10 Mbps	Bandwidth at 100 Mbps	Bandwidth at 1000 Mbps
30	3.3 Mbps	33 Mbps	330 Mbps
35	3.5 Mbps	35 Mbps	350 Mbps
40	4.2 Mbps	42 Mbps	420 Mbps
50	5 Mbps	50 Mbps	500 Mbps
60	5.7 Mbps	57 Mbps	570 Mbps
65	6.5 Mbps	65 Mbps	650 Mbps
70	7.3 Mbps	73 Mbps	730 Mbps
80	7.9 Mbps	79 Mbps	790 Mbps
95	9.5 Mbps	95 Mbps	950 Mbps
100	10 Mbps	100 Mbps	1000 Mbps

If you choose a setting not listed in Table 23, the setting is rounded up to the next value.

Minimum Bandwidth Settings

The minimum bandwidth settings determine the port bandwidth reserved for each queue. Use Table 24 to determine the bandwidth associated with each setting.

Table 24: Minimum Bandwidth Settings

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

NOTE

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

If you choose a setting not listed in Table 24, the setting is rounded up to the next value. If the actual bandwidth used is below the minimum bandwidth, the additional bandwidth is available for other queues on that physical port.

Bi-Directional Rate Shaping Limitations

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

- You must delete all rate-shaped ports before deleting the loopback port.
- If rate-shaped ports within a VLAN use different bandwidth parameters, set the priority of the QoS profiles on the loopback port and rate-shaped ports to `low`.
- Layer 2 rate-shaping only affects a single VLAN.
- On a BlackDiamond switch, the loopback port must be on the same I/O module as the rate-shaped ports.
- You must enable IP forwarding on the VLAN prior to adding the loopback port to a VLAN for layer 3 rate shaping.
- You cannot use tagged ports for rate shaping.
- You cannot use load-shared ports for rate-shaping.
- You cannot run VRRP on a VLAN that is configured for ingress rate shaping.

Dynamic Link Context System

The Dynamic Link Context System (DLCS) is a feature that snoops WINS NetBIOS packets and creates a mapping between a user name, the IP address or MAC address, and the switch/port. Based on the information in the packet, DLCS can detect when an end station boots up or a user logs in or out, and dynamically maps the end station name to the current IP address and switch/port. This information is available for use by ExtremeWare Enterprise Manager (EEM) version 2.1 or later or EPICenter in setting policies that can be applied to users and can dynamically follow a user's location. DLCS provides you with valuable information on a user’s location and associated network attributes. For DLCS to operate within ExtremeWare, the user or end station must allow for automatic DLCS updates.

This feature is intended for use in conjunction with EPICenter Policy Manager. Refer to the EPICenter documentation for more information.

DLCS Guidelines

Follow these guidelines when using DLCS:

- Only one user is allowed on one workstation at a given time.
- A user can be logged into many workstations simultaneously.
- An IP-address can be learned on only one port in the network at a given time.
- Multiple IP-addresses can be learned on the same port.
- DLCS mapping is flushed when a user logs in or logs out, or when an end-station is shutdown.

DLCS Limitations

Consider the following limitations concerning data received from WINS snooping:

- DLCS does not work for the WINS server. This is because the WINS server does not send NETBIOS packets on the network (these packets are address to itself).
- When the IP address of a host is changed, and the host is not immediately rebooted, the old host-to-IP address mapping is never deleted. You must delete the mapping of the host-to-IP address through the Policy Manager.
- When the host is moved from one port to another port on a switch, the old entry does not age out unless the host is rebooted or a user login operation is performed after the host is moved.
- DLCS information is dynamic, therefore, if the switch is rebooted, the information is lost. This information is still stored in the policy-server. To delete the information from the policy system, you must explicitly delete configuration parameters from the EEM or EPICenter Policy Applet user interface. As a workaround, you can delete the switch that was rebooted from the list of managed devices in the EEM or EPICenter Inventory Applet, and re-add the switch to the Inventory Manager.
- DLCS is not supported on hosts that have multiple NIC cards.
- IPQoS is not supported to a WINS server that is serving more than one VLAN. If you attempt to add a WINS server to serve more than one VLAN, and there are IPQoS rules defined for that server, the command to add the WINS server is rejected.

9 Network Address Translation (NAT)

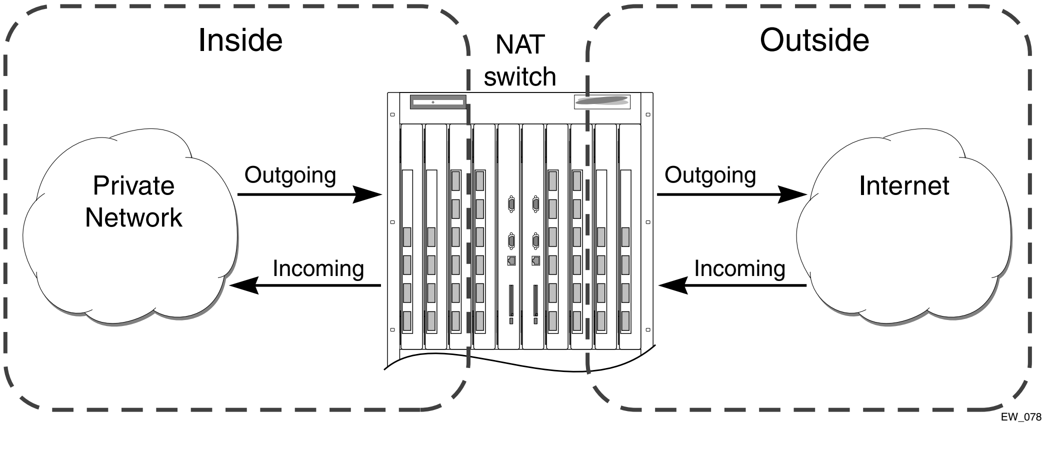
This chapter covers the following topics:

- Overview on page 175
- Internet IP Addressing on page 176
- Configuring VLANs for NAT on page 176
- Configuring NAT on page 178
- Creating NAT Rules on page 178
- Displaying NAT Settings on page 180
- Disabling NAT on page 181

Overview

NAT is a feature that allows one set of IP addresses, typically private IP addresses, to be converted to another set of IP addresses, typically public Internet IP addresses. This conversion is done transparently by having a NAT device (any Extreme Networks switch using the "*i*" chipset) rewrite the source IP address and Layer 4 port of the packets.

Figure 18: NAT Overview



You can configure NAT to conserve IP address space by mapping a large number of inside (private) addresses to a much smaller number of outside (public) addresses.

In implementing NAT, you must configure at least two separate VLANs involved. One VLAN is configured as inside, and corresponds to the private IP addresses you would like to translate into other IP addresses. The other type of VLAN is configured as outside, which corresponds to the public (probably Internet) IP addresses you want the inside addresses translated to. The mappings between inside and outside IP addresses are done via rules that specify the IP subnets involved and the algorithms used to translate the addresses.

NOTE

The NAT modes in ExtremeWare support translating traffic that initiates only from inside addresses.

NAT rules are associated with a single outside VLAN. Multiple rules per outside VLAN are allowed. The rules take effect in the order they are displayed using the `show nat` command. Any number of inside VLANs can use a single outside VLAN, assuming that you have created proper rules. Similarly, a single inside VLAN can use any number of different outside VLANs, assuming that the rules and routing are set up properly.

Both TCP and UDP have layer 4 port numbers ranging from 1 to 65535. These layer 4 ports, in combination with the IP addresses, form a unique identifier which allows hosts (as well as the NAT switch) to distinguish between separate conversations. NAT operates by replacing the inside IP packet’s source IP and layer 4 port with an outside IP and layer 4 port. The NAT switch maintains a connection table to map the return packets on the outside VLAN back into their corresponding inside sessions.

Internet IP Addressing

When implementing NAT in an Internet environment, it is strongly recommended that you use one of the reserved private IP address ranges for your inside IP addresses. These ranges have been reserved specifically for networks not directly attached to the Internet. Using IP addresses within these ranges prevents addressing conflicts with public Internet sites to which you want to connect. The ranges are as follows:

- 10.0.0.0/8—Reserved Class A private address space
- 172.16.0.0/12—Reserved Class B private address space
- 192.168.0.0/16—Reserved Class C private address space

Configuring VLANs for NAT

You must configure each VLAN participating in NAT as either an inside or outside VLAN. To configure a VLAN as an inside or outside VLAN, use the following command:

```
configure nat vlan <vlan name> [inside | outside | none]
```

When a VLAN is configured to be `inside`, traffic from that VLAN is translated only if it has a matching NAT rule. Any unmatched traffic will be routed normally and not be translated. Because all traffic runs through the central processing unit (CPU), it cannot run at line-rate.

When a VLAN is configured to be `outside`, it routes all traffic. Because all traffic runs through the CPU, it cannot run at line-rate. Normally, outside traffic will be able to initiate connections to the internal private IP addresses. If you want to prevent this, you can create IP and ICMP access-lists on the outside VLAN ports to deny traffic destined for the inside IP addresses. There is a NAT performance penalty when you do this.

When a VLAN is configured to be `none`, all NAT functions are disabled and the VLAN operates normally.

Below is a set of example ACL rules to deny outside traffic. These examples assume the inside network is 192.168.1.0/24 and the outside VLAN is on port 1.

```
create access-list deny_ip ip destination 192.168.1.0/24 source any deny ports 1
create access-list deny_icmp icmp destination 192.168.1.0/24 source any type any code
any deny ports 1
```

NAT Modes

There are 4 different modes used to determine how the outside IP addresses and layer 4 ports are assigned.

- Static mapping
- Dynamic mapping
- Port-mapping
- Auto-constraining

Static Mapping

When static mapping is used, each inside IP address uses a single outside IP address. The layer 4 ports are not changed, only the IP address is rewritten. Because this mode requires a 1:1 mapping of internal to external addresses, it does not make efficient use of the external address space. However, it is useful when you have a small number of hosts that need to have their IP addresses rewritten without conflicting with other hosts. Because this mode does not rely on layer 4 ports, ICMP traffic is translated and allowed to pass.

Dynamic Mapping

Dynamic mapping is similar to static mapping in that the layer 4 ports are not rewritten during translation. Dynamic mapping is different in that the number of inside hosts can be greater than the number of outside hosts. The outside IP addresses are allocated on a first-come, first-serve basis to the inside IP addresses. When the last session for a specific inside IP address closes, that outside IP address can be used by other hosts. Since this mode does not rely on layer 4 ports, ICMP traffic is translated and allowed to pass.

Port-mapping

Port-mapping gives you the most efficient use of the external address space. As each new connection is initiated from the inside, the NAT device picks the next available source layer 4 port on the first available outside IP address. When all ports on a given IP address are in use, the NAT device uses ports off of the next outside IP address. Some systems reserve certain port ranges for specific types of traffic, so it is possible to map specific source layer 4 port ranges on the inside to specific outside source ranges. However, this may cause a small performance penalty. In this case, you would need to make several rules using the same inside and outside IP addresses, one for each layer 4 port range. ICMP traffic is not translated in this mode. You must add a dynamic NAT rule for the same IP address range to allow for ICMP traffic.

Auto-constraining

The auto-constraining algorithm for port-mapping limits the number of outside layer 4 ports a single inside host can use simultaneously. The limitation is based on the ratio of inside to outside IP addresses. The outside IP address and layer 4 port space is evenly distributed to all possible inside hosts. This guarantees that no single inside host can prevent other traffic from flowing through the NAT device. Because of the large number of simultaneous requests that can be made from a web browser, it is not recommended that this mode be used when a large number of inside hosts are being translated to a small number of outside IP addresses. ICMP traffic is not translated in this mode. You must add a dynamic NAT rule for the same IP address range to allow for ICMP traffic.

Configuring NAT

The behavior of NAT is determined by the rules you create to translate the IP addresses. You must attach each rule to a specific VLAN. All rules are processed in order. The options specified on the NAT rule determine the algorithm used to translate the inside IP addresses to the outside IP addresses. For outgoing (inside to outside) packets, the first rule to match is processed. All following rules are ignored. All return packets must arrive on the same outside VLAN on which the session went out. For most configurations, make sure that the outside IP addresses specified in the rule are part of the outside VLAN's subnet range, so that the switch can proxy the address resolution protocol (ARP) for those addresses.

To enable NAT functionality, use the following command:

```
enable nat
```

Creating NAT Rules

This section describes how to configure the various types of NAT (static, dynamic, portmap, and auto-constrain). In the examples in this section, advanced port and destination matching options have been removed. For information on how to use some of the more advanced rule matching features, see "Advanced Rule Matching" on page 180.

Creating Static and Dynamic NAT Rules

To create static or dynamic NAT rules, use this command:

```
configure nat add vlan <vlan name> map source [any | <source_ipaddress>/<mask>]
{l4-port [any | <port> {- <port>}]} {destination <dest_ipaddress>/<mask> {l4-port [any
| <port> {- <port>}]}} to <ip address> [/<mask> | - <ip address>] [tcp | udp | both]
[portmap {<min> - <max>} | auto-constrain]
```

This is the simplest NAT rule. You specify the outside vlan name, and a subnet of inside IP addresses, which get translated to the outside IP address using the specified mode (static in this case). For the outside IP addresses, you can either specify an IP address and netmask or a starting and ending IP range to determine the IP addresses the switch will translate the inside IP addresses to. If the netmask for both the source and NAT addresses is /32, the switch will use static NAT translation. If the netmask for both the source and NAT addresses are not both /32, the switch will use dynamic NAT translation.

Static NAT Rule Example

```
configure nat add out_vlan_1 map source 192.168.1.12/32 to 216.52.8.32/32
```

Dynamic NAT Rule Example

```
configure nat add out_vlan_1 map source 192.168.1.0/24 to 216.52.8.1 - 216.52.8.31
```

Creating Portmap NAT Rules

To configure portmap NAT rules, use this command:

```
configure nat add vlan <vlan name> map source [any | <source_ipaddress>/<mask>]
{l4-port [any | <port> {- <port>}]} {destination <dest_ipaddress>/<mask> {l4-port [any
| <port> {- <port>}]}} to <ip address> [/<mask> | - <ip address>] [tcp | udp | both]
[portmap {<min> - <max>} | auto-constrain]
```

The addition of an L4 protocol name and the `portmap` keyword tells the switch to use portmap mode. Optionally, you may specify the range of L4 ports the switch chooses on the translated IP addresses, but there is a performance penalty for doing this. Remember that portmap mode will only translate TCP and/or UDP, so a dynamic NAT rule must be specified after the portmap rule in order to allow ICMP packets through without interfering with the portmapping.

Portmap NAT Rule Example

```
configure nat add out_vlan_2 map source 192.168.2.0/25 to 216.52.8.32 /28 both portmap
```

Portmap Min-Max Example

```
configure nat add out_vlan_2 map source 192.168.2.128/25 to 216.52.8.64/28 tcp portmap
1024 - 8192
```

Creating Auto-Constrain NAT Rules

To create auto-constrain NAT rules, use the following command:

```
configure nat add vlan <vlan name> map source [any | <source_ipaddress>/<mask>]
{l4-port [any | <port> {- <port>}]} {destination <dest_ipaddress>/<mask> {l4-port [any
| <port> {- <port>}]}} to <ip address> [/<mask> | - <ip address>] [tcp | udp | both]
[portmap {<min> - <max>} | auto-constrain]
```

This rule uses auto-constrain NAT. Remember that each inside IP address will be restricted in the number of simultaneous connections. Most installations should use portmap mode.

Auto-Constrain Example

```
configure nat add out_vlan_3 map source 192.168.3.0/24 to 216.52.8.64/32 both
auto-constrain
```

Advanced Rule Matching

By default, NAT rules only match connections based on the source IP address of the outgoing packets. Using the `L4-port` and `destination` keywords, you can further limit the scope of the NAT rule so that it only applied to specific TCP/UDP layer 4 port numbers, or specific outside destination IP addresses.

NOTE

Once a single rule is matched, no other rules are processed.

Destination Specific NAT

```
configure nat add vlan <vlan name> map source [any | <source_ipaddress>/<mask>]
{l4-port [any | <port> {- <port>}]} {destination <dest_ipaddress>/<mask> {l4-port [any
| <port> {- <port>}]}} to <ip address> [/<mask> | - <ip address>] [tcp | udp | both]
[portmap {<min> - <max>} | auto-constrain]
```

The addition of the `destination` optional keyword after the source IP address and mask allows the NAT rule to be applied to only packets with a specific destination IP address.

L4-Port Specific NAT

The addition of the `L4-port` optional keyword after the source IP address and mask allows the NAT rule to be applied to only packets with a specific L4 source or destination port. If you use the L4-port command after the source IP/mask, the rule will only match if the port(s) specified are the source L4-ports. If you use the L4-port command after the destination IP/mask, the rule will only match if the port(s) specified are the destination L4-ports. Both options may be used together to further limit the rule.

Configuring Time-outs

When an inside host initiates a session, a session table entry is created. Depending on the type of traffic or the current TCP state, the table entries time out after the configured time-out expires.

Displaying NAT Settings

To display NAT rules, use the following command:

```
show nat {timeout | stats | connections | rules {vlan <outside_vlan>}}
```

This command displays the NAT rules for a specific VLAN. Rules are displayed in the order they are processed, starting with the first one.

To display NAT traffic statistics, use the following command:

```
show nat stats
```

This command displays statistics for the NAT traffic, and includes:

- The number of rules
- The number of current connections
- The number of translated packets on the inside and outside VLANs

- Information on missed translations

To display NAT connection information, use the following command:

```
show nat connections
```

This command displays the current NAT connection table, including source IP/layer 4 port mappings from inside to outside.

Disabling NAT

To disable NAT, use the following command:

```
disable nat
```

10 Server Load Balancing (SLB)

This chapter describes the following topics:

- Overview on page 183
- SLB Components on page 184
- SLB Traffic Types on page 187
- Forwarding Modes on page 188
- Load-Balancing Methods on page 193
- Advanced SLB Application Example on page 194
- Using Persistence on page 197
- Using High Availability System Features on page 200
- Health Checking on page 205
- Flow Redirection on page 208

Overview

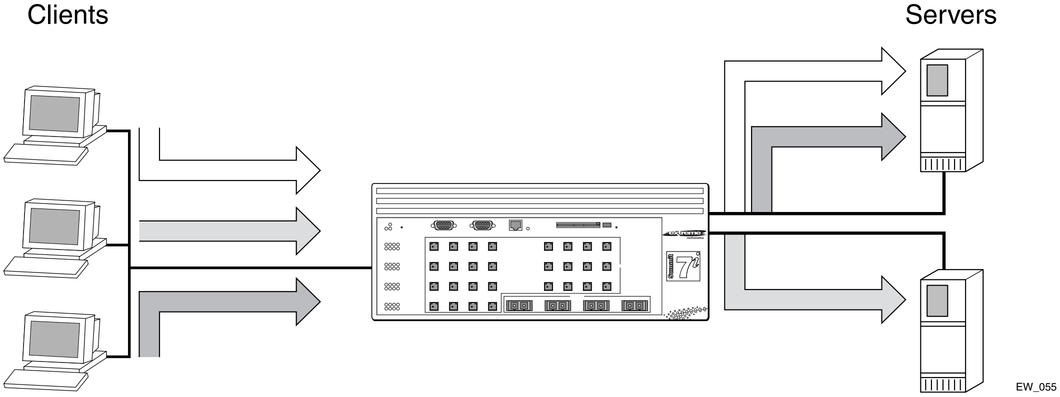
Server load balancing (SLB) transparently distributes client requests among several servers. The main use for SLB is for web hosting (using redundant servers to increase the performance and reliability of busy websites).

You can use SLB to manage and balance traffic for client equipment such as web servers, cache servers, routers, and proxy servers. SLB is especially useful for e-commerce sites, Internet service providers, and managers of large intranets.

Server load balancing (SLB), longest prefix matching (LPM), and destination-sensitive accounting (DSA) are mutually exclusive functions. None of these functions can be simultaneously enabled.

A basic SLB application is shown in Figure 19.

Figure 19: Basic SLB application



All content must be duplicated on all physical servers for server load balancing. To configure SLB, perform the following basic steps:

1. Create pools and configure the load balancing method for each pool.
2. Add nodes to the pools.
3. Create virtual servers and select the forwarding mode for each virtual server.
4. Assign an SLB traffic type to the server and client VLANs.
5. Enable IP forwarding on the server and client VLANs.
6. Enable SLB.

SLB Components

Three components comprise an SLB system:

- Nodes
- Pools
- Virtual servers

All three components are required for every SLB configuration.

Nodes

A *node* is an individual service on a physical server, and consists of an IP address and a port number. All nodes must have identical content. Nodes cannot belong to the same VLAN as the virtual servers they access.

Pools

A *pool* is a group of nodes that are mapped to a corresponding virtual server. You can use pools to easily scale large networks with many nodes.

Each pool contains its own load-balancing method. A pool must be associated with a virtual server to be used for load balancing. You must create pools before associating them with virtual servers, and must delete virtual servers before deleting their associated pools. You cannot delete pools that are still associated with a virtual server.

Virtual Servers

Virtual servers are the backbone of the SLB configuration. A virtual server is a virtual IP address that points to a group of servers. The switch then load balances those groups of servers (or other network equipment). Before you configure virtual servers, you need the following:

- The forwarding mode
- The name of the pool
- The virtual IP address
- The virtual port number

Virtual servers cannot belong to the same VLAN as the nodes in the pool they reference. Do not configure a virtual server with the same IP address as a VLAN.

Using Standard or Wildcard Virtual Servers

Each virtual server is associated with a single pool, which can be a group of content servers, routers, or cache servers.

You can configure two different types of virtual servers:

- Standard virtual servers

  A standard virtual server represents a site (such as a web site or an FTP site), and provides load balancing for content. Configure the virtual server IP address to be the same IP address as that of the site that the virtual server represents.

- Wildcard virtual servers

  A wildcard virtual server load balances transparent network devices such as routers or cache servers. Wildcard virtual servers use a special wildcard IP address (0.0.0.0), and require Transparent mode.

NOTE

For cache server applications, see "Web Cache Redirection" on page 209.

Network Advertisement

Three modes are available for controlling network connectivity to virtual servers. The switch will automatically select a method based on the virtual server’s subnet.

- Proxy ARP

  If the virtual server is a member of an existing subnet to which the switch is directly attached, the switch will respond to ARP requests on behalf of the virtual server. This allows you to implement server load balancing on a layer 2 network. The VLAN containing the servers is in a different subnet than the client VLAN's subnet. The virtual server will appear to be a member of the client subnet.

- Host-Route

  If the virtual server is not a member of an existing subnet to which the switch is directly attached, the switch will add a host-route entry to the routing table. In this situation, all clients require a routed path (to the virtual server) that points to the switch's IP address on the client VLAN.

- Subnet-Route

  If the virtual server is separated from the switch by a router, the switch propagates the subnet containing the virtual server. You must create a loopback VLAN with the virtual server as a member of the loopback VLAN's subnet.

  When you enable the routing protocol to advertise the entire subnet to directly connected routers, a single entry is created in the routing table for each subnet advertised. For example, the following command enables RIP to advertise routes to all directly connected routers with a cost of 1:

  ```
  enable rip export direct cost 1
  ```

  When you enable the routing protocol to advertise specific virtual servers, an entry is created in the routing table for each virtual server you advertise. For example, the following command enables OSPF to advertise a specific virtual server with a cost of 1:

  ```
  enable ospf export vip cost 1
  ```

  This command exports the virtual servers to the entire network. Extreme Networks recommends this method to advertise virtual servers.

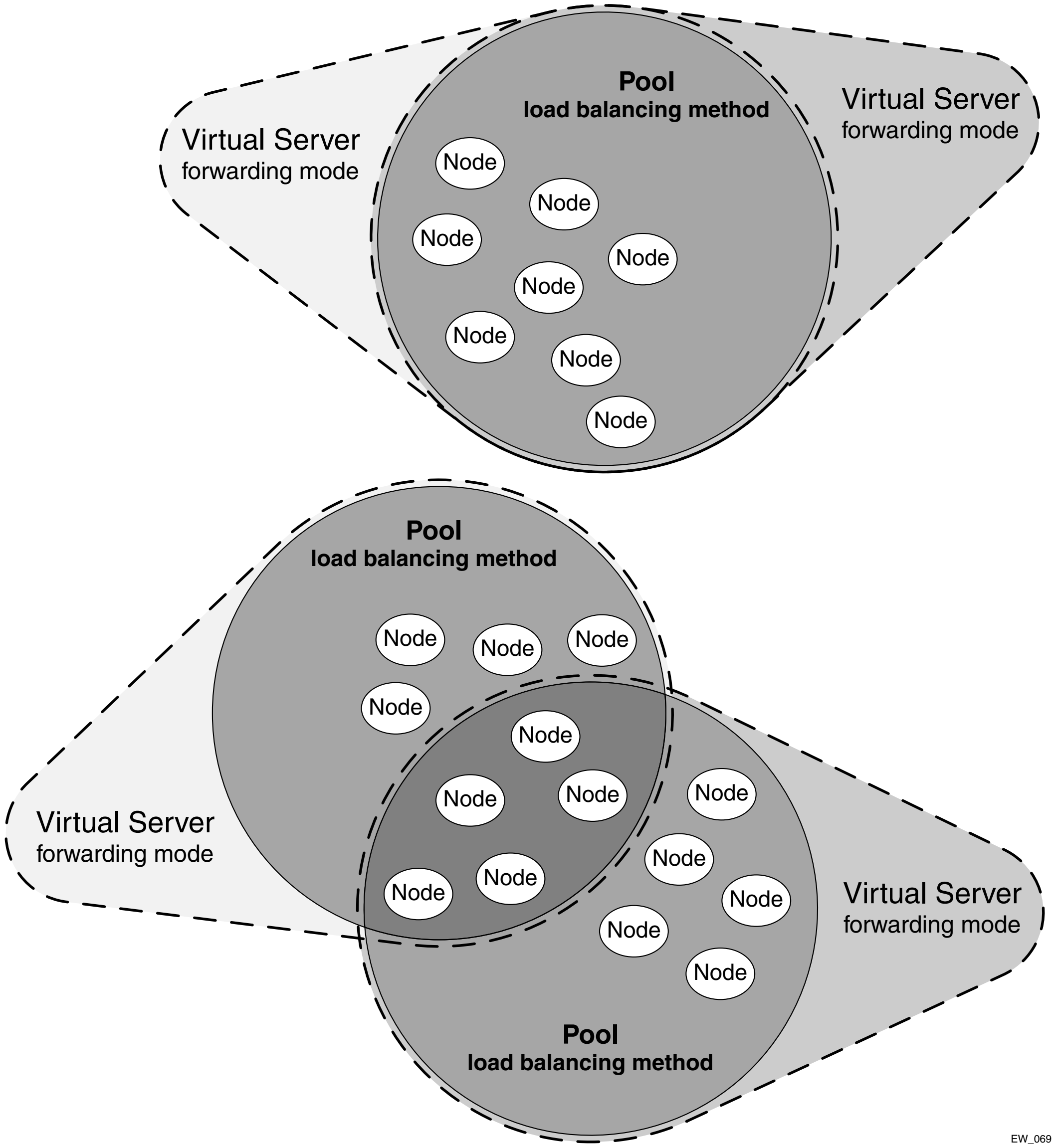
Node, Pool, and Virtual Server Relationships

Nodes, pools, and virtual servers have the following relationships:

- Nodes can belong to multiple pools
- Pools can contain multiple nodes
- Pools can be associated with multiple virtual servers
- Virtual servers can be associated with only a single pool

Figure 20 illustrates the relationships of these basic components.

Figure 20: Basic SLB components



SLB Traffic Types

SLB traffic must cross a routing boundary for SLB to work. To ensure that traffic crosses a routing boundary, assign clients and servers to separate VLANs. You must specify an SLB traffic type for each VLAN. The four SLB traffic types are:

- **None**—Disables SLB on the VLAN. This is the default setting.
- **Client—**Specifies that the VLAN contains clients, and originates requests for virtual servers.

- **Server—**Specifies that the VLAN contains nodes, and receives requests for virtual servers.
- **Both—**Specifies that the VLAN contains both clients and nodes. Clients in this VLAN can only access virtual servers whose nodes are outside this VLAN.

NOTE

You must enable IP forwarding on each VLAN involved in SLB.

You can assign the same SLB traffic type to as many different VLANs as necessary, up to the number of VLANs supported by the switch.

Forwarding Modes

The forwarding mode is the method the switch uses to forward traffic to the virtual servers. The forwarding mode determines what happens to the packets as they travel through the switch. The switch supports the following forwarding modes:

- Transparent
- Translation
- Port Translation
- GoGo

Table 25 summarizes the features supported by each forwarding mode.

Table 25: Forwarding Mode Feature Summary

	Transparent	Translation	Port Translation	GoGo
Performance	Hardware-based from server-to-client	CPU-based in both directions	CPU-based in both directions	Hardware-based in both directions
Load sharing algorithms	Round-robin, Ratio, Priority, Least Connections	Round-robin, Ratio, Priority, Least Connections	Round-robin, Ratio, Priority, Least Connections	Round-robin (hash)
Persistence	IPSA + Mask, IP list	IPSA + Mask, IP list	IPSA + Mask, IP list	IPSA
Health checking	Layer 3, 4, and 7	Layer 3, 4, and 7	Layer 3, 4, and 7	Layer 3, 4, and 7

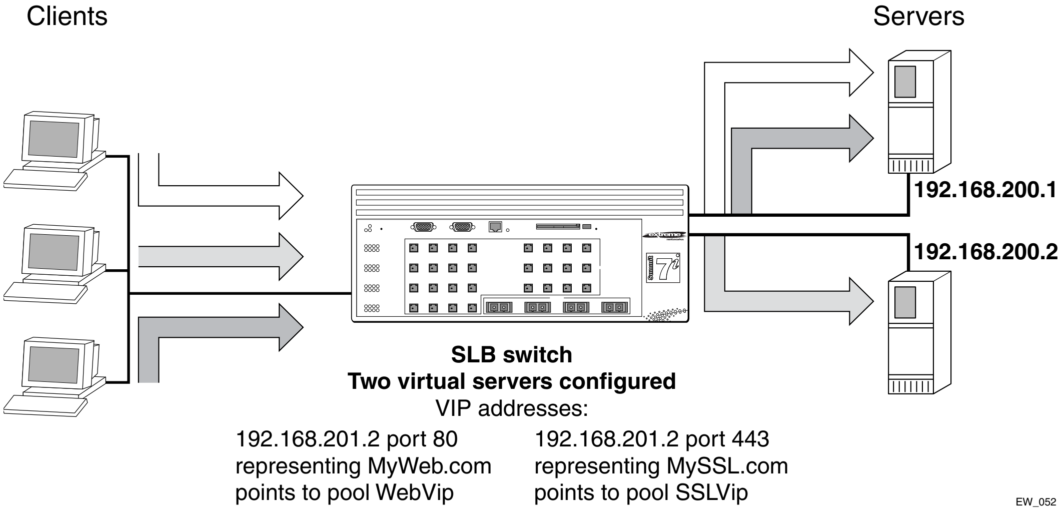
Transparent Mode

In transparent mode, the switch does not modify IP addresses before forwarding traffic to the servers. You must configure all physical servers with the virtual IP address associated with the virtual server. This virtual IP address is the address seen by clients. You must configure the physical servers with this address as a loopback address. Configure the loopback address with the most specific subnet mask that your operating system supports.

In transparent mode, you can directly attach servers or have a layer 2 switch between the SLB switch and the servers. You cannot have a router between the SLB switch and the servers.

Use transparent mode when you want a balance between features and performance. Figure 21 shows transparent mode.

Figure 21: Transparent mode



In Figure 21, the switch is configured to respond to requests for the virtual server by forwarding them to the load-balanced servers.

The servers are configured as follows:

- The interface for server 1 is 192.168.200.1.
- The interface for server 2 is 192.168.200.2.
- The loopback address on the servers is 192.168.201.1 (virtual server).
- The service is configured to use the appropriate address and port, as specified in the switch configuration.

Use the following commands to configure the VLANs and the switch IP addresses and subnets:

```
create vlan srvr
create vlan clnt
create vlan vips
configure srvr ipaddress 192.168.200.10 /24
configure clnt ipaddress 10.1.1.1 /24
configure vips ipaddress 192.168.201.1 /24
configure srvr add port 29-32
configure client add port 1-4
enable ipforwarding
```

Use the following commands to create a round-robin pool (MyWeb) and add nodes to the new pool.

```
create slb pool MyWeb lb-method round
configure slb pool MyWeb add 192.168.200.1:80
configure slb pool MyWeb add 192.168.200.2:80
```

Use the following command to create a transparent mode virtual server for the website and assign MyWeb to it:

```
create slb vip WebVip pool MyWeb mode transparent 192.168.201.2:80
```

Use the following commands to create a round-robin pool, MySSL and add nodes to the new pool.

```
create slb pool MySSL lb-method round-robin
configure slb pool MySSL add 192.168.200.1:443
configure slb pool MySSL add 192.168.200.2:443
```

Use the following command to create a transparent mode virtual server for the website and assign MySSL to it.

```
create slb vip SSLVip pool MySSL mode transparent 192.168.201.2:443
```

Use the following commands to enable SLB, configure the server VLAN to act as the server side, and configure the client VLAN to act as the client side:

```
enable slb
configure vlan srvr slb-type server
configure vlan clnt slb-type client
```

You must configure a loopback address for each IP address to which the server will respond.

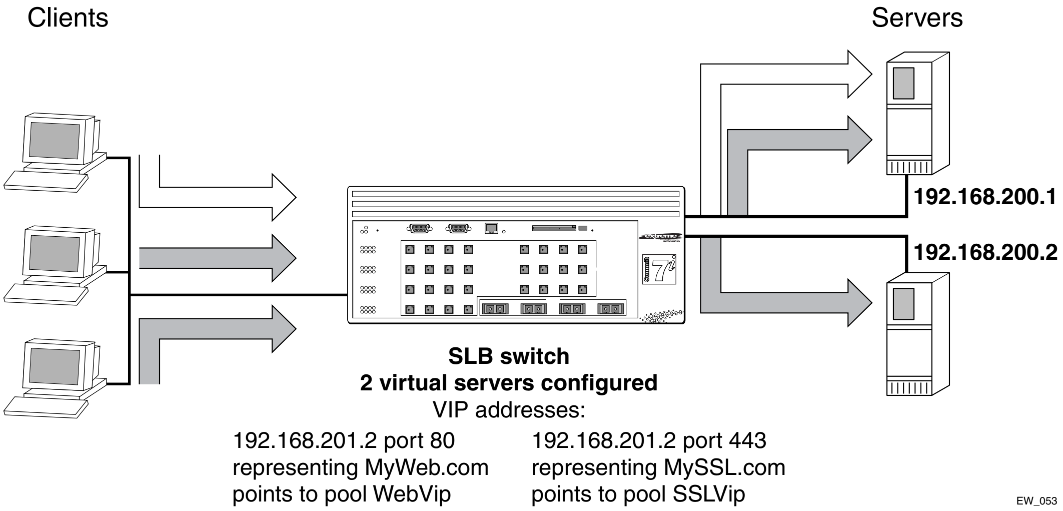
Translation Mode

In translation mode, the switch translates the IP address to that of the server to be balanced. You do not need to configure a loopback address for translation mode.

In translation mode, you can directly attach servers or have a layer 2 switch between the SLB switch and the servers. You cannot have a router between the SLB switch and the servers.

Use translation mode when you cannot have a loopback address. Figure 22 shows translation mode.

Figure 22: Translation Mode



In Figure 22, the switch is configured to respond to requests for the virtual server by translating them and forwarding them to the load balanced servers. No additional server configuration is needed.

Use the following commands to configure the VLANs and the switch IP addresses and subnets:

```
create vlan srvr
create vlan clnt
create vlan vips
configure srvr ipaddress 192.168.200.10 /24
configure clnt ipaddress 10.1.1.1 /24
configure vips ipaddress 192.168.201.1 /24
configure srvr add port 29-32
configure client add port 1-4
enable ipforwarding
```

Use the following commands to create a round-robin pool, MyWeb, and add nodes to the new pool:

```
create slb pool MyWeb lb-method round
configure slb pool MyWeb add 192.168.200.1:80
configure slb pool MyWeb add 192.168.200.2:80
```

Use the following command to create a translation mode virtual server for the website and assign MyWeb to it:

```
create slb vip WebVip pool MyWeb mode translation 192.168.201.2:80
```

Use the following commands to create a round-robin pool, MySSL, and add nodes to the new pool:

```
create slb pool MySSL lb-method round
configure slb pool MySSL add 192.168.200.1:443
configure slb pool MySSL add 192.168.200.2:443
```

Use the following command to create a translation mode virtual server for the website and assign MySSL to it:

```
create slb vip SSLVip pool MySSL mode translation 192.168.201.2:443
```

Use the following commands to enable SLB, configure the server VLAN to act as the server side, and configure the client VLAN to act as the client side:

```
enable slb
configure vlan srvr slb-type server
configure vlan clnt slb-type client
```

Port Translation Mode

Port translation mode is similar to translation mode, except that the layer 4 port on the virtual server can be different from the layer 4 port on the nodes. The switch translates the IP address and port address to that of the severs to be balanced.

In port translation mode, you can directly attach servers or have a layer 2 switch between the SLB switch and the servers. You cannot have a router between the SLB switch and the servers.

Use port translation mode when you must translate layer 4 port numbers in addition to translating IP addresses.

GoGo Mode

GoGo mode is a line rate method of server load balancing that forwards traffic without changing packet content. You must directly attach servers to the SLB switch in GoGo mode.

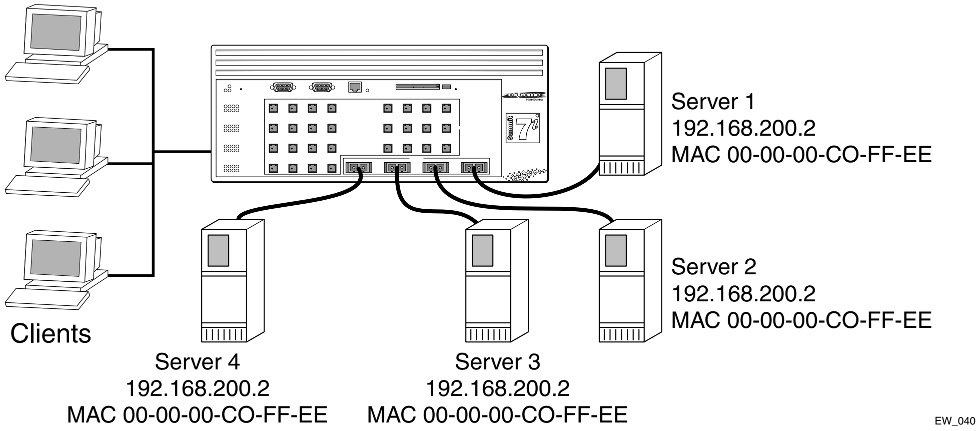
The optimal configuration is groups of 2, 4, or 8 servers. Because you must directly attach servers, you do not need to configure nodes, pools, or virtual servers. Instead, you configure all servers with the same MAC and IP addresses. Clients then see the group of servers as a single server, much like port-based load sharing.

As in port-based load sharing, the first port in the GoGo mode group is designated the “master” logical port. Use this port to represent the entire GoGo mode group when configuring health checks or VLAN membership.

In GoGo mode, the load balancing method is fixed, based on a hashing of the client IP address. GoGo mode persistence is based on source IP information: a given source address will map to one, and only one, physical server.

Use GoGo mode when you require performance without any traffic management features. Figure 23 shows GoGo mode.

Figure 23: GoGo mode



In Figure 23, the switch is configured to balance all traffic sent to the virtual server based on the client IP address.

The servers are configured as follows:

- All servers have the same MAC address.
- All servers have the same IP address.
- All servers have the same content.

To configure the switch as indicated in the example, use the following commands:

```
create vlan server
create vlan client
configure server ipaddress 192.168.200.2 /24
configure client ipaddress 1.1.1.1 /24
configure server add port 29-32
configure client add port 1-4
enable slb gogo 29 grouping 29-32
enable ipforwarding
```

In this example, port 29 is designated the master port.

GoGo mode requires you to place clients and servers into separate VLANs.

Load-Balancing Methods

Load-balancing methods are algorithms that determine which node receives a connection hosted by a particular virtual server. The forwarding mode determines *how* the switch forwards traffic; the load-balancing method determines *where* the switch forwards traffic.

Individual load-balancing methods take into account dynamic factors such as current connection count. Because each application of SLB is unique, node performance depends on a number of different factors. We recommend that you experiment with different load-balancing methods and choose the one that offers the best performance in your particular environment.

The switch supports the following load balancing methods:

- Round-robin
- Ratio
- Least connections
- Priority

NOTE

When using Microsoft load balancing, if you replace existing hardware and use the same IP address on the new hardware (thus associating the same IP address with a new MAC address), IP traffic through the IPFDB is not forwarded. To work around this characteristic, manually clear the IPFDB.

Round-Robin

Round robin passes each new connection request to the next server in line. Because round robin is simple and predictable, it is the default load-balancing method.

Use round-robin if the equipment that you are load balancing is roughly equal in processing speed and memory.

Ratio

Ratio distributes connections among servers according to ratio weights that you set. The number of connections that each server receives is proportionate to the ratio weight you defined for each server.

Use ratio if the equipment that you are load balancing varies significantly in processing speed and memory. For example, if you have one new, high-speed server and two older servers, you can set the ratio so that the high-speed server receives twice as many connections as either of the two older servers.

A ratio of 2 results in twice as much traffic as a ratio of 1. If all nodes use the same weight, connections are distributed equally among the nodes. The default ratio is 1.

Least Connections

Least connections method passes a new connection to the node having the least number of active sessions. The number of active sessions includes only those sessions occurring within the same virtual server.

Use least connections when the equipment that you are load balancing has similar capabilities. Because least connections requires more processing, it works best with small pools (under 25 nodes) when you require intelligent distribution.

Priority

Priority is a variant of round-robin designed to provide redundant “standby” nodes within a pool. When you add a node to a pool, you can assign a priority level ranging from 1 - 65535, with a higher number indicating a higher priority.

In priority, the switch uses round-robin to distribute traffic among the active nodes with the highest priority. If all nodes at that priority level become inactive or reach a session limit maximum, all new sessions are directed to the nodes at the next lowest priority. The switch monitors the status of the inactive nodes. As each node becomes active, the switch redistributes traffic according to the priorities.

For example, in a pool with six nodes divided evenly into two priority levels (2 and 1), all sessions are evenly distributed to the priority 2 nodes. If one of the priority 2 nodes becomes inactive, all traffic is assigned to the remaining priority 2 nodes. If all of the priority 2 nodes become inactive, all sessions are directed to the priority 1 nodes. If one of the level 2 nodes becomes active, all new sessions are assigned to it.

Use priority when you want a set of servers held in reserve, as a back-up pool.

Advanced SLB Application Example

The advanced features described in this section are:

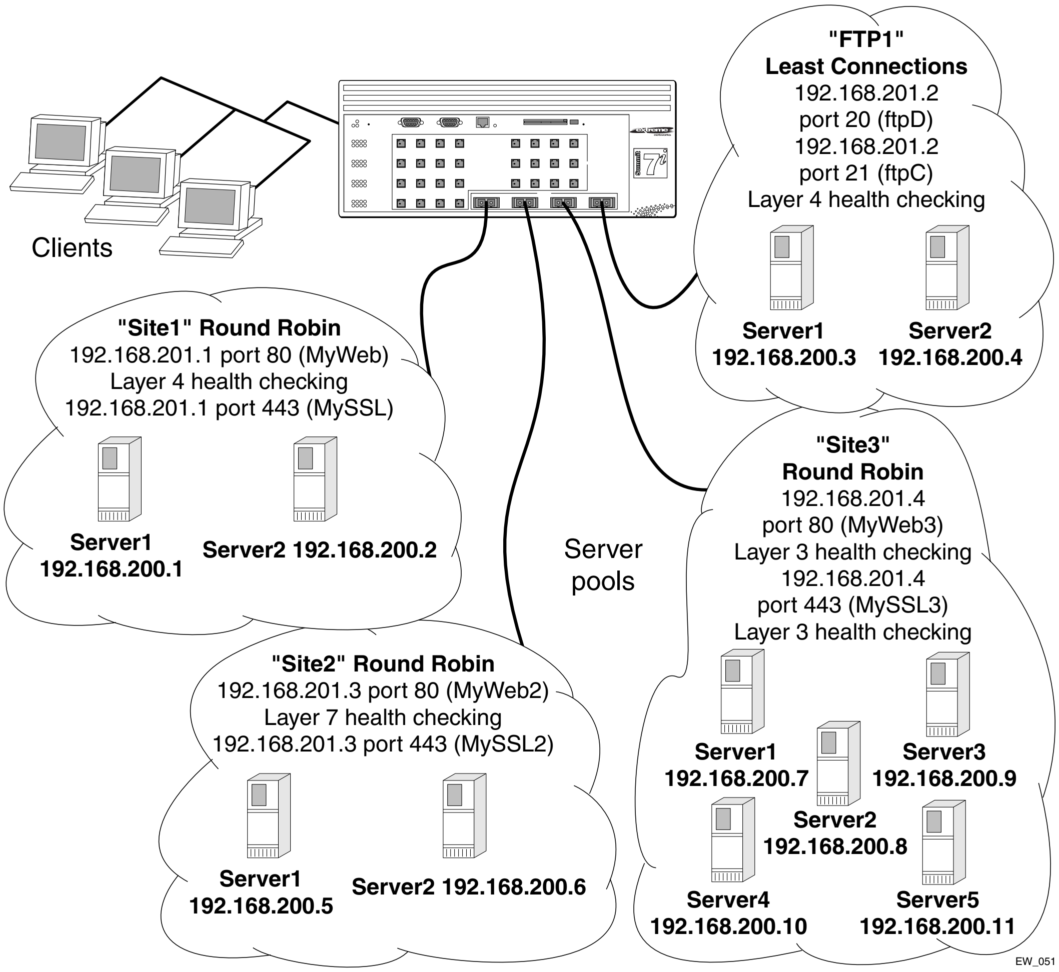
- Persistence
- High availability
- 3DNS support
- Flow redirection
- Health checking

The advanced SLB application example builds upon the basic SLB application example. The advanced concepts included in this example are:

- Multiple pools.
- Multiple virtual servers.
- Multiple balancing algorithms.
- Multiple types of health checking.

Figure 24 is an example of an advanced SLB application.

Figure 24: Advanced SLB configuration



To create the VLAN from which outside connections will come, use the following commands:

```
create vlan outside
configure vlan outside ipaddress 172.16.0.1 /16
configure vlan outside add ports 1-8
```

To create is the virtual IP VLAN, use the following commands:

```
create vlan sites
configure vlan sites ipaddress 192.168.201.254 /24
```

All virtual servers will use this subnet. There are no ports associated with this VLAN.

Use the following commands to create the VLAN *servers* and enable IP forwarding:

```
create vlan servers
configure vlan servers ipaddress 192.168.200.254 /24
configure vlan servers add ports 9-16
enable ipforwarding
```

Use the following series of commands to create a web site. The site is defined as having two servers: 192.168.200.1 and 192.168.200.2, each with two services (HTTP and SSL). Two virtual servers point at the appropriate pools. The load-balancing method is round-robin. Both virtual servers use the same IP address; the difference is the port number. Finally, port checking is enabled to ensure fault tolerance on each of the servers.

```
create slb pool site1web
configure slb site1 add 192.168.200.1:80
configure slb site1 add 192.168.200.2:80
create slb pool site1ssl
configure slb site1 add 192.168.200.1:443
configure slb site1 add 192.168.200.2:443
create slb vip myweb pool site1web mode transparent 192.168.201.1:80
create slb vip myssl pool site1ssl mode transparent 192.168.201.1:443
enable slb node 192.168.200.1:80 tcp-port-check
enable slb node 192.168.200.2:80 tcp-port-check
enable slb node 192.168.200.1:443 tcp-port-check
enable slb node 192.168.200.2:443 tcp-port-check
```

Use the following series of commands to create a second web site. This site is similar to the first site, except that content checking is enabled on this site.

```
create slb pool site2web
configure slb site2web add 192.168.200.5:80
configure slb site2web add 192.168.200.6:80
create slb pool site2ssl
configure slb site2ssl add 192.168.200.5:443
configure slb site2ssl add 192.168.200.6:443
create slb vip myweb2 pool site2web mode transparent 192.168.201.3:80
create slb vip myssl2 pool site2ssl mode transparent 192.168.201.3:443
enable slb vip myweb2 service-check
configure slb vip myweb2 service-check http url “/testpage.htm” match-string “test
successful”
```

Use the following series of commands to create a third web site. This example has one pool with a wildcard port. The wildcard port allows any port sent to it by the virtual server. All five servers respond to requests on both port 80 and port 443.

```
create slb pool site3web
configure slb site3web add 192.168.200.7:0
configure slb site3web add 192.168.200.8:0
configure slb site3web add 192.168.200.9:0
configure slb site3web add 192.168.200.10:0
configure slb site3web add 192.168.200.11:0
create slb vip myweb3 pool site3web mode transparent 192.168.201.4:80
create slb vip myssl3 pool site3web mode transparent 192.168.201.4:443
```

Use the following series of commands to create an FTP site. The site has two servers: 192.168.200.3 and 192.168.200.4. The servers provide only FTP service. The two different virtual servers and port numbers refer to the control and data channels used by the FTP service. Two virtual servers point at the appropriate pools.

The load-balancing method is round-robin. Layer 7 health checking is enabled for the ftpc virtual server.

```
create slb pool ftp1c
configure slb ftp1c add 192.168.200.3:21
configure slb ftp1c add 192.168.200.4:21
create slb pool ftp1d
configure slb ftp1d add 192.168.200.3:20
configure slb ftp1d add 192.168.200.4:20
create slb vip ftpc pool ftp1c mode transparent 192.168.201.2:21
create slb vip ftpd pool ftp1d mode transparent 192.168.201.2:20
enable slb vip ftpc service-check
configure slb vip ftpc service-check ftp user test password testpass
```

Finally, enable SLB and configure the VLANs to be either client or server, using the following commands.

```
enable slb
configure vlan outside slb-type client
configure vlan servers slb-type server
```

Using Persistence

Persistence ensures that subsequent connections from the same client attach to the same server. To configure persistence, you select:

- persistence method
- persistence level
- persistence type

Persistence is not affected by the load-balancing method unless you select GoGo mode, where the persistence is fixed, as described on page 192.

Persistence Methods

Persistence methods determine how the persistence table times-out entries. The persistence methods are:

- Per-session
- Per-packet

Per-Session Persistence

Per-session persistence creates a persistence entry when the first packet arrives from a client with the time-out value configured for the virtual server. The entry is removed after the time-out period. The entry is not refreshed. Per-session is the default persistence method.

Use per-session persistence when you want the smallest impact on performance and you can accurately gauge your total connection time.

Per-Packet Persistence

Per-packet persistence creates a persistence entry when the first packet arrives and refreshes that entry each time a new packet arrives. Thus, the entry remains as long as new packets continue to arrive.

Use per-packet persistence when you want to sacrifice a small amount of performance in return for a time-out period based on connection idle time instead of total connection time.

Persistence Levels

Persistence levels determine how the persistence entries affect multiple virtual servers. Use persistence levels if you have servers that provide multiple services to a single client (such as, HTTP and SSL). To use persistence levels, your virtual servers must contain the same physical servers.

The persistence levels are as follows:

- Same-VIP-same-port
- Same-VIP-any-port
- Any-VIP

Same-VIP-Same-Port Persistence

Same-VIP-same-port matches a new client request to a persistence entry only if the destination is the same virtual server and same port as the original client request. Same-VIP-same-port is the default persistence method.

Use same-VIP-same-port persistence to ensure that connections from a client are only persistent on the specific virtual server that is connecting to that client.

Same-VIP-Any-Port Persistence

Same-VIP-any-port persistence directs client requests to the same virtual server even if the port is different.

Use same-VIP-any-port persistence to ensure that connections from a client are persistent on the virtual server for all layer 4 services offered on that particular virtual server. For example, if you use HTTP (port 80) to build a shopping cart, then need to use SSL (port 443) for the credit card transaction at the end, use same-VIP-any-port persistence to preserve the client session.

If you have virtual servers with the same IP address but a different port, you must configure associated pools with identical nodes that can service requests on either port.

Any-VIP Persistence

Any-VIP persistence directs all connections from a client to the same virtual server regardless of the destination.

Use any-VIP persistence to ensure that connections from a client always go to the same server no matter what layer 4 service they connect to. When you use any-VIP persistence, you must ensure that all servers have the same content for all services.

Persistence Types

The switch supports the following types of persistence:

- Client persistence
- Proxy client persistence
- Sticky persistence

Client Persistence

Client persistence provides a persist mask feature. You can define a range of IP addresses that map to a persistent connection. Any client whose source IP address falls within the range is considered a match for the entry.

Use client persistence to ensure that transactions, from your defined range of IP addresses, that span multiple TCP sessions are always connected to the same virtual servers. For example, if you assume that a single client uses multiple sessions to fill a shopping cart, you can force all traffic from the same range of IP addresses (which you assume to be the same client) to connect to the same virtual server.

Proxy Client Persistence

Some networks translate addresses internally with an array of proxy servers. Proxy client persistence allows the switch to maintain connections for clients in these types of networks. You can define ranges of IP addresses that map to a persistent connection. Any client whose source IP address falls within one of the ranges is considered a match for the entry. You must add every range of possible source IP addresses.

Use proxy client persistence to provide persistence for users who are behind proxy servers that change the source IP address of client requests from session to session.

Sticky Persistence

Sticky persistence is available only on wildcard virtual servers and is especially useful for cache servers. Sticky persistence tracks destination IP addresses. When a client attempts to connect to a destination IP address, the switch directs the client to the same cache server previously used for that destination IP address. This helps you reduce the amount of duplicated content on cache servers in your network.

Use sticky persistence to provide persistence based on destination IP address. Sticky persistence is especially useful when you load balance caching proxy servers. A caching proxy server intercepts web requests and returns a cached web page (if that page is available). You can improve the efficiency of cache proxy servers by sending similar requests to the same server. Sticky persistence can cache a given web page on one proxy server instead of on every proxy server. This saves the other servers from duplicating the content.

NOTE

For additional cache server applications, see "Web Cache Redirection" on page 209.

Using High Availability System Features

The switch supports several advanced redundant system features. Advanced redundant system features provide additional assurance that your content remains available if a switch experiences a problem. The advanced redundant system options include:

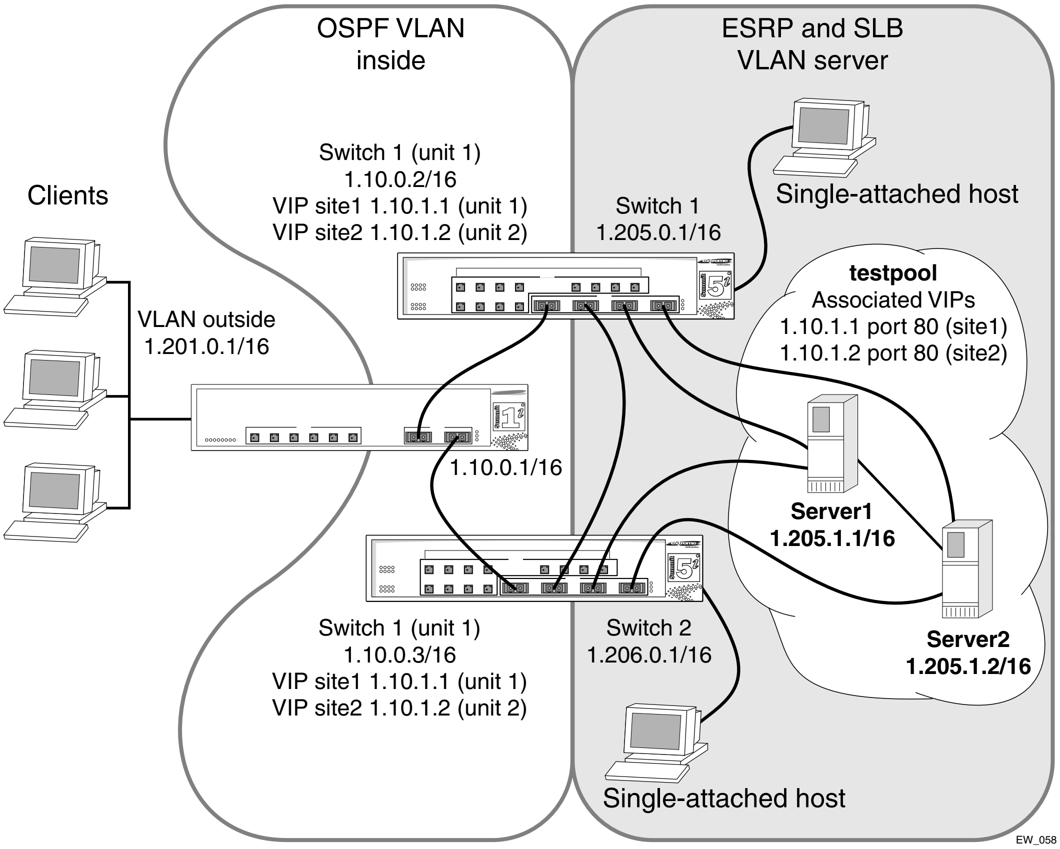
- SLB with ESRP
- Active-active operation

Server Load Balancing with ESRP

You can use ESRP to make SLB, along with the layer 2 and layer 3 services of the switch, redundant. SLB with ESRP allows single- or dual-attached servers to have redundant gateway services and very fast recovery from a fault. When you enable ESRP, all servers can be online simultaneously, and recovery from a switch failure occurs in less than 8 seconds.

Figure 25 shows SLB enabled using ESRP and dual-attached servers.

Figure 25: SLB using ESRP and dual-homed servers



Configuring the Switches for SLB and ESRP

To create the VLANs, use the following commands:

```
create vlan inside
create vlan server
```

To connect the gateway to the VLAN *inside*, use the following commands:

```
configure inside ipaddress 1.10.0.2 /16
configure inside add port 31
```

To configure the servers to connect to the VLAN *server* on ports 1-4, and configure port 32 to connect to the other ESRP switch, use the following commands:

```
configure server ipaddress 1.205.0.1 /16
configure server add port 1-4, 32
```

To enable IP forwarding, create a server pool called *testpool,* and add four servers to it using TCP port 80, use the following commands:

```
enable ipforwarding
create slb pool testpool
configure slb pool testpool add 1.205.1.1:80
configure slb pool testpool add 1.205.1.2:80
configure slb pool testpool add 1.205.1.3:80
configure slb pool testpool add 1.205.1.4:80
```

To create SLB virtual server addresses for the two websites (*site1* and *site2*) and associate the server pool *testpool* with it, use the following commands:

```
create slb vip site1 pool testpool mode transparent 1.10.1.1:80
create slb vip site2 pool testpool mode transparent 1.10.1.2:80
```

To enable SLB and configure it for the appropriate VLANs (client connections enter from the VLAN *inside*), use the following commands:

```
enable slb
configure inside slb client
configure server slb server
```

To enable OSPF, use the following command:

```
enable ospf
```

To enable ESRP on the VLAN *server* and configure the ESRP direct-attached hosts mode to allow the proper failover of services, use the following commands:

```
enable esrp server
configure esrp port-mode host ports 1-4, 32
```

the interconnection between the switches is also configured as a host port.

To configure SLB to use ESRP, use the following command:

```
configure slb esrp server add unit 1
```

Note the following about the configurations for the switches running SLB and ESRP:

- You must configure all switch ports connected directly to the servers as ESRP host ports.
- You must configure the link between the two switches as an ESRP host port.
- The configuration uses transparent mode and HTTP services, but can be configured to support any of the currently supported load-balancing protocols.
- Both switches are configured as unit 1.
- The SLB and ESRP port configurations are identical on both switches.

Web-Server Configuration

The services must match those configured on the switch; for example, HTTP services configured at TCP port 7080 on the switch require the servers to allow connections at port 7080. You must ensure that the SLB configuration is valid before trying to transfer the configuration to an ESRP/SLB configuration.

The two types of ESRP hosts that you can connect to the switches are single-attached hosts and dual-attached hosts. Single-attached hosts provide no server link redundancy, but allow hosts to be connected to the same VLAN as the web servers. Dual-attached hosts allow for redundant NICs in the servers, as well as connections to the switch. When configured as dual-attached hosts, the servers are supported fully by the ESRP redundant gateway services.

NOTE

For information on specific NIC card configurations, please contact your NIC vendor.

Active-Active Operation

Active-active operation is a redundant configuration of two switches. If one switch fails, the second switch takes over the SLB function. By preparing a redundant switch for the possibility of failover, you provide reliability and availability.

To create an active-active configuration, configure redundant switches with identical SLB configurations, except for the failover parameters.

Active-active operation uses a gateway ping-check to determine if the active SLB switch has network connectivity. If the specified IP address is unreachable for a specified duration, the gateway ping-check triggers a failover to the redundant switch.

NOTE

When you configure the gateway ping check, specify the IP address of a device other than the redundant SLB switch.

Configuring Active-Active Operation

Using active-active redundant SLB, you configure one switch as unit 1 and the other switch as unit 2. You then assign the virtual servers either to unit 1 or to unit 2 (unit 1 is the default). When both switches are active, each switch performs SLB only for the virtual servers assigned to it. If a switch fails, the remaining switch performs SLB for the virtual servers assigned to the failed switch.

Use the following command to assign the unit number:

```
configure slb failover unit <number> remote-ipaddress <ip address> local-ipaddress <ip
address> {L4-port <port number>}
```

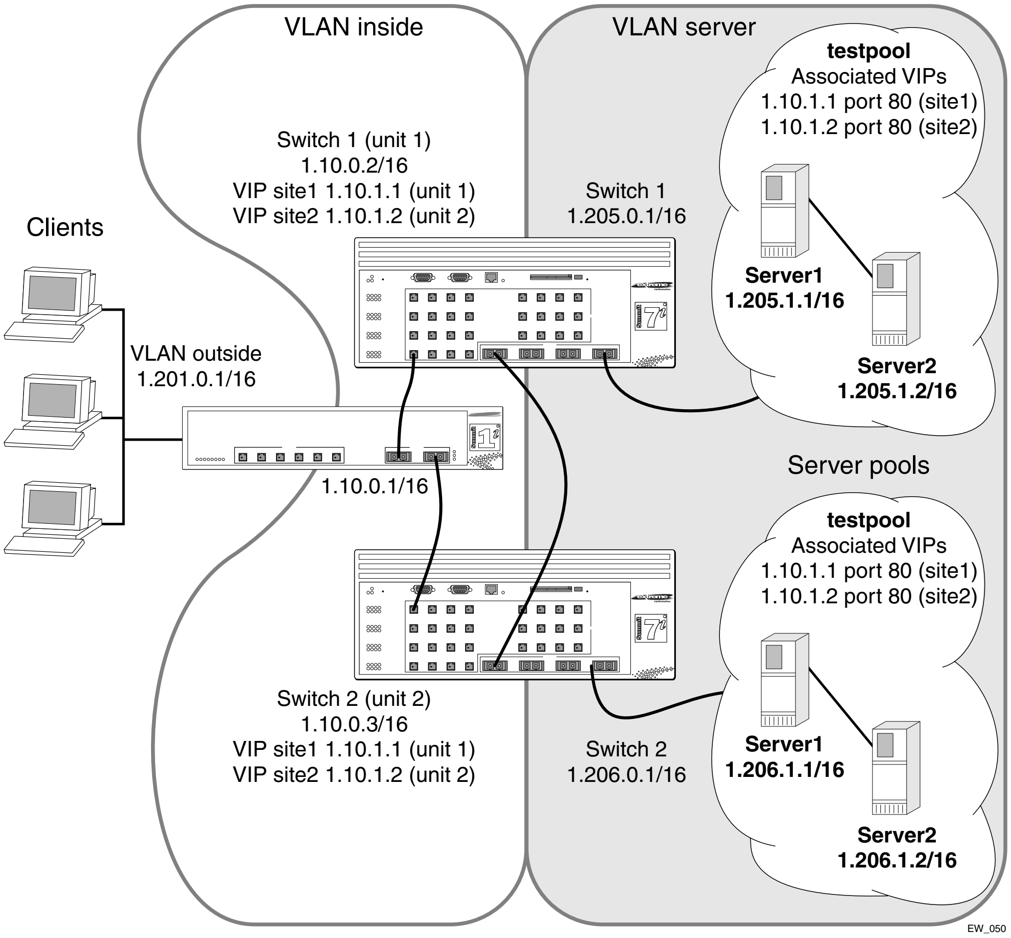
The `remote-ip` specifies the IP address of the redundant SLB switch. The `local-ip` specifies the IP address of the switch you are configuring.

You must assign virtual servers with the same virtual IP address to the same unit.

Sample Active-Active Configuration

Figure 26 is an example of an active-active failover configuration.

Figure 26: Active-active configuration



To configure this example on the first switch, use the following commands:

```
create vlan inside
create vlan server
configure vlan inside ipaddress 1.10.0.2 /16
configure vlan inside add port 31
configure vlan server ipaddress 1.205.0.1 /16
configure vlan server add port 29-30

enable ipforwarding

create slb pool testpool
configure slb pool testpool add 1.205.1.1:80
configure slb pool testpool add 1.205.1.2:80
create slb vip site1 pool testpool mode transparent 1.10.1.1:80
create slb vip site2 pool testpool mode transparent 1.10.1.2:80

enable slb
configure vlan inside slb-type client
configure vlan server slb-type server

configure slb failover unit 1 remote 1.10.0.3 local 1.10.0.2:1028

enable slb failover

enable slb failover ping

configure slb vip site1 unit 1
configure slb vip site2 unit 2

configure slb fail ping-check 1.10.0.1 freq 1
```

To configure this example on the second switch, use the following commands:

```
create vlan inside
create vlan server
configure vlan inside ipaddress 1.10.0.3 /16
configure vlan inside add port 31
configure vlan server ipaddress 1.206.0.1 /16
configure vlan server add port 29-30

enable ipforwarding

create slb pool testpool
configure slb pool testpool add 1.206.1.1:80
configure slb pool testpool add 1.206.1.2:80
create slb vip site1 pool testpool mode transparent 1.10.1.1:80
create slb vip site2 pool testpool mode transparent 1.10.1.2:80

enable slb
configure vlan inside slb-type client
configure vlan server slb-type server

configure slb failover unit 2 remote 1.10.0.2 local 1.10.0.3:1028
enable slb failover
enable slb fail ping

configure slb vip site1 unit 1
configure slb vip site2 unit 2

configure slb fail ping-check 1.10.0.1 freq 1
```

The differences between the configurations of these two switches are the IP addresses and the designation of the first switch as unit 1 of the active-active configuration.

If you use this configuration with only one virtual server, you have an active switch and a standby switch, because only one switch is actively performing SLB. This configuration is called "active-standby."

Active-Active Configuration Notes

Note the following about active-active configurations:

- In the design shown in Figure 26, only the servers directly connected to the switch that is actively servicing the virtual server are used in the load-balancing scheme. Without ESRP, you must have another switch interconnecting all the servers.
- One switch is designated as unit 1 and the other is unit 2. This designation determines which virtual servers are active on each switch in the failover pair.
- In this configuration, *site1* is serviced by switch 1 and has two servers that respond to client requests. *Site2* is be serviced by the remote switch (switch 2) and has two other servers that respond to client requests.
- If you enable ping-check, do not direct it at the remote switch. The ping-check works best when directed at a gateway to ensure that a path out of the network is available to the switch.
- The configuration uses transparent mode and HTTP services, but can be configured to support any of the currently supported load balancing protocols.
- The configurations for the switches are identical, with the exception of the failover command.
- The remote switch is set to unit 2, and the remote/local IP addresses are reversed to accurately describe the network.

Using Manual Fail-Back

With manual fail-back, fail-back occurs only when you enter the fail-back command. In an active-active configuration, fail-back occurs automatically. If the minor disruption of fail-back makes automatic fail-back undesirable, you can enable manual fail-back.

Health Checking

Health checking allows you to actively poll nodes to determine their health. The switch makes new connections only if the virtual server and node are both enabled and passing health checks. The switch considers a virtual server or node active unless a health check fails. If a health check fails, the switch considers the virtual server or node inactive. A virtual server or node is also considered inactive if it is disabled and has zero active connections. If it is inactive for this reason, the switch stops ping-checks and port-checks on the virtual server or node to conserve system resources. The switch resumes ping checks and port checks when you enable the virtual server or node.

The switch does not establish new connections with an inactive node until that node passes all configured health checks. If a health check fails and you have enabled the `ign-reset` parameter on an associated virtual server, the switch closes all existing connections for the virtual server by sending a TCP reset to the client and node.

The switch supports three types of health checking:

- Ping-check
- Port-check
- Service-check

The switch also supports 3DNS health checking.

Ping-Check

Ping-check operates at layer 3 and is the default health check. The switch sends an ICMP ping to the configured server or next hop. The default ping frequency is 10 seconds and the default time-out is 30 seconds (three pings). If the node does not respond within 30 seconds, it is considered down. If a server is configured not to respond to ICMP echo requests, the server will be marked "down" after the first ping check interval. Ping check is the only health check that will accept a wildcard as the IP port.

TCP-Port-Check

TCP-port-check operates at layer 4 and tests the physical node. The default frequency is 30 seconds and the default time-out is 90 seconds. If the node does not respond within 90 seconds, it is considered down. You can use TCP-port-checking to determine if a TCP service, such as httpd, is available. If a TCP-port-check fails, the IP/port combination is considered unavailable.

Service-Check

Service-check operates at layer 7 and is an application-dependent check defined on a virtual server. The switch performs a service-check on each node in the pool. The default frequency is 60 seconds and the default time-out is 180 seconds. Table 26 describes the service-check parameters.

Table 26: Service-Check Parameters

Service	Attribute	Global Default Value
HTTP	URL	"/"
	Match-string	Any-content
FTP	Userid	"anonymous"
	Password	"anonymous"
Telnet	Userid	"anonymous"
	Password	"anonymous"
SMTP	Dns-domain	Same as the switch DNS domain. If no DNS domain is configured for the switch, the value is "".
NNTP	Newsgroup	"ebusiness"
POP3	Userid	"anonymous"
	Password	"anonymous"

If you do not specify the service-check parameters, the switch uses the global default values. You can configure the global default values.

For HTTP, you can specify both the URL to be retrieved, and a `match-string`, such as "Welcome." If the switch finds the `match-string` in the first 1000 bytes of the retrieved URL, the service-check passes.

A `match-string` specified as `any-content` matches any retrieved text. Extreme Networks recommends that you create a text file that contains a single word, such as "ok."

The FTP, Telnet, and POP3 service-checks establish a connection between the switch and the next hop. Service-check logs on and off using the specified `userid` and `password`.

For SMTP, service-check identifies the switch by providing the DNS domain you configure. Extreme Networks recommends that you specify a DNS domain that is used only for identification.

The NNTP service-check connects to the node, logs in, and attaches to the newsgroup specified.

You configure service-checks for each virtual server, and nodes can be members of multiple virtual servers. Therefore, because each node can have multiple service-checks, some service-checks can fail while others pass. So to accept a new connection for a virtual server, a node must have passed the service-check configured for that virtual server. When showing detailed virtual server information, the status for individual nodes is shown with respect to that virtual server.

3DNS Health Checking

3DNS is a global load balancing and site redundancy tool. Additional information concerning individual server health and performance is gathered by 3DNS when using Transparent or Translational modes. When you enable SLB, the switch reports health status to 3DNS using the iQuery™ protocol from F5 Networks®. The health status of the nodes within the server farm is based on layer 3, layer 4, layer 7, or external health check mechanisms. To enable 3DNS:

```
enable slb 3dns iquery-client
```

To see what 3DNS devices are currently communicating with the SLB enabled switch:

```
show slb 3dns members
```

To disable responses to 3DNS queries:

```
disable slb 3dns iquery-client
```

The switch responds to directed queries from 3DNS. To direct 3DNS queries to the switch, add a "Big/IP" device to the 3DNS configuration. Encrypted communications with 3DNS are currently not supported.

Maintenance Mode

You can put a node or virtual server into maintenance mode by disabling the node or virtual server. In maintenance mode, existing connections remain active, but no new connections are permitted. The existing connections are either closed by the client and server or are aged out if idle for more than 600 seconds.

Health Checking in GoGo Mode

GoGo mode does not use nodes, pools, or virtual servers. Therefore, to configure health checking when using GoGo mode, you must use the GoGo mode health checking commands.

Flow Redirection

Flow redirection overrides routing decisions to transparently redirect client requests to a target device (or group of devices). Unlike SLB, you do not duplicate content on the target device(s).

The switch can only redirect traffic that crosses a VLAN boundary within the switch, because flow redirection operates at layer 3. If the clients and servers belong to the same subnet as the switch, use the proxy ARP feature with minimal configuration changes to clients or servers.

Flow redirection automatically includes health checking. You can configure the type of health check, but you cannot disable flow redirection health checking.

Flow redirection examines traffic and redirects it based on the following criteria, in order of priority:

1. Destination IP address and mask
2. Layer 4 port
3. Source IP address and mask

Multiple flow redirection rules can overlap. In these cases, the most specific redirection rule that satisfies the criteria takes precedence. In general, the following rules apply:

- If a flow with a better matching mask on an IP address satisfies the content of a packet, that flow will be observed.
- If one flow redirection rule contains "any" as a layer 4 protocol and a second flow redirection rule contains explicit layer 4 port information, the second takes precedence if the packet contains matching layer 4 information.
- If one flow has a better match on source information and a second flow has better match on destination information then the rule with the match on the destination information is selected.

For example, in the following 2 cases, the rule with the best match (using the above criteria) is selected.

Table 27: Flow rule example A

Rule #	Destination IP Address	Destination Port	Source IP Address	Priority Selection
A1	192.0.0.0/8	80	ANY	1
A2	192.168.0.0/16	ANY	ANY	2

In example A, rule A1 is the best match as it contains an explicit destination port, even though rule A2 has a more specific destination IP address mask.

Table 28: Flow rule example B

Rule #	Destination IP Address	Destination Port	Source IP Address	Priority Selection
B1	192.168.2.0/24	80	ANY	2
B2	192.168.0.0/16	ANY	10.10.10.0/24	4
B3	192.168.2.0/24	ANY	10.10.0.0/16	3
B4	192.168.2.0/24	80	10.10.0.0/16	1

In example B, rule B4 is the best match as it contains an explicit destination port and a better match on the source IP address mask than rule B1.

NOTE

Extreme Networks recommends that you use flow redirection and SLB on separate switches; do not use flow redirection and SLB on the same switch. If you must use SLB and flow redirection on the same switch, ensure that no overlapping layer 4 IP ports exist in the configuration.

You must prevent logical loops of redirected traffic. You can use flow redirection for the following:

- Web cache redirection
- Policy-based routing

Web Cache Redirection

Web cache redirection operates at line rate to redirect traffic from the requested server to a web cache server. If the web cache server has a copy of the requested content, it sends the content to the client. If the web cache server does not have the requested content, it queries the server for the data, stores it locally, and sends a copy to the client.

When you have web cache redirection enabled, clients connect exclusively to your web cache servers; clients never connect to the requested server.

The switch automatically load-balances your cache servers based on the destination IP address of the requested content. Thus, subsequent requests for a destination IP address are redirected to the same web cache server, because that web cache server is most likely to contain the requested content. This load-balancing reduces the amount of content duplication on your web cache servers.

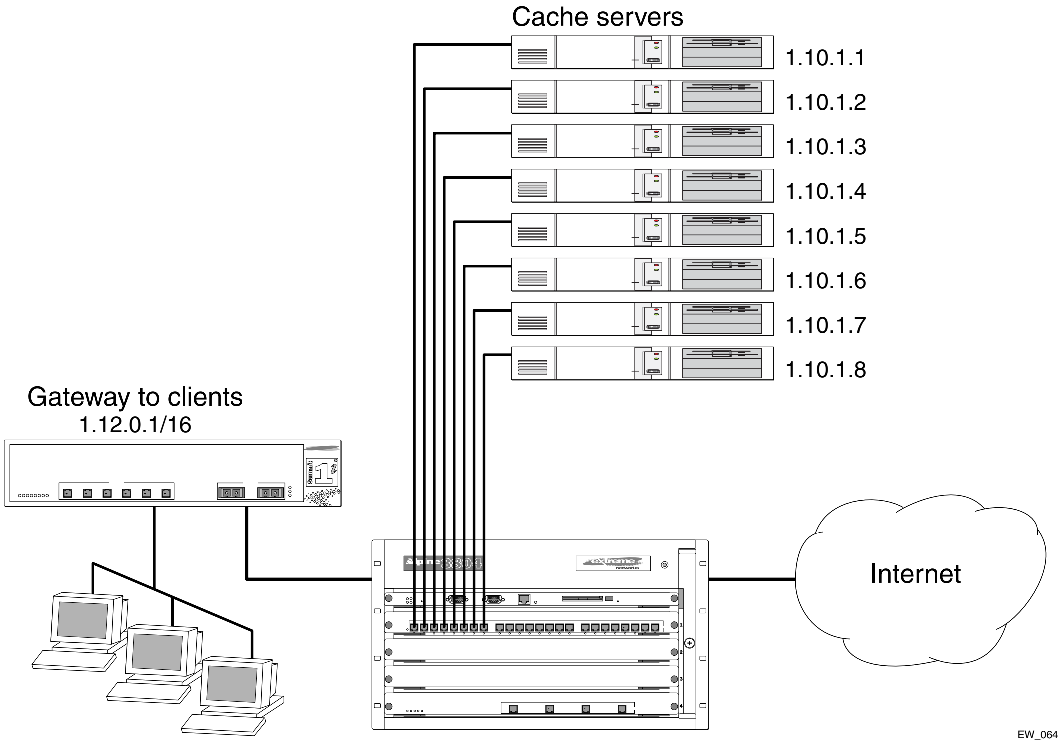
NOTE

Ensure that the FDB time-out on the switch is higher than the IPARP time-out.

Web Cache Redirection Example

Figure 27 uses flow redirection to redirect Web traffic to cache servers. In this example, the clients and the cache devices are located on different networks. This is done by creating a different VLAN for the clients and cache devices.

Figure 27: Web cache redirection example



To configure the switch in this example, use the following commands:

```
create vlan client
configure vlan client add port 1
configure vlan client ipaddress 1.12.0.1/16

create vlan cache
configure vlan cache add port 2
configure vlan cache ipaddress 1.10.1.1/24

create vlan internet
configure vlan internet add port 3
configure vlan internet ipaddress 1.11.1.1/16

enable ipforwarding

create flow-redirect flow1 tcp destination 1.11.1.0/24 ip-port 80 source any

configure flow1 add next-hop 1.10.1.2
configure flow1 add next-hop 1.10.1.3
configure flow1 add next-hop 1.10.1.4
configure flow1 add next-hop 1.10.1.5
configure flow1 add next-hop 1.10.1.6
configure flow1 add next-hop 1.10.1.7
configure flow1 add next-hop 1.10.1.8
```

Health Checking Example

This section provides examples that show how to configure Layer 4 and Layer 7 health checking using several different methods. Ping-based health checking is the default mode.

The following example demonstrates server health checking using the L4 destination port. This type of health checking is useful for cases where an L7 service check is either undesirable or unavailable:

```
create flow-redirect http1 tcp destination 0.0.0.0/0 ip-port 80 source 0.0.0.0 0.0.0.0

configure flow-redirect http1 service-check L4-port

configure flow-redirect http1 add next-hop 192.168.0.66
```

The following example shows how to configure an L7 service check using HTTP. A server is considered available if the switch is able to retrieve the file home.html and that file contains the string "banana."

```
create flow-redirect http2 tcp destination 0.0.0.0/0 ip-port 80 source 0.0.0.0 0.0.0.0

configure flow-redirect http2 service-check http url 192.168.0.66/home.html
match-string banana

configure flow-redirect http2 add next-hop 192.168.0.66
```

The principle demonstrated in the preceding HTTP example also applies to verifying functionality of a mail server. In this case, an L7 health check supplies the server with the specified username and password. As long as the switch can successfully log in, the check passes.

```
create flow-redirect pop31 tcp destination 0.0.0.0/0 ip-port 110 source 0.0.0.0
0.0.0.0

configure flow-redirect pop31 service-check pop3 user extreme extreme

configure flow-redirect pop31 add next-hop 192.168.0.66
```

The following example shows how to verify that an NNTP newsgroup is active on a server farm:

```
create flow-redirect nntp2 tcp destination 0.0.0.0/0 ip-port 119 source 0.0.0.0
0.0.0.0

configure flow-redirect nntp2 service-check nntp ng

configure flow-redirect nntp2 add next-hop 192.168.0.66
```

Policy-Based Routing

Policy based routing is an application of flow redirection that allows you to control routed traffic regardless of the routing protocol configured. For example, you can use policy-based routing to force SNMP traffic to follow a less efficient but more secure path.

As with web cache redirection, policy-based routing examines traffic and redirects it based on the following criteria (in order of priority):

1. Destination IP address and mask
2. Layer 4 port
3. Source IP address and mask

If the next-hop address is unavailable, the switch routes the traffic normally. You can define several rules; the precedence of rules is determined by the best match of the rule to the packet. If no rule is satisfied, no redirection occurs.

If you define multiple next-hop addresses, traffic satisfying the rule is load-shared across the next hop addresses based on destination IP address. If next hop addresses do not respond to ICMP pings, the switch resumes normal routing.

Policy-based routing has no impact on switch performance unless you use policy-based routing and SLB on the same switch.

11 Status Monitoring and Statistics

This chapter describes the following topics:

- Status Monitoring on page 213
- Slot Diagnostics on page 214
- Port Statistics on page 216
- Port Errors on page 217
- Port Monitoring Display Keys on page 218
- System Temperature on page 218
- System Health Checking on page 219
- Setting the System Recovery Level on page 224
- Event Management System/Logging on page 225
- Configuring and Monitoring Flow Statistics on page 237
- Using sFlow® on page 246
- RMON on page 249

Viewing statistics on a regular basis allows you to see how well your network is performing. If you keep simple daily records, you will see trends emerging and notice problems arising before they cause major network faults. In this way, statistics can help you get the best out of your network.

Status Monitoring

The status monitoring facility provides information about the switch. This information may be useful for your technical support representative if you have a problem. ExtremeWare includes many show commands that display information about different switch functions and facilities.

NOTE

For more information about show commands for a specific ExtremeWare feature, see the appropriate chapter in this guide.

Slot Diagnostics

The BlackDiamond switch provides a facility for running normal or extended diagnostics on an I/O module or a Management Switch Fabric Module (MSM) without affecting the operation of the rest of the system.

If you select to run the diagnostic routine on an I/O module, that module is taken off-line while the diagnostic test is performed. Traffic to and from the ports on the module are temporarily unavailable. Once the diagnostic test is completed, the I/O module is reset and becomes operational again.

You can run normal or extended diagnostics on the slave MSM. The normal diagnostic routing is a short series of tests that do not test all the internal Application-Specific Integrated Circuit (ASIC) functions. The extended diagnostic routine tests coverage of all MSM components including the internal ASIC functions. The slave MSM is taken off-line while the diagnostic test is performed. It is reset and operational once the test is completed.

If you want the diagnostic routine to run on the master MSM every time the system boots, use the following command:

```
configure diagnostics fastpost
```

To turn off the diagnostic routine, use the following command:

```
configure diagnostics off
```

If you want the diagnostic routine to run one time (rather than with each system boot), use the following command:

```
run diagnostics [extended | normal | packet memory] slot [<slot number> | msm-a |
msm-b]
```

where the following is true:

- `normal`—Takes the switch fabric and ports offline, and performs a simple ASIC and packet loopback test on all ports. The test is completed in 30 seconds. CPU and out-of-band management ports are not tested in this mode. As a result, console and Telnet access from the management port is available during this routine.
- `extended`—Takes the switch fabric and ports offline, and performs extensive ASIC, ASIC-memory, and packet loopback tests. Extended diagnostic tests take a maximum of 15 minutes. The CPU is not tested. Console access is available during extended diagnostics.
- `<slot>`—Specifies the slot number of an I/O module. Once the diagnostics test is complete, the system attempts to bring the I/O module back online. This parameter is applicable to the BlackDiamond switch, only.
- `msm-a | msm-b`—Specifies the slot letter of an MSM. If the master MSM is specified, the diagnostic routine is performed when the system reboots. Both switch fabric and management ports are taken offline during diagnostics. This parameter is applicable to the BlackDiamond switch, only.

Runtime Diagnostics (BlackDiamond Switches)

BlackDiamond switch runtime diagnostics perform a single test on a single I/O module. All error messages are logged. To perform diagnostics on an I/O module, use the following command:

```
run diagnostics [extended | normal | packet memory] slot [<slot number> | msm-a |
msm-b]
```

Use the `normal` option when you want a fast (30 – 60 seconds) hardware status check. Use the `extended` option when you want a more thorough test. The `extended` option requires significantly more time to complete, depending on the number of ports on the blade.

You can also execute packet memory scanning for all packet memory associated with the specified I/O slot on a BlackDiamond 6804, 6808, or 6816 switches, using the following command:

```
run diagnostics packet-memory slot <slot number>
```

The packet memory diagnostic scans the specified blade to detect single bit-related memory defects and their associated buffer locations. If packet memory defects are detected, their locations are recorded in the blade's EEPROM. Up to eight occurrences can be recorded. If a defect was found during the scan process, the card is reset, the defective buffer is mapped out from further use, and the I/O card is returned to the operational state. If more than eight defects are detected, or if the defects cannot be mapped out, the card is treated as a failed card and left offline. The card should then be returned through the RMA process with Extreme Networks Technical Support.

NOTE

Only run extended or packet-memory diagnostics when the switch can be brought off-line. The tests conducted during these diagnostics are extensive and can affect traffic that must be processed by the system CPU.

To view results of the normal or extended diagnostics test, use the following command:

```
show diagnostics
```

To view the results of a packet memory scan, use the following command:

```
show diagnostics packet-memory [slot <slot number>]
```

Packet Memory Scanning (BlackDiamond Switches)

You can scan and check the health of individual BlackDiamond modules rather than the overall system by configuring packet memory scanning on a per slot basis. If you have the system health check configured for auto-recovery, and you configure packet memory scanning on a slot, you can define that slot's behavior if an error is discovered. By default, packet memory scanning is disabled.

To configure packet memory scanning on a BlackDiamond module, use the following command:

```
configure packet-mem-scan-recovery-mode [offline | online] [msm-a | msm-b | <slot
number>]
```

where the following is true:

- `offline`—Specifies that a module is taken offline and kept offline if one of the following occurs:
  - — More than eight defects are detected.
  - — Three consecutive checksum error were detected by the health checker, but no new defects were found by the memory scanning and mapping process.
  - — After defects were detected and mapped out, the same checksum errors are again detected by the system health checker.
- `online`—Specifies that a faulty module is kept online, regardless of how many errors are detected.
- `msm-a`—Specifies the MSM module installed in slot A.

- `msm-b`—Specifies the MSM module installed in slot B.
- `slot number`—Specifies a module installed in a slot.

This command overrides the system health check auto-recovery setting. If you have the system health check alarm level configured, the individual packet memory scanning configuration is ignored. See "System Health Checking" on page 219 for more information about the system health checker.

To disable packet memory scanning and to return to the system health check configured behavior, use the following command:

```
unconfigure packet-mem-scan-recovery-mode slot [msm-a | msm-b | <slot number>]]
```

To view the recovery mode configuration for slots that have packet memory scanning enabled, use the following command:

```
show packet-mem-scan-recovery-mode
```

Where the following information is displayed:

- Global settings for the system health check
- Auto-recovery settings for slots that have packet memory scanning enabled

The following is sample output from this command:

```
Global sys-health-check 'online' setting  is ONLINE
slot 3: AUTORECOVERY MODE is OFFLINE
MSM-B: AUTORECOVERY MODE is ONLINE

# NOTE Global setting is always online for sys-health-check alarm-level
configurations.
       It is only offline when "sys-health-check auto-recovery <#> offline" is
configured.
```

Port Statistics

ExtremeWare provides a facility for viewing port statistic information. The summary information lists values for the current counter against each port on each operational module in the system, and it is refreshed approximately every 2 seconds. Values are displayed to nine digits of accuracy.

To view port statistics, use the following command:

```
show ports {mgmt | <portlist>} stats {cable-diagnostics}
```

The following port statistic information is collected by the switch:

- **Link Status—**The current status of the link. Options are:
  - — Ready (the port is ready to accept a link).
  - — Active (the link is present at this port).
  - — Chassis (the link is connected to a Summit Virtual Chassis).
- **Transmitted Packet Count (Tx Pkt Count)—**The number of packets that have been successfully transmitted by the port.

- **Transmitted Byte Count (Tx Byte Count)—**The total number of data bytes successfully transmitted by the port.
- **Received Packet Count (Rx Pkt Count)—**The total number of good packets that have been received by the port.
- **Received Byte Count (RX Byte Count)—**The total number of bytes that were received by the port, including bad or lost frames. This number includes bytes contained in the Frame Check Sequence (FCS), but excludes bytes in the preamble.
- **Received Broadcast (RX Bcast)—**The total number of frames received by the port that are addressed to a broadcast address.
- **Received Multicast (RX Mcast)—**The total number of frames received by the port that are addressed to a multicast address.

Port Errors

The switch keeps track of errors for each port.

To view port transmit errors, use the following command:

```
show ports {mgmt | <portlist>} txerrors
```

The following port transmit error information is collected by the system:

- **Port Number**
- **Link Status—**The current status of the link. Options are:
  - — Ready (the port is ready to accept a link).
  - — Active (the link is present at this port).
- **Transmit Collisions (TX Coll)—**The total number of collisions seen by the port, regardless of whether a device connected to the port participated in any of the collisions.
- **Transmit Late Collisions (TX Late Coll)—**The total number of collisions that have occurred after the port's transmit window has expired.
- **Transmit Deferred Frames (TX Deferred)—**The total number of frames that were transmitted by the port after the first transmission attempt was deferred by other network traffic.
- **Transmit Errored Frames (TX Error)—**The total number of frames that were not completely transmitted by the port because of network errors (such as late collisions or excessive collisions).
- **Transmit Parity Frames (TX Parity)**—The bit summation has a parity mismatch.

To view port receive errors, use the following command:

```
show ports {mgmt | <portlist>} rxerrors
```

The following port receive error information is collected by the switch:

- **Receive Bad CRC Frames (RX CRC)—**The total number of frames received by the port that were of the correct length, but contained a bad FCS value.
- **Receive Oversize Frames (RX Over)—**The total number of good frames received by the port greater than the supported maximum length of 1,522 bytes. For products that use the "*i*" chipset, ports with jumbo frames enabled do not increment this counter.
- **Receive Undersize Frames (RX Under)—**The total number of frames received by the port that were less than 64 bytes long.

- **Receive Fragmented Frames (RX Frag)—**The total number of frames received by the port were of incorrect length and contained a bad FCS value.
- **Receive Jabber Frames (RX Jab)—**The total number of frames received by the port that was of greater than the support maximum length and had a Cyclic Redundancy Check (CRC) error.
- **Receive Alignment Errors (RX Align)—**The total number of frames received by the port that occurs if a frame has a CRC error and does not contain an integral number of octets.
- **Receive Frames Lost (RX Lost)—**The total number of frames received by the port that were lost because of buffer overflow in the switch.

Port Monitoring Display Keys

Table 29 describes the keys used to control the displays that appear when you issue any of the `show port` commands.

Table 29: Port Monitoring Display Keys

Key(s)	Description
U	Displays the previous page of ports.
D	Displays the next page of ports.
[Esc] or [Return]	Exits from the screen.
0	Clears all counters.
[Space]	Cycles through the following screens: • Packets per second • Bytes per second • Percentage of bandwidth Available using the `show port utilization` command only.

System Temperature

You can record the system temperature in celsius for the BlackDiamond and Alpine systems to the syslog. The temperature is recorded every hour.

To record the temperature, use the following command:

```
enable temperature-logging
```

By default, the system temperature is not recorded to the syslog.

After you enable the temperature logging feature, you can view the temperature of the system. To view the temperature, use the following command:

```
show log
```

The following is sample temperature output from the `show log` command:

```
06/12/2003 19:50:59.00 <Info:ELRP> Current temperature reading [197] is 49C.
06/12/2003 18:50:59.00 <Info:ELRP> Current temperature reading [196] is 48C.
```

```
06/12/2003 17:50:59.00 <Info:ELRP> Current temperature reading [195] is 48C.
```

To stop recording the temperature, use the following command:

```
disable temperature-logging
```

If you already enabled temperature logging, and you want to view the current temperature of the system, do the following:

1. Disable the temperature logging feature using the following command:

   ```
   disable temperature-logging
   ```

2. Re-enable the temperature logging feature using the following command:

   ```
   enable temperature-logging
   ```

3. Display the syslog using the following command:

   ```
   show log
   ```

System Health Checking

The system health checker tests the backplane, the CPU, and I/O modules by periodically forwarding packets and checking for the validity of the forwarded packets.

The system health checker can be configured to handle a failure as an error condition, logging the problem to the syslog, or it can attempt auto-recovery of the module that generated the errors.

The alarm-level and auto-recovery options are mutually exclusive.

To enable the system health checker, use the following command:

```
enable sys-health-check
```

To disable the system health checker, use the following command:

```
disable sys-health-check
```

To configure the switch to respond to a failed health check based on an alarm-level, use the following command:

```
configure sys-health-check alarm-level [log | system-down | traps | default |
auto-recovery <number of tries> [online | offline]]
```

This command provides the following options:

- `card-down`—Posts a CRIT message to the log, sends a trap, and turns off the module.
- `log`—Posts a CRIT message to the log.
- `system-down`—Posts a CRIT message to the log, sends a trap, and turns off the system.
- `traps`—Posts a CRIT message to the log and sends a trap.

The default option is `log`.

If you configure the system health check mode to `offline` and no new errors are detected, the device scanned now remains online. This behavior is identical to the current behavior if you use the `run diagnostics` command.

To configure the switch for auto-recovery, use the following command:

```
configure sys-health-check auto-recovery <number> [offline | online] | alarm-level
[card-down | default | log | system-down | traps]
```

The auto-recovery option is used to configure the number of times the system health checker attempts to automatically reset a faulty module and bring it online. If the module continues to fail more than the configured number of attempts, the system health checker sets the module to card-down. The auto-recovery threshold applies only to BlackDiamond I/O modules.

When auto-recovery is configured, the occurrence of three consecutive checksum errors will cause a packet memory (PM) defect detection program to be run against the I/O module. Checksum errors can include internal and external MAC port parity errors, EDP checksum errors, and CPU packet or diagnostic packet checksum errors. If defects are detected, the card is taken offline, the memory defect information is recorded in the card EEPROM, the defective buffer is mapped out of further use, and the card is returned to operational state. A maximum of 8 defects can be stored in the EEPROM.

After the PM defect detection and mapping process has been run, a card is considered failed and is taken offline in the following circumstances:

- More than eight defects are detected.
- Three consecutive checksum errors were detected by the health checker, but no new PM defects were found by the PM defect detection process.
- After defects were detected and mapped out, the same checksum errors are again detected by the system health checker.

The auto-recovery repetition value is ignored in these cases. In any of these cases, please contact Extreme Technical Support.

To view the status of the system health checker, use the following command:

```
show diagnostics
```

Extreme Networks support personnel can configure the action taken by the system health check if diagnostics are run or if checksum errors trigger diagnostics. If diagnostics are run or triggered in previous releases of ExtremeWare, the module is reset and diagnostics are run. Support personnel can use the following command to configure ExtremeWare to simply to reset the module without running diagnostics:

```
configure sys-health-check scan-recovery [reset | remap]
```

Entering this command generates the following message:

```
This command should only be used at the direction of Extreme Personnel. Do you wish
you continue (y/n)?
```

Answering `y` immediately implements the change. Answering `n` implements no change and returns you to the command line.

Use the `reset` option to reset the module without running diagnostics. This option is useful for recovering from transient hardware failures. In these cases, resetting the module stops the checksum errors.

Use the `remap` option to reset the module and run diagnostics. This is the default.

(This command is not available on the BlackDiamond 6816 switch.)

Checking the Integrity of the FDB

The system health checker also checks the integrity of the FDB. If you enable the system health checker, a section of the FDB memory on each module's switching fabric is non-intrusively compared to the software copy of the FDB. The switch takes one of the following actions if it detects a bad entry:

- If the entry is not in use—remaps around the entry location
- If the entry is in use, but is safely removable (most MAC and IP-DA entries)—removes the questionable entry, allows the table to be rebuilt naturally, and remaps around the entry location
- If the entry is in use and is *not* safely removable (MAC_NH, IPSA, IPMCDA, IPDP, IPSP, IPXSN)—sends a warning message to the log

If the switch detects more than eight questionable entries, it executes the configured failure action and stops remapping on the switch fabric. To see the questionable and remapped entries, use the `show fdb` command. The following information is displayed:

- Questionable entries are marked with a "Q" flag
- Remapped entries are marked with an "R" flag
- Total FDB count

You can also display FDB scan statistics using the following commands:

```
show diagnostics sys-health-check
```

To clear the questionable and remapped entries, use the following command:

```
clear fdb remap
```

Testing the Transceivers

The transceiver test is a useful diagnostic tool that allows you to test the integrity of the transceivers used for communication between the ASICS and the CPU on an MSM or SMMi module. The transceiver test is available on modular switches only.

Enabling the Transceiver Test

By default, transceiver testing is disabled. To enable the transceiver test on an Alpine switch, use the following command:

```
enable transceiver-test [all | slot <slot number> {backplane} | msm-a | msm-b]
```

To enable the transceiver test on a BlackDiamond switch, use the following command:

```
enable transceiver-test [all | slot <slot number> {backplane} | msm-a | msm-b]
```

where the following is true:

- `all`—Specifies all of the slots in the chassis.
- `backplane`—Specifies the backplane of the Alpine chassis. This is available on Alpine switches only.

- slot number—Specifies the slot number of the module to scan.
- msm-a—Specifies the MSM installed in slot A. This is available on BlackDiamond switches only.
- msm-b—Specifies the MSM installed in slot B. This is available on BlackDiamond switches only.

To determine if you have the transceiver test enabled and the failure action the switch takes, use the show switch command. The following is sample transceiver test output:

```
Transceiver Diag: Enabled.    Failure action:  log only
```

Disabling the Transceiver Test

To disable the transceiver test on an Alpine switch, use the following command:

```
disable transceiver-test [all | slot <slot number> {backplane} | msm-a | msm-b]
```

To disable the transceiver test on a BlackDiamond switch, use the following command:

```
disable transceiver-test [all | slot <slot number> {backplane} | msm-a | msm-b]
```

Configuring the Transceiver Test Parameters

You can configure the following test parameters:

- How often the test runs
- The amount of errors accepted
- The number of 20-second windows the switch uses to check for errors
- The action the switch takes if too many failures are detected

NOTE

Extreme Networks does not recommend changing the default transceiver test parameters. The default parameters are adequate for most networks.

Configuring the Test Period. To configure how often to run the transceiver test, use the following command:

```
configure transceiver-test period <period <1-60>>
```

where the:

- Default is 12 seconds
- Range is 1 - 60 seconds

To return the transceiver test period to the factory default of 12 seconds, use the following command:

```
unconfigure transceiver-test period
```

Configuring the Test Threshold. To configure how many errors the switch accepts before an action is taken, use the following command:

```
configure transceiver-test threshold <1-8>
```

where the:

- Default is 3 errors
- Range is 1 - 8 errors

To return the transceiver test threshold to the factory default of 3 errors, use the following command:

```
unconfigure transceiver-test threshold
```

Configuring the Test Window. To configure the number of 20-second windows within which the configured number of errors can occur, use the following command:

```
configure transceiver-test window <1-8>
```

where the:

- Default is 8 windows
- Range is 1 - 8 windows

This configuration provides a sliding window. If you keep the window configuration at 8, the switch checks for errors within the *last* eight 20-second windows.

To return the transceiver test window to the factory default of 8, use the following command:

```
unconfigure transceiver-test window
```

Configuring the Test Failure Action. If the switch detects too many failures within the specified window, the messages are either sent to the syslog or the configured system health check action is taken.

To configure the action the switch takes when too many failures are detected, use the following command:

```
configure transceiver-test failure-action [log | sys-health-check]
```

where the following is true:

- `log`—Messages are sent to the syslog. Only one instance of an error messages is logged at this level. This is the default.
- `sys-health-check`—The configured system health check action is taken.

To return the switch to the default mode of sending messages to the syslog, use the following command:

```
unconfigure transceiver-test failure-action
```

For more information about these and other transceiver test commands, see the *Extreme Networks Command Reference Guide*.

Displaying Transceiver Statistics

To view the transceiver statistics, use the following command:

```
show diagnostics
```

In addition to other switch diagnostics, you can view the following transceiver statistics:

- Slot number or backplane

- Cardtype (if no module is installed in the slot, the card type is unknown)
- Cardstate
- Test
- Pass
- Fail
- Time of the last failure

The following is an example of the type of transceiver statistics output displayed:

```
Transceiver system health diag result
Pass/Fail Counters Are in HEX
Slot    Cardtype Cardstate   Test        Pass     Fail Time_last_fail
----    -------- ---------   ----     -------- -------- --------------
slot 1  Unknown
slot 2  WM4T1    Operational MAC        7d456        0
slot 3  FM8V     Operational MAC        7d456        0
slot 4  GM4X     Operational MAC        7d456        0
BPLNE   SMMI     Operational UART       7d454        0
BPLNE   SMMI     Operational FLASH      7d454        0
BPLNE   SMMI     Operational SRAM       7d454        0
BPLNE   SMMI     Operational NVRAM      7d454        0
BPLNE   SMMI     Operational ENET       7d454        0
BPLNE   Basbrd   Operational QUAKE      7d454        0
BPLNE   Basbrd   Operational TWISTER    7d454        0
```

To clear the transceiver statistics, use the following command:

```
clear transceiver-test
```

Setting the System Recovery Level

You can configure the system to automatically reboot after a software task exception, using the following command:

```
configure sys-recovery-level [none | [all | critical] [msm-failover | reboot |
shutdown | system-dump [maintenance-mode | msm-failover | reboot | shutdown]]]
```

Where the following is true:

- `none`—Configures the level to no recovery.
- `all`—Configures ExtremeWare to log an error into the syslog and automatically reboot the system after any task exception.
- `critical`—Configures ExtremeWare to log an error into the syslog and automatically reboot the system after a critical task exception.

The default setting is `none`.

Event Management System/Logging

Beginning in ExtremeWare 7.1.0, the system responsible for logging and debugging was updated and enhanced. We use the general term, event, for any type of occurrence on a switch which could generate a log message, or require an action. For example, a link going down, a user logging in, a command entered on the command line, or the software executing a debugging statement, are all events that might generate a log message. The new system for saving, displaying, and filtering events is called the Event Management System (EMS). With EMS, you have a lot more options about which events generate log messages, where the messages are sent, and how they are displayed. Using EMS you can:

- send event messages to a number of logging targets (for example, syslog host and NVRAM)
- filter events on a per-target basis
  - by component, subcomponent, or specific condition (for example, BGP messages, *IGMP.Snooping* messages, or the *IP.Forwarding.SlowPathDrop* condition)
  - by match expression (for example, any messages containing the string "user5")
  - by matching parameters (for example, only messages with source IP addresses in the 10.1.2.0/24 subnet)
  - by severity level (for example, only messages of severity critical, error, or warning)
- change the format of event messages (for example, display the date as "12-May-2003" or "2003-05-12")
- display log messages in real-time, and filter the messages that are displayed, both on the console and from telnet sessions
- display stored log messages from the memory buffer or NVRAM
- upload event logs stored in memory to a TFTP server
- display counts of event occurrences, even those not included in filter
- display debug information, using a consistent configuration method

Sending Event Messages to Log Targets

There are five types of targets that can receive log messages:

- console display
- current session (telnet or console display)
- memory buffer (can contain 200-20,000 messages)
- NVRAM (messages remain after reboot)
- syslog host

The first four types of targets exist by default, but before enabling any syslog host, the host's information needs to be added to the switch using the `configure syslog` command. Extreme Networks EPICenter can be a syslog target.

By default, the memory buffer and NVRAM targets are already enabled and receive messages. To start sending messages to the targets, use the following command:

```
enable log target [console-display | memory-buffer | nvram | session | syslog [<host
name/ip> {:<udp-port>} [local0 ... local7]]]
```

Once enabled, the target receives the messages it is configured for. See the section "Target Configuration" for information on viewing the current configuration of a target. The memory buffer can only contain the configured number of messages, so the oldest message is lost when a new message arrives, and the buffer is full.

Use the following command to stop sending messages to the target:

```
disable log target [console-display | memory-buffer | nvram | session | syslog
[<host name/ip> {:<udp-port>} [local0 ... local7]]]
```

NOTE

Refer to your UNIX documentation for more information about the syslog host facility.

Filtering Events Sent to Targets

Not all event messages are sent to every enabled target. Each target receives only the messages that it is configured for.

Target Configuration

To specify the messages to send to a enabled target, you will set a message severity level, a filter name, and a match expression. These items determine which messages are sent to the target. You can also configure the format of the messages in the targets. Each target has a default configuration that mimics the expected behavior of prior ExtremeWare releases. For example, the console display target is configured to get messages of severity `info` and greater, the NVRAM target gets messages of severity `warning` and greater, and the memory buffer target gets messages of severity `debug-data` and greater. All the targets are associated by default with a filter named *DefaultFilter*, that passes all events at or above the default severity threshold, like the behavior of earlier releases (the earlier releases had no filters). All the targets are also associated with a default match expression that matches any messages (the expression that matches any message is displayed as `Match : (none)` from the command line). And finally, each target has a format associated with it.

To display the current log configuration of the targets, use the following command:

```
show log configuration target {console-display | memory-buffer | nvram | session |
syslog <host name/ip> {: <udp-port>}[local0 ... local7]}
```

To configure a target, there are specific commands for filters, formats, and severity that are discussed in the following sections.

Severity

Messages are issued with one of the severity level specified by the standard BSD syslog values (RFC 3164), `critical`, `error`, `warning`, `notice`, and `info`, plus three severity levels for extended debugging, `debug-summary`, `debug-verbose`, and `debug-data`. Note that RFC 3164 syslog values `emergency` and `alert` are not needed since `critical` is the most severe event in the system.

The three severity levels for extended debugging, `debug-summary`, `debug-verbose`, and `debug-data`, require that debug mode be enabled (which may cause a performance degradation). See the section "Displaying Debug Information" for more information about debugging.

Table 30: Severity Levels Assigned by the Switch[1]

Level	Description
Critical	A serious problem has been detected which is compromising the operation of the system and that the system can not function as expected unless the situation is remedied. The switch may need to be reset.
Error	A problem has been detected which is interfering with the normal operation of the system and that the system is not functioning as expected.
Warning	An abnormal condition, not interfering with the normal operation of the system, has been detected which may indicate that the system or the network in general may not be functioning as expected.
Notice	A normal but significant condition has been detected, which signals that the system is functioning as expected.
Info (Informational)	A normal but potentially interesting condition has been detected, which signals that the system is functioning as expected and simply provides potentially detailed information or confirmation.
Debug-Summary	A condition has been detected that may interest a developer determining the reason underlying some system behavior.
Debug-Verbose	A condition has been detected that may interest a developer analyzing some system behavior at a more verbose level than provided by the debug summary information.
Debug-Data	A condition has been detected that may interest a developer inspecting the data underlying some system behavior.

[1] In ExtremeWare version 7.1.0, the levels alert and emergency were deprecated. The equivalent level is critical.

To configure the severity level of the messages sent to a target, there is more than one command that you can use. The most direct way to set the severity level of all the sent messages is to use the following command:

```
configure log target [console-display | memory-buffer | nvram | session |
syslog [<host name/ip> {: <udp-port>} [local0 ... local7]]]
filter <filter name> {severity <severity> {only}}
```

When you specify a severity level, messages of that severity and greater will be sent to the target. If you want only messages of the specified severity to be sent to the target, use the keyword `only`. For example, specifying `severity warning` will send warning, error, and critical messages, but specifying `severity warning only` will just send warning messages.

Another command that can be used to configure severity levels is the command used to associate a filter with a target:

```
configure log target [console-display | memory-buffer | nvram | session |
syslog [<host name/ip> {: <udp-port>} [local0 ... local7]]]
filter <filter name> {severity <severity> {only}}
```

When you specify a severity level as you associate a filter with a target, you further restrict the messages reaching the target. The filter may only allow certain categories of messages to pass. Only the messages that pass the filter, and then pass the specified severity level will reach the target.

Finally, you can specify the severity levels of messages that reach the target by associating a filter with a target. The filter can specify exactly which message it will pass. Constructing a filter is discussed in the section "Filtering By Components and Conditions".

Components and Conditions

Beginning with the introduction of EMS in release 7.1.0, the event conditions detected by ExtremeWare were organized into components and subcomponents. This is somewhat similar to the fault log subsystems used in previous versions. Not all conditions have been placed in the component/subcomponent structure of EMS, but all the conditions will be moved over time into this structure. To get a listing of the components and subcomponents in your release of ExtremeWare, use the following command:

```
show log components {<event component> | all}
```

For example, to get a listing of the subcomponents that make up the STP component, use the following command:

```
show log components stp
```

The output produced by the command is similar to the following:

```
                                                                   Severity
Component            Title                                         Threshold
------------------- ---------------------------------------------- ----------
STP                  Spanning-Tree Protocol (STP)                  Error
        InBPDU       STP In BPDU subcomponent                      Warning
        OutBPDU      STP Out BPDU subcomponent                     Warning
        System       STP System subcomponent                       Error
```

In the display above is listed the component, the subcomponents that make up that component, and the default severity threshold assigned to that component. A period (.) is used to separate component, subcomponent, and condition names in EMS. For example, you can refer to the *InBPDU* subcomponent of the *STP* component as *STP.InBPDU*. On the CLI, you can abbreviate or TAB complete any of these.

A component or subcomponent will often have several conditions associated with it. To see the conditions associated with a component, use the following command:

```
show log events {<event condition> | [all | <event component>] {severity <severity>
{only}}} {detail}
```

For example, to see the conditions associated with the *STP.InBPDU* subcomponent, use the following command:

```
show log events stp.inbpdu
```

The output produced by the command is similar to the following:

```
Comp    SubComp     Condition               Severity      Parameters
------- ----------- ----------------------- ------------- ----------
STP     InBPDU
                    Drop                    Error          3
                    Dump                    Debug-Data     3
                    Ign                     Debug-Summary  2
                    Trace                   Info           2
```

In the display above is listed the four conditions contained in the *STP.InBPDU* component, the severity of the condition, and the number of parameters in the event message. In this example, the severities of the events in the *STP.InBPDU* subcomponent range from error to debug-summary.

When you use the `detail` keyword you will see the message text associated with the conditions. For example, if you want to see the message text and the parameters for the event condition *STP.InBPDU.Trace*, use the following command:

```
show log events stp.inbpdu.trace detail
```

The output produced by the command is similar to the following:

```
Comp    SubComp     Condition               Severity      Parameters
------- ----------- ----------------------- ------------- ----------
STP     InBPDU      Trace                   Info           2 Total
                                                           0 - ports
                                                           1 - string
                    "Port=%0%: %1%"
```

The `Comp` heading shows the component name, the `SubComp` heading shows the subcomponent (if any), the `Condition` heading shows the event condition, the `Severity` heading shows the severity assigned to this condition, the `Parameters` heading shows the parameters for the condition, and the text string shows the message that the condition will generate. The parameters in the text string (for example, `%0%` and `%1%` above) will be replaced by the values of these parameters when the condition is encountered, and output as the event message.

Beginning in ExtremeWare 7.2, component initialization messages include the component serial number. In addition, checksum errors include the serial number of the module.

Filtering By Components and Conditions. You may want to send the messages that come from a specific component that makes up ExtremeWare, or send the message generated by a specific condition. For example, you might want to send only the messages that come from the STP component, or send the message that occurs when the *IP.Forwarding.SlowPathDrop* condition occurs. Or you may want to exclude messages from a particular component or event. To do this, you will construct a filter that passes only the items of interest, and associate that filter with a target.###

The first step is to create the filter using the `create log filter` command. You can create a filter from scratch, or copy another filter to use as a starting point. It may be easiest to copy an existing filter and modify it. Use the following command to create a filter:

```
create log filter <name> {copy <filter name>}
```

If you create a filter from scratch, it will initially block all events until you add events (either the events from a component or a specific event condition) to pass. You might create a filter from scratch if you wanted to pass a small set of events, and block most. If you want to exclude a small set of events, there is a default filter that passes events at or above the default severity threshold (unless the filter has been modified), named *DefaultFilter*, that you can copy to use as a starting point for your filter.

Once you have created your filter, you can then configure filter items that include or exclude events from the filter. Included events are passed, excluded events are blocked. Use the following command to configure your filter:

```
configure log filter <filter name> [add | delete] {exclude} events [<event condition>
| [all | <event component>] {severity <severity> {only}}]
```

For example, if you create the filter *myFilter* from scratch, then issue the following command:

```
configure log filter myFilter add events stp
```

all STP events will pass *myFilter* of at least the default threshold severity (for the STP component, the default severity threshold is `error`). You can further modify this filter by specifying additional conditions. For example, assume that *myFilter* is configured as before, and assume that you want to exclude any events from the STP subcomponent, *STP.OutBPDU*. Use the following command to add that condition:

```
configure log filter myFilter add exclude events stp.outbpdu
```

You can continue to modify this filter by adding more filter items. The filters process events by comparing the event with the most recently configured filter item first. If the event matches this filter item, the incident is either included or excluded, depending on whether the `exclude` keyword was used. Subsequent filter items on the list are compared if necessary. If the list of filter items has been exhausted with no match, the event is excluded, and is blocked by the filter.

To examine the configuration of a filter, use the following command:

```
show log configuration filter {<filter name>}
```

The output produced by the command (for the earlier filter) is similar to the following:

```
Log Filter Name : myFilter
I/                                            Severity
E  Comp    SubComp     Condition              CEWNISVD
-  ------- ----------- ---------------------- --------
E  STP     OutBPDU     *                      CEWNI+++
I  STP     *           *                      ********

Include/Exclude: (I) Include,  (E) Exclude
Severity Values: (C) Critical,  (E) Error,  (W) Warning,  (N) Notice,  (I) Info
                 (*) Pre-assigned severities in effect for each subcomponent
Debug Severity : (S) Debug-Summary,  (V) Debug-Verbose,  (D) Debug-Data
                 (+) Debug Severity requested, but log debug-mode not enabled
If Match parameters present:
Parameter Flags: (S) Source,  (D) Destination  (as applicable)
                 (I) Ingress,  (E) Egress,  (B) BGP
Parameter Types: Port - Physical Port list,  Slot - Physical Slot #
                 MAC  - MAC address,  IP - IP Address/netmask,  Mask - Netmask
                 VID  - Virtual LAN ID (tag),  VLAN - Virtual LAN name
                 L4   - Layer-4 Port #,  Num  - Number,  Str  - String
                 Nbr  - Neighbor, Rtr  - Routerid, EAPS - EAPS Domain
Strict Match   : (Y) every match parameter entered must be present in the event
                 (N) match parameters need not be present in the event
```

The show log configuration filter command shows each filter item, in the order that it will be applied and whether it will be included or excluded. The above output shows the two filter items, one excluding events from the *STP.OutBPDU* component, the next including the remaining events from the *STP* component. The severity value is shown as "*", indicating that the component's default severity threshold controls which messages are passed. The `Parameter(s)` heading is empty for this filter, since no match was configured for this filter. Matches are discussed in the section, "Matching Expressions".

Each time a filter item is added to or deleted from a given filter, the events specified are compared against the current configuration of the filter to try to logically simplify the configuration. Existing items will be replaced by logically simpler items if the new item enables rewriting the filter. If the new item is already included or excluded from the currently configured filter, the new item is not added to the filter.

Matching Expressions

You can specify that messages that reach the target match a specified match expression. The message text is compared with the match expression to determine whether to pass the message on. To require that messages match a match expression, is to use the following command:

```
configure log target [console-display | memory-buffer | nvram | session |
syslog [<host name/ip> {: <udp-port>} [local0 ... local7]]] match [any
|<match-expression>]
```

The messages reaching the target will match the `match-expression`, a simple regular expression. The formatted text string that makes up the message is compared with the match expression, and is passed to the target if it matches. This command does not affect the filter in place for the target, so the match expression is only compared with the messages that have already passed the target's filter. For more information on controlling the format of the messages, see the section, "Formatting Event Messages".

Simple Regular Expressions. A simple regular expression is a string of single characters including the dot character (.), which are optionally combined with quantifiers and constraints. A dot matches any single character while other characters match only themselves (case is significant). Quantifiers include the star character (*) that matches zero or more occurrences of the immediately preceding token. Constraints include the caret character (^) that matches at the beginning of a message, and the currency character ($) that matches at the end of a message. Bracket expressions are not supported. There are a number of sources available on the Internet and in various language references describing the operation of regular expressions. Table 31 shows some examples of regular expressions.

Table 31: Simple Regular Expressions

Regular Expression	Matches	Does not match
port	port 2:3 import cars portable structure	poor por pot
..ar	baar bazaar rebar	bar
port.*vlan	port 2:3 in vlan test add ports to vlan port/vlan	
myvlan$	delete myvlan error in myvlan	myvlan port 2:3 ports 2:4,3:4 myvlan link down

Matching Parameters

Rather than using a text match, ExtremeWare's EMS allows you to filter more efficiently based on the message parameter values. In addition to event components and conditions and severity levels, each filter item can also use parameter values to further limit which messages are passed or blocked. The process of creating, configuring, and using filters has already been described in the section, "Filtering By Components and Conditions", so this section will discuss matching parameters with a filter item. To configure a parameter match filter item, use the following command:

```
configure log target [console-display | memory-buffer | nvram | session |
syslog [<host name/ip> {: <udp-port>} [local0 ... local7]]]
filter <filter name> {severity <severity> {only}}
```

Each event in ExtremeWare is defined with a message format and zero or more parameter types. The `show log events detail` command can be used to display event definitions (the event text and parameter types). Only those parameter types that are applicable given the events and severity specified are exposed on the CLI. The syntax for the parameter types (represented by <type> in the command syntax above) is:

```
[bgp [neighbor | routerid] <ip address>
| eaps <eaps domain name>
| {destination | source} [ipaddress <ip address> | L4-port <L4-port>| mac-address
<mac-address>]
| {egress | ingress} [slot <slot number> | ports <portlist>]
| netmask <netmask>
| number <number>
| string <match expression>
| vlan <vlan name>
| vlan tag <vlan tag>]
```

The <value> depends on the parameter type specified. As an example, an event may contain a physical port number, a source MAC address, and a destination MAC address. To allow only those Bridging incidents, of severity `notice` and above, with a specific source MAC address, use the following command:

```
configure log filter myFilter add events bridge severity notice match source
mac-address 00:01:30:23:C1:00
```

The string type is used to match a specific string value of an event parameter, such as a user name. A string can be specified as a simple regular expression.

Use the `and` keyword to specify multiple parameter type/value pairs that must match those in the incident. For example, to allow only those events with specific source and destination MAC addresses, use the following command:

```
configure log filter myFilter add events bridge severity notice match source
mac-address 00:01:30:23:C1:00 and destination mac-address 01:80:C2:00:00:02
```

Match Versus Strict-Match. The `match` and `strict-match` keywords control the filter behavior for incidents whose event definition does not contain all the parameters specified in a `configure log filter events match` command. This is best explained with an example. Suppose an event in the *XYZ* component, named *XYZ.event5*, contains a physical port number, a source MAC address, but no destination MAC address. If you configure a filter to match a source MAC address and a destination MAC address, *XYZ.event5* will match the filter when the source MAC address matches regardless of the destination MAC address, since the event contains no destination MAC address. If you specify the `strict-match` keyword, then the filter will never match event *XYZ.event5,* since this event does not contain the destination MAC address.

In other words, if the `match` keyword is specified, an incident will pass a filter so long as all parameter values in the incident match those in the match criteria, but all parameter types in the match criteria need not be present in the event definition.

Formatting Event Messages

Event messages are made up of a number of items. The individual items can be formatted, however, EMS does not allow you to vary the order of the items. To format the messages for a particular target, use the following command:

```
configure log target [console-display | memory-buffer | nvram | session |
syslog [<host name/ip> {:<udp-port>} [local0 ... local7]]]
format [timestamp [seconds | hundredths | none]
| date [dd-mm-yyyy | dd-Mmm-yyyy | mm-dd-yyyy | Mmm-dd | yyyy-mm-dd | none]
| severity [on | off]
| event-name [component | condition | none | subcomponent]
| host-name [on | off]
| priority [on | off]
| tag-id [on | off]
| tag-name [on | off]
```

```
   | sequence-number [on | off]
   | process-name [on | off]
   | process-id [on | off]
   | source-function [on | off]
   | source-line [on | off]]
```

Using the default format for the session target, an example log message might appear as:

```
05/29/2003 12:15:25.00 <Warn:SNTP.RslvSrvrFail> The SNTP server parameter value
(TheWrongServer.example.com) can not be resolved.
```

If you set the current session format using the following command:

```
configure log target session format date mm-dd-yyy timestamp seconds event-name
component
```

The same example would appear as:

```
05/29/2003 12:16:36 <Warn:SNTP> The SNTP server parameter value
(TheWrongServer.example.com) can not be resolved.
```

In order to provide some detailed information to technical support, you set the current session format using the following command:

```
configure log target session format date mmm-dd timestamp hundredths event-name
condition source-line on process-name on
```

The same example would appear as:

```
May 29 12:17:20.11 SNTP: <Warn:SNTP.RslvSrvrFail> tSntpc: (sntpcLib.c:606) The SNTP
server parameter value (TheWrongServer.example.com) can not be resolved.
```

Displaying Real-Time Log Messages

You can configure the system to maintain a running real-time display of log messages on the console display or on a (telnet) session. To turn on the log display on the console, use the `console-display` option north following command:

```
enable log target [console-display | memory-buffer | nvram | session | syslog [<host
name/ip> {:<udp-port>} [local0 ... local7]]]
```

This setting may be saved to the FLASH configuration and will be restored on boot up (to the console-display session).

To turn on log display for the current session:

```
enable log target session
```

This setting only affects the current session, and is lost when you log off the session.

The messages that are displayed depend on the configuration and format of the target. See the section, “Filtering Events Sent to Targets”, for information on message filtering, and the section, “Formatting Event Messages”, for information on message formatting.

Displaying Events Logs

The log stored in the memory buffer and the NVRAM can be displayed on the current session (either the console display or telnet). Use the following command to display the log:

```
show log {messages [memory-buffer | nvram]} {severity <severity> {only}}
{starting [date <date> time <time> | date <date> | time <time>]} {ending [date
<date> time <time> | date <date> | time <time>]} {match <match-expression>}
{format <format>} {chronological}
```

There are many options you can use to select the log entries of interest. You can select to display only those messages that conform to the specified:

- severity
- starting and ending date and time
- match expression

The displayed messages can be formatted differently from the format configured for the targets, and you can choose to display the messages in order of newest to oldest, or in chronological order (oldest to newest).

Uploading Events Logs

The log stored in the memory buffer and the NVRAM can be uploaded to a TFTP server. Use the following command to upload the log:

```
upload log <host name/ip> <filename> {messages [memory-buffer | nvram]}
{severity <severity> {only}} {starting [date <date> time <time> | date <date>
| time <time>]} {ending [date <date> time <time> | date <date> | time <time>]}
{match <match-expression>} {format <format>} {chronological}
```

You must specify the TFTP host and the filename to use in uploading the log. There are many options you can use to select the log entries of interest. You can select to upload only those messages that conform to the specified:

- severity
- starting and ending date and time
- match expression

The uploaded messages can be formatted differently from the format configured for the targets, and you can choose to upload the messages in order of newest to oldest, or in chronological order (oldest to newest).

Displaying Counts of Event Occurrences

EMS adds the ability to count the number of occurrences of events. Even when an event is filtered from all log targets, the event is counted. (The exception to this is events of any of the debug severities, which are only counted when the log debug mode is enabled.) To display the event counters, use the following command:

```
show log counters {<event condition> | [all | <event component>] {severity <severity>
{only}}}
```

Two counters are displayed. One counter displays the number of times an event has occurred, and the other displays the number of times that notification for the event was made to the system for further processing. Both counters reflect totals accumulated since reboot or since the counters were cleared using the `clear log counters` or `clear counters` command.

This command also displays an included count (the column titled `In` in the output). The reference count is the number of enabled targets receiving notifications of this event without regard to matching parameters.

The keywords `included`, `notified`, and `occurred` only display events with non-zero counter values for the corresponding counter.

Output of the command:

```
show log counters stp.inbpdu severity debug-summary
```

will be similar to the following:

```
Comp    SubComp     Condition               Severity      Occurred  In Notified
------- ----------- ----------------------- ------------- --------  -- --------
STP     InBPDU
                    Drop                    Error                0   1        0
                    Ign                     Debug-Summary        0+  0        0
                    Trace                   Info                 0   0        0
Occurred  : # of times this event has occurred since last clear or reboot
Flags     : (+) Debug events are not counted while log debug-mode is disabled
In(cluded): # of enabled targets whose filter includes this event
Notified  : # of times this event has occurred when 'Included' was non-zero
```

Output of the command:

```
show log counters stp.inbpdu.drop
```

will be similar to the following:

```
Comp    SubComp     Condition               Severity      Occurred  In Notified
------- ----------- ----------------------- ------------- --------  -- --------
STP     InBPDU
                    Drop                    Error                0   1        0
```

Displaying Debug Information

By default, a switch will not generate events of severity `Debug-Summary`, `Debug-Verbose`, and `Debug-Data` unless the switch is in debug mode. Debug mode causes a performance penalty, so it should only be enabled for specific cases where it is needed. To place the switch in debug mode, use the following command:

```
enable log debug-mode
```

Once debug mode is enabled, any filters configured for your targets will still affect which messages are passed on or blocked.

NOTE

Previous versions of ExtremeWare used the debug-trace *command to enable debugging. Not all systems in ExtremeWare were converted to use EMS in the initial release. As a result, some debug information still requires you to use the corresponding* debug-trace *command. The* show log component *command displays the systems in your image that are part of EMS. Any systems in EMS will not have* debug-trace *commands, and vice-versa*

Compatibility with previous ExtremeWare commands

Since EMS provides much more functionality, there are a number of new commands introduced to support it. However, if you do not require the enhanced capabilities provided by EMS, you can continue to use many of the logging commands that existed in earlier versions of ExtremeWare. For consistency, the earlier commands are still supported. Listed below are earlier commands with their new command equivalents.

Enable / disable log display

The following commands related to the serial port console:

```
enable log display
disable log display
```

are equivalent to using the console-display option in the following commands:

```
enable log target [console-display | memory-buffer | nvram | session | syslog [<host
name/ip> {:<udp-port>} [local0 ... local7]]]

disable log target [console-display | memory-buffer | nvram | session | syslog
[<host name/ip> {:<udp-port>} [local0 ... local7]]]
```

Note that the existing command `enable log display` applies only to the serial port console. Since the ability to display log messages on other sessions was added, the target name `session` was chosen. For clarity, the target name `console-display` was chosen to refer to the serial port console, previously referred to as simply `display`.

Configure log display

The following command related to the serial port console:

```
configure log display {<severity>}
```

is equivalent to:

```
configure log target console-display severity <severity>
```

Remote syslog commands

The following command related to remote syslog hosts:

```
configure syslog {add} <host name/ip> {: <udp-port>} [local0 ... local7] {<severity>}
```

is equivalent to the following two commands:

```
configure syslog add <hostname/IP> {: <udp-port>} [local0 ... local7]
configure log target syslog <hostname/IP> {: <udp-port>} [local0 ... local7] severity
<severity>
```

NOTE

Refer to your UNIX documentation for more information about the syslog host facility.

Logging Configuration Changes

ExtremeWare allows you to record all configuration changes and their sources that are made using the CLI by way of telnet or the local console. The changes cause events that are logged to the target logs. Each log entry includes the user account name that performed the change and the source IP address of the client (if telnet was used). Configuration logging applies only to commands that result in a configuration change. To enable configuration logging, use the following command:

```
enable cli-config-logging
```

To disable configuration logging, use the following command:

```
disable cli-config-logging
```

CLI configuration logging is enabled by default.

Configuring and Monitoring Flow Statistics

NOTE

This section describes the process of configuring and monitoring flow statistics on Ethernet links. If you plan to configure and monitor flow statistics on PoS links, see the Packet Over SONET Installation and User Guide *for more information.*

The broad growth in Internet and intranet usage has brought with it an increased demand for network bandwidth and performance that is based on predictable quality of service and security. This movement is paralleled by the related need for measurement technology that makes it possible to gather, analyze, and manipulate information about network and application use. NetFlow, originally developed by Cisco, provides a way for a switch to capture and export traffic classification or precedence information as data traverses, or flows, across portions of a network.

A network flow is defined as a unidirectional sequence of packets between a particular source device and destination device that share the same protocol and transport-layer information. Flows are defined by the following fields: source IP address, destination IP address, source port, destination port, and protocol type. Per-flow statistics are useful for many management purposes, including:

- Accounting and billing
- Network capacity planning and trend analysis
- Network monitoring
- Workload characterization
- User profiling
- Data warehousing and mining

Flow Statistics Background Information

Per-flow statistics are exported in the NetFlow Version 1 record format described in Table 32. NetFlow records are unidirectional in nature, which implies that two flow records are maintained for a typical TCP connection: one record for flow in the ingress direction; a second for the flow in the egress direction. Also, records are maintained only for TCP and UDP flows.

Table 32: NetFlow Version 1 Record Format

Field Name	Octets	Field Description
srcaddr	4	Source IP address.
dstaddr	4	Destination IP address.
nexthop	4	IP address of next-hop router; set to zero for per-flow statistics; set to xFFFF for filter-based aggregated statistics.
input	2	(Not supported.) Input interface index.
output	2	(Not supported.) Output interface index.
dPkts	4	Number of packets sent in this flow.
dOctets	4	(Not Supported.) Number of octets sent in this flow.
First	4	(Not supported.) SysUptime when flow record was created.
Last	4	(Not supported.) SysUptime at most-recent, or last packet of flow.
srcport	2	Source port number, valid only for TCP and UDP flows.
dstport	2	Destination port number, valid only for TCP and UDP flows.
pad	2	Unused field.
prot	1	Number identifying the IP protocol; for example, 6=TCP and 17=UDP.
tos	1	(Not supported.) IP Type-of-Service (TOS) field value from initial packet that caused this flow record to be created.
tcp_flags	1	(Not supported.) Cumulative OR of TCP flags field, valid only when *prot*=6.
pad	7	Unused field.

Flow records are grouped together into UDP datagrams for export to a flow-collector device. A NetFlow Version 1 export datagram can contain up to 25 flow records. Figure 28 shows the format of the export datagram; Table 33 describes the export datagram header.

Figure 28: Format of NetFlow export datagram

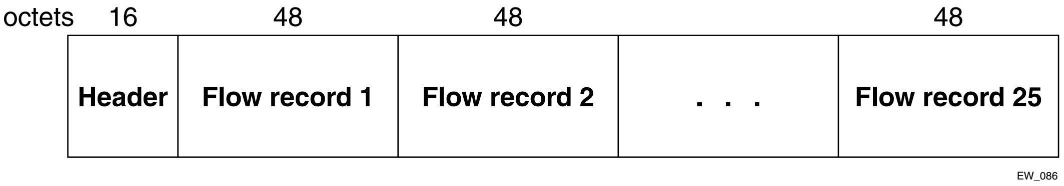
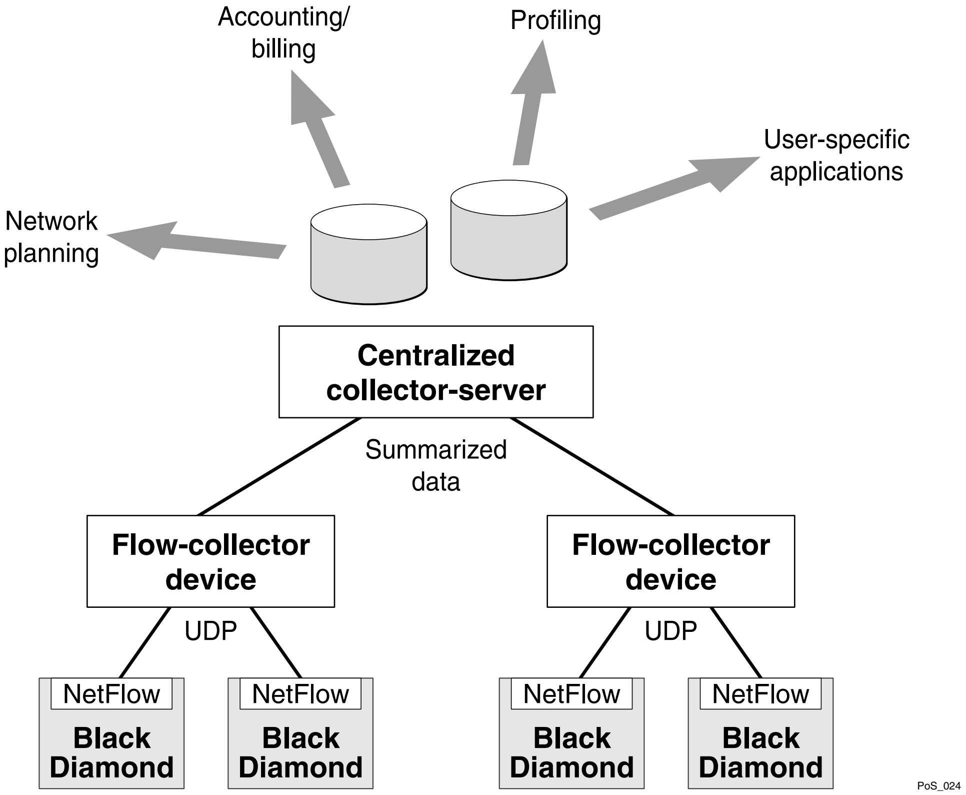


Table 33: Format of NetFlow Version 1 Export Datagram Header

Field Name	Octets	Field Description
version	2	Header version=1.
count	2	Number of flow records in datagram.
SysUptime	4	Current time in milliseconds since the switch booted.
unix_secs	4	(Not Supported.) Current count of seconds since 0000 UTC 1970.
unix_nsecs	4	(Not Supported.) Current count of residual nanoseconds since 0000 UTV 1970.

The IP addresses (or host names) and UDP port numbers of the available flow collectors can be configured on a per-switch basis. The flow collection architecture example in Figure 29 illustrates how multiple BlackDiamond switches might export flow records to flow-collector devices that, in turn, feed records into a central collector-server. Other flow-collector architectures are also possible. For example, each switch port configured for flow switching might export statistics to a dedicated flow-collector device.

Figure 29: NetFlow Collection Architecture Example



The ExtremeWare NetFlow implementation also enables a single port to distribute statistics across multiple groups of flow-collector devices. This NetFlow distribution feature enables a scalable collection architecture that is able to accommodate high volumes of exported data. The NetFlow distribution feature is enabled by configuring *export distribution groups* that contain the addresses of multiple flow-collector devices. The feature uses a distribution algorithm that ensures all of the records for a given flow are exported to the same collector. The algorithm also ensures that the flow records of the ingress direction of a TCP or UDP connection are exported to the same collector. (For Ethernet applications, only ingress traffic is monitored on Ethernet ports.) For example, multiple filters can be assigned to a set of ports for the same group. The flow records that match the filters are then sent to one of the flow collector devices in that group. You can also establish redundancy by configuring multiple flow collector devices per group so that data is still collected as long as there is one working flow collector device in that group.

To implement flow-collector devices, you can choose from commercial software products and public-domain software packages.

Collection Port and Filtering Options

By default, each Ethernet port configured for flow switching maintains statistics for all the flows traversing the link in the ingress direction.

Generalized filtering options exist that enable you to configure an Ethernet port to maintain statistics selectively for only those flows that match a specified filter. For example, to monitor aggregated flow records on Ethernet ports, you could configure an aggregation filter that specifies a range of IP addresses or ports.

Up to eight filters are supported for each Ethernet port, with a total of 128 filters possible per each I/O module. The filters consist of a {*value, mask*} pair for each of the following flow components: destination IP address, source IP address, destination port, source port, and protocol. Conceptually, the filters work by logically ANDing the contents of each of these five components of a forwarded flow with the associated *masks* from the first filter. Statistics are maintained if the results of the AND operations match the configured filter values for all fields of the five flow components. If there is not a match on all fields of the five components, then the operation is repeated for the second filter, and so on. If there is no match for any of the filters, then statistics are not maintained for the flow.

Collection Architecture Scalability and Reliability

By supporting statistics distribution across groups of flow-collector devices, the NetFlow distribution function enables a scalable collection architecture that is able to accommodate high volumes of exported data. The function also includes a health-check feature that significantly improves the reliability of the collection architecture. The health-checker ensures that only responsive flow-collector devices are included in the effective export distribution lists.

Up to 32 export distribution groups can be configured on a Black Diamond 6800 series switch. Each of these groups can contain the addresses of up to eight flow-collector devices. A particular export group can then be specified for each filter, which provides a high-degree of flexibility.

A filter-based aggregation capability is also offered to further enhance scalability. Each filter can be configured to be either a *per-flow filter* or an *aggregation* filter. When a flow matches a filter that is configured as an aggregation, normal per-flow statistics are not maintained for the flow. Instead, a single set of statistics is maintained for all the flows that match the aggregation filter, which can substantially reduce the volume of exported data.

Aggregated flow statistics are also exported in the NetFlow Version 1 format. The *srcaddr*, *dstaddr*, *srcport*, *dstport*, and *prot* fields of an aggregated flow record are set to the corresponding value components of the associated filter specification.

Export Criteria

For Ethernet ports, flow records are exported on an age basis. If the age of the flow is greater than a configurable time, the record is exported.

An Ethernet port configured for flow switching transmits a NetFlow Export Datagram when 25 flow records are ready for export, or when at least one flow has been awaiting export for one second.

An Ethernet port configured for capturing flows transmits NetFlow export datagrams when the configured time-out expires and exports the data collected by the flow filters configured on that port. As the NetFlow on Ethernet links is modeled as port-based, individual ports maintain their configured time-outs and export the flows collected by the configured flow filters on the expiry of flow export time-out.

Enabling and Disabling the Flow Statistics Feature on a Switch

To enable the flow statistics feature on a switch, use the following command:

```
enable flowstats
```

The flow statistics feature is disabled by default.

To disable the flow statistics feature on a switch, use the following command:

```
disable flowstats
```

Enabling and Disabling Flow Statistics on a Port

To enable the flow statistics function on the specified port, use the following command:

```
enable flowstats ports <portlist>
```

The flow statistics function is disabled by default.

To disable the flow statistics function on the specified port, use the following command:

```
disable flowstats ports <portlist>
```

Configuring the Export Destination

A single port can distribute statistics across multiple groups of flow-collector devices. This NetFlow distribution capability makes it possible to create a collection architecture that scales to accommodate high volumes of exported data. It also offers a health-checking function that improves the reliability of the collection architecture by ensuring that only responsive flow-collector devices are included in active export distribution lists. The distribution algorithm also ensures that all the ingress flow records for a given flow are exported to the same collector.

NetFlow distribution is enabled by configuring export distribution groups that identify the addresses of multiple flow-collector devices. You can configure up to 32 export distribution groups on a BlackDiamond 6800 series switch, and each group can contain as many as eight flow-collector devices.

To configure the export groups and flow-collector devices to which NetFlow datagrams are exported, use the following command:

```
configure flowstats export <group#> [add | delete] [<ipaddress> | <hostname>]
<udp_port>
```

The group# parameter is an integer in the range from 1 through 32 that identifies the specific group for which the destination is being configured.

You can use the add and delete keywords to add or delete flow-collector destinations.

To export NetFlow datagrams to a group, you must configure at least one flow-collector destination. By default, no flow-collector destinations are configured. To configure a flow-collector destination, use either an IP address and UDP port number pair or a hostname and UDP port number pair to identify the flow-collector device to which NetFlow export datagrams are to be transmitted. You can configure up to eight flow-collector destinations for each group. When multiple flow-collectors are configured as members of the same group, the exported NetFlow datagrams are distributed across the available destinations.

Configuring the Source IP Address

To configure the IP address that is to be used as the source IP address for NetFlow datagrams to be exported, use the following command:

```
configure flowstats source ipaddress <ipaddress>
```

By default, flow records are exported with the VLAN interface address that has a route to the configured flow-collector device. Depending on how it is configured, a flow-collector device can use the source IP address of received NetFlow datagrams to identify the switch that sent the information.

The following command example specifies that the IP address 192.168.100.1 is to be used as the source IP address for exported NetFlow datagrams.

```
configure flowstats source ipaddress 192.168.100.1
```

Configuring Flow Record Time-out

Flow records are exported on an age basis. If the age of the flow record is greater than the configured time-out, the record is exported.

To configure the time-out value for flow records on the specified port, use the following command:

```
configure flowstats timeout <minutes> ports [<portlist> | all]
```

The time-out value is the number of minutes to use in deciding when to export flow records. The default time-out is 5 minutes.

The following command example specifies a 10-minute time-out for exported NetFlow datagrams on port 1 of the Ethernet module installed in slot 8 of the BlackDiamond switch.

```
configure flowstats timeout 10 ports 8:1
```

Configuring a Flow Record Filter

You can configure an Ethernet port to maintain statistics selectively for only those flows that match a specified filter. Each Ethernet port supports eight filters for ingress flows.

To configure a flow record filter for the specified Ethernet port, use the following command:

```
configure flowstats filter <filter#> {aggregation} {export <group#>} ports <portlist>
[ingress | egress] <filterspec>
```

where:

filter#	The `filter#` parameter is an integer in the range from 1 to 8 that identifies the filter being defined.
<group#>	Specifies the group number that identifies the set of flow collector devices to which records for flows matching the filter are to be exported. If Group is not specified, then group # 1 will be used as default export group.
aggregation	To reduce the volume of exported data, use this optional keyword to maintain a single set of statistics for all the flows that match the specified filter.
filterspec	Specifies a set of five parameters (four are value/mask pairs) that define the criteria by which a flow is evaluated to determine if it should be exported. The parameters are: `[{dest-ip <ipaddress_value/mask ipaddress_filtermask>} {source-ip <ipaddress_value/mask ipaddress_filtermask>} {dest-port <port_value/port_filtermask>} {source-port <port_value/port_filtermask>} {protocol <tcp/udp/ip/protocol_value/protocol_filtermask>} | match-all-flows |match-no-flows]` All five specifications must be included in the order specified. The range for port/port_mask is calculated using the following formula: (minport = port, maxport = 2^(32-port_mask)-1). Conceptually, the filters work by ANDing the contents of each of the five components of a forwarded flow with the associated masks from the first defined filter (filter #1). Statistics are maintained if the results of the AND operations match the configured filter values for all fields of the sequence. If there is no match, then the operation is repeated for filter #2, and so on. If there is no match for any of the filters, then statistics are not maintained for the flow. Filters for any or all of the sequence components can be configured with a single command.
match-all-flows	Specifies that the filter should match any flow.
match-no-flows	Specifies that the filter should discard all flow. This option is not valid for Ethernet blades.
egress	Specifies that the filter should capture only egress traffic. This option is not valid for Ethernet blades.
ingress	Specifies that the filter should capture only ingress traffic.

The following command example configures a filter to collect aggregate statistics for all traffic flowing through ports 1-8 from the 192.170.0.0/16 subnet to the 192.171.132.0/24 subnet:

```
configure flowstats filter 2 aggregation export 1 ports 1-8 ingress dest-ip
192.171.132.0/24 source-ip 192.170.0.0/16 dest-port 0/0 source-port 0/0 protocol ip
```

Likewise, the following command example configures a filter to collect aggregate statistics for all ingress traffic flowing from the 192.171.0.0/16 subnet to the 192.170.0.0/16 subnet and export the flows to group 3 for ports 6:1, 7:9, and 8:42

```
configure flowstats filter 2 aggregation export 3 ports  6:1,7:9,8:42 ingress dest-ip
192.170.0.0/16 source-ip 192.171.0.0/16 dest-port 0/0 source-port 0/0 protocol ip
```

Finally, the following command configures filter 3 to collect statistics on any flows for ports 4-32 that did not match the filters defined in the two previous commands:

```
configure flowstats filter 3 aggregation export 1 ports 4-32 ingress match-all-flows
```

Enabling and Disabling a Flow Record Filter

To enable a specified flow record filter for the specified Ethernet port, use the following command:

```
enable flowstats filter <filter#> ports <portlist> {ingress | egress}
```

By default, all filters are enabled after they are configured.

To disable a specified flow record filter for the specified Ethernet port, use the following command:

```
disable flowstats filter <filter#> ports <portlist> {ingress | egress}
```

where:

filter#	The `filter#` parameter is an integer in the range from 1 to 8 that identifies the filter that is being enabled or disabled.

NOTE

Ethernet blades can capture ingress traffic only.

The following command example enables filter #2 on port 1 of the Ethernet module installed in slot 8 of the BlackDiamond switch.

```
enable flowstats filter 2 ports 8:1
```

The following command example disables filter #2 on port 1 of the Ethernet module installed in slot 8 of the BlackDiamond switch.

```
disable flowstats filter 2 ports 8:1
```

Enabling and Disabling Flow Statistics Ping-Check

To enable the flow statistics ping-check function for a specified group of collector devices, use the following command:

```
enable flowstats ping-check {<group#>}
```

The ping-check function is disabled by default. The group identifier is option. Not specifying a group identifier selects all groups.

When the ping-check function is enabled, each of the flow collector devices is `ping`ed periodically to check its network connectivity. If a flow collector device is repetitively unresponsive, it is temporarily removed from the export distribution list for that group. The flow collector device will be returned to the export distribution list automatically when subsequent ping checks are consistently successful.

The following command example enables the ping-check function for export group 2.

```
enable flowstats ping-check 2
```

To disable the flow statistics ping-check function for a specified group of collector devices, use the following command:

```
disable flowstats ping-check {<group#> | all}
```

The following command example disables the ping-check function for export group 2.

```
disable flowstats ping-check 2
```

Unconfiguring Flow Statistics

To reset the flow statistics configuration parameters for a specified Ethernet port to their default values, use the following command:

```
unconfigure flowstats ports [<portlist> | all]
```

NOTE

This command does not affect the enabled or disabled status of flow statistics collection, nor does it affect the configured export destinations.

The following command example resets the flow statistics configuration parameters for port 1 of the module installed in slot 8 of the BlackDiamond switch to their default values.

```
unconfigure flowstats ports 8:1
```

Displaying Flow Statistics Status Information

To display status information for the flow statistics function, use the following command:

```
show flowstats <portlist>
```

where:

detail	Use this optional keyword to display detailed NetFlow configuration information.
group#	Use this optional parameter with the `group` keyword to display status information for a specific export group.
portlist	Use this optional parameter to specify one or more ports or slots and ports for which status information is to be displayed.

If you enter the `show flowstats` command with none of the optional keywords or parameters, the command displays a summary of status information for all ports.

The summary status display for a port shows the values for all flow statistics configuration parameters for the port.

The summary status display for an export group includes the following information:

- Values for all configuration parameters
- Status of each export destination device

An example of `show flowstats` output is shown below:

```
# show  flowstats
Flowstats enabled

Port      Filter     proto   timeout     group    OverflowPkts     flags
--------------------------------------------------------------------------
1:1         1         -            5        1        N/A           EIA
Dest/Src Info: match-all-flows

Flags:  E - Enable, D - Disable; I - Ingress, S - Egress; A - Aggregation
```

The detailed status display for an export group includes the summary information, plus the following management information:

- Counts of the number of times each flow collector destination has been taken out of service due to health-check (ping check) failures
- The source IP address configuration information

Using sFlow®

sFlow® is a technology for monitoring traffic in data networks containing switches and routers. It relies on statistical sampling of packets from high-speed networks, plus periodic gathering of various statistics. A UDP datagram format is defined to send the information to an external entity for analysis. sFlow consists of a MIB and a specification of the packet format for forwarding information to a remote agent.

sFlow is primarily a mechanism to statistically sample a small portion of the traffic from a network, and extrapolate from this small sample to infer information about the network as a whole. sFlow defines a packet format, where the sFlow agent (in ExtremeWare) collects information from a number of sampled packets plus snapshots of various counters and statistics. The UDP frame is forwarded to a central monitoring station referred to as an sFlow collector.

Details of sFlow specifications can be found in RFC 3176, and specifications and more information can be found at the following website:

http://www.sflow.org

Configuring sFlow

ExtremeWare allows you to collect sFlow statistics in hardware on a per port basis. An agent, residing in ExtremeWare, sends data to a collector, residing on another machine. You will configure the local agent, the address of the remote collector, and the ports of interest for sFlow statistics gathering. You can also modify default values for how frequently on average a sample is taken, how often the data is sent to the collector, and the maximum number of packets sent to the collector before throttling the statistics gathering.

To configure sFlow on a switch, you will need to do the following tasks:

- Configure the IP address for the local agent
  - — The agent IP address must be configured before an sFlow collector can be configured.
  - — The agent IP address must be configured before sFlow can be enabled on any of the ports.
- Configure the addresses of the remote collectors
  - — A maximum of four collectors is supported.
- Enable sFlow globally on the switch
  - — sFlow must be globally enabled before it can be enabled on any of the ports.
- Enable sFlow on the desired ports
  - — sFlow cannot be disabled if it is enabled on any of the ports.

Optionally, you may also change the default values of the following items:

- How often data is sent to the collector(s)
- How frequently a sample is taken, globally or per-port

- The limit of how many samples per second can be sent to the Sflow collector

Configuring the Local Agent

The local agent is responsible for collecting the data from the samplers and sending it to the remote collector as a series of UDP datagrams. By default, the agent uses 0.0.0.0 as the source IP address for these datagrams. You should not use the default value. Typically, you would use an IP address that your network management software associates with the switch. Configure the agent IP address using the following command:

```
configure sflow agent <ip-address>
```

You can unconfigure the agent using this command:

```
unconfigure sflow agent
```

Configuring the Remote Collector Address

You can specify up to four remote collectors to which to send the sFlow data. Typically, you would configure the IP address of each collector. You may also specify a UDP port number different from the default value of 6343. When you configure a collector, a database entry is created for it that remains until the collector is unconfigured. All the configured collectors are displayed in the `show sflow configuration` command. Configure the remote collector using the following command:

```
configure sflow collector <ip-address> : <udp-port>
```

To unconfigure the remote collector, and remove it from the database, use the following command:

```
unconfigure sflow collector [<ip-address> | all]
```

Enabling sFlow Globally on the Switch

Before the switch will start sampling packets for sFlow, you must enable sFlow globally on the switch. Sampling will not begin, however, unless you have also enabled sFlow on the ports of interest. To enable sFlow globally, use the following command:

```
enable sflow
```

You can disable sFlow globally with the following command:

```
disable sflow
```

When sFlow is globally disabled, the individual ports are also put into the disabled state. If you later enable the global sFlow state, individual ports will return to their previous state.

Enabling sFlow on the Desired Ports

Enable sFlow on specific ports using the following command:

```
enable sflow ports <portlist>
```

You may enable and disable sFlow on ports irrespective of the global state of sFlow, but samples will not be taken until both the port state and the global state are enabled.

To disable sFlow on ports, use the following command:

```
disable sflow ports <portlist>
```

Additional sFlow Configuration Options

There are three global options that you can configure to different values from the defaults. They affect how frequently the sFlow data is sent to the remote collector and how frequently packets are sampled.

Polling Interval. Each sFlow counter is periodically polled to gather the statistics to send to the collector. If there is more than one counter to be polled, the polling is distributed in such a way that each counter is visited once during each polling interval, and the data flows are spaced evenly in time. For example, assume that the polling interval is 20 seconds and there are two counters to poll. The second counter will be polled ten seconds after the first, and the first counter ten seconds after the second. Once polled, the counter data is sent to the collector, so the collector will see the gathered data every ten seconds in this example. To configure the polling interval, use the following command:

```
configure sflow poll-interval <seconds>
```

Global Sampling Rate. The default sample rate is 8192, so by default sFlow samples one packet out of every 8192 received. You can configure the switch to use a different sampling frequency with the following command:

```
configure sflow sample-rate <number>
```

For example, if you set the sample rate number to 16384, the switch will sample one out of every 16384 packets received. Higher numbers mean fewer samples, and longer times between samples. If you set the number too low, the number of samples can be very large, increasing the load on the switch. Do not configure the sample rate to a number lower than the default unless you are sure that the traffic rate on the source is low.

Backoff Threshold. You can limit the number of packets sent to the sFlow collector per second by setting a backoff threshold. If the number of packets exceeds this limit, the sampling rate will be doubled. For example, if the number of packets sent to the sFlow collector is more than 256 per second, then the sampling rate will be doubled to 512. To configure the backoff threshold, use the following command:

```
configure sflow backoff-threshold <rate>
```

Use the following command to reset the backoff threshold to 0 (zero):

```
unconfigure sflow backoff-threshold
```

Once the backoff threshold has been configured (a rate has been set), the backoff threshold must be enabled through the following command:

```
enable sflow backoff-threshold
```

Use the following command to disable the backoff threshold:

```
disable sflow backoff-threshold
```

Displaying sFlow Information

To display the current configuration of sFlow, use the following command:

```
show sflow configuration
```

To display the sFlow statistics, use the following command:

```
show sflow statistics
```

RMON

Using the Remote Monitoring (RMON) capabilities of the switch allows network administrators to improve system efficiency and reduce the load on the network.

The following sections explain more about the RMON concept and the RMON features supported by the switch.

NOTE

You can only use the RMON features of the system if you have an RMON management application, and have enabled RMON on the switch.

About RMON

RMON is the common abbreviation for the Remote Monitoring Management Information Base (MIB) system defined by the Internet Engineering Task Force (IETF) documents RFC 1271 and RFC 1757, which allows you to monitor LANs remotely.

A typical RMON setup consists of the following two components:

- **RMON probe—**An intelligent, remotely controlled device or software agent that continually collects statistics about a LAN segment or VLAN. The probe transfers the information to a management workstation on request, or when a predefined threshold is crossed.
- **Management workstation—**Communicates with the RMON probe and collects the statistics from it. The workstation does not have to be on the same network as the probe, and can manage the probe by in-band or out-of-band connections.

RMON Features of the Switch

The IETF defines nine groups of Ethernet RMON statistics. The switch supports the following four of these groups:

- Statistics
- History
- Alarms
- Events

This section describes these groups and discusses how they can be used.

Statistics

The RMON Ethernet Statistics group provides traffic and error statistics showing packets, bytes, broadcasts, multicasts, and errors on a LAN segment or VLAN.

Information from the Statistics group is used to detect changes in traffic and error patterns in critical areas of the network.

History

The History group provides historical views of network performance by taking periodic samples of the counters supplied by the Statistics group. The group features user-defined sample intervals and bucket counters for complete customization of trend analysis.

The group is useful for analysis of traffic patterns and trends on a LAN segment or VLAN, and to establish baseline information indicating normal operating parameters.

Alarms

The Alarms group provides a versatile, general mechanism for setting threshold and sampling intervals to generate events on any RMON variable. Both rising and falling thresholds are supported, and thresholds can be on the absolute value of a variable or its delta value. In addition, alarm thresholds can be autocalibrated or set manually.

Alarms inform you of a network performance problem and can trigger automated action responses through the Events group.

Events

The Events group creates entries in an event log and/or sends SNMP traps to the management workstation. An event is triggered by an RMON alarm. The action taken can be configured to ignore it, to log the event, to send an SNMP trap to the receivers listed in the trap receiver table, or to both log and send a trap. The RMON traps are defined in RFC 1757 for rising and falling thresholds.

Effective use of the Events group saves you time. Rather than having to watch real-time graphs for important occurrences, you can depend on the Event group for notification. Through the SNMP traps, events can trigger other actions, which provides a mechanism for an automated response to certain occurrences.

Configuring RMON

RMON requires one probe per LAN segment, and standalone RMON probes traditionally have been expensive. Therefore, Extreme's approach has been to build an inexpensive RMON probe into the agent of each system. This allows RMON to be widely deployed around the network without costing more than traditional network management. The switch accurately maintains RMON statistics at the maximum line rate of all of its ports.

For example, statistics can be related to individual ports. Also, because a probe must be able to see all traffic, a stand-alone probe must be attached to a nonsecure port. Implementing RMON in the switch means that all ports can have security features enabled.

To enable or disable the collection of RMON statistics on the switch, use one of the following commands:

```
enable rmon
disable rmon
```

By default, RMON is disabled. However, even in the disabled state, the switch responds to RMON queries and sets for alarms and events. By enabling RMON, the switch begins the processes necessary for collecting switch statistics.

Event Actions

The actions that you can define for each alarm are shown in Table 34.

Table 34: Event Actions

Action	High Threshold
No action	
Notify only	Send trap to all trap receivers.
Notify and log	Send trap; place entry in RMON log.

To be notified of events using SNMP traps, you must configure one or more trap receivers, as described in Chapter 3.

12 Security

This chapter describes the following topics:

- Security Overview on page 253
- Network Access Security on page 253
  - — MAC-Based VLANs on page 254
  - — IP Access Lists (ACLs) on page 254
  - — MAC Address Security on page 261
  - — Network Login on page 264
  - — Unified Access Security on page 279
- Switch Protection on page 308
  - — Routing Access Profiles on page 308
  - — Route Maps on page 318
  - — Denial of Service Protection on page 323
- Duplicate IP Protection on page 329
- Management Access Security on page 332
  - — Authenticating Users Using RADIUS or TACACS+ on page 332
  - — Secure Shell 2 (SSH2) on page 342

Security Overview

Extreme Networks products incorporate a number of features designed to enhance the security of your network. No one feature can insure security, but by using a number of features in concert, you can substantially improve the security of your network. The features described in this chapter are part of an overall approach to network security.

Network Access Security

Network access security features control devices accessing your network. In this category are the following features:

- MAC-Based VLANs
- IP Access Lists (ACLs)
- MAC Address Security
- Network Login
- Unified Access Security

MAC-Based VLANs

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

Detailed information about configuring and using MAC-based VLANs can be found in Chapter 6.

IP Access Lists (ACLs)

IP access lists consist of IP access rules and are used to perform packet filtering and forwarding decisions on incoming traffic. Each packet arriving on an ingress port is compared to the access list in sequential order and is either forwarded to a specified QoS profile or dropped. Using access lists has no impact on switch performance.

Access lists are typically applied to traffic that crosses layer 3 router boundaries, but it is possible to use access lists within a layer 2 VLAN.

Access lists are often referred to as Access Control Lists (ACLs).

Using IP Access Lists

Each entry that makes up an IP access list contains a unique name. It can also contain an optional, unique precedence number. The rules of an IP access list consist of a combination of the following six components:

- IP source address and mask
- IP destination address and mask
- TCP or UDP source port range
- TCP or UDP destination port range
- Physical source port
- Precedence number (optional)

How IP Access Lists Work

When a packet arrives on an ingress port, the packet is compared with the access list rules to determine a match. When a match is found, the packet is processed. If the access list is of type deny, the packet is dropped. If the list is of type permit, the packet is forwarded. A permit access list can also apply a QoS profile to the packet.

Precedence Numbers

The precedence number is optional, and determines the order in which each rule is examined by the switch. Access list entries that contain a precedence number are evaluated from highest to lowest. Precedence numbers range from 1 to 25,600, with the *number 1 having the highest precedence*.

You can specify overlapping rules; however, if you are using precedence numbers, overlapping rules without precedence numbers are ignored. Therefore, the precedence numbers must be specified among all overlapping rules. If a new rule without a precedence number is entered, and this rule overlaps with already existing rules, the switch rejects the new rule and resolves the precedences among all remaining overlapping rules.

Configuring access list precedence with an interval value of less than 5 between each rule is recommended. This configuration avoids any adverse performance issues, such as very long delays between add transactions and loss of access to configuration sessions.

IP Access Rules

There are a number of different types of IP access rules and different limits apply to each type. This section describes the different types of IP access rules, what each rule is capable of supporting, and any limitations associated with each type of rule. The switch allows a maximum total of 5,120 rules to be stored in non-volatile configuration storage. This maximum is a sum of IP and ICMP access rule entries.

ICMP Access Rules

An access list for ICMP is only effective for traffic routed by the switch. ICMP traffic can either be forwarded (routed) by the switch or discarded, but can not contain options for assigning a QoS profile. Other configuration options for filtering ICMP include:

- IP source and destination address and mask.
- ICMP type code.
- Physical source port (optional).
- Numbered precedence (optional).

Flow Redirect Policies

IP traffic can either be forwarded (routed) by the switch or redirected to another next-hop MAC address. The switch will monitor the next-hop system using system health checks and will stop forwarding traffic to a device that is down. You can configure up to 64 flow redirect rules. Flow redirect rules are stored separately and therefore are not limited by other ACLs. These rules are identified by:

- IP source and destination address and mask
- Layer 4 source port
- Layer 4 destination port

If a flow redirect rule is specified with an IP source address mask of less than /20, the system automatically enables the subnet mode. Flow redirect rules with mask lengths greater than /20 automatically enable enumeration mode.

Use the `show flow-redirect` command to display whether the system is in subnet mode or enumeration mode.

Netflow Record Filters

Up to eight filters are supported for each Ethernet port, with a total of 128 filters for each switch. Netflow filters share the same space as ACLs. That means that the total number of ACLs allowed is limited by the number of Netflow record filters configured. For example, if 128 filters are created, the numbers of ACLs allowed decreases by 128.

Specifying a Default Rule

To begin constructing an access list, you should specify a default rule. A *default rule* is a rule that contains wildcards for destination and source IP address, with no layer 4 information. A default rule determines if the behavior of the access list is an “implicit deny” or “implicit accept.” If no access list entry is satisfied, the default rule is used to determine whether the packet is forwarded or dropped. If no default rule is specified, the default implicit behavior is to forward the packet.

The following example shows a default entry that is used to specify an explicit deny:

```
create access-list denyall ip dest 0.0.0.0/0 source 0.0.0.0/0 deny ports any
```

Once the default behavior of the access list is established, you can create additional entries using precedence numbers.

The following access-list example performs packet filtering in the following sequence, as determined by the precedence number:

- Deny UDP port 32 and TCP port 23 traffic to the 10.2.XX network.
- All other TCP port 23 traffic destined for other 10.X.X.X networks is permitted using QoS profile Qp4.
- All remaining traffic to 10.2.0.0 uses QoS profile Qp3.

With no default rule specified, all remaining traffic is allowed using the default QoS profile.

```
create access-list deny102_32 udp dest 10.2.0.0/16 ip-port 32 source any ip-port any
deny ports any precedence 10

create access-list deny102_23 tcp dest 10.2.0.0/16 ip-port 23 source any ip-port any
deny ports any precedence 20

create access-list allow10_23 tcp dest 10.0.0.0/8 ip-port 23 source any ip-port any
permit qosprofile qp4 ports any precedence 30

create access-list allow102 ip dest 10.2.0.0/16 source 0.0.0.0/0 permit qosprofile qp3
ports any precedence 40
```

The permit-established Keyword

The `permit-established` keyword is used to directionally control attempts to open a TCP session. The permit-established keyword denies all traffic that matches the TCP source/destination, and has the SYN=1 and ACK=0 flags set. Thus, TCP session initiation can be explicitly blocked using this keyword. Traffic from TCP sessions that are already established continue to be permitted.

NOTE

For an example of using the permit-established keyword, see "Using the Permit-Established Keyword" on page 258.

Adding and Deleting Access List Entries

Entries can be added and deleted to the access list. To add an entry, you must supply a unique name and, optionally, a unique precedence number. To modify an existing entry, you must delete the entry and retype it, or create a new entry with a new unique name.

To delete an access list entry, use the following command:

```
delete access-list [<name> | all]
```

Maximum Entries

A maximum of 255 entries with an assigned precedence can be used. In addition to the 255 entries, entries that do not use precedence can also be created, with the following restrictions:

- A source IP address must use wildcards or a completely specified mask.
- The layer 4 source and destination ports must use wildcards or be completely specified (no ranges).
- No physical source port can be specified.
- Access list rules that apply to all physical ports are implemented on all BlackDiamond I/O modules.

On a BlackDiamond switch, the maximum number of access list entries is 255 entries per I/O module. One way to economize on the number of entries on a BlackDiamond switch is to provide a physical ingress port as a component of an access list rule. In this case, the rule is implemented only on the I/O modules that contain the specified ports. By restricting rules to specific I/O modules, you can extend the number of access list rules to 5120 (NVRAM limit).

On BlackDiamond switches, there is a resource on each "*i*" series I/O module so that the total maximum number of ACL entries can be up to 4080 (255*16). Each ACL must specify an ingress physical port specific to a single I/O module to avoid using those resources on any other module.

On Alpine switches, a maximum of 255 ACL entries are supported.

Verifying Access List Configurations

To verify access list settings, you can view the access list configuration and see real-time statistics on which access list entries are being accessed when processing traffic.

To view the access list configuration and statistics screen, use the following command:

```
show access-list {<name> | port <portlist>}
```

To initiate and refresh a running display of access list statistics, use the following command:

```
show access-list-monitor
```

IP Access List Examples

This section presents two IP access list examples:

- Using the permit-establish keyword
- Filtering ICMP packets

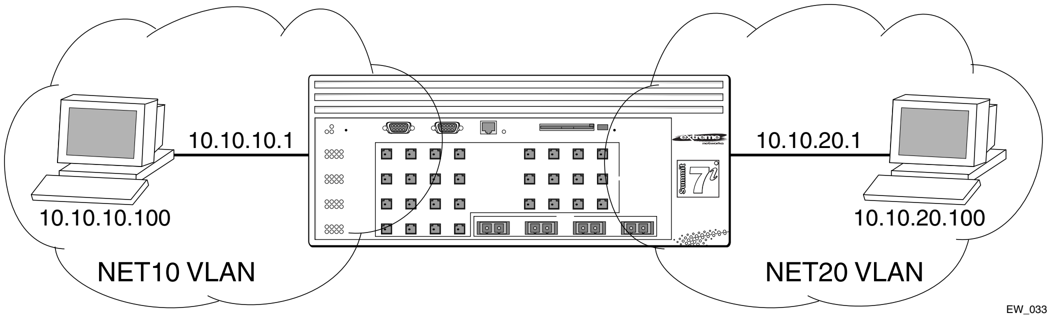
Using the Permit-Established Keyword

This example uses an access list that permits TCP sessions (Telnet, FTP, and HTTP) to be established in one direction.

The Summit7i, shown in Figure 30, is configured as follows:

- Two VLANs, NET10 VLAN and NET20 VLAN, are defined.
- The IP addresses for NET10 VLAN is 10.10.10.1/24.
- The IP address for NET20 VLAN is 10.10.20.1/24.
- The workstations are configured using addresses 10.10.10.100 and 10.10.20.100.
- IP Forwarding is enabled.

Figure 30: Permit-established access list example topology



The following sections describe the steps used to configure the example.

Step 1 – Deny IP Traffic.

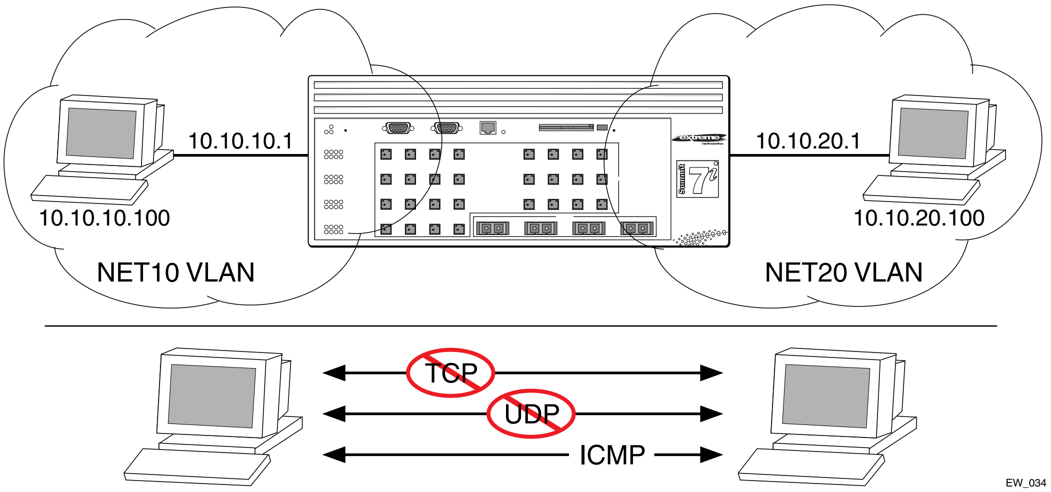
First, create an access-list that blocks all IP-related traffic. This includes any TCP- and UDP-based traffic. Although ICMP is used in conjunction with IP, it is technically not an IP data packet. Thus, ICMP data traffic, such as ping traffic, is not affected.

The following command creates the access list:

```
create access-list denyall ip destination any source any deny ports any
```

Figure 31 illustrates the outcome of the access list.

Figure 31: Access list denies all TCP and UDP traffic



Step 2 – Allow TCP traffic.

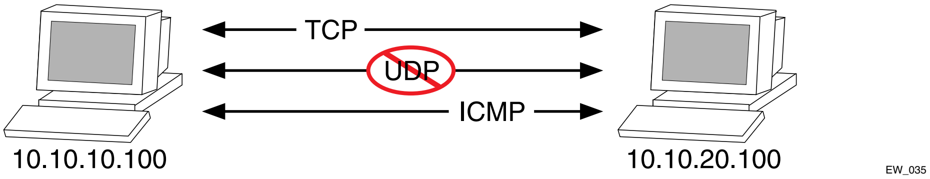
The next set of access list commands permits TCP-based traffic to flow. Because each session is bi-directional, an access list must be defined for each direction of the traffic flow. UDP traffic is still blocked.

The following commands create the access list:

```
create access-list tcp1 tcp destination 10.10.20.100/32 ip any source 10.10.10.100/32
ip any permit qp1 ports any precedence 20

create access-list tcp2 tcp destination 10.10.10.100/32 ip any source 10.10.20.100/32
ip any permit qp1 ports any precedence 21
```

Figure 32 illustrates the outcome of this access list.

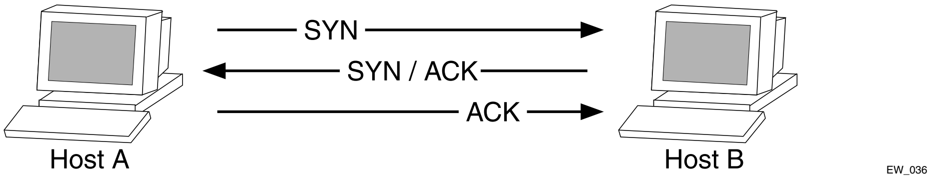
Figure 32: Access list allows TCP traffic



Step 3 - Permit-Established Access List.

When a TCP session begins, there is a three-way handshake that includes a sequence of a SYN, SYN/ACK, and ACK packets. Figure 33 shows an illustration of the handshake that occurs when host A initiates a TCP session to host B. After this sequence, actual data can be passed.

Figure 33: Host A initiates a TCP session to host B



An access list that uses the permit-established keyword filters the SYN packet in one direction.

Use the permit-established keyword to allow only host A to be able to establish a TCP session to host B and to prevent any TCP sessions from being initiated by host B, as illustrated in Figure 33. The syntax for this access list is as follows:

```
create access-list <name> tcp destination HostA ip-port 23 source HostB ip-port any
permit-established ports any pre 8
```

NOTE

This step may not be intuitive. Pay attention to the destination and source address, and the desired affect.

The exact command line entry for this example is as follows:

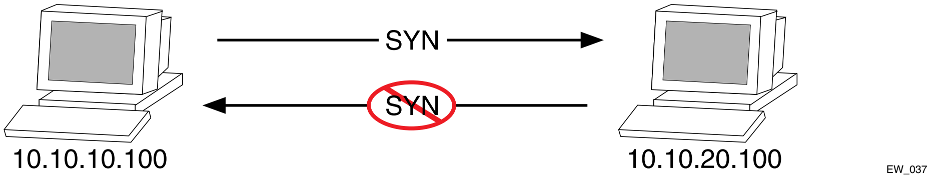
```
create access-list telnet-allow tcp destination 10.10.10.100/32 ip-port 23 source any
ip-port any permit-established ports any pre 8
```

NOTE

This rule has a higher precedence than the rule "tcp2."

Figure 34 shows the final outcome of this access list.

Figure 34: Permit-established access list filters out SYN packet to destination



Example 2: Filter ICMP Packets

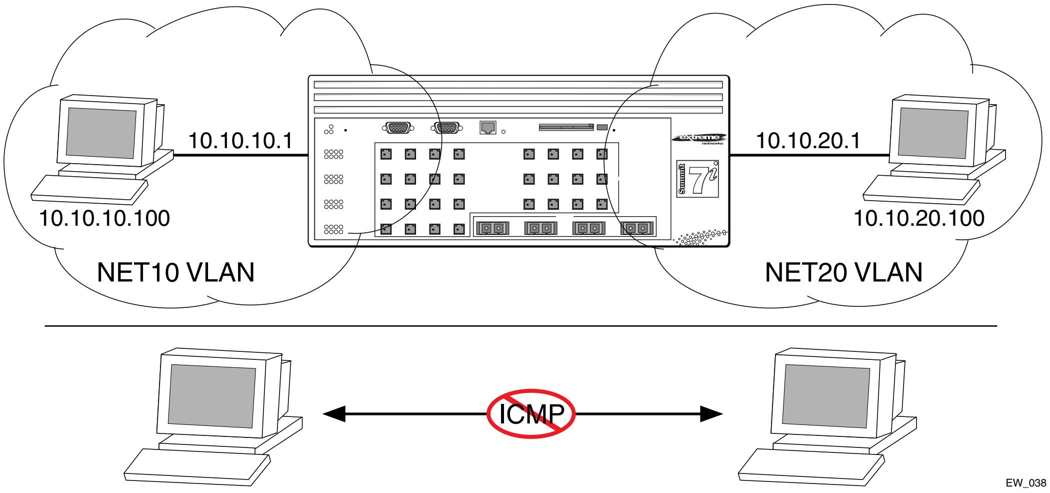
This example creates an access list that filters out ping (ICMP echo) packets. ICMP echo packets are defined as type 8 code 0.

The command line syntax to create this access list is as follows:

```
create access-list denyping icmp destination any source any type 8 code 0 deny ports
any
```

The output for this access list is shown in Figure 35.

Figure 35: ICMP packets are filtered out



MAC Address Security

The switch maintains a database of all media access control (MAC) addresses received on all of its ports. It uses the information in this database to decide whether a frame should be forwarded or filtered. MAC address security allows you to control the way the Forwarding Database (FDB) is learned and populated. By managing entries in the FDB, you can block, assign priority (queues), and control packet flows on a per-address basis.

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

NOTE

You can either limit dynamic MAC FDB entries, or lock down the current MAC FDB entries, but not both.

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

Limiting Dynamic MAC Addresses

You can set a predefined limit on the number of dynamic MAC addresses that can participate in the network. After the FDB reaches the MAC limit, all new source MAC addresses are blackholed at both the ingress and egress points. These dynamic blackhole entries prevent the MAC addresses from learning and responding to Internet control message protocol (ICMP) and address resolution protocol (ARP) packets.

To limit the number of dynamic MAC addresses that can participate in the network, use the following command:

```
configure ports [<portlist>  vlan <vlan name> | all]  limit-learning <number>
```

This command specifies the number of dynamically-learned MAC entries allowed for these ports in this VLAN. The range is 0 to 500,000 addresses.

When the learned limit is reached, all new source MAC addresses are blackholed at the ingress and egress points. This prevent these MAC addresses from learning and responding to Internet control message protocol (ICMP) and address resolution protocol (ARP) packets.

Dynamically learned entries still get aged and can be cleared. If entries are cleared or aged out after the learning limit has been reached, new entries will then be able to be learned until the limit is reached again.

Permanent static and permanent dynamic entries can still be added and deleted using the `create fdbentry` and `delete fdbentry` commands. These override any dynamically learned entries.

For ports that have a learning limit in place, the following traffic will still flow to the port:

- Packets destined for permanent MAC addresses and other non-blackholed MAC addresses
- Broadcast traffic
- EDP traffic

Traffic from the permanent MAC and any other non-blackholed MAC addresses will still flow from the virtual port.

To remove the learning limit, use the following command:

```
configure ports [<portlist> vlan <vlan name>  | all] unlimited-learning
```

To verify the configuration, use the following commands:

```
show vlan <vlan name> security
```

This command displays the MAC security information for the specified VLAN.

```
show ports info
```

This command displays detailed information, including MAC security information, for the specified port.

SNMP Traps and Syslog Messages For MAC Address Limits

To generate a syslog message and an SNMP trap when the limit is reached and a new source MAC address attempts to participate in the network, use the following command:

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

The information generated should help detect unauthorized devices that attempt to access the network. Enabling the trap also enables the syslog; there is no separate command for that. The command is a global command; there is no per port or per VLAN control.

To disable the generation of MAC address limit SNMP traps and syslog messages, use the following command:

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

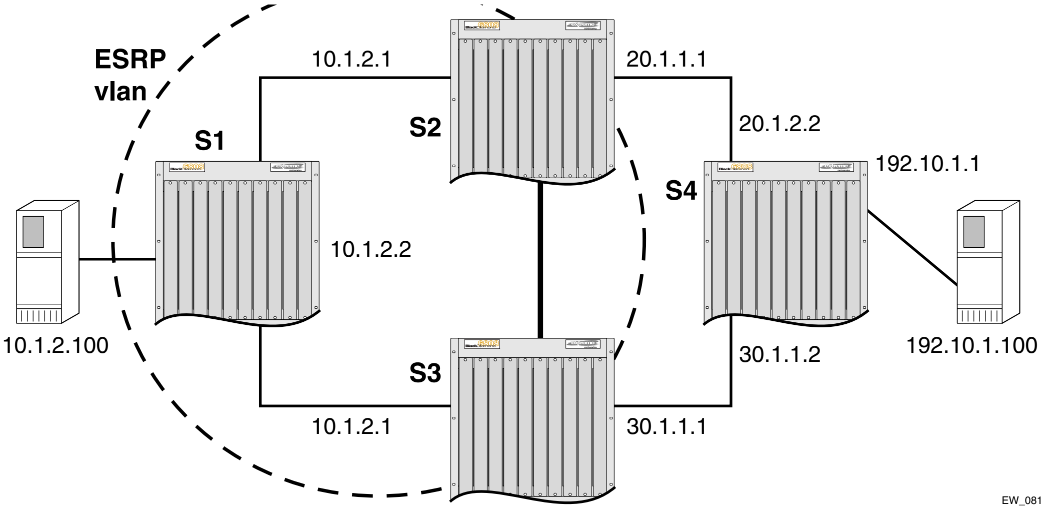
For more information about configuring SNMP and the MAC limit SNMP trap, see "Using SNMP" on page 65, in Chapter 3, "Managing the Switch".

Limiting MAC Addresses with ESRP Enabled

If you configure a MAC address limit on VLANS that have ESRP enabled, you should add an additional back-to-back link (that has no MAC address limit on these ports) between the ESRP-enabled switches. Doing so prevents ESRP PDU from being dropped due to MAC address limit settings.

Figure 36 is an example of configuring a MAC address limit on an ESRP-enabled VLAN.

Figure 36: MAC address limits and ESRP-enabled VLANs



In Figure 36, S2 and S3 are ESRP-enabled switches, while S1 is an ESRP-aware (regular layer 2) switch. Configuring a MAC address limit on all S1 ports might prevent ESRP communication between S2 and S3. To resolve this, you should add a back-to-back link between S2 and S3. This link is not needed if MAC address limiting is configured only on S2 and S3, but not on S1.

MAC Address Lock Down

In contrast to limiting learning on virtual ports, you can lock down the existing dynamic FDB entries and prevent any additional learning using the following command:

```
configure ports [<portlist> vlan <vlan name> | all] lock-learning
```

This command causes all dynamic FDB entries associated with the specified VLAN and ports to be converted to locked static entries. It also sets the learning limit to zero, so that no new entries can be learned. All new source MAC addresses are blackholed.

Locked entries do not get aged, but can be deleted like a regular permanent entry.

For ports that have lock-down in effect, the following traffic will still flow to the port:

- Packets destined for the permanent MAC and other non-blackholed MAC addresses
- Broadcast traffic

- EDP traffic

Traffic from the permanent MAC will still flow from the virtual port.

To remove MAC address lock down, use the following command:

```
configure ports [<portlist>  vlan <vlan name> | all] unlock-learning
```

When you remove the lock down using the unlock-learning option, the learning-limit is reset to unlimited, and all associated entries in the FDB are flushed.

Network Login

Network login controls the admission of user packets into a network by giving addresses only to users that are properly authenticated. Network login is controlled on a per port, per VLAN basis. When network login is enabled on a port in a VLAN, that port does not forward any packets until authentication takes place.

Network login is compatible with two types of authentication, web-based and 802.1x, and two different modes of operation, Campus mode and ISP mode. The authentication types and modes of operation can be used in any combination.

When web-based network login is enabled on a switch port, that port is placed into a non-forwarding state until authentication takes place. To authenticate, a user (supplicant) must open a web browser and provide the appropriate credentials. These credentials are either approved, in which case the port is placed in forwarding mode, or not approved, in which case the port remains blocked. Three failed login attempts disables the port for a configured length of time. User logout can be initiated by submitting a logout request or closing the logout window.

The following capabilities are included in network login:

- Web-based login using http and https available on each wired and wireless port
- 802.1x and web based network login supported on the same wired ports
- Multiple supplicants on each wired 10/100 and wireless port
- Single VLAN assignment for all users authenticated on a wired port
- Per-user VLAN support for all users authenticated on a wireless port

Web-Based and 802.1x Authentication

Authentication is handled as a web-based process, or as described in the IEEE 802.1x specification. Web-based network login does not require any specific client software and can work with any HTTP-compliant web browser. By contrast, 802.1x authentication may require additional software installed on the client workstation, making it less suitable for a user walk-up situation, such as a cyber-café or coffee shop.[1] Extreme Networks supports a smooth transition from web-based to 802.1x authentication.

DHCP is required for web-based network login because the underlying protocol used to carry authentication request-response is HTTP. The client requires an IP address to send and receive HTTP

[1] A workstation running Windows XP supports 802.1x natively and does not require additional authentication software.

packets. Before the client is authenticated, however, the only connection exists is to the authenticator. As a result, the authenticator must be furnished with a temporary DHCP server to distribute the IP address.

The switch responds to DHCP requests for unauthenticated clients when DHCP parameters such as `dhcp-address-range` and `dhcp-options` are configured on the Netlogin VLAN. The switch can also answer DHCP requests following authentication if DHCP is enabled on the specified VLAN. If netlogin clients are required to obtain DHCP leases from an external DHCP server elsewhere on the network, DHCP should not be enabled on the VLAN.

The DHCP allocation for network login has a short time default duration of 10 seconds and is intended to perform web-based network login only. As soon as the client is authenticated, it is deprived of this address. The client must obtain a operational address from another DHCP server in the network. DHCP is not required for 802.1x, because 802.1x uses only Layer 2 frames (EAPOL).

URL redirection (applicable to web-based mode only) is a mechanism to redirect any HTTP request to the base URL of the authenticator when the port is in unauthenticated mode. In other words, when the user tries to log in to the network using the browser, the user is first redirected to the network login page. Only after a successful login is the user connected to the network.

Web-based and 802.1x authentication each have advantages and disadvantages, as summarized next.

Advantages of 802.1x Authentication:.

- In cases where the 802.1x is natively supported, login and authentication happens transparently.
- Authentication happens at Layer 2. It does not involve getting a temporary IP address and subsequent release of the address to obtain a more permanent IP address.
- Allows for periodic, transparent, re-authorization of supplicants.

Disadvantages of 802.1x Authentication:.

- 802.1x native support is available only on newer operating systems, such as Windows XP.
- 802.1x requires an EAP-capable RADIUS Server. Most current RADIUS servers support EAP, so this is not a major disadvantage.
- TLS authentication method involves Public Key Infrastructure, which adds to the administrative requirements.
- TTLS is still a Funk/Certicom IETF draft proposal, not a fully accepted standard. It is easy to deploy and administer.

Advantages of Web-based Authentication:.

- Works with any operating system. There is need for special client side software.; only a web browser is needed.

Disadvantages of Web-based Authentication:.

- The login process involves manipulation of IP addresses and must be done outside the scope of a normal computer login process. It is not tied to Windows login. The client must bring up a login page and initiate a login.
- Supplicants cannot be re-authenticated transparently. They cannot be re-authenticated from the authenticator side.

- Since wireless web-based network login supports only static WEP encryption, it is vulnerable to attack. Therefore, care should be taken when deploying this authentication mechanism. Using a secure web server (HTTP with SSL) alleviates some of this problem.
- This method is not as effective in maintaining privacy protection.

802.1x Authentication Methods

802.1x authentication methods govern interactions between the supplicant (client) and the authentication server. The most commonly used methods are Transport Layer Security (TLS) and Tunneled TLS (TTLS), which is a Funk/Certicom standards proposal.

TLS is the most secure of the currently available protocols, although TTLS is advertised to be as strong as TLS. Both TLS and TTLS are certificate-based and require a Public Key Infrastructure (PKI) that can issue, renew, and revoke certificates. TTLS is easier to deploy, as it requires only server certificates, by contrast with TLS, which requires client and server certificates. With TTLS, the client can use the MD5 mode of username/password authentication.

If you plan to use 802.1x authentication, refer to the documentation for your particular RADIUS server, and 802.1x client on how to set up a PKI configuration.

Campus and ISP Modes

Network login supports two modes of operation, Campus and ISP. Campus mode is intended for mobile users who tend to move from one port to another and connect at various locations in the network. ISP mode is meant for users who connect through the same port and VLAN each time (the switch functions as an ISP).

In campus mode, the clients are placed into a permanent VLAN following authentication with access to network resources. For wired ports, the port is moved from the temporary to the permanent VLAN.

In ISP mode, the port and VLAN remain constant. Before the supplicant is authenticated, the port is in an unauthenticated state. After authentication, the port forwards packets.

User Accounts

You can create two types of user accounts for authenticating network login users: netlogin-only enabled and netlogin-only disabled. A netlogin-only disabled user can log in using network login and can also access the switch using Telnet, SSH, or HTTP. A netlogin-only enabled user can only log in using network login and cannot access the switch using the same login.

Add the following line to the RADIUS server dictionary file for netlogin-only disabled users:

```
Extreme:Extreme-Netlogin-Only = Disabled
```

Add the following line to the RADIUS server dictionary file for netlogin-only enabled users:

```
Extreme:Extreme-Netlogin-Only = Enabled
```

Table 35 contains the Vendor Specific Attribute (VSA) definitions for web-based network login. The Extreme Network Vendor ID is 1916.

Table 35: VSA Definitions for Web-based and 802.1x Network Login

VSA	Attribute Value	Type	Sent-in	Description
Extreme-Netlogin-VLAN	203	String	Access-Accept	Name of destination VLAN after successful authentication (must already exist on switch).
Extreme-Netlogin-URL	204	String	Access-Accept	Destination web page after successful authentication.
Extreme-Netlogin-URL-Desc	205	String	Access-Accept	Text description of network login URL attribute.
Extreme-Netlogin-Only	206	Integer	Access-Accept	Indication of whether the user can authenticate using other means, such as telnet, console, SSH, or Vista. A value of “1” (enabled) indicates that the user can only authenticate via network login. A value of zero (disabled) indicates that the user can also authenticate via other methods.

Interoperability Requirements

For network login to operate, the user (supplicant) software and the authentication server must support common authentication methods. Not all combinations provide the appropriate functionality.

Supplicant Side

On the client or supplicant side, the following platforms natively support 802.1x and perform MD5 and TSL:

- Windows XP
- Windows 2000 Professional with Service Pack 4
- Mac OS 10.3

802.1x clients can be obtained for other operating systems and may support a combination of authentication methods.

A Windows XP 802.1x supplicant can be authenticated as a computer or as a user. Computer authentication requires a certificate installed in the computer certificate store, and user authentication requires a certificate installed in the individual user's certificate store.

By default, the Windows XP machine performs computer authentication as soon as the computer is powered on, or at link-up when no user is logged into the machine. User authentication is performed at link-up when the user is logged in.

Windows XP also supports guest authentication, but this is disabled by default. Refer to relevant Microsoft documentation for further information. The Windows XP machine can be configured to perform computer authentication at link-up even if user is logged in.

Authentication Server Side

The RADIUS server used for authentication must be EAP-capable. Consider the following when choosing a RADIUS server:

- Types of authentication methods supported on RADIUS, as mentioned previously.
- Need to support Vendor Specific Attributes (VSA). Parameters such as `Extreme-Netlogin-Vlan` (destination vlan for port movement after authentication) and `Extreme-NetLogin-only` (authorization for network login only) are brought back as VSAs.
- Need to support both EAP and traditional username-password authentication. These are used by network login and switch console login respectively.

Multiple Supplicant Support

An important enhancement over the IEEE 802.1x standard, is that ExtremeWare supports multiple clients (supplicants) to be individually authenticated on the same port. This feature makes it possible for two client stations to be connected to the same port, with one being authenticated and the other not. A port's authentication state is the logical “OR” of the individual MAC's authentication states. In other words, a port is authenticated if any of its connected clients is authenticated. Multiple clients can be connected to a single port of authentication server through a hub or layer-2 switch.

Multiple supplicants are supported in ISP mode for both web-based and 802.1x authentication. Multiple supplicants are not supported in Campus mode. Versions of ExtremeWare previous to version 7.1.0 did not support multiple supplicants.

The choice of web-based versus 802.1x authentication is again on a per-MAC basis. Among multiple clients on the same port, it is possible that some clients use web-based mode to authenticate, and some others use 802.1x.

There are certain restrictions for multiple supplicant support:

- Web-based mode will not support Campus mode for multiple supplicant because once the first MAC gets authenticated, the port is moved to a different VLAN and therefore other unauthenticated clients (which are still in the original VLAN), cannot have layer 3 message transactions with the authentication server.
- Once the first MAC is authenticated, the port is transitioned to the authenticated state and other unauthenticated MACs can listen to all data destined for the first MAC. This could raise some security concerns as unauthenticated MACs can listen to all broadcast and multicast traffic directed to a Network Login-authenticated port.

Exclusions and Limitations

The following are limitations and exclusions for Network Login:

- For wired netlogin ports, all unauthenticated MACs see broadcasts and multicasts sent to the port if even a single MAC is authenticated on that port.
- Network Login must be disabled on a port before that port can be deleted from a VLAN.
- In Campus mode, once the port moves to the destination VLAN, the original VLAN for that port is not displayed.
- A Network Login VLAN port should be an untagged Ethernet port and should not be a part of following protocols:
  - — ESRP
  - — STP
  - — VLAN Aggregation
  - — VLAN Translation

- Network Login is not supported for T1, E1, T3, ATM, PoS and MPLS TLS interfaces.
- No Hitless Failover support has been added for Network Login.
- Rate-limiting is not supported on Network Login ports (both web-based and 802.1x).
- Network Login and MAC-limits cannot be used together on the same switch (see "MAC Address Security" on page 261).
- EAP-NAK cannot be used to negotiate 802.1x authentication types.
- You cannot enable wired netlogin on a port that has been enabled for wireless access.
- Enabling a port for wireless access automatically disables wired netlogin on that port.

Configuring Wired Network Login

The following configuration example demonstrates how users can initially log in using web-based authentication, allowing them limited access to the network in order to download the 802.1x client and a certificate. After the client is configured, the user is then able to access the network by using 802.1x. The example illustrates the following configuration steps:

1. Create a VLAN on all edge switches called "temp," which is the initial VLAN to which users will connect before they are authenticated.
2. Create a VLAN on all edge and core switches called "guest," which is the VLAN from which users will access the Certificate Authority and be able to download the 802.1x software.

The following example demonstrates the first network login configuration step for a Summit 48si edge switch:

```
create vlan temp
configure temp ipaddress 192.168.1.1/24
configure temp add port 1-48
configure vlan temp dhcp-address-range 192.168.1.11 - 192.168.1.200
configure vlan temp dhcp-options default-gateway 192.168.1.1
enable netlogin port 1-48 vlan temp
enable dhcp ports 1-48 vlan temp
```

Note that the 192.168 IP address range can be used on all switches because the user is on the VLAN only long enough to log in to the network. After the login is complete, the user is switched to a permanent VLAN with a real IP address delivered from a real DHCP server.

The following example demonstrates the second network login configuration step for a Summit 48si edge switch, in which the guest VLAN is created:

```
create vlan guest
configure guest ipa 45.100.1.101/16
configure guest tag 100
configure guest add port 49-50 tagged
enable bootp relay
configure bootp relay add 45.100.2.101
```

These commands create the special VLAN called "guest" on the real area of the network. Special configuration is needed on the RADIUS server to place users on to the appropriate VLAN when they log in as guests. By using network login in this way, the user goes from unauthenticated to a guest authentication with limited access to resources.

Note that the 45.100.x.x VLAN does not need to be able to route. Extra authentication can be enabled on the Certificate Authority server to more firmly verify the identity of users. The 45.100.x.x VLAN will have the Certificate Authority located on it as well as an HTTP/FTP server to allow the user to download the needed files.

Once the user has installed the certificate from the Certificate Authority and downloaded the 802.1x client, the user can reconnect to the network using 802.1x without the need to authenticate via a web browser. The authentication is handled using PEAP and certificates. The user will be placed in the VLAN that is appropriate for that user's group.

Configuring Wireless Network Login

The following configuration example shows the Extreme Networks switch configuration and the associated RADIUS server entries for network login. VLAN *corp* is assumed to be a corporate subnet with connections to DNS, WINS servers, and network routers. For wired network login, VLAN *temp* is a temporary VLAN created to provide connections to unauthenticated network login clients.

For wireless network login, VLAN *wlan-mgmt* is the wireless management VLAN. It is also the VLAN used by unauthenticated network login clients. In this security model, unauthenticated clients do not connect to the corporate subnet and are not able to send or receive data. They must be authenticated in order to gain access to the network.

NOTE

A wireless interface can be in web-based netlogin mode or 802.1x netlogin mode, but not both, at one time. A wired port can support both web-based and 802.1x simultaneously.

ISP Mode:. Wireless clients connected to ports 1:15-1:20, interfaces 1 and 2, are logged into the network in ISP mode using web-based network login. This is controlled by the VLAN in which they reside in unauthenticated mode and the RADIUS server Vendor Specific Attributes (VSA) Extreme-Netlogin-Vlan. Since the VLAN, *wlan-mgmt*, is the same, there will be no port movement.

When missing VSA, the port will stay at the same VLAN. If VSA returns the same VLAN as current, there will be no port movement.

Campus Mode: Wireless clients connected to ports 1:6 - 1:9, interfaces 1 and 2, are logged into the network in campus mode using web-based network login. This is because the clients are placed in the VLAN *corp* following authentication.

ISP and Campus modes are not tied to ports, but rather to a user profile. In other words, if the VSA `Extreme:Extreme-Netlogin-Vlan` represents a VLAN different from the one in which user currently resides, then for wired network login, VLAN movement occurs after login and after logout. For wireless network login, the clients are placed in the specified VLAN. The ports should already be added as tagged ports in the VLAN.

The example that follows uses these assumptions:

- Wired ISP users are connected to ports 1:10-1:14.
- Wireless campus users using web-based network login are connected to ports 1:6-1:9, interfaces 1 or 2.
- Wireless ISP users using web-based network login are connected to ports 1:15-1:20, interfaces 1 or 2.

NOTE

In the following configuration, any lines marked `(Default)` *represent default settings and do not need to be explicitly configured.*

```
create vlan "temp"
create vlan "corp"
create vlan wlan-mgmt

# Configure the wireless network.
configure vlan wlan-mgmt ipaddress 192.168.0.1
configure wireless management-vlan wlan-mgmt
configure vlan wlan-mgmt add ports 1:6-1:9 untagged
configure vlan wlan-mgmt add ports 1:15-1:20 untagged
enable wireless ports 1:6-1:9
enable wireless ports 1:15-1:20

# Configuration information for VLAN corp.
configure vlan "corp" ipaddress 10.203.0.224 255.255.255.0
configure vlan "corp" add port 1:15 - 1:20 tagged
configure vlan "corp" add port 1:6 - 1:9 tagged

# Configuration of generic web-based netlogin parameters
config netlogin base-url "network-access.net" (Default)
config netlogin redirect-page http://www.extremenetworks.com (Default)
enable netlogin Session-Refresh  3 (Default)

# Configuration information for wireless web-based campus network login.
configure vlan temp dhcp-address-range 192.168.32.20 - 192.168.32.80
configure vlan temp dhcp-options default-gateway 192.168.10.255
configure vlan temp dhcp-options dns-server 10.0.1.1
configure vlan temp dhcp-options wins-server 10.0.1.85
enable netlogin port 1:10 - 1:14 vlan corp
enable netlogin port 1:2 - 1:5 vlan temp

# Configuration information for wireless campus network login.
configure vlan wlan-mgmt dhcp-address-range 192.168.0.100 - 192.168.0.200
configure vlan wlan-mgmt dhcp-options default-gateway 192.168.0.1
configure vlan wlan-mgmt dhcp-options dns-server 10.0.1.1
configure vlan wlan-mgmt dhcp-options wins-server 10.0.1.85


# Configuration of security profiles for wireless network login
create security-profile web-based-netlogin
configure security-profile web-based-netlogin dot11-auth none network-auth web-based
encryption none
configure wireless port 1:6 - 1:9 interface 1 security-profile web-based-netlogin
configure wireless port 1:6 - 1:9 interface 2 security-profile web-based-netlogin
configure wireless port 1:15 - 1:20 interface 1 security-profile web-based-netlogin
configure wireless port 1:15 - 1:20 interface 2 security-profile web-based-netlogin

# DNS Client Configuration
configure dns-client add name-server 10.0.1.1
configure dns-client add name-server 10.0.1.85
```

The following is a sample of the settings for the RADIUS server:

```
#RADIUS server setting (VSAs)(optional)
session-Timeout = 60 (timeout for 802.1x reauthentication)
Extreme:Extreme-Netlogin-Only = Enabled (if no CLI authorization)
Extreme:Extreme-Netlogin-Vlan = "corp" (destination vlan for CAMPUS mode network
login)
```

Web-Based Authentication User Login Using Campus Mode

When web-based authentication is used in Campus mode, the user will follow these steps:

1 Set up the Windows IP configuration for DHCP.

2 Plug into the port that has network login enabled.

3 Log in to Windows.

4 Release any old IP settings and renew the DHCP lease.

This is done differently depending on the version of Windows the user is running:

— **Windows 9x**—use the `winipcfg` tool. Choose the Ethernet adapter that is connected to the port on which network login is enabled. Use the buttons to release the IP configuration and renew the DHCP lease.

— **Windows NT/2000**—use the `ipconfig` command line utility. Use the command `ipconfig/release` to release the IP configuration and `ipconfig/renew` to get the temporary IP address from the switch. If you have more than one Ethernet adapter, specify the adapter by using a number for the adapter following the ipconfig command. You can find the adapter number using the command `ipconfig/all`.

At this point, the client will have its temporary IP address. In this example, the client should have obtained the an IP address in the range 198.162.32.20 - 198.162.32.80.

NOTE

The idea of explicit release/renew is required to bring the network login client machine in the same subnet as the connected VLAN. In Campus Mode using web-based authentication, this requirement is mandatory after every logout and before login again as the port moves back and forth between the temporary and permanent VLANs. On other hand in ISP Mode, release/renew of IP address is not required, as the network login client machine stays in the same subnet as the network login VLAN. In ISP mode, when the network login client connects for the first time, it has to make sure that the machine IP address is in the same subnet as the VLAN to which it is connected.

5 Bring up the browser and enter any URL as `http://www.123.net` or `http://1.2.3.4` or switch IP address as http://<IP address>/login (where IP address could be either temporary or Permanent VLAN Interface for Campus Mode). URL redirection redirects any URL and IP address to the network login page. This is significant where security matters most, as no knowledge of VLAN interfaces is required to be provided to network login users, as they can login using a URL or IP address.

A page opens with a link for Network Login.

6 Click the Network Login link.

A dialog box opens requesting a username and password.

7 Enter the username and password configured on the RADIUS server.

After the user has successfully logged in, the user will be redirected to the URL configured on the RADIUS server.

During the user login process, the following takes place:

- Authentication is done through the RADIUS server.
- After successful authentication, the connection information configured on the RADIUS server is returned to the switch:
  - the permanent VLAN
  - the URL to be redirected to (optional)
  - the URL description (optional)
- The port is moved to the permanent VLAN.

  You can verify this using the `show vlan` command. For more information on the `show vlan` command, see “Displaying VLAN Settings” on page 132.

After a successful login has been achieved, there are several ways that a port can return to a non-authenticated, non-forwarding state:

- The user successfully logs out using the logout web browser window.
- The link from the user to the switch’s port is lost.
- There is no activity on the port for 20 minutes.
- An administrator changes the port state.

NOTE

Because network login is sensitive to state changes during the authentication process, Extreme Networks recommends that you do not log out until the login process is complete. The login process is complete when you receive a permanent address.

DHCP Server on the Switch

A DHCP server with limited configuration capabilities is included in the switch to provide IP addresses to clients. The DHCP server is not supported as a standalone feature. It is used only as part of the Network Login feature.

DHCP is enabled on a per port, per VLAN basis. To enable or disable DHCP on a port in a VLAN, use one of the following commands:

```
enable dhcp ports <portlist> vlan <vlan name>
disable dhcp ports <portlist> vlan <vlan name>
configure vlan <vlan name> netlogin-lease-timer <seconds>
```

The switch responds to DHCP requests for unauthenticated clients when DHCP parameters such as `dhcp-address-range` and `dhcp-options` are configured on the network login VLAN. The switch can also answer DHCP requests after authentication if DHCP is enabled on the specified port. If you want network login clients to obtain DHCP leases from an external DHCP server elsewhere on the network, then do not enable DHCP on the switch ports.

Displaying DHCP Information

To display the DHCP configuration, including the DHCP range, DHCP lease timer, network login lease timer, DHCP-enabled ports, IP address, MAC address, and time assigned to each end device, use the following command:

```
show vlan <vlan-name> dhcp-config
```

To display current leases (IP address, MAC address, and time assigned to each end device), use the following command:

```
show vlan <vlan name> dhcp-address-allocation
```

Network Login Configuration Commands

Table 36 describes the commands used to configure network login.

Table 36: Network Login Configuration Commands

Command	Description
enable netlogin [web-based | dot1x]	Enables the netlogin feature using web-based or 802.1x authentication. By default netlogin is disabled.
disable netlogin [web-based | dot1x]	Disables the netlogin feature for web-based or 802.1x authentication. By default netlogin is disabled.
show netlogin	Displays all network login parameters.
config netlogin [base-url | redirect-page] <url>	Configures the network login base URL or the network login redirect URL.
config vlan <name> dhcp-address-range <ipaddress1> - <ipaddress2>	Configures a set of DHCP addresses for a VLAN.
config vlan <name> dhcp-lease-timer <lease-timer>	Configures the timer value in seconds returned as part of the DHCP response.
config vlan <name> dhcp-options [default-gateway | dns-server | wins-server] <ipaddress>	Configures the DHCP options returned as part of the DHCP response by a switch configured as a DHCP server.
config vlan <name> netlogin-lease-timer <lease-timer>	Configures the timer value in seconds returned as part of the DHCP response for clients attached to network enabled ports. The default value is 10 seconds.
enable netlogin session-refresh <minutes>	Changes the refresh rate of the session. Specify the rate in minutes from 1 to 255. The default is 3 minutes.
enable dhcp ports <portlist> vlan <name>	Enables DHCP on a specified port in a VLAN without network login enabled or with network login authenticated.
enable netlogin ports <portlist> vlan <name>	Enables network login on a specified port in a VLAN.
disable dhcp ports <portlist> vlan <name>	Disables DHCP on a specified port in a VLAN.
disable netlogin ports <portlist> vlan <name>	Disables network login on a specified port in a VLAN.

Displaying Network Login Settings

To display network login settings, use the following command:

```
show netlogin {port <portlist> vlan <vlan name>}
```

This command displays the netlogin configuration along with wired network login clients. To view the wireless network login clients, use the following command:

```
show wireless ports <portlist> interface [1|2] clients
```

Example

```
#show netlogin info ports 9 vlan temporary
Port 9: VLAN: temporary
Port State: Not Authenticated
Temp IP: Unknown
DHCP: Not Enabled
User: Unknown MAC: Unknown
```

In this example, the user is using campus mode and no authentication has taken place. Therefore, the port state displays as not authenticated. No packets sent by the user on port nine pass the port until authentication takes place. After authentication has taken place and the permanent IP address is obtained, the show command displays the port state as authenticated.

```
#show netlogin info ports 9 vlan corp
Port 9: VLAN: corp
Port State: Authenticated
Temp IP: Unknown
DHCP: Not Enabled
User: auto MAC: 00:10:A4:A9:11:3B
```

Disabling Network Login

Network login must be disabled on a port before you can delete a VLAN that contains that port. To disable network login, use the following command:

```
disable netlogin ports <portlist> vlan <vlan name>
```

Wireless Network Login Considerations

As an authentication framework, network login is equivalent to MAC RADIUS authentication and does not directly support encryption (see “Unified Access MAC RADIUS” on page 290). Since MAC spoofing is easy in wireless networks, care is recommended when deploying web based network login.

Each wireless port must be manually configured as a tagged port for every VLAN in which it may be necessary to connect a client. If no RADIUS VSA is present, then the traffic is assigned to the untagged VLAN on the port.

NOTE

During authentication the RADIUS packets use the Alpine switch address as the client IP address. The Altitude 300 address is not disclosed.

Additional Configuration Details

This section discusses additional configuration details such as switch DNS names, a default redirect page, session refresh, and logout-privilege.

URL redirection requires the switch to be assigned a DNS name. The default name is `network-access.net`. Any DNS query coming to the switch to resolve switch DNS name in unauthenticated mode is resolved by the DNS server on the switch in terms of the interface (to which the network login port is connected) IP-address.

To configure the network login base URL (the URL for the login web page), use the following command:

```
configure netlogin base-url <url>
```

Where <url> is the DNS name of the switch. For example, `configure netlogin base-url network-access.net` makes the switch send DNS responses back to the netlogin clients when a DNS query is made for `network-access.net`.

To configure the network login redirect page, use the following command:

```
configure netlogin redirect-page <url>
```

Where `<url>` defines the redirection information for the users once logged in. This redirection information is used only in case the redirection info is missing from RADIUS server. For example, `configure netlogin base-url http://www.extremenetworks.com` redirects all users to this URL after they get logged in.

The network login session refresh is enabled by default on the switch. You can disable network login session refresh by using the following command:

```
disable netlogin session-refresh
```

To change the timer for the network login session refresh, use the following command:

```
enable netlogin session-refresh {<minutes>}
```

where `<minutes>` ranges from 1 - 255. The default setting is 3 minutes. `enable netlogin session-refresh {<minutes>}` makes the logout window refresh at the configured time interval. The purpose of this command is to log out users who are indirectly connected to the switch, such as through a hub. The command also monitors and logs out users who have disconnected the computer or have closed the logout window.

`Session-refresh` is disabled by default. When you configure the Network Login session refresh for the logout window on a BlackDiamond, ensure that the FDB aging timer is greater than the Network Login session refresh timer.

To enable or disable network login logout privilege, use one of the following commands:

```
enable netlogin logout-privilege
disable netlogin logout-privilege
```

This command turns the privilege for netlogin users to logout by popping up (or not popping up) the logout window. `Logout-privilege` is enabled by default.

To enable or disable network login, use one of the following commands:

```
enable netlogin [web-based | dot1x]
disable netlogin [web-based |dot1x]
```

By default netlogin is enabled.

To show all network login parameters, use the following command:

```
show netlogin
```

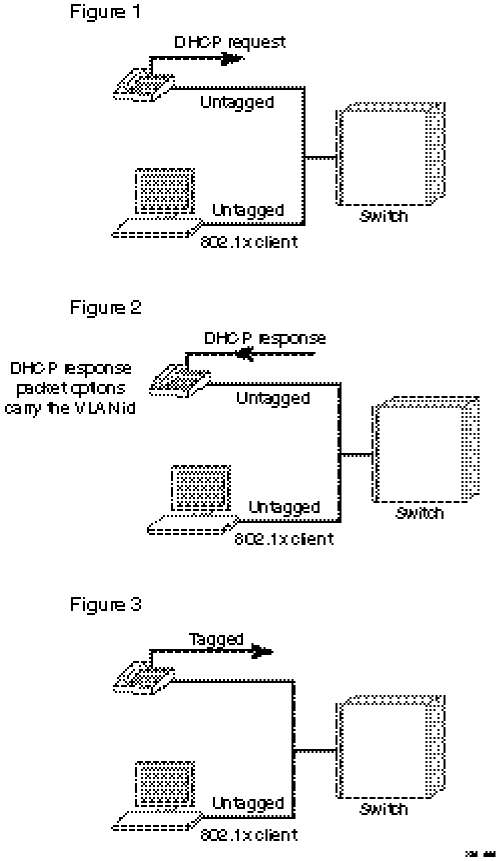
Trusted Organizational Unique Identifier

The Trusted Organizational Unique Identifier (OUI) feature allows devices, such as IP phones, without 802.1x (Network Login) capability to obtain IP addresses through DHCP on a network login enabled port.

A trusted OUI configuration requires an IP phone and a desktop PC, both of which are connected to a single wired port on an Extreme Networks switch. The desktop PC must use untagged 802.1x authentication. The IP phone must be capable of sending DHCP requests after booting up to obtain IP address and VLAN ID through the DHCP response. The phone then configures itself to be tagged for the VLAN ID obtained through the DHCP response.

Figure 37shows the sequence of operation for the trusted OUI feature.

Figure 37: Trusted OUI sequence of operation



Trusted OUI and Trusted MAC CLI Commands

The switch forwards packets based on the MAC addresses, independent of the 802.1x port state.Prio to this feature, a network login enabled port cannot be part of a different tagged VLAN. This does not apply if the trusted MAC feature is enabled on both a global and a VLAN basis.

New CLI commands have been introduced to configure this feature. The following describes each command:

- Use the `create trusted-mac-address` command to configure a trusted MAC -address. The `mask` keyword is optional. If you do not specify a mask, the default mask of ff:ff:ff:ff:ff:ff is used. If you do not specify a port list, the trusted MAC is applied to all of the ports in the VLAN. Devices matching a created trusted-OUI list are allowed to bypass network login using a specified protocol.

```
create trusted-mac-address {mac-addresss} <xx:yy:zz:aa:bb:cc> {mask
<dd:ee:ff:gg:hh:kk>} vlan <vlan-name | all> {port <portlist>} {protocol[DHCP|ARP]}
```

- Use the `delete trusted-mac-address` to delete a MAC address. If you do not specify the MAC address to be deleted, all the MAC addresses in the VLAN are deleted.

```
delete trusted-mac-address {mac-address} <xx:yy:zz:aa:bb:cc> {mask
<dd:ee:ff:gg:hh:kk>} vlan <vlan-name | all> {port <portlist>} {protocol[DHCP|ARP]}
```

- Use the `enable trusted-mac-address` command to enable trusted OUI or MAC addresses for port-specific configurations. Disabling this feature will not remove the previous port-specific configurations. The system default is `disable trusted-mac-address`.

```
enable trusted-mac-address {vlan <vlan-name>}
```

The global trusted MAC feature should be enabled globally and also with a VLAN for this feature to be effective.

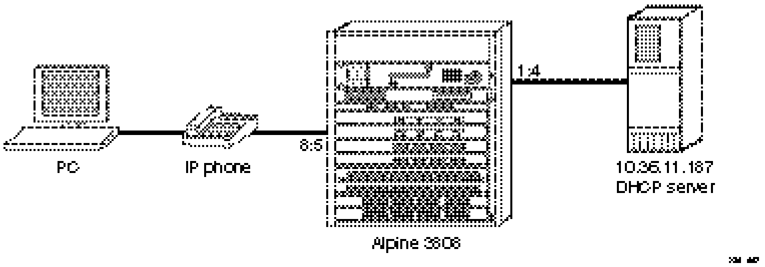
- Use the `disable trusted-mac-address` command to disable trusted OUI or MAC addresses for port-specific configurations. Disabling this feature will not remove the previous port-specific configurations.

```
disable trusted-mac-address {vlan <vlan-name>}
```

- Use the `show trusted-mac-address` command to display the status of the enable/disable keywords and then displays all of the configured trusted MAC addresses.

```
show trusted-mac-address {vlan <vlan-name>} {port <portlist>}
```

Figure 38: show trusted mac-address Command Sequence



```
Command sequence

create vlan "voice"
configure vlan "voice" tag 120
configure vlan "voice" ipaddress 20.36.11.1 255.255.255.0
configure vlan "voice" add port 8:5 tagged
enable ipforwarding vlan "voice"

create vlan "corp"
configure vlan "corp" tag 9
configure vlan "corp" ipaddress 10.36.11.186 255.0.0.0
configure vlan "corp" add port 8:5 untagged
configure vlan "corp" add port 1:4 tagged
enable ipforwarding vlan "corp"

enable netlogin port 8:5 vlan corp

create trusted-mac-address mac-address 00:04:0D:28:45:C2 mask FF:FF:FF:FF:FF:FF
corp ports 8:5 protocol dhcp
enable trusted-mac-address
enable trusted-mac-address vlan corp

enable bootprelay
configure bootprelay add 10.36.11.187
```

Unified Access Security

The Extreme Unified Access™ Security architecture provides secure access for all wired and wireless stations within the unified network. You can maintain the network with a single, unified security policy, provide service to all stations without requiring upgrades, and take advantage of integrated policy and management capabilities not available in overlay networks or those with “thick” access points. Unified Access Security provides the following capabilities:

- Consolidated management — Up to 16 wireless ports from a single Alpine switch, greater network support with reduced management overhead
- Scalable encryption — ASIC based AES encryption, WPA with TKIP support, and RC4 based WEP support on the Altitude 300 wireless port
- 802.1x Authentication — 802.1x authentication (PEAP, EAP-TTLS, EAP-TLS)
- Web-based network login—http and https based user authentication

The unified structure simplifies security policies without compromising protection and provides the following benefits:

- Single user experience — Same authentication procedures for wired and wireless users
- Unified management — Single management platform for wired and wireless networks

- Unified configuration — Consistent CLI for wired and wireless functions
- Single authentication infrastructure — Single set of policies, RADIUS, and certificate servers

Table 37 summarizes the wireless security options available with the Alpine switch. Campus mode refers to a network with multiple users who connect at different places. ISP mode refers to a network with stationary users who access the network through the same port each time. The per user VLANs assignment column indicates whether users can be placed in a VLAN when they are authenticated according to the given method.

Table 37: Wireless Security Options

Wireless Security Feature	Campus Mode	ISP Mode	Per User VLANs Assignment
802.1x - Single Supplicant	X	X	X
802.1x - Multiple Supplicants	X	X	X
Web-based Netlogin Single Supplicants	X	X	X
Web-based Netlogin Multiple Supplicants	X	X	X
MAC Radius - Single Client	X	X	X
MAC Radius - Multiple Clients	X	X	X

Wireless User Access Security

Effective user security meets the following objectives:

- Authentication — Assuring that only approved users are connected to the network at permitted locations and times.
- Privacy — Assuring that user data is protected.

Authentication

The authentication process is responsible for screening users who attempt to connect to the network and granting or denying access based on the identity of the user, and if needed, the location of the client station and the time of day. The authentication function also includes secure encryption of passwords for user screening.

For an authentication scheme to be practical and effective, it must be compatible with the currently-installed client software base. That requires accommodating multiple versions of software, including legacy systems with older-generation security support. Effective authentication is mutual, from client-to-network and network-to-client. Finally, authentication requires the appropriate authentication servers.

The Unified Access Architecture provides authentication methods that meet all these requirements, while also permitting flexibility for individual network environments.

Authentication Method: Open. The Alpine switch and associated Altitude 300 wireless ports, support 802.11 open system authentication, in which the station identifies the SSID. Although open authentication can be acceptable for wired networks, it is not effective on the wireless side, and is therefore not recommended for the enterprise wireless network.

Authentication Method: WEP. Wired Equivalency Privacy (WEP) is the first generation security option for 802.11 networks and includes both an authentication and encryption (privacy) mechanism. Unfortunately, weaknesses in the RC4 encryption scheme have left the WEP method open to theft of login and password information and, consequently, to compromise of the authentication process. WEP is best used as part of a multi-tiered security scheme and in legacy environments.

Authentication Method: 802.1x/EAP. Extensible Authentication Protocol (EAP) provides numerous improvements over earlier generation WEP authentication methods. The 802.1x specification incorporates EAP as implemented directly on Ethernet. In 802.1X/EAP authentication, the user's identity, not MAC address, is the basis for authentication. When the user requests access to the wireless port, the access point forces the user's station into an unauthorized state. In this state, the client station sends an EAP start message. The switch responds with a request for user identity, which it passes to a central authentication server. The server software authenticates the user and returns an permit or deny message to the switch, which then extends or denies access as instructed, and passes along configuration information such as VLAN and priority.

802.1x supports several EAP-class advanced authentication protocols, which differ in the specific identification types and encryption methods for the authentication:

- EAP-TLS (Transport Layer Security) — Performs mutual authentication using security certificates. Good for wired and wireless networks
- EAP-TTLS (Tunneled TLS) — Extends TLS flexibility and is compatible with a wide range of authentication algorithms. Good for wired and wireless networks
- PEAP (protected EAP) — Is compatible with a wide range of authentication algorithms and is effective for wired and wireless networks

802.1x security is compatible with legacy 802.1x and with newer clients that support Wi-Fi Protected Access (WPA) based 802.1x. It is possible to configure both versions (legacy and WPA) on the same Alpine switch port. When a client associates to the Alpine switch port, it indicates 802.11 open authentication. Then if 802.1x is enabled on the port, the client is able to associate, and further authentication is performed. If the authentication is successful, a backend RADIUS server optionally specifies a VLAN tag using Vendor Specific Attributes in the Access Accept message.

Location Based Authentication. Location-based authentication restricts access to users in specific buildings. The Alpine switch sends the user's location information to the RADIUS server, which then determines whether or not to permit user access. When you configure a location field, the information is sent out in RADIUS access request packets as a VSA and can be used to enforce location-based policies.

Time-Based Authentication. Time-based authentication restricts access to users to certain dates or times. The RADIUS server can determine policies based on the time of day when the authentication request is received from the Alpine switch.

Encryption

Encryption is used to protect the privacy and integrity of user data sent over the network. It is a major concern in wireless networks, since physical security is not possible for data sent over wireless links. While encryption is the major component of a privacy solution, an effective approach also requires management of encryption keys, integrity checks to protect against packet tampering, and ability to scale as the network grows.

Cipher Suites

Table 38 lists several cipher suites that standards organizations have identified to group security capabilities under a common umbrella. The Extreme Unified Security Architecture supports or will incorporate each of these suites, and the Altitude 300 wireless port supports hardware-based AES and RC4 encryption.

Table 38: Wi-Fi Security Cipher Suites

Name	Authentication	Privacy	Sponsoring Organization
WEP	None or MAC	WEP/RC4	IEEE
WPA	802.1x	TKIP/RC4	Wi-Fi Alliance
WPA	802.1x	CCMP/AES/TKIP	IEEE

WPA-Only Support. To support WPA clients, the Alpine switch port sets the privacy bit in the beacon frames it advertises. The switch also advertises the set of supported unicast and multicast cipher suites and the configured and supported authentication modes as part of the association request.

WPA support is compatible with 802.1x authentication and with pre-shared keys. With pre-shared keys, key derivation and distribution are done using the EAPOL-KEY messages. All clients that indicate PSK are assigned to the default user VLAN, which is configured on the Alpine switch port.

Legacy and WPA 802.1x Support. When network authentication is set to dot1x, WPA clients can use TKIP for their unicast data exchange and the specified WEP64 or WEP128 cipher for multicast traffic. Legacy 802.1x clients should use the specified WEP64 or WEP128 cipher for both their unicast and multicast cipher.

Network Security Policies for Wireless Interfaces

Network security policy refers to a set of network rules that apply to user access. You can base the rules on a variety of factors, including user identification, time and location, and method of authentication. It is possible to design network security policies to do all of the following:

- Permit or deny network access based on location and time of day.
- Place the user into a VLAN based on identity or authentication method.
- Limit where the user is permitted to go on the network based on identity or authentication method.

Policy Design

When designing a security policy for your network, keep the following objectives in mind:

- Make each wired and wireless client as secure as possible.
- Protect company resources.
- Make the network infrastructure as secure as possible.
- Be able to track and identify wired and wireless rogues.

To achieve these objectives, it is necessary to work within the constraints of your environment:

- Technology of all the clients
  - — 802.11 radio technology (b, a, g, a/b, a/g)

- — Operating system (W2K, XP, Pocket PC, ….)
- — Client readiness for 802.1x; client upgrades

- Authentication servers available or planned
  - — Operating System Login only (i.e. Domain Access, LDAP)
  - — RADIUS for Users
  - — PKI Infrastructure
- Nature of the user population
- Ability to divide users into meaningful groups
- Network resources required by users
- Desired access restrictions based on resources, locations, times, and security level
- Acceptable level of network management and user training
- Anticipated changes in the network

Policy Example

You want to restrict user access to certain locations or times. The solution is to include the Altitude 300 as a component of network access and include time restrictions for certain locations.

Policies and RADIUS Support

The authentication features of the Alpine switch are tightly integrated with RADIUS. You can specify the following types of RADIUS access control policies:

- User-based — 802.1x requests provide the RADIUS server with the user name and password. Based on the user name, the RADIUS server sends back authentication information, including allow/deny, assigned VLAN, and VLAN tag.
- Location-based — You can configure a location string for each wireless port. The location is sent to the RADIUS server as a vendor-specific attribute. The RADIUS server uses this information to determine the access policy.

RADIUS Attributes

Table 39 lists the attributes included in each request for access:

Table 39: RADIUS Request Attributes

Attribute	Description
User-Name	User name for dot1x or MAC address
User-Password	User-specified for dot1x or blank
Service-Type	Value is login (1)
Vendor-Specific	Extreme-vendor 1916

Vendor-Specific Attributes. Table 40 lists the supported vendor-specific attributes (VSAs).

Table 40: Vendor-Specific Attributes

VSA	Attribute Value	Type	Sent In
EXTREME_NETLOGIN_VLAN	203	String	Access-accept
EXTREME_NETLOGIN_VLAN_TAG	209	Integer	Access-accept
EXTREME_USER_LOCATION	208	String	Access-request

The following rules apply for VSAs:

- For locations, the switch receives Extreme VSA containing the location of the Altitude 300. The RADIUS server uses the location VSA to determine whether to allow or deny access.
- For WPA and legacy 802.1 clients, the RADIUS server sends the VLAN value to use for the client.

Security Profiles

A security profile is the mechanism that prevents persons who do not have proper access authority or the proper credentials from accessing a wireless network. A security profile also helps:

- Establish access levels for different groups
- Regulate the flow of user data traffic after authentication using VLANs
- Manage users
- Stop access for some users by setting time or date limits.

Security profiles can have different authentication and encryption methods such as static WEP, 802.1x, WPA-PSK, and WPA-Dynamic. A radio interface may only have one security profile, however, the same security profile can be attached to multiple interfaces.

The security profile is configured on the switch and its downloaded to the AP after it is powers up. The following security profile commands are described in detail in the *ExtremeWare Command Reference Guide*:

Creating Security Profiles

This section describes the commands used to:

- Create a new security profile
- Copy values from an existing security profile
- Delete a security profile

To create a new security profile, use the following command:

```
create security-profile <name> {copy <existing_profile>}
```

You can optionally use this command to copy an existing profile and then apply a new name to create a new security profile.

To delete a security profile, use the following command:

```
delete security-profile <name>
```

Cofiguring Security Profile Authentication and Encryption

This section describes the command used to configure authentication and encryption properties for security profiles.

To configure dot11 authentication, network authentication, and encryption type, use the following command:

```
configure security-profile <name> dot11-auth [open | shared] network-auth [none |
dot1x |mac-radius |web-based | wpa | wpa-psk] encryption [none | aes |tkip | wep64 |
wep128]
```

Table 41 lists the valid combinations of authentication and encryption:

Table 41: Security Configuration Options

Dot11 Authentication	Network Authentication	Encryption
open	none	Choices: • none • wep64 • wep128
open	web-based	Choices: • none • wep64 • wep128
open	mac-radius	Choices: • none • wep64 • wep128
open	dot1x	Choices: • wep64 • wep128
open	wpa	Choices: • wep64 • wep128 • tkip • aes
open	wpa-psk	Choices: • wep64 • wep128 • tkip • aes
shared	none	Choices: • wep64 • wep128
shared	web-based	Choices: • wep64 • wep128
shared	mac-radius	Choices: • wep64 • wep128

Configuring Security Profile Properties

This section describes commands used to configure security profiles. Configuration properties for security profiles are grouped according to the following categories:

- General properties
- WPA properties
- WEP properties
- Authentication and Encryption properties

Configuring General Properties. This section describes commands used to configure general properties for security profiles.

To configure the default data VLAN for wireless users, use the following command:

```
configure security-profile <name> default-user-vlan <vlan>
```

Wireless users are placed in `default-user-vlan` after authentication. Users who do not have a VSA-VLAN assignment on the RADIUS server are placed in this VLAN.

To set the name of the wireless network for the 802.11 interface associated with the security profile, use the following command:

```
configure security-profile <name> ess-name <ess_name>
```

ESS names can be shared across wireless ports and interfaces.

To establish whether the service set identifier (SSID) is advertised in the beacon frame, use the following command:

```
configure security-profile <name> ssid-in-beacon {on | off}
```

The beacon turns on whether the SSID is published in the beacon or not. If you set this command to off, then the beacon does not contain the SSID and the client must know the SSID before it can associate. Sniffing on the beacon shows an empty SSID.

Configuration changes take effect immediately and are propagated to all ports sharing the named profile. If the command fails, none of the changes is propagated to any of the ports.

To determine whether the security profile uses the dynamic VLAN (VLAN pushed by the RADIUS server through a VSA (Vendor Specific Attribute)), use the following command:

```
configure security-profile <name> use-dynamic-vlan {y | n}
```

If the variable is set to `Y` (yes), VSAs 203, 209 are expected from the RADIUS server. If the variable is set to `N` (no), then no VSA is expected from the RADIUS server, and the user will be placed in `default-user-vlan` after authentication. Use the following command to configure the `default-user-vlan`:

```
configure security-profile <name> default-user-vlan <vlan>
```

Configuring WPA Properties. This section describes commands used to configure WPA properties for security profiles.

When the network-authentication is set to dot1x, WPA, or WPA-PSK, the following command configures the interval when group keys for dot1x and WPA clients are updated:

```
configure security-profile <name> dot1x-wpa group-update-timer <minutes>
```

Use the dot1x configuration command to change WPA and dot1x key update time values. Change timers only when you do not want the keys to be updated frequently.

When the network-authentication is set to dot1x, WPA, or WPA-PSK, the following command configures the interval when pairwise keys for dot1x and WPA clients are updated:

```
configure security-profile <name> dot1x-wpa pairwise-update-timer <minutes>
```

When the network-authentication is set to dot1x or WPA, the following command configures the interval when clients are re-authenticated:

```
configure security-profile <name> dot1x-wpa reauth-period <seconds>
```

To configure the WPA pre-shared key, use the following command:

```
configure security-profile <name> wpa-psk [hex <hexadecimal_digit> | passphrase
<alphanumeric_string>]
```

Configuring WEP Properties. This section describes commands used to configure WEP properties for security profiles.

To set the default key index for the security profile in case of static WEP encryption, use the following command:

```
configure security-profile <name> wep default-key-index <index>
```

To add the given WEP key at the specified index, use the following command:

```
configure security-profile <name> wep key add <index> [hex <hexoctet> | plaintext
<string>]
```

This key is used for WEP encryption. If you use hex mode, then the key should be made up of hex digits (i.e., if encryption-length is 64 the key should be 10 hex digits (64-24 (ICV) = 40bits = 5 bytes = 10 hex digits). When you specify plaintext mode, the key is simply the ASCII value of the letters in the specified key (for example, A = 35 and so on...). Plaintext does not mean passphrase.

Configuration changes take effect immediately and are propagated to all ports sharing the named profile. If the command fails, none of the changes is propagated to any of the ports.

To delete a specified WEP key, use the following command:

```
configure security-profile <name> wep key delete <integer>
```

When you delete a WEP key whose index is the default WEP key index, then the default index is changed automatically to the lowest specified WEP key (or N/A if no WEP keys have been specified).

Viewing Security Profiles

This section describes the command used to display security profile properties.

To display the configured parameters of the security profile, use the following command:

```
show security-profile {<name>}
```

Secure Web Login Access

The existing web server in ExtremeWare allows HTTP clients to access the VISTA pages (for management) and access the network login page (for network login users). By using HTTPS on the web server, wireless clients can securely access the network login page using a HTTPS enabled web browser.[1]

HTTPS access is provided through Secure Socket Layer (SSLv3) and Transport Layer Security (TLS1.0). These protocols enable clients to verify the authenticity of the server to which they are connecting, thereby ensuring that wireless users are not compromised by intruders. SSL supports encryption of the data exchanged between the server and the client, preventing the network login credentials from exposure on the wireless channel.

A default server certificate is provided in the factory default configuration. The following security algorithms are supported:

- RSA for public key cryptography (generation of certificate and public-private key pair, certificate signing). RSA key size between 1024 and 4096 bits
- Symmetric ciphers (for data encryption): RC4, DES and 3DES
- Message Authentication Code (MAC) algorithms: MD5 and SHA

The following command enables HTTP on the default port (80):

```
enable web http
```

To disable HTTP on the web, enter the following command:

```
disable web http
```

To enable secure HTTP (HTTPS) on the default port (443), enter the following command:

```
enable web https
```

To disable HTTP, enter the following command:

```
disable web https
```

However, if you want to enable HTTP on a non-default port, use the following command:

```
enable web http access-profile [none | <access-profile>] port <port number>
```

The corresponding command for HTTPS is:

```
enable web https access-profile [none | <access-profile>] port <port number>
```

To display session information, including HTTPS sessions, enter the following command:

```
show session
```

You can also use the following command to display whether the switch has a valid private and public key pair and the state of HTTPS access:

```
show management
```

Creating Certificates and Private Keys

A default certificate and private key are stored in the NVRAM factory default settings. The certificate generated is in X509v3 format. The certificate generated is in PEM format.

To create a self-signed certificate and private key that can be saved in NVRAM, enter the following command:

```
configure ssl certificate prikeylen <length> country <code> organization <org_name>
common-name <name>
```

[1] HTTPS is allowed only in an SSH build with the appropriate license enabled.

Be sure to specify the following:

- Country code (exactly 2 characters),
- Organization name (max size of 64 characters) and
- Common Name (max size of 64 chars) in the command.

Any existing certificate and private key is overwritten.

Most web browsers check whether the common-name field in the received server certificate is the same as the URL used to reach the site, otherwise they give a warning.

The size of the certificate generated depends on the RSA Key length (privkeylen) and the length of the other parameters (country, organization name etc.) supplied by the user. If the RSA key length is 1024, then the certificate size is ~ 1kb and the private key length is ~1kb. For RSA Key length of 4096, the certificate length is ~2kb and the private key length is ~3kb

Downloading a Certificate Key from a TFTP Server. You can download a certificate key from files stored in a TFTP server. If the operation is successful, any existing certificate is overwritten. After a successful download, the software attempts to match the public key in the certificate matches the private key stored. If the private and public keys do not match, a warning message is displayed ("Warning: The Private Key does not match with the Public Key in the certificate."). This warning acts as a reminder to the user to also download the private key.

The certificate and private key should be in PEM format and generated using RSA as the cryptography algorithm.

Use the following command to download a certificate key from files stored in a TFTP server:

```
download ssl <ip address> certificate <cert file>
```

To see whether the private key matches with the public key stored in the certificate, use the following command:

```
show ssl
```

This command also displays:

- HTTPS port configured. This is the port on which the clients will connect.
- Length of RSA key (number of bits used to generate the private key)
- Basic information about the stored certificate

To also see the full certificate, use the `detail` keyword:

```
show ssl {detail}
```

Downloading a Private Key from a TFTP Server. To download a private key from files stores in a TFTP server, use the following command:

```
download ssl <ip address> privkey <key file>
```

When this command is executed, if the private key is encrypted, the user is prompted to enter the passphrase that was used to encrypt the private key when the private key was generated. Only DES and 3DES encryption mechanisms are supported for private key encryption. If the operation is successful the existing private key is overwritten.

After the download is successful, a check is performed to find out whether the private key downloaded matches with the public key stored in the certificate. If they do not match, a warning message is displayed (“Warning: The Private Key does not match with the Public Key in the certificate.”). This warning acts as a reminder to the user to download the corresponding certificate.

The certificate and private key file should be in PEM format and generated using RSA as the cryptography algorithm.

Configuring Pre-generated Certificates and Keys. Use the following command to get the pre-generated certificate from the user:

```
configure ssl certificate pregenerated
```

This command is also used when downloading/uploading the configuration. The certificate information stored in the uploaded configuration file should not be modified, because it is signed using the issuer’s private key.

The certificate and private key file should be in PEM format and generated using RSA as the cryptography algorithm.

To get a pre-generated private key from the user, user the following command:

```
configure ssl privkey pregenerated
```

This command will also be used when downloading/uploading the configuration. The private key will be stored in the uploaded configuration file in an encrypted format using a hard coded passphrase. Hence the private key information in the configuration file should not be modified.

The certificate and private key file should be in PEM format and generated using RSA as the cryptography algorithm.

Unified Access MAC RADIUS

Unified Access MAC RADIUS is a mechanism for authenticating wireless users in a legacy environment. The RADIUS server is populated with the MAC addresses of all clients, which are used as the basis of authentication. The Altitude 300 sends out an Access-Request packet to the RADIUS server with the user name and password set to the MAC address of the client. If the Access-Request is successful, then the client is placed in a forwarding state. If the Access-Request fails then the client is deauthenticated.

During the authentication process, when the Altitude 300 has sent the request to the RADIUS server and is waiting for a response, any traffic generated by the client is blocked. This means that DHCP and DNS packets will be dropped during this time. Since the clients are not aware of MAC RADIUS authentication, this may possibly cause a problem for the client.

NOTE

MAC RADIUS is an authentication protocol, not a privacy protocol. Due to the ease with which MAC addresses can be spoofed on a wireless network, MAC RADIUS should be used only for legacy clients that do not support any other advanced authentication schemes.

Managing Wireless Clients

This section describes the commands for configuring interactions with client stations. The Port Authentication Entity (PAE) is used during Extensible Authentication Protocol (EAP) exchange.

To display wireless client state, user the following command:

```
show wireless ports [<portlist> | all] interface [1 | 2] clients {detail}
```

Client current state information is available for all clients that have sent an authentication message to the Altitude 300. Information in the client state table is timed out if no packets are received from the client by the configurable period of time set by the administrator.

The following example shows the clients on port 1:8 on interface 1:

```
show wireless ports 1:8 interface 1 clients
```

It produces output similar to the following:

```
                          Wireless Client Statistics
MAC ADDR          Port   STATE    ENC     AUTH      TIME     RSS
================================================================================
00:09:5B:A1:1F:8F 1:1  FORWARD  AES     PSK       4:36:20  200
```

To display PAE diagnostics for the selected port and interface, user the following command:

```
show wireless ports [<portlist> | all] interface [1 | 2] pae-diagnostics
```

Use this command to display the PAE diagnostics of the clients associated with the access point (AP).

The following example lists the output of the PAE diagnostics for ports 1:11 on interface 2:

```
show wireless ports 1:11 interface 2 pae-diagnostics
```

The output of the command is similar to:

```
                 PAE Diagnostic Statistics
CLIENT MAC        Port  Intf Failures Timeouts Success  Logoffs  ReAuth
================================================================================
00:0D:54:98:AC:35 1:25   1      0        0       2       0        0
```

To display PAE statistics for the selected port and interface, user the following command:

```
show wireless ports [<portlist> | all] interface [1 | 2] pae-statistics
```

Use this command to display the PAE statistics of the clients associated with the AP.

The following example lists the output of the PAE statistics for ports 1:11 on interface 2:

```
show wireless ports 1:11 interface 2 pae-statistics
```

The output of the command is similar to:

```
                                PAE Statistics
CLIENT MAC        Port  Intf STATE   TX     RX     ERRORS CLIENT ID
================================================================================
00:0D:54:98:AC:35 1:25 1    AUTHED  16     17     0      sqalab\labu
```

Example Wireless Configuration Processes

This section provides examples of configuration processes. In the first example, the wireless management VLAN is configured, IP addresses are assigned, and RF profiles are created and configured. Next, security profile examples are given for a variety of security options. Finally, example steps are provided for assigning profiles to ports.

NOTE

The commands provided in each step are examples.

Security reference options used in the configuration examples are provided for reference in Table 41 on page 285.

Wireless Management Configuration Example

Refer to the following example when configuring VLAN, IP addresses, and RF profiles.

NOTE

Any addition, deletion or movement of wireless ports from vlan to vlan must be preceded by disabling the wireless port(s).

Configure the VLAN, Wireless Port IP Addresses and RF-profiles: . Follow these steps:

1 Create a vlan to be use as the wireless management VLAN.

```
create vlan manage-wireless
```

2 Remove the wireless port from the default VLAN.

```
config vlan default delete ports 1:5
```

NOTE

NOTE: Following warning message may be displayed as a result of the above command. This will not prevent the port from being deleted from the default vlan:

```
WARNING: Security profile applied to port 1:5 refers to the VLAN Default. Removing
the port from the VLAN will cause incorrect behavior
```

3 Add the wireless port to the management VLAN as an untagged port.

```
config vlan manage-wireless add ports 1:5 untagged.
```

4 Assign an IP address to the VLAN.

```
config vlan manage-wireless ipaddress 10.211.37.1/24
```

5 Configure this VLAN as the management VLAN.

```
config wireless management-vlan manage-wireless
```

NOTE

Following warning message may occur as a result of the above command. This will not prevent the command from executing.

```
Warning: Changing the management VLAN can cause access points to loose contact with
LAC.
```

6 Assign a management IP address for each wireless port (port 1:5 in the example). Be sure that the address is in the same network as the wireless management-vlan.

```
config wireless port 1:5 ip-address 10.211.37.105
```

7 Create an RF profile for the A interfaces by copying from the default profile.

```
create rf-profile RF_A copy DEFAULT_A
```

8 Create an RF profile for the G interfaces by copying from the default profile.

```
create rf-profile RF_G copy DEFAULT_G
```

Security Configuration Examples

Refer to the examples in this section when configuring any of the available wireless security options for the Alpine switch. The examples encompass most typical security scenarios.

NOTE

Because of the requirement to add potential wireless ports to the wireless management-vlan as untagged ports, adding a wireless port to a data/client vlan requires that the port be added as a tagged port.

NOTE

The "default-user-vlan" parameter is NOT used as a destination vlan in the case of an authentication failure. For this parameter, if the client authentication succeeds, the client will be placed into the VLAN indicated in the parameter or into the VLAN indicated by a Vendor Specific Attribute (VSA) VLAN-ID or VLAN Name. Any authentication failures will deny the client access to the network.

NOTE

In the following examples, the heading of each example is formatted as follows:

Dot11 Authentication – Network Authentication – Encryption/Multicast Cipher

Open - None - None. Follow these steps:

1 Create a security profile (open-auth) by copying from the default unsecure profile.

```
create security-profile open-auth copy unsecure
```

2 Create a VLAN (open-vlan) for the potential clients that will connect to the network using this security-profile.

```
create vlan open-vlan
```

3 Configure the tag for the VLAN

```
config vlan open-vlan tag 10
```

4 Add the wireless port to the VLAN.

```
config vlan open-vlan add ports 1:5 tagged
```

5 Configure the Dot11 Authentication, Network Authentication and Multicast Cipher/Encryption and also assign the "default-user-vlan" parameter.

```
config security-profile open-auth dot11-auth open network-auth none encryption none
config security-profile open-auth default-user-vlan open-vlan
```

6 Configure the name of the ESS

```
config security-profile open-auth ess-name open-ess
```

Open - None – Wep 64. Follow these steps:

1 Create a security profile (wep-secure) by copying from the default unsecure profile.

```
create security-profile wep-secure copy unsecure
```

2 Create a VLAN (wep-vlan) for the potential clients that will connect to the network using this security-profile.

```
create vlan wep-vlan
```

3 Configure the tag for the VLAN

```
config vlan wep-vlan tag 10
```

4 Add the wireless port to the VLAN.

```
config vlan wep-vlan add ports 1:5 tagged
```

5 Configure the Dot11 Authentication, Network Authentication and Multicast Cipher/Encryption and also assign the "default-user-vlan" parameter.

```
config security-profile wep-secure dot11-auth open network-auth none encryption
wep64
config security-profile wep-secure default-user-vlan wep-vlan
```

NOTE

If you attach this security-profile to a port before configure at least 1 WEP key, an error message will be generated:

```
Warning: At least one WEP key has to be specified before applying this security
profile to the interface
```

6 Configure the security profile with WEP key to match the encryption length indicated in Step 5.

```
config security-profile wep-secure wep key add 0 hex abcdefaaaa
```

NOTE

If you enter the wrong number of characters for the code, a message similar to the following appears.

```
Invalid number of bytes in key. Expected <xx> bytes, got <yy> bytes.
```

7 Configure the security profile to use the 0 key you just defined as the default encryption key.

```
config security-profile wep-secure wep default-key-index 0
```

8 Configure the name of the ESS

```
config security-profile wep-secure ess-name open-wep64-ess
```

Open - None – WEP 128. Follow these steps:

1 Create a security profile (wep-secure) by copying from the default unsecure profile.

```
create security-profile wep-secure copy unsecure
```

2 Create a VLAN (wep-vlan) for the potential clients that will connect to the network using this security-profile.

```
create vlan wep-vlan
```

3 Configure the tag for the VLAN

```
config vlan wep-vlan tag 10
```

4 Add the wireless port to the VLAN.

```
config vlan wep-vlan add ports 1:5 tagged
```

5 Configure the Dot11 Authentication, Network Authentication and Multicast Cipher/Encryption and also assign the “default-user-vlan” parameter.

```
config security-profile wep-secure dot11-auth open network-auth none encryption
wep128
config security-profile wep-secure default-user-vlan wep-vlan
```

NOTE

If you attach this security-profile to a port before configure at least 1 WEP key, an error message will be generated:

```
Warning: At least one WEP key has to be specified before applying this security
profile to the interface
```

6 Configure the security profile with WEP key to match the encryption length indicated in Step 5.

```
config security-profile wep-secure wep key add 0 hex aaaaaaaaaaaaacccccccccccccc
```

NOTE

If you enter the wrong number of characters for the code, a message similar to the following appears.

```
Invalid number of bytes in key. Expected <xx> bytes, got <yy> bytes.
```

7 Configure the security profile to use the 0 key you just defined as the default encryption key.

```
config security-profile wep-secure wep default-key-index 0
```

8 Configure the name of the ESS

```
config security-profile wep-secure ess-name open-wep128-ess
```

Open – Web Based Network Login - None. Follow these steps:

1 Create a security profile (web-based-open) by copying from the default unsecure profile.

```
create security-profile web-based-open copy unsecure
```

2 Create a VLAN (web-vlan) for the potential clients that will connect to the network using this security-profile.

```
create vlan web-vlan
```

3 Configure the tag for the VLAN

```
config vlan web-vlan tag 10
```

4 Add the wireless port to the VLAN.

```
config vlan web-vlan add ports 1:5 tagged
```

5 Configure the Dot11 Authentication, Network Authentication and Multicast Cipher/Encryption and also assign the “default-user-vlan” parameter.

```
config security-profile web-based-open dot11-auth open network-auth web-based
encryption none
config security-profile web-based-open default-user-vlan web-vlan
```

6 Configure the name of the ESS

```
config security-profile web-based-open ess-name open-web-ess
```

Open – Web Based Network Login - WEP 64. Follow these steps:

1 Create a security profile (web-based-64) by copying from the default unsecure profile.

```
create security-profile web-based-64 copy unsecure
```

2 Create a VLAN (web-vlan) for the potential clients that will connect to the network using this security-profile.

```
create vlan web-vlan
```

3 Configure the tag for the VLAN

```
config vlan web-vlan tag 10
```

4 Add the wireless port to the VLAN.

```
config vlan web-vlan add ports 1:5 tagged
```

5 Configure the Dot11 Authentication, Network Authentication and Multicast Cipher/Encryption and also assign the “default-user-vlan” parameter.

```
config security-profile web-based-64 dot11-auth open network-auth web-based
encryption wep64
config security-profile web-based-64 default-user-vlan web-vlan
```

6 Configure the security profile with a WEP key of encryption length 64.

```
config Security-profile web-based-64 wep key add 0 hex abcdefaaaa
```

NOTE

If you enter the wrong number of characters for the code, a message similar to the following appears.

```
Invalid number of bytes in key. Expected <xx> bytes, got <yy> bytes.
```

7 Configure the security profile to use the 0 key you just defined as the default encryption key.

```
config security-profile web-based-64 wep default-key-index 0
```

8 Configure the name of the ESS

```
config security-profile web-based-64 ess-name web-based-64-ess
```

Open – Web Based Network Login - WEP 128. Follow these steps:

1 Create a security profile (web-based-128) by copying from the default unsecure profile.

```
create security-profile web-based-128 copy unsecure
```

2 Create a VLAN (web-vlan) for the potential clients that will connect to the network using this security-profile.

```
create vlan web-vlan
```

3 Configure the tag for the VLAN

```
config vlan web-vlan tag 10
```

4 Add the wireless port to the VLAN.

```
config vlan web-vlan add ports 1:5 tagged
```

5 Configure the Dot11 Authentication, Network Authentication and Multicast Cipher/Encryption and also assign the “default-user-vlan” parameter.

```
config security-profile web-based-128 dot11-auth open network-auth web-based
encryption wep128
config security-profile web-based-128 default-user-vlan web-vlan
```

6 Configure the security profile with a WEP key of encryption length 128

```
config security-profile web-based-128 wep key add 0 hex  abcdefaaaaaaaaaaaaaaaaaaaa
```

NOTE

If you enter the wrong number of characters for the code, a message similar to the following appears.

```
Invalid number of bytes in key. Expected <xx> bytes, got <yy> bytes.
```

7 Configure the security profile to use the 0 key you just defined as the default encryption key.

```
config security-profile web-based-128 wep default-key-index 0
```

8 Configure the name of the ESS

```
config security-profile web-based-128 ess-name web-based-128-ess
```

Open - MAC Radius - None. Follow these steps:

1 Create a security profile (mac-radius-open) by copying from the default unsecure profile.

```
create security-profile mac-radius-open copy unsecure
```

2 Create a VLAN (mac-radius-vlan) for the potential clients that will connect to the network using this security-profile.

```
create vlan mac-radius-vlan
```

3 Configure the tag for the VLAN

```
config vlan mac-radius-vlan tag 10
```

4 Add the wireless port to the VLAN.

```
config vlan mac-radius-vlan add ports 1:5 tagged
```

5 Configure the Dot11 Authentication, Network Authentication and Multicast Cipher/Encryption and also assign the "default-user-vlan" parameter.

```
config security-profile mac-radius-open dot11-auth open network-auth mac-radius
encryption none
config security-profile mac-radius-open default-user-vlan mac-radius-vlan
```

6 Configure the name of the ESS

```
config security-profile mac-radius-open ess-name mac-radius-open-ess
```

Open - MAC Radius - WEP 64. Follow these steps:

1 Create a security profile (mac-radius-64) by copying from the default unsecure profile.

```
create security-profile mac-radius-64 copy unsecure
```

2 Create a VLAN (mac-radius-vlan) for the potential clients that will connect to the network using this security-profile.

```
create vlan mac-radius-vlan
```

3 Configure the tag for the VLAN

```
config vlan mac-radius-vlan tag 10
```

4 Add the wireless port to the VLAN.

```
config vlan mac-radius-vlan add ports 1:5 tagged
```

5 Configure the Dot11 Authentication, Network Authentication and Multicast Cipher/Encryption and also assign the "default-user-vlan" parameter.

```
config security-profile mac-radius-64 dot11-auth open network-auth mac-radius
encryption wep64
config security-profile mac-radius-64 default-user-vlan mac-radius-vlan
```

6 Configure the security profile with a WEP key of encryption length 64.

```
config security-profile mac-radius-64 wep key add 0 hex abcdefaaaa
```

NOTE

If you enter the wrong number of characters for the code, a message similar to the following appears.

```
Invalid number of bytes in key. Expected <xx> bytes, got <yy> bytes.
```

7 Configure the security profile to use the 0 key you just defined as the default encryption key.

```
config security-profile mac-radius-64 wep default-key-index 0
```

8 Configure the name of the ESS

```
config security-profile mac-radius-64 ess-name mac-radius-64-ess
```

Open - MAC Radius - WEP 128. Follow these steps:

1 Create a security profile (mac-radius-128) by copying from the default unsecure profile.

```
create security-profile mac-radius-128 copy unsecure
```

2 Create a VLAN (mac-radius-vlan) for the potential clients that will connect to the network using this security-profile.

```
create vlan mac-radius-vlan
```

3 Configure the tag for the VLAN

```
config vlan mac-radius-vlan tag 10
```

Add the wireless port to the VLAN.

```
config vlan mac-radius-vlan add ports 1:5 tagged
```

4 Configure the Dot11 Authentication, Network Authentication and Multicast Cipher/Encryption and also assign the “default-user-vlan” parameter.

```
config security-profile mac-radius-128 dot11-auth open network-auth mac-radius
encryption wep128
config security-profile mac-radius-128 default-user-vlan mac-radius-vlan
```

5 Configure the security profile with a WEP key of encryption length 128

```
config security-profile mac-radius-128 wep key add 0 hex  abcdefaaaaaaaaaaaaaaaaaaaa
```

NOTE

If you enter the wrong number of characters for the code, a message similar to the following appears.

```
Invalid number of bytes in key. Expected <xx> bytes, got <yy> bytes.
```

6 Configure the security profile to use the 0 key you just defined as the default encryption key.

```
config security-profile mac-radius-128 wep default-key-index 0
```

7 Configure the name of the ESS

```
config security-profile mac-radius-128 ess-name mac-radius-128-ess
```

Open - Dot1x - WEP 64. Follow these steps:

1 Create a security profile (open-dot1x-64) by copying from the default unsecure profile.

```
create security-profile open-dot1x-64 copy unsecure
```

2 Create a VLAN (dot1x-vlan) for the potential clients that will connect to the network using this security-profile.

```
create vlan dot1x-vlan
```

3 Configure the tag for the VLAN

```
config vlan dot1x-vlan tag 10
```

4 Add the wireless port to the VLAN.

```
config vlan dot1x-vlan add ports 1:5 tagged
```

5 Configure the Dot11 Authentication, Network Authentication and Multicast Cipher/Encryption and also assign the “default-user-vlan” parameter.

```
config security-profile open-dot1x-64 dot11-auth open network-auth dot1x encryption
wep64
config security-profile open-dot1x-64 default-user-vlan dot1x-vlan
```

6 Configure the name of the ESS

```
config security-profile open-dot1x-64 ess-name open-dot1x-64-ess
```

Open - Dot1x - WEP 128. Follow these steps:

1 Create a security profile (open-dot1x-128) by copying from the default unsecure profile.

```
create security-profile open-dot1x-128 copy unsecure
```

2 Create a VLAN (dot1x-vlan) for the potential clients that will connect to the network using this security-profile.

```
create vlan dot1x-vlan
```

3 Configure the tag for the VLAN

```
config vlan dot1x-vlan tag 10
```

4 Add the wireless port to the VLAN.

```
config vlan dot1x-vlan add ports 1:5 tagged
```

5 Configure the Dot11 Authentication, Network Authentication and Multicast Cipher/Encryption and also assign the “default-user-vlan” parameter.

```
config security-profile open-dot1x-128 dot11-auth open network-auth dot1x encryption
wep128
config security-profile open-dot1x-128 default-user-vlan dot1x-vlan
```

6 Configure the name of the ESS

```
config security-profile open-dot1x-128 ess-name open-dot1x-128-ess
```

Open - WPA (Dynamic) - WEP 64. Follow these steps:

1 Create a security profile (open-wpa-64) by copying from the default unsecure profile.

```
create security-profile open-wpa-64 copy unsecure
```

2 Create a VLAN (wpa-vlan) for the potential clients that will connect to the network using this security-profile.

```
create vlan wpa-vlan
```

3 Configure the tag for the VLAN

```
config vlan wpa-vlan tag 10
```

4 Add the wireless port to the VLAN.

```
config vlan wpa-vlan add ports 1:5 tagged
```

5 Configure the Dot11 Authentication, Network Authentication and Multicast Cipher/Encryption and also assign the “default-user-vlan” parameter.

```
config security-profile open-wpa-64 dot11-auth open network-auth wpa encryption
wep64
config security-profile open-wpa-64 default-user-vlan wpa-vlan
```

6 Configure the name of the ESS

```
config security-profile open-wpa-64 ess-name open-wpa-64-ess
```

Open - WPA (Dynamic) - WEP 128. Follow these steps:

1 Create a security profile (open-wpa-128) by copying from the default unsecure profile.

```
create security-profile open-wpa-128 copy unsecure
```

2 Create a VLAN (wpa-vlan) for the potential clients that will connect to the network using this security-profile.

```
create vlan wpa-vlan
```

3 Configure the tag for the VLAN

```
config vlan wpa-vlan tag 10
```

4 Add the wireless port to the VLAN.

```
config vlan wpa-vlan add ports 1:5 tagged
```

5 Configure the Dot11 Authentication, Network Authentication and Multicast Cipher/Encryption and also assign the “default-user-vlan” parameter.

```
config security-profile open-wpa-128 dot11-auth open network-auth wpa encryption
wep128
config security-profile open-wpa-128 default-user-vlan wpa-vlan
```

6 Configure the name of the ESS

```
config security-profile open-wpa-128 ess-name open-wpa-128-ess
```

Open - WPA (Dynamic) - TKIP. Follow these steps:

1 Create a security profile (open-wpa-tkip) by copying from the default unsecure profile.

```
create security-profile open-wpa-tkip copy unsecure
```

2 Create a VLAN (wpa-vlan) for the potential clients that will connect to the network using this security-profile.

```
create vlan wpa-vlan
```

3 Configure the tag for the VLAN

```
config vlan wpa-vlan tag 10
```

4 Add the wireless port to the VLAN.

```
config vlan wpa-vlan add ports 1:5 tagged
```

5 Configure the Dot11 Authentication, Network Authentication and Multicast Cipher/Encryption and also assign the “default-user-vlan” parameter.

```
config security-profile open-wpa-tkip dot11-auth open network-auth wpa encryption
tkip
config security-profile open-wpa-tkip default-user-vlan wpa-vlan
```

6 Configure the name of the ESS

```
config security-profile open-wpa-tkip ess-name open-wpa-tkip-ess
```

Open - WPA (Dynamic) - AES. Follow these steps:

1 Create a security profile (open-wpa-aes) by copying from the default unsecure profile.

```
create security-profile open-wpa-aes copy unsecure
```

2 Create a VLAN (wpa-vlan) for the potential clients that will connect to the network using this security-profile.

```
create vlan wpa-vlan
```

3 Configure the tag for the VLAN

```
config vlan wpa-vlan tag 10
```

4 Add the wireless port to the VLAN.

```
config vlan wpa-vlan add ports 1:5 tagged
```

5 Configure the Dot11 Authentication, Network Authentication and Multicast Cipher/Encryption and also assign the “default-user-vlan” parameter.

```
config security-profile open-wpa-aes dot11-auth open network-auth wpa encryption aes
config security-profile open-wpa-aes default-user-vlan wpa-vlan
```

6 Configure the name of the ESS

```
config security-profile open-wpa-aes ess-name open-wpa-aes-ess
```

Open - WPA PSK (Pre-Shared Key) - WEP 64. Follow these steps:

1 Create a security profile (open-wpapsk-64) by copying from the default unsecure profile.

```
create security-profile open-wpapsk-64 copy unsecure
```

2 Create a VLAN (wpa-vlan) for the potential clients that will connect to the network using this security-profile.

```
create vlan wpa-vlan
```

3 Configure the tag for the wpa-vlan

```
config vlan wpa-vlan tag 10
```

4 Add the wireless port to the VLAN.

```
config vlan wpa-vlan add ports 1:5 tagged
```

5 Configure the Dot11 Authentication, Network Authentication and Multicast Cipher/Encryption and also assign the “default-user-vlan” parameter.

```
config security-profile open-wpapsk-64 dot11-auth open network-auth wpa-psk
encryption wep64
config security-profile open-wpapsk-64 default-user-vlan wpa-vlan
```

6 Configure the pre-shared key (PSK) for the security-profile.

```
config security-profile open-wpapsk-64 wpa-psk hex <hexadecimal digits>
…or…
config security-profile open-wpapsk-64 wpa-psk passphrase <alphanumeric string>
```

7 Configure the name of the ESS

```
config security-profile open-wpapsk-64 ess-name open-wpapsk-64-ess
```

Open - WPA PSK (Pre-Shared Key) - WEP 128. Follow these steps:

1 Create a security profile (open-wpapsk-128) by copying from the default unsecure profile.

```
create security-profile open-wpapsk-128 copy unsecure
```

2 Create a VLAN (wpa-vlan) for the potential clients that will connect to the network using this security-profile.

```
create vlan wpa-vlan
```

3 Configure the tag for the wpa-vlan

```
config vlan wpa-vlan tag 10
```

4 Add the wireless port to the VLAN.

```
config vlan wpa-vlan add ports 1:5 tagged
```

5 Configure the Dot11 Authentication, Network Authentication and Multicast Cipher/Encryption and also assign the “default-user-vlan” parameter.

```
config security-profile open-wpapsk-128 dot11-auth open network-auth wpa-psk
encryption wep128
config security-profile open-wpapsk-128 default-user-vlan wpa-vlan
```

6 Configure the pre-shared key (PSK) for the security-profile.

```
config security-profile open-wpapsk-128 wpa-psk hex <hexadecimal digits>
…or…
config security-profile open-wpapsk-128 wpa-psk passphrase <alphanumeric string>
```

7 Configure the name of the ESS

```
config security-profile open-wpapsk-128 ess-name open-wpapsk-128-ess
```

Open - WPA PSK (Pre-Shared Key) - TKIP. Follow these steps:

1 Create a security profile (open-wpapsk-tkip) by copying from the default unsecure profile.

```
create security-profile open-wpapsk-tkip copy unsecure
```

2 Create a VLAN (wpa-vlan) for the potential clients that will connect to the network using this security-profile.

```
create vlan wpa-vlan
```

3 Configure the tag for the wpa-vlan

```
config vlan wpa-vlan tag 10
```

4 Add the wireless port to the VLAN.

```
config vlan wpa-vlan add ports 1:5 tagged
```

5 Configure the Dot11 Authentication, Network Authentication and Multicast Cipher/Encryption and also assign the “default-user-vlan” parameter.

```
config security-profile open-wpapsk-tkip dot11-auth open network-auth wpa-psk
encryption tkip
config security-profile open-wpapsk-tkip default-user-vlan wpa-vlan
```

6 Configure the pre-shared key (PSK) for the security-profile.

```
config security-profile open-wpapsk-tkip wpa-psk hex <hexadecimal digits>
…or…
config security-profile open-wpapsk-tkip wpa-psk passphrase <alphanumeric string>
```

7 Configure the name of the ESS

```
config security-profile open-wpapsk-tkip ess-name open-wpapsk-tkip-ess
```

Open - WPA PSK (Pre-Shared Key) - AES. Follow these steps:

1 Create a security profile (open-wpapsk-aes) by copying from the default unsecure profile.

```
create security-profile open-wpapsk-aes copy unsecure
```

2 Create a VLAN (wpa-vlan) for the potential clients that will connect to the network using this security-profile.

```
create vlan wpa-vlan
```

3 Configure the tag for the wpa-vlan

```
config vlan wpa-vlan tag 10
```

4 Add the wireless port to the VLAN.

```
config vlan wpa-vlan add ports 1:5 tagged
```

5 Configure the Dot11 Authentication, Network Authentication and Multicast Cipher/Encryption and also assign the "default-user-vlan" parameter.

```
config security-profile open-wpapsk-aes dot11-auth open network-auth wpa-psk
encryption aes
config security-profile open-wpapsk-aes default-user-vlan wpa-vlan
```

6 Configure the pre-shared key (PSK) for the security-profile.

```
config security-profile open-wpapsk-aes wpa-psk hex <hexadecimal digits>
…or…
config security-profile open-wpapsk-aes wpa-psk passphrase <alphanumeric string>
```

7 Configure the name of the ESS

```
config security-profile open-wpapsk-aes ess-name open-wpapsk-aes-ess
```

Shared - None - WEP 64. Follow these steps:

1 Create a security profile (shared-none-64) by copying from the default unsecure profile.

```
create security-profile shared-none-64 copy unsecure
```

2 Create a VLAN (wep-vlan) for the potential clients that will connect to the network using this security-profile.

```
create vlan wep-vlan
```

3 Configure the tag for the wep-vlan

```
config vlan wep-vlan tag 10
```

4 Add the wireless port to the VLAN.

```
config vlan wep-vlan add ports 1:5 tagged
```

5 Configure the Dot11 Authentication, Network Authentication and Multicast Cipher/Encryption and also assign the "default-user-vlan" parameter.

```
config security-profile shared-none-64 dot11-auth shared network-auth none
encryption wep64
config security-profile shared-none-64 default-user-vlan wep-vlan
```

6 Configure the security profile for WEP encryption length of 64.

```
config security-profile shared-none-64 wep key add 0 hex abcdefaaaa
```

NOTE

If you enter the wrong number of characters for the code, a message similar to the following appears.

```
Invalid number of bytes in key. Expected <xx> bytes, got <yy> bytes.
```

7 Configure the security profile to use the 0 key you just defined as the default encryption key.

```
config security-profile shared-none-64 wep default-key-index 0
```

8 Configure the name of the ESS

```
config security-profile shared-none-64 ess-name shared-none-64-ess
```

Shared - None - WEP 128. Follow these steps:

1 Create a security profile (shared-none-128) by copying from the default unsecure profile.

```
create security-profile shared-none-128 copy unsecure
```

2 Create a VLAN (wep-vlan) for the potential clients that will connect to the network using this security-profile.

```
create vlan wep-vlan
```

3 Configure the tag for the wep-vlan

```
config vlan wep-vlan tag 10
```

4 Add the wireless port to the VLAN.

```
config vlan wep-vlan add ports 1:5 tagged
```

5 Configure the Dot11 Authentication, Network Authentication and Multicast Cipher/Encryption and also assign the “default-user-vlan” parameter.

```
config security-profile shared-none-128 dot11-auth shared network-auth none
encryption wep128
config security-profile shared-none-128 default-user-vlan wep-vlan
```

6 Configure the security profile for WEP encryption length of 128.

```
config security-profile shared-none-128 wep key add 0 hex abcdefaaaaaaaaaaaaaaaaaaaa
```

NOTE

If you enter the wrong number of characters for the code, a message similar to the following appears.

```
Invalid number of bytes in key. Expected <xx> bytes, got <yy> bytes.
```

7 Configure the security profile to use the 0 key you just defined as the default encryption key.

```
config security-profile shared-none-128 wep default-key-index 0
```

8 Configure the name of the ESS

```
config security-profile shared-none-128 ess-name shared-none-128-ess
```

Shared - Web Based Network Login - WEP 64. Follow these steps:

1 Create a security profile (shared-web-64) copying from the default unsecure profile.

```
create security-profile shared-web-64 copy unsecure
```

2 Create a VLAN (web-vlan) for the potential clients that will connect to the network using this security-profile.

```
create vlan web-vlan
```

3 Configure the tag for the web-vlan

```
config vlan web-vlan tag 10
```

4 Add the wireless port to the VLAN.

```
config vlan web-vlan add ports 1:5 tagged
```

5 Configure the Dot11 Authentication, Network Authentication and Multicast Cipher/Encryption and also assign the “default-user-vlan” parameter.

```
config security-profile shared-web-64 dot11-auth shared network-auth web-based
encryption wep64
config security-profile shared-web-64 default-user-vlan web-vlan
```

6 Configure the security profile for WEP encryption length of 64.

```
config security-profile shared-web-64 wep key add 0 hex abcdefaaaa
```

NOTE

If you enter the wrong number of characters for the code, a message similar to the following appears.

```
Invalid number of bytes in key. Expected <xx> bytes, got <yy> bytes.
```

7 Configure the security profile to use the 0 key you just defined as the default encryption key.

```
config security-profile shared-web-64 wep default-key-index 0
```

8 Configure the name of the ESS

```
config security-profile shared-web-64 ess-name shared-web-64-ess
```

Shared - Web Based Network Login - WEP 128. Follow these steps:

1 Create a security profile (shared-web-128) by copying from the default unsecure profile.

```
create security-profile shared-web-128 copy unsecure
```

2 Create a VLAN (web-vlan) for the potential clients that will connect to the network using this security-profile.

```
create vlan web-vlan
```

3 Configure the tag for the web-vlan

```
config vlan web-vlan tag 10
```

4 Add the wireless port to the VLAN.

```
config vlan web-vlan add ports 1:5 tagged
```

5 Configure the Dot11 Authentication, Network Authentication and Multicast Cipher/Encryption and also assign the “default-user-vlan” parameter.

```
config security-profile shared-web-128 dot11-auth shared network-auth web-based
encryption wep128
config security-profile shared-web-128 default-user-vlan web-vlan
```

6 Configure the security profile for WEP encryption length of 128.

```
config security-profile shared-web-128 wep key add 0 hex abcdefaaaaaaaaaaaaaaaaaaaa
```

NOTE

If you enter the wrong number of characters for the code, a message similar to the following appears.

```
Invalid number of bytes in key. Expected <xx> bytes, got <yy> bytes.
```

7 Configure the security profile to use the 0 key you just defined as the default encryption key.

```
config security-profile shared-web-128 wep default-key-index 0
```

8 Configure the name of the ESS

```
config security-profile shared-web-128 ess-name shared-web-128-ess
```

Shared - MAC Radius - WEP 64. Follow these steps:

1 Create a security profile (shared-macradius-64) by copying from the default unsecure profile.

```
create security-profile shared-macradius-64 copy unsecure
```

2 Create a VLAN (mac-vlan) for the potential clients that will connect to the network using this security-profile.

```
create vlan mac-vlan
```

3 Configure the tag for the mac-vlan

```
config vlan mac-vlan tag 10
```

4 Add the wireless port to the VLAN.

```
config vlan mac-vlan add ports 1:5 tagged
```

5 Configure the Dot11 Authentication, Network Authentication and Multicast Cipher/Encryption and also assign the “default-user-vlan” parameter.

```
config security-profile shared-macradius-64 dot11-auth shared network-auth
mac-radius encryption wep64
config security-profile shared-macradius-64 default-user-vlan mac-vlan
```

6 Configure the security profile for WEP encryption length of 128.

```
config security-profile shared-macradius-64 wep key add 0 hex abcdefaaaa
```

NOTE

If you enter the wrong number of characters for the code, a message similar to the following appears.

```
Invalid number of bytes in key. Expected <xx> bytes, got <yy> bytes.
```

7 Configure the security profile to use the 0 key you just defined as the default encryption key.

```
config security-profile shared-macradius-64 wep default-key-index 0
```

8 Configure the name of the ESS

```
config security-profile shared-marcradius-64 ess-name shared-macradius-64-ess
```

Shared - MAC Radius - WEP 128. Follow these steps:

1 Create a security profile (shared-macradius-128) by copying from the default unsecure profile.

```
create security-profile shared-macradius-128 copy unsecure
```

2 Create a VLAN (mac-vlan) for the potential clients that will connect to the network using this security-profile.

```
create vlan mac-vlan
```

3 Configure the tag for the mac-vlan

```
config vlan mac-vlan tag 10
```

4 Add the wireless port to the VLAN.

```
config vlan mac-vlan add ports 1:5 tagged
```

5 Configure the Dot11 Authentication, Network Authentication and Multicast Cipher/Encryption and also assign the “default-user-vlan” parameter.

```
config security-profile shared-macradius-128 dot11-auth shared network-auth
mac-radius encryption wep128
config security-profile shared-macradius-128 default-user-vlan mac-vlan
```

6 Configure the security profile for WEP encryption length of 128.

```
config security-profile shared-macradius-128 wep key add 0 hex
abcdefaaaaaaaaaaaaaaaaaaaa
```

NOTE

If you enter the wrong number of characters for the code, a message similar to the following appears.

```
Invalid number of bytes in key. Expected <xx> bytes, got <yy> bytes.
```

7 Configure the security profile to use the 0 key you just defined as the default encryption key.

```
config security-profile shared-macradius-128 wep default-key-index 0
```

8 Configure the name of the ESS

```
config security-profile shared-macradius-128 ess-name shared-macradius-128-ess
```

Profile Assignment Example

Refer to the following example when assigning and RF profile or security profile to a wireless interface.

Assign Profiles to Wireless Interfaces. Follow these steps:

1 Configure interface 1 on port 1:5 to use the RF profile RF_A.

```
config wireless ports 1:5 interface 1 rf-profile RF_A
```

2 Configure interface 2 on port 1:5 to use the RF profile RF_G.

```
config wireless ports 1:5 interface 2 rf-profile RF_G
```

3 Configure interfaces 1 and 2 on port 1:5 to use the wep-secure security profile or the dotx1x-secure security profile.

```
config wireless ports 1:5 interface 1 security-profile wep-secure
config wireless ports 1:5 interface 2 security-profile wep-secure
```

OR

```
config wireless port 1:5 interface 1 security-profile dot1x-secure
config wireless port 1:5 interface 2 security-profile dot1x-secure
```

4 Configure the channel on wireless port interface 1 and/or 2. Specifying “0” means that the channel will be “auto-selected”. Using a channel assignment of “0” will usually result in the selection of a channel with the least interference for that radio mode. Available non-auto select channels will vary depending upon the regulatory limitations of the country in which the access point (AP) is being operated (i.e. The selected "country-code" global wireless parameter).

```
config wireless ports 1:5 interface 1 channel 0
config wireless ports 1:5 interface 2 channel 11
```

Switch Protection

Switch protection features enhance the robustness of switch performance. In this category are the following features:

- Routing Access Profiles
- Route Maps
- Denial of Service Protection

Routing Access Profiles

Routing access profiles are used to control the advertisement or recognition of routing protocols, such as RIP, OSPF, IS-IS, or BGP. Routing access profiles can be used to 'hide' entire networks, or to trust only specific sources for routes or ranges of routes. The capabilities of routing access profiles are specific to the type of routing protocol involved, but are sometimes more efficient and easier to implement than access lists.

Using Routing Access Profiles

To use routing access profiles, you must perform the following steps:

1. Create an access profile.
2. Configure the access profile to be of type *permit*, *deny*, or *none*.
3. Add entries to the access profile. Entries can be one of the following types:
   - IP addresses and subnet masks
   - IPX node, IPX RIP, and IPX SAP
   - Autonomous system path expressions (as-paths) (BGP only)
   - BGP communities (BGP only)
   - VLAN
4. Apply the access profile.

Creating an Access Profile

The first thing to do when using routing access profiles is to create an *access profile*. An access profile has a unique name and contains one of the following entry types:

- A list of IP addresses and associated subnet masks
- A list of IPX NetIDs
- A list of IPX node addresses

- A list of IPX SAP advertisements
- One or more autonomous system path expressions (BGP only)
- One or more BGP community numbers (BGP only)
- A VLAN

You must give the access profile a unique name (in the same manner as naming a VLAN, protocol filter, or Spanning Tree Domain). To create an access profile, use the following command:

```
create access-profile <access profile> type [ipaddress | ipx-node | ipx-net | ipx-sap
| as-path | bgp-community | vlan]
```

Configuring an Access Profile Mode

After the access profile is created, you must configure the access profile mode. The access profile mode determines whether the items in the list are to be permitted access or denied access.

Three modes are available:

- **Permit**—The permit access profile mode permits the operation, as long as it matches any entry in the access profile. If the operation does not match any entries in the list, the operation is denied.
- **Deny**—The deny access profile mode denies the operation, as long as it matches any entry in the access profile. If it does not match all specified entries in the list, the operation is permitted.
- **None**—Using the none mode, the access profile can contain a combination of permit and deny entries. Each entry must have a permit or deny attribute. The operation is compared with each entry in the list. Once a match is found, the operation is either permitted or denied, depending on the configuration of the matched entry. If no match is found, the operation is implicitly denied.

To configure the access profile mode, use the following command:

```
configure access-profile <access profile> mode [permit | deny | none]
```

Adding an Access Profile Entry

Next, configure the access profile, using the following command:

```
configure access-profile <access profile> add {<seq_number>} {permit | deny}
[ipaddress <ip address> <mask> {exact} | as-path <path-expression> | bgp-community
[internet | no-export | no-advertise | no-export-subconfed | <as_no:number> | number
<community>] | ipxnet <netid> <netid mask> | ipxsap <sap_type> <service_name> | vlan]
```

The following sections describe the `configure access-profile add` command.

Specifying Subnet Masks

The subnet mask specified in the access profile command is interpreted as a *reverse mask*. A reverse mask indicates the bits that are significant in the IP address. In other words, a reverse mask specifies the part of the address that must match the IP address to which the profile is applied.

If you configure an IP address that is an exact match that is specifically denied or permitted, use a mask of /32 (for example, 141.251.24.28/32). If the IP address represents all addresses in a subnet address that you want to deny or permit, then configure the mask to cover only the subnet portion (for example, 141.251.10.0/24). The keyword exact can be used when you wish to match only against the subnet address, and ignore all addresses within the subnet.

If you are using off-byte boundary subnet masking, the same logic applies, but the configuration is more tricky. For example, the network address 141.251.24.128/27 represents any host from subnet 141.251.24.128.

Sequence Numbering

You can specify the sequence number for each access profile entry. If you do not specify a sequence number, entries are sequenced in the order they are added. Each entry is assigned a value of 5 more than the sequence number of the last entry.

Permit and Deny Entries

If you have configured the access profile mode to be none, you must specify each entry type as either 'permit' or 'deny'. If you do not specify the entry type, it is added as a permit entry. If you have configured the access profile mode to be permit or deny, it is not necessary to specify a type for each entry.

IPX Access Profiles

IPX routing access profiles consist of access rules and are used to perform packet filtering and forwarding decisions on incoming traffic. Each IPX RIP or SAP packet arriving on an ingress port is compared to each access profile rule in sequential order and is either forwarded or dropped.

Autonomous System Expressions

The AS-path keyword uses a regular expression string to match against the AS path. Regular expression notation can include any of the characters listed in Table 42.

Table 42: Regular Expression Notation

Character	Definition
N	As number
N_1 - N_2	Range of AS numbers, where N_1 and N_2 are AS numbers and $N_1 < N_2$
[N_x ... N_y]	Group of AS numbers, where N_x and N_y are AS numbers or a range of AS numbers
[^N_x ... N_y]	Any AS numbers other than the ones in the group
.	Matches any number
^	Matches the beginning of the AS path
$	Matches the end of the AS path
–	Matches the beginning or end, or a space
-	Separates the beginning and end of a range of numbers
*	Matches 0 or more instances
+	Matches 1 or more instances
?	Matches 0 or 1 instance
{	Start of AS SET segment in the AS path
}	End of AS SET segment in the AS path
(	Start of a confederation segment in the AS path

Table 42: Regular Expression Notation (Continued)

Character	Definition
)	End of a confederation segment in the AS path

Autonomous System Expression Example

The following example uses combinations of the autonomous system expressions to create a complicated access profile:

```
create access-profile AS1 type as-path
configure access-profile AS1 mode none
```

These commands create the access profile.

```
configure access-profile AS1 add 5 permit as-path “^65535$”
```

This command configures the access profile to permit AS paths that contain only (begin and end with) AS number 65535.

```
configure access-profile AS1 add 10 permit as-path “^65535 14490$”
```

This command configures the access profile to permit AS paths beginning with AS number 65535, ending with AS number 14490, and containing no other AS paths.

```
configure access-profile AS1 add 15 permit as-path “^1 2-8 [11 13 15]$”
```

This command configures the access profile to permit AS paths beginning with AS number 1, followed by any AS number from 2 - 8, and ending with either AS number 11, 13, or 15.

```
configure access-profile AS1 add 20 deny as-path “111 [2-8]”
```

This command configures the access profile to deny AS paths beginning with AS number 111 and ending with any AS number from 2 - 8.

```
configure access-profile AS1 add 25 permit as-path “111 .?”
```

This command configures the access profile to permit AS paths beginning with AS number 111 and ending with any additional AS number, or beginning and ending with AS number 111.

Deleting an Access Profile Entry

To delete an access profile entry, use the following command:

```
configure access-profile <access profile> delete <seq_number>
```

Applying Access Profiles

Once the access profile is defined, apply it to one or more routing protocols or VLANs. When an access profile is applied to a protocol function (for example, the export of RIP routes) or a VLAN, this forms an access policy. A profile can be used by multiple routing protocol functions or VLANs, but a protocol function or VLAN can use only one access profile.

Routing Profiles for RIP

If you are using the RIP protocol, the switch can be configured to use an access profile to determine:

- **Trusted Neighbor**—Use an access profile to determine trusted RIP router neighbors for the VLAN on the switch running RIP. To configure a trusted neighbor policy, use the following command:

  ```
  configure rip vlan [<vlan name> | all] trusted-gateway [<access profile> | none]
  ```

- **Import Filter—**Use an access profile to determine which RIP routes are accepted as valid routes. This policy can be combined with the trusted neighbor policy to accept selected routes only from a set of trusted neighbors. To configure an import filter policy, use the following command:

  ```
  configure rip vlan [<vlan name> | all] import-filter [<access profile> | none]
  ```

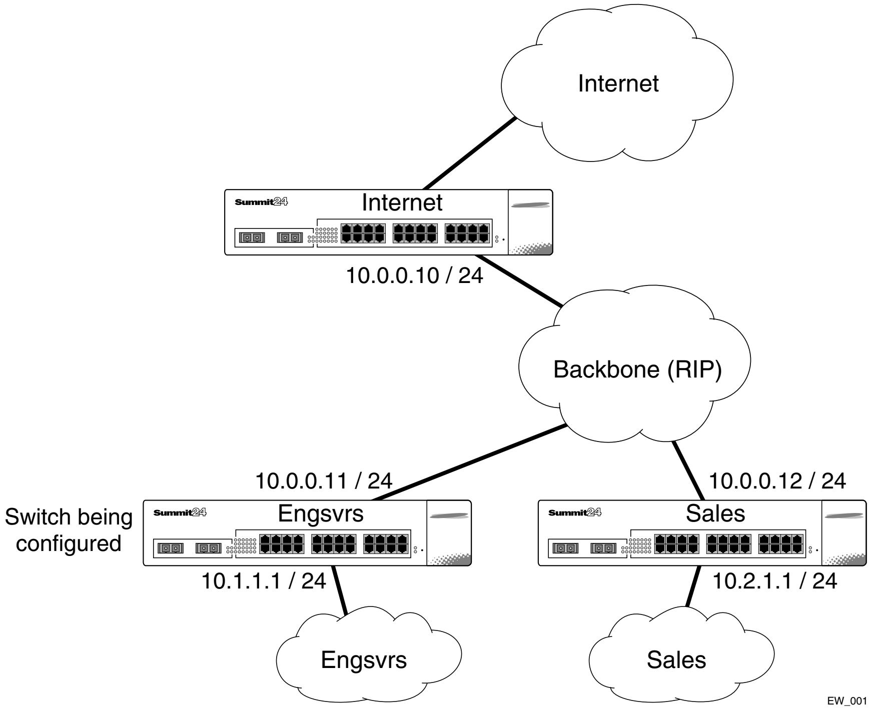
- **Export Filter—**Use an access profile to determine which RIP routes are advertised into a particular VLAN, using the following command:

  ```
  configure rip vlan [<vlan name> | all] export-filter [<access profile> | none]
  ```

Examples

In the example shown in Figure 39, a switch is configured with two VLANs, *Engsvrs* and *Backbone*. The RIP protocol is used to communicate with other routers on the network. The administrator wants to allow all internal access to the VLANs on the switch, but no access to the router that connects to the Internet. The remote router that connects to the Internet has a local interface connected to the corporate backbone. The IP address of the local interface connected to the corporate backbone is 10.0.0.10/24.

Figure 39: RIP access policy example



Assuming the backbone VLAN interconnects all the routers in the company (and, therefore, the Internet router does not have the best routes for other local subnets), the commands to build the access policy for the switch would be:

```
create access-profile nointernet ipaddress
configure access-profile nointernet mode deny
configure access-profile nointernet add 10.0.0.10/32
configure rip vlan backbone trusted-gateway nointernet
```

In addition, if the administrator wants to restrict any user belonging to the VLAN *Engsvrs* from reaching the VLAN *Sales* (IP address 10.2.1.0/24), the additional access policy commands to build the access policy would be:

```
create access-profile nosales ipaddress
configure access-profile nosales mode deny
configure access-profile nosales add 10.2.1.0/24
configure rip vlan backbone import-filter nosales
```

This configuration results in the switch having no route back to the VLAN *Sales*.

Routing Access Profiles for IPX

If you are using the IPX protocol, the switch can be configured to use an access profile to determine:

- **Import Filter**—Use an access profile to determine which IPX/RIP or IPX/SAP routes are accepted as valid routes. To configure an import filter policy, use the following command:

  ```
  configure ipxrip vlan [<vlan name> | all] import-filter [none | <access_profile>]
  configure ipxsap vlan [<vlan name> | all] import-filter [none | access_profile]]
  ```

- **Export Filter**—Use an access profile to determine which IPX/RIP and IPX/SAP routes are advertised into a particular VLAN, using the following command:

  ```
  configure ipxrip vlan [<vlan name> | all] export-filter [none | <access_profile>]
  configure ipxsap vlan [<vlan name> | all] export-filter [none | access_profile]
  ```

Routing Access Profiles for OSPF

Because OSPF is a link-state protocol, the access profiles associated with OSPF are different in nature than those associated with RIP. Access profiles for OSPF are intended to extend the existing filtering and security capabilities of OSPF (for example, link authentication and the use of IP address ranges). If you are using the OSPF protocol, the switch can be configured to use an access profile to determine any of the following:

- **Inter-area Filter**—For switches configured to support multiple OSPF areas (an ABR function), an access profile can be applied to an OSPF area that filters a set of OSPF inter-area routes from being sourced from any other areas. To configure an inter-area filter policy, use the following command:

  ```
  configure ospf area <area identifier> interarea-filter [<access profile> | none]
  ```

- **External Filter**—For switches configured to support multiple OSPF areas (an ABR function), an access profile can be applied to an OSPF area that filters a set of OSPF external routes from being advertised into that area. To configure an external filter policy, use the following command:

  ```
  configure ospf area <area identifier> external-filter [<access profile> |none]
  ```

NOTE

If any of the external routes specified in the filter have already been advertised, those routes will remain until the associated LSAs in that area time-out.

- **ASBR Filter**—For switches configured to support RIP and static route re-distribution into OSPF, an access profile can be used to limit the routes that are advertised into OSPF for the switch as a whole. To configure an ASBR filter policy, use the following command:

  ```
  configure ospf asbr-filter [<access profile> | none]
  ```

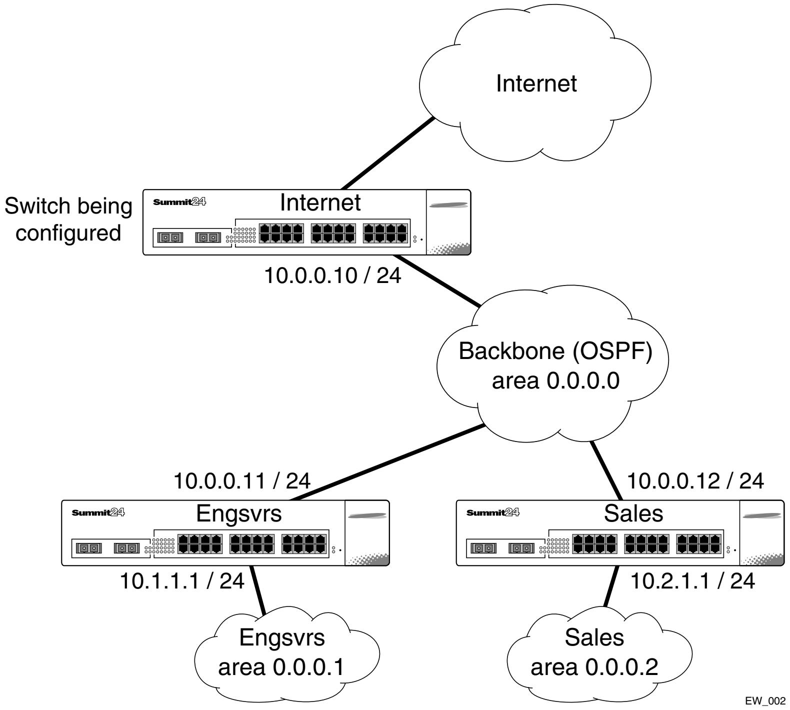
- **Direct Filter**—For switches configured to support direct route re-distribution into OSPF, an access profile can be used to limit the routes that are advertised into OSPF for the switch as a whole. To configure a direct filter policy, use the following command:

  ```
  configure ospf direct-filter [<access profile> | none]
  ```

Example

Figure 40 illustrates an OSPF network that is similar to the network used previously in the RIP example. In this example, access to the Internet is accomplished by using the ASBR function on the switch labeled Internet. As a result, all routes to the Internet will be done through external routes. Suppose the network administrator wishes to only allow access to certain internet addresses falling within the range 192.1.1.0/24 to the internal backbone.

Figure 40: OSPF access policy example



To configure the switch labeled Internet, the commands would be as follows:

```
create access-profile okinternet ipaddress
configure access-profile okinternet mode permit
configure access-profile okinternet add 192.1.1.0/24
configure ospf asbr-filter okinternet
```

Routing Access Profiles for DVMRP

The access policy capabilities for DVMRP are very similar to those for RIP. If you are using the DVMRP protocol is used for routing IP multicast traffic, you can configure the switch to use an access profile to determine:

- **Trusted Neighbor**—Use an access profile to determine trusted DVMRP router neighbors for the VLAN on the switch running DVMRP. To configure a trusted neighbor policy, use the following command:

  ```
  configure dvmrp vlan [<vlan name> | all] trusted-gateway [<access profile> |
  none]
  ```

- **Import Filter**—Use an access profile to determine which DVMRP routes are accepted as valid routes. To configure an import filter policy, use the following command:

  ```
  configure dvmrp vlan [<vlan name> | all] import-filter [<access profile> | none]
  ```

- **Export Filter**—Use an access profile to determine which DVMRP routes are advertised into a particular VLAN, using the following command:

  ```
  configure dvmrp vlan [<vlan name> | all] export-filter [<access profile> | none]
  ```

Example

In this example, the network used in the previous RIP example is configured to run DVMRP. The network administrator wants to disallow Internet access for multicast traffic to users on the VLAN *Engsvrs*. This is accomplished by preventing the learning of routes that originate from the switch labeled Internet by way of DVMRP on the switch labeled Engsvrs.

To configure the switch labeled Engsvrs, use the following commands:

```
create access-profile nointernet ipaddress
configure access-profile nointernet mode deny
configure access-profile nointernet add 10.0.0.10/32
configure dvmrp vlan backbone trusted-gateway nointernet
```

In addition, suppose the administrator wants to preclude users on the VLAN *Engsvrs* from seeing any multicast streams that are generated by the VLAN *Sales* across the backbone. The additional configuration of the switch labeled Engsvrs is as follows:

```
create access-profile nosales ipaddress
configure access-profile nosales mode deny
configure access-profile nosales add 10.2.1.0/24
configure dvmrp vlan backbone import-filter nosales
```

Routing Access Profiles for PIM

Because PIM leverages the unicast routing capability that is already present in the switch, the access policy capabilities are, by nature, different. If you are using the PIM protocol for routing IP multicast traffic, you can configure the switch to use an access profile to determine:

- **Trusted Neighbor**—Use an access profile to determine trusted PIM router neighbors for the VLAN on the switch running PIM. To configure a trusted neighbor policy, use the following command:

  ```
  configure pim vlan [<vlan name> | all] trusted-gateway [<access profile> | none]
  ```

Example

Using PIM, the unicast access profiles can be used to restrict multicast traffic. In this example, a network similar to the example used in the previous RIP example is also running PIM. The network administrator wants to disallow Internet access for multicast traffic to users on the VLAN *Engsvrs*. This is accomplished by preventing the learning of routes that originate from the switch labeled Internet by way of PIM on the switch labeled Engsvrs.

To configure the switch labeled Engsvrs, the commands would be as follows:

```
create access-profile nointernet ipaddress
configure access-profile nointernet mode deny
configure access-profile nointernet add 10.0.0.10/32
configure pim vlan backbone trusted-gateway nointernet
```

Routing Access Profiles for BGP

If the BGP protocol is being used, the switch can be configured to use an access profile to determine:

- **NLRI filter—**Use an access profile to determine the NLRI information that must be exchanged with a neighbor. To configure an NLRI filter policy, use the following command:

  ```
  configure bgp neighbor [<ipaddress> | all] nlri-filter [in | out]
  [<access_profile> | none]
  ```

  The NLRI filter access policy can be applied to the ingress or egress updates, using the `in` and `out` keywords, respectively.
- **Autonomous system path filter—**Use an access profile to determine which NLRI information must be exchanged with a neighbor based on the AS path information present in the path attributes of the NLRI. To configure an autonomous system path filter policy, use the following command:

  ```
  configure bgp neighbor [<ipaddress> | all] as-path-filter [in | out]
  [<access_profile> | none]
  ```

  The autonomous system path filter can be applied to the ingress or egress updates, using the `in` and `out` keywords, respectively.

Making Changes to a Routing Access Policy

You can change the routing access policy by changing the associated access profile. However, the propagation of the change depends on the protocol and policy involved. Propagation of changes applied to RIP, DVMRP, and PIM access profiles depend on the respective protocol timers to age-out entries.

In BGP, the change to the policy is immediately effective on the routing information exchanged after the policy changes. The changes can be applied on the routing information that had been exchanged before the policy changes by issuing a soft reset on the ingress or egress side, depending on the change. For soft resets to be applied on the ingress side, the changes must have been previously enabled on the neighbor.

NOTE

Changes to profiles applied to OSPF typically require rebooting the switch, or disabling and re-enabling OSPF on the switch.

Removing a Routing Access Policy

To remove a routing access policy, you must remove the access profile from the routing protocol or VLAN. All the commands that apply an access profile to form an access policy also have the option of choosing `none` as the access profile. Using the `none` option removes any access profile of that particular type from the protocol or VLAN, and, therefore, removes the access policy.

Route Maps

Route maps are used to modify or filter routes. They are also used to modify or filter routing information.

Using Route Maps

Route maps are a mechanism that can be used to conditionally control the redistribution of routes between two routing domains, and to modify the routing information that is redistributed.

Route maps are used in conjunction with the match and set operations. A match operation specifies a criteria that must be matched. A set operation specifies a change that is made to the route when the match operation is successful.

To create a route map, follow these steps:

1 Create a route map.

2 Add entries to the route map.

3 Add statements to the route map entries.

Creating a Route Map

To create a route map, use the following command:

```
create route-map <name>
```

Add Entries to the Route Map

To add entries to the route map, use the following command:

```
configure route-map <route-map> add <seq_number> [permit | deny] {match-one |
match-all} {set lpm-routing | set iphost-routing}
```

where the following is true:

- The `sequence number` uniquely identifies the entry, and determines the position of the entry in the route map. Route maps are evaluated sequentially.
- The `permit` keyword permits the route; the `deny` keyword denies the route and is applied only if the entry is successful.
- The `match-one` keyword is a logical “or”. The route map is successful as long as at least one of the matching statements is true.

- The `match-all` keyword is a logical "and". The route map is successful when all match statements are true. This is the default setting.

Add Statements to the Route Map Entries

To add statements to the route map entries, use one of the following four commands:

```
configure route-map <route-map> <seq_number> add match [nlri-list <access profile> |
as-path [access-profile <access profile> | <as_number>] | community [access-profile
<access profile> | <as_number>:<number> | number <community> | no-advertise |
no-export | no-export-subconfed] | next-hop <ip address> | med <number> | tag <number>
| origin [igp | egp | incomplete]]]

configure route-map <route-map> <seq_number> add set [as-path <as_number> | community
[[access-profile <access-profile> | <as_number>:<number> | number <community> |
no-advertise | no-export | no-export-subconfed] | remove | [add | delete]
[access-profile <access-profile> | <as no> : <number> | number <community> |
no-advertise | no-export | no-export-subconfed]] | next-hop <ip address> | med
[internal | <med_number> | remove | [add | delete] <med_number>] local-preference
<number> | weight <number> | origin [igp | egp | incomplete] | tag <tag_number> |
accounting index <index_number> value <value_number> | cost <number> | cost-type
[ase-type-1 | ase-type-2]]]

configure route-map <route_map> <seq_number> add goto <new_route_map>

configure route-map <route-map> add <seq_number> [permit | deny] {match-one |
match-all} {set lpm-routing | set iphost-routing}
```

where the following is true:

- The `route-map` is the name of the route map.
- The `sequence number` identifies the entry in the route map to which this statement is being added.
- The `match`, `set`, and `goto` keywords specify the operations to be performed. Within a entry, the statements are sequenced in the order of their operation. The match statements are first, followed by set, and then goto.
- The `nlri-list`, `as-path`, `community`, `next-hop`, `med`, `origin`, and `weight` keywords specify the type of values that must be applied using the specified operation against the corresponding attributes as described in Table 43 and Table 44.
- The `accounting-index` keyword specifies the bin number assigned to a specific route map as discussed in Table 45.

Table 43: Match Operation Keywords

Keyword	Description
nlri-list <access_profile>	Matches the NLRI against the specified access profile.
as-path [<access_profile> | <as-no>]	Matches the AS path in the path attributes against the specified access profile or AS number.
community [access-profile <access-profile> | <as no>: <number> | number <community> | no-advertise | no-export | no-export-subconfed]	Matches the communities in the path attribute against the specified BGP community access profile or the community number.

Table 43: Match Operation Keywords (Continued)

Keyword	Description
next-hop <ipaddress>	Matches the next hop in the path attribute against the specified IP address.
med <number>	Matches the MED in the path attribute against the specified MED number.
origin [igp | egp | incomplete]	Matches the origin in the path attribute against the specified origin.
tag <number>	Matches the tag associated with the redistributed OSPF route.

Table 44: Set Operation Keywords

Keyword	Definition
as-path <as no>	Prepends the specified AS number to the AS path in the path attribute.
community [[access-profile <access-profile> | <as no>: <number> | number <community> | no-advertise | no-export | no-export-subconfed] | remove | [add | delete] [access-profile <access-profile> | <as no>: <number> | number <community> | no-advertise | no-export | no-export-subconfed]]	Adds the specified community to the existing community in the path attribute.
next-hop <ipaddress>	Sets the next hop in the path attribute to the specified IP address.
med [internal | <number> | remove | [add | delete] <number>]	Modifies the MED in the path attribute as specified: • internal—When used in the BGP neighbor output route map, the MED attribute is set to a value equal to the metric to reach the nexthop. • <number>—Sets the MED attribute to the specified value. • remove—Removes the MED attribute, if present. • [add | delete] <number>—Adds or deletes the specified value to or from the MED that is received. The final result is bound by 0 and 2147483647.
local-preference <number>	Sets the local preference in the path attribute to the specified local preference number.
weight <number>	Sets the weight associated with the NLRI to the specified number.
origin [igp | egp | incomplete]	Sets the origin in the path attributes to the specified origin.
tag <number>	Sets the tag in the route to the specified number.
cost <number>	Sets the cost of the route to the specified number
cost-type <number>	Sets the type of the cost associated with the route.
accounting index [ase-type-1 | ase-type-2]	Sets the specified accounting index to the specified number.

Table 45: Set Operation Keywords

Command	Description of Change
accounting-index <index> value <value>	Sets the accounting bin number for the route-mapped accounting index. The accounting index value is always set to 1 for Destination Sensitive Accounting.

Route Map Operation

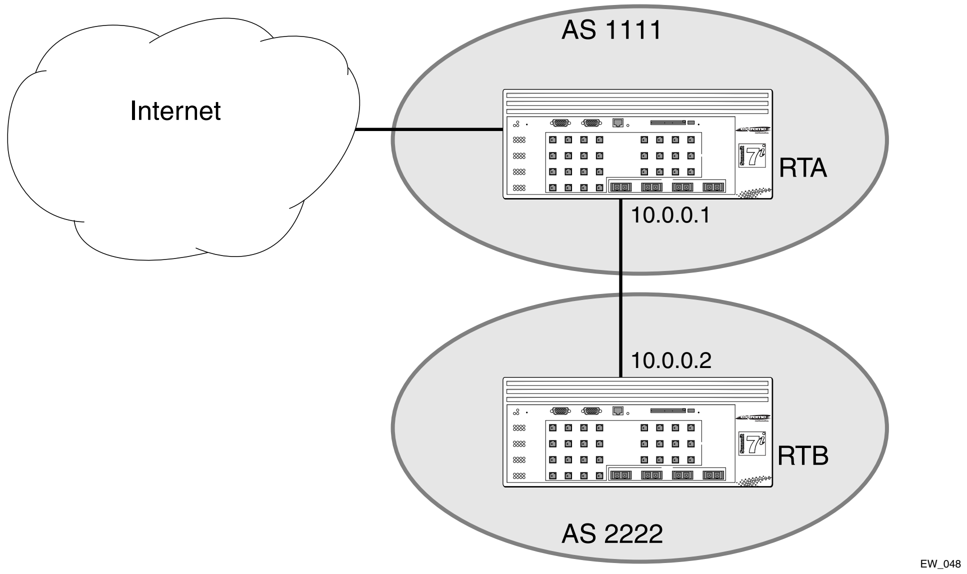
The entries in the route map are processed in the ascending order of the sequence number. Within the entry, the match statements are processed first. When the match operation is successful, the set and goto statements within the entry are processed, and the action associated with the entry is either applied, or else the next entry is processed. If the end of the route map is reached, it is implicitly denied.

When there are multiple match statement, the primitive match-one or match-all in the entry determines how many matches are required for success. When there are no match statements in an entry, the entry is considered a successful match.

Route Map Example

Figure 41 shows a topology in which route maps are used to filter or modify routing information that is exchanged between the neighbors RTA and RTB using BGP.

Figure 41: Route maps



The following points apply to this example:

- RTA is a member of in AS 1111 and peers with a router in the Internet to receive the entire Internet routing table.
- RTB is a member of AS 2222, and has an EBGP connection with RTA through which it receives the Internet routing table.
- AS 1111 is acting as a transit AS for all traffic between AS 2222 and the Internet. If the administrator of AS 1111 wants to filter out route information about network 221.1.1.0/24 and it's subnets from being passed on to AS 2222, the administrator can configure a route-map on the egress side of RTA's EBGP connection with RTB and filter out the routes.

To configure RTA, use the following commands:

```
create access-profile iplist type ipaddress
configure iplist add ipaddress 221.1.1.0 / 24

create route-map bgp-out
configure bgp-out add 10 deny
configure bgp-out 10 add match nlri-list iplist
configure bgp-out add 20 permit

configure bgp neighbor 10.0.0.2 route-map-filter out bgp-out
configure bgp neighbor 10.0.0.2 soft-reset out
```

If you wish to modify the routing information originated from AS 300 to include a MED value of 200, the sequence of commands would be:

```
create access-profile aslist type as-path
configure aslist add as-path "^300"

configure bgp-out add 15 permit
configure bgp-out 15 add match as-path access-profile aslist
configure bgp-out 15 add set med 200

configure bgp neighbor 10.0.0.2 soft-reset out
```

Changes to Route Maps

Changes to the route maps used to modify or filter NLRI information exchanged with neighbors is immediately effective on the routing information exchanged after the policy changes. The changes can be applied on the NLRI information that had been exchanged before the policy changes by issuing a soft reset on the ingress or egress side, depending on the changes. For soft resets to be applied on the ingress side, the changes must be previously enabled on the neighbor.

Changes to the route maps associated with network aggregation or redistribution commands becomes effective after a maximum interval of 30 seconds. You can immediately apply them by using the soft reconfiguration command.

Route Maps in BGP

Route maps are used in BGP to modify/filter NLRI information exchanged with neighbors. They are also used NLRI information that originates by way of network command, aggregation, or redistribution.

Denial of Service Protection

A Denial-of-Service (DoS) attack occurs when a critical network or computing resource is overwhelmed and rendered inoperative in a way that legitimate requests for service cannot succeed. In its simplest form, a Denial of Service attack is indistinguishable from normal heavy traffic. Extreme Network switches are not vulnerable to this simple attack because they are all designed to process packets in hardware at wire speed. However, there are some operations in any switch or router that are more costly than others, and although normal traffic is not a problem, exception traffic must be handled by the switch's CPU in software.

Some packets that the switch processes in the CPU software include:

- learning new traffic
- routing and control protocols including ICMP, BGP and OSPF
- switch management traffic (switch access by Telnet, SSH, HTTP, SNMP, etc...)
- other packets directed to the switch that must be discarded by the CPU

If any one of these functions is overwhelmed, the CPU may be too busy to service other functions and switch performance will suffer. Even with very fast CPUs, there will always be ways to overwhelm the CPU by with packets requiring costly processing.

DoS Protection is designed to help prevent this degraded performance by attempting to characterize the problem and filter out the offending traffic so that other functions can continue. When a flood of packets is received from the switch, DoS Protection will count these packets. When the packet count nears the alert threshold, packets headers will be saved. If the threshold is reached, then these headers are analyzed, and a hardware access control list (ACL) is created to limit the flow of these packets to the CPU. This ACL will remain in place to provide relief to the CPU. Periodically, the ACL will expire, and if the attack is still occurring, it will be re-enabled. With the ACL in place, the CPU will have the cycles to process legitimate traffic and continue other services.

NOTE

DoS Protection can create an ACL at any one time for only one specific source. Only one ACL can be active at any time, so when the switch is suffering an attack from multiple hosts, the CPU will still get flooded.

Configuring Denial of Service Protection

To configure denial of service protection, use the following command:

```
configure cpu-dos-protect [alert-threshold <packets per second>] [notice-threshold
<packets per second>] [timeout <seconds>] [messages [on | off]] [filter-precedence
<number>] [filter-type-allowed {destination | source | destination source} {protocol}]
```

The default values for the parameters are as follows:

- alert-threshold—4000 packets per second
- notice-threshold—4000 packets per second
- timeout—15 seconds
- messages—on (messages are sent to syslog)
- filter-precedence—10

- filter-type-allowed—destination
- trusted ports—none

If you wish to set all the parameters back to their default values, use the following command:

```
unconfigure cpu-dos-protect
```

NOTE

If you set the filter-precedence to 0, the ACLs created by DoS protection will be overwritten by the default VLAN QoS profile.

Enabling Denial of Service Protection

Enable denial of service protection using the following command:

```
enable cpu-dos-protect
```

Once enabled, denial of service protection creates an access list for packets when the receive packet on a port is greater than the alert level. For example, if `cpu-dos-protect` is enabled on a Summit7i switch and the threshold alert level is set to 3000 packets per second, an access list is created if one of the ports on the switch receives 3000 or more packets per second. The precedence is set at 10 for the duration of the timeout.

For example, if you set the timeout to 15 seconds, the ACL is created for 15 seconds. The switch continues to create access lists for the duration of the timeout until the packet rate declines to less than the configured threshold alert level.

Disabling Denial of Service Protection

To disable denial of service protection, use the following command:

```
disable cpu-dos-protect
```

Displaying Denial of Service Settings

To display denial of service settings and the status of the access list, use the following command:

```
show cpu-dos-protect
```

How to Deploy DoS Protection

The conservative way to deploy DoS Protection is to use the simulated mode first. In simulated mode, DoS Protection is enabled, but no ACLs are generated. To enable the simulated mode, use the command:

```
enable cpu-dos-protect simulated
```

Next, configure the notice threshold. This will help determine the actual traffic received by the CPU by logging when the traffic exceeds the threshold. This can help understand the types of traffic encountered, and evaluate whether legitimate traffic may be accidentally blocked. Some examples of heavy legitimate traffic to the cpu include:

- route loss—during this period, the switch may receive lots of routing updates that cause heavy traffic processing loads on the CPU.
- configuration or image upload/download

To configure the notice threshold, use the following command:

```
configure cpu-dos-protect notice-threshold <packets per second>
```

Next, configure the alert threshold. If the alert threshold is reached, a simulated ACL is put in place. Although packets will not be dropped, this provides good information about the heavy traffic, which might be legitimate or might be an attack. The Ethernet address of the source and the type of traffic can be characterized by the type of ACL put in place. This is another way to judge if legitimate traffic would have been cut off. To configure the alert threshold, use the following command:

```
configure cpu-dos-protect alert-threshold <packets per second>
```

After normal traffic is characterized, steps should be taken to set:

- the appropriate notice level if some warning is desired
- the appropriate alert level at which an ACL is put in place
- trusted ports from which traffic won't be blocked

In some cases, traffic from a switch port or group of ports will never cause an attack. These ports can be configured as trusted port and will never be considered for traffic that will generate an ACL. This can prevent innocent hosts from being blocked, or ensure that when an innocent host responds to an attack that the flood of response packets is not mistaken for the attack. To configure a trusted port, use the following command:

```
configure cpu-dos-protect trusted-ports [add <port number> | delete <port number> |
all | none]
```

The last step is to enable DoS Protection. At this point, only attack traffic should be blocked and legitimate traffic should pass through. To enable the creation of ACLs for DoS Protection, use the following command:

```
enable cpu-dos-protect
```

Blocking SQL Slammer DoS Attacks

You can block the SQL Slammer DoS attack. SQL Slammer causes high CPU utilization on the next-hop switch serving multicast requests as ICMP sender entries are quickly populated into the multicast sender list. This leads to a high number of multicast entries in the IGMP snooping entry table, and a message similar to the following in the system log:

```
<WARN:HW> tBGTask: Reached maximum otp ExtraMC index allocation
```

To block and clean up after this task:

1. Block the attack by creating an ACL to block port 1434 using the following command:

   ```
   create access-list UDP dest any ip-port 1434 source any ip-port any
   ```

2. Remove affected SQL servers from the network

   You can simply disable the port connecting the server.

3. Clean up the existing IGMP snooping entries and IPMC cache using the following commands:

```
igmp snooping
clear ipmc cache
```

4 Disable IGMP snooping on the affected switches.

Disabling IGMP snooping affects routing protocols using multicast addresses and multicast traffic on that switch.

Improving Performance with Enhanced DoS Protection

Standard DoS Protection installs an Access Control List (ACL) to protect against Internet Control Message Protocol (ICMP) attacks. To counter the reduced CPU time for processing real data and control packets as a result of an ICMP attack, DoS Protection creates an ACL based on the number of ICMP packets being handled by the CPU. ACLs can also affect real traffic, resulting in a performance cost.

Enhanced DoS Protection provides a complimentary level of security that allows detection and protection against attacks that have an address sweep signature. It does this in two ways:

- First, Enhanced DoS Protection allows you to limit the rate of unresolved IP packets that reach the CPU in case of a DoS attack.
- Second, Enhanced DoS Protection identifies valid streams before installing IPFDB entries, reducing IPFDB thrashing.

To enable Enhanced DoS Protection globally, use the following command without any keywords:

```
enable enhanced-dos-protect {rate-limit | ipfdb} {ports [<portlist> | all]}
```

To disable Enhanced DoS Protection globally, use the following command without any keywords:

```
disable enhanced-dos-protect {rate-limit | ipfdb} {ports [<portlist> | all]}
```

Configuring Rate Limiting

Rate limiting (or software rate shaping) provides the ability to limit the rate of Protocol Data Units (PDUs) being sent to the CPU, effectively dropping a specific percentage of slow path traffic on a per port basis. Enhanced DoS Protection limits the following types of PDUs:

- Unresolved IP packets
- ICMP packets

Enabling and Disabling Rate Limiting. Rate limiting on a particular port will be enabled only if rate limiting is enabled both globally and on the selected port. To enable rate limiting both globally and for selected ports, use the `rate-limit` keyword in the following command:

```
enable enhanced-dos-protect {rate-limit | ipfdb} {ports [<portlist> | all]}
```

To disable rate limiting both globally and for selected ports, use the `rate-limit` keyword in the following command:

```
disable enhanced-dos-protect {rate-limit | ipfdb} {ports [<portlist> | all]}
```

To verify that rate limiting is enabled, use the `rate-limit` keyword in the following command:

```
show enhanced-dos-protect [rate-limit | ipfdb] ports [<portlist> | all]
```

Configuring Ports as Trusted or Untrusted. Rate limiting is applied to packets arriving on **untrusted** ports. You can configure each port as **trusted** or **untrusted**. A trusted port behaves as a normal port. An untrusted port behaves according to the configuration parameter used in IPFDB thrashing. To configure a port as trusted or untrusted, use the following command:

configure enhanced-dos-protect ports [trusted | untrusted] <portlist>

Setting and Verifying Threshold Values. Rate limit threshold values can be configured for selected ports. If the number of packets received on an untrusted port reaches the configured threshold limit, the packets are randomly dropped. The number of packets dropped is proportional to the configured drop probability rate. For example, if the drop probability rate is set to 60%, then 60% of packets received after the configured threshold within the time duration to be considered (the learning window) will be dropped.

Use the `threshold` keyword in the following command to set rate limit thresholds:

configure enhanced-dos-protect rate-limit [threshold <threshold> | drop-probability <drop-probability> | learn-window <learn-window> | protocol [all | icmp]] ports <portlist>

Use the following command to verify the rate limit threshold configuration:

show enhanced-dos-protect [rate-limit | ipfdb] ports [<portlist> | all]

Use the `threshold` keyword in the following command to remove selected ports from the rate limit threshold configuration:

unconfigure enhanced-dos-protect rate-limit [threshold | drop-probability | learn-window | protocol] ports <portlist>

Setting and Verifying Learn Window Values. You can specify learn window values for selected ports by using the `learn-window` keyword in the following command:

configure enhanced-dos-protect rate-limit [threshold <threshold> | drop-probability <drop-probability> | learn-window <learn-window> | protocol [all | icmp]] ports <portlist>

Use the following command to verify the learn window configuration:

show enhanced-dos-protect [rate-limit | ipfdb] ports [<portlist> | all]

Use the `learn-window` keyword in the following command to remove selected ports from the rate limit learn window configuration:

unconfigure enhanced-dos-protect rate-limit [threshold | drop-probability | learn-window | protocol] ports <portlist>

Setting and Verifying Drop Probability Rates. You can specify the percentage of slow-path traffic to be dropped by using the `drop-probability` keyword in the following command:

configure enhanced-dos-protect rate-limit [threshold <threshold> | drop-probability <drop-probability> | learn-window <learn-window> | protocol [all | icmp]] ports <portlist>

Use the following command to verify the drop probability configuration:

show enhanced-dos-protect [rate-limit | ipfdb] ports [<portlist> | all]

Use the `drop-probability` keyword in the following command to remove selected ports from the rate limit drop probability configuration:

unconfigure enhanced-dos-protect rate-limit [threshold | drop-probability | learn-window | protocol] ports <portlist>

Setting and Verifying Protocol Types. To change the rate limit protocol type, use the `protocol` keyword in the following command:

configure enhanced-dos-protect rate-limit [threshold <threshold> | drop-probability <drop-probability> | learn-window <learn-window> | protocol [all | icmp]] ports <portlist>

Use the following command to verify the `drop probability` configuration:

show enhanced-dos-protect [rate-limit | ipfdb] ports [<portlist> | all]

Use the `protocol` keyword in the following command to remove selected ports from the rate limit protocol configuration:

unconfigure enhanced-dos-protect rate-limit [threshold | drop-probability | learn-window | protocol] ports <portlist>

Configuring the IPFDB Learning Qualifier

Enhanced DoS Protection lets you configure an IPFDB learning qualifier to identify valid IP streams before installing IPFDB entries. IPFDB entries are installed only for valid IP flows, which reduces IPFDB thrashing. An IP stream is considered valid only if it meets the qualification criteria, which include a defined **learning threshold** and **aging time**. If the number of packets received for a given IP stream is greater than the defined learning threshold during the defined aging time, the stream is considered valid and the entry is installed.

Enabling and Disabling the IPFDB Learning Qualifier. To globally enable reduced IPFDB thrashing, use the `ipfdb` keyword without any port qualification in the following command:

enable enhanced-dos-protect {rate-limit | ipfdb} {ports [<portlist> | all]}

To globally disable reduced IPFDB thrashing, use the `ipfdb` keyword without any port qualification in the following command:

disable enhanced-dos-protect {rate-limit | ipfdb} {ports [<portlist> | all]}

To enable reduced IPFDB thrashing for specific ports, use the `ipfdb` and `port` keywords in the following command:

enable enhanced-dos-protect {rate-limit | ipfdb} {ports [<portlist> | all]}

To disable reduced IPFDB thrashing for specific ports, use the `ipfdb` and `port` keywords in the following command:

disable enhanced-dos-protect {rate-limit | ipfdb} {ports [<portlist> | all]}

To verify that reduced IPFDB thrashing is enabled or disabled, use the `ipfdb` keyword in the following command:

show enhanced-dos-protect [rate-limit | ipfdb] ports [<portlist> | all]

Configuring Ports as Trusted or Untrusted. You can configure each port as **trusted** or **untrusted**. A trusted port behaves as a normal port. An untrusted port behaves according to the configuration parameter used in IPFDB thrashing. To configure a port as trusted or untrusted, use the following command:

```
configure enhanced-dos-protect ports [trusted | untrusted] <portlist>
```

Setting and Verifying the Learning Limit. You can configure a learning limit value to define the number of packets to be counted before ExtremeWare can create an IPFDB entry in the hardware. To configure the learning limit, use the following command:

```
configure enhanced-dos-protect ipfdb learn-limit <learn-limit> ports <portlist>
```

To verify the status of reduced IPFDB thrashing for each port, use the `ipfdb` keyword in the following command and view data in the Learn-Limit column:

```
show enhanced-dos-protect [rate-limit | ipfdb] ports [<portlist> | all]
```

Setting and Verifying the Learn Window. You can set a learn window value used by the switch to wait for a certain amount of time to reach the threshold value. Use the following command to set the learn window for the IPFDB learning qualifier:

```
configure enhanced-dos-protect ipfdb learn-window <learn-window> ports <portlist>
```

To verify the status of reduced IPFDB thrashing for each port, use the `ipfdb` keyword in the following command and view data in the Learn-Window column:

```
show enhanced-dos-protect [rate-limit | ipfdb] ports [<portlist> | all]
```

Setting and Verifying the Aging Value. You can set an aging value that defines the software cache timeout period that the switch will wait to delete an IPFDB entry. To set the aging value, use the following command:

```
configure enhanced-dos-protect ipfdb agingtime <aging> ports <portlist>
```

To verify the aging value status of reduced IPFDB thrashing for each port, use the `ipfdb` keyword in the following command and view data in the Aging column:

```
show enhanced-dos-protect [rate-limit | ipfdb] ports [<portlist> | all]
```

Configuring the IPFDB Cache Size. Enhanced DoS Protection maintains the number of IPFDB entries according to the cache-size limit. To set the cache size, use the following command:

```
configure enhanced-dos-protect ipfdb cache-size <cache-size>
```

To verify the cache-size status of the IPFDB learning qualifier, use the `ipfdb` keyword in the following command:

```
show enhanced-dos-protect [rate-limit | ipfdb] ports [<portlist> | all]
```

Duplicate IP Protection

Duplicate IP protection is designed to allow only those hosts whose IP addresses are assigned by a DHCP server to access the network. The process works by disabling ARP learning. Hosts with manually configured IP addresses are not able to access the network because the switch does not follow the ARP procedures to create its ARP table. Since all clients' IP addresses can be centrally managed and allocated, duplicate IP protection can increase network security, provide better user management, keep network operation from being interrupted by IP address duplication, and benefit IP address based accounting and billing. By default, arp-learning is enabled on all ports and vlans.

When a packet is forwarded through routing, the destination IP address is generally compared with information in the hardware forwarding entry. The information used for comparison enables classification into two categories: host lookup and network lookup

Host Lookup

Host lookup is based on the exact match of the full 32bit IP address of the hardware forwarding entry and the destination IP address of the packet. Because the full length of IP address is used, the hardware forwarding entry does not hold netmask information.

Network Lookup

In network lookup, packet forwarding is performed on the basis of the network prefix formed with network and netmask information rather than host address. Depending on whether a variable length prefix is supported and what kind of match criteria is used, two kinds of network lookup methods exist.

The first method is based on a fixed length network prefix with exact match. One global mask is provided to generate a fixed length network prefix. The fixed length network prefix means that the network forwarding entry does not hold netmask information separately.

The second method is LPM (Longest Prefix Match). Network lookup is based on a variable length network prefix. Higher priority is given to the longest network prefix match case. The fixed length network prefix means that the network forwarding entry must hold netmask information separately.

The Extreme Switch with can support both host forwarding lookup and fixed length network prefix lookup as IPDA SUBNET Lookup. The lookup method is dependent on the destination IP address of incoming packet and the route entry. In both control plane and data plane, all operations are based on condition and lookup method.

The IPDA SUBNET lookup feature makes it possible for a switch to cover the whole IP address ranges from A class to C class through the proper setting of length of the IPDA SUBNET lookup mask. The expansion can guarantee wire-speed performance in a L3 switch for all ports at a certain amount.

Scanning of virus-infected end-clients or from malicious users can cause the FDB table to fill up very quickly and FDB replacements to happen at higher rate. The attacks can hurt the quality of internal traffic significantly, if all L3 forwarding is made by host lookup. The IPDA SUBNET lookup feature forces the attack traffic to use the IPFDB SUBNET forwarding table instead of the host forwarding table. Internal traffic that uses the host forwarding table can still preserve the same quality under attack.

Because IPDA SUBNET lookup covers the greater range of IP Addresses, there is a lower change of FDB replacement than in the host forwarding entry. This decreases the number of FDB miss-packets that must be processed in the CPU. Additional CPU resources can be used for more critical cases.

By controlling length of IPDA SUBNET lookup mask, it is possible to decide what kind of lookup is used for route entry. This increase of flexibility makes it possible for end-users to design the customized network easily.

Duplicate IP Address Protection Commands

To enable IPDA SUBNET lookup feature in a switch, use the following command:

```
enable ip-subnet-lookup
```

To disable IPDA SUBNET lookup feature in a switch, use the following command:

```
disable ip-subnet-lookup
```

To change the length of IPDA SUBNET lookup mask, use the following command:

```
configure ip-subnet-lookup maskbits <length>
```

To show all IPDA SUBNET forwarding entries, use the following command:

```
show ip-subnet-lookup
```

To enable the ARP-learning feature on the switch, use the following command:

```
enable arp-learning
```

To disable the ARP-learning feature, use the following command.

```
disable arp-learning
```

To enable arp-learning on a port, use the following command:

```
enable arp-learning ports <portlist>
```

To disable arp-learning on a port, use the following command:

```
disable arp-learning ports <portlist>
```

To display the arp-learning configuration on ports, use the following command:

```
show arp-learning ports <portlist>
```

To enable arp-learning on a vlan, use the following command:

```
enable arp-learning vlan <vlan name>
```

To disable arp-learning on a vlan, use the following command;

```
disable arp-learning vlan <vlan name>
```

To display the arp-learning configuration on this vlan, use the following command:

```
show arp-learning vlan <vlan name>
```

To enable arp-learning on a port in the given vlan, use the following command:

```
enable arp-learning vlan <vlan name> port <portlist>
```

To disable arp-learning on a port in the given vlan, use the following command:

```
disable arp-learning vlan <vlan name> port <portlist>
```

To display the arp-learning configuration a port in the given vlan, use the following command:

```
show arp-learning vlan <vlan name> port <portlist>
```

Management Access Security

Management access security features control access to the management functions available on the switch. These features help insure that any configuration changes to the switch can only be done by authorized users. In this category are the following features:

- Authenticating Users Using RADIUS or TACACS+
- Secure Shell 2 (SSH2)

Authenticating Users Using RADIUS or TACACS+

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

- RADIUS client
- TACACS+

RADIUS Client

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

You can define a primary and secondary RADIUS server for the switch to contact. When a user attempts to login using Telnet, http, or the console, the request is relayed to the primary RADIUS server, and then to the secondary RADIUS server, if the primary does not respond. If the RADIUS client is enabled, but access to the RADIUS primary and secondary server fails, the switch uses its local database for authentication.

The privileges assigned to the user (admin versus nonadmin) at the RADIUS server take precedence over the configuration in the local switch database.

NOTE

The switch does not forward a password greater than 16 characters for a Radius client. If you define an account on the RADIUS server with a password greater than 16 characters, authentication fails.

To configure the RADIUS servers, use the following command:

```
configure radius [primary | secondary] server [<ipaddress> | <hostname>] {<udp_port>
<L4 port no>} client-ip [<ipaddress>]
```

To configure the timeout if a server fails to respond, use the following command:

```
configure radius timeout <seconds>
```

Configuring the Shared Secret Password

In addition to specifying the RADIUS server IP information, RADIUS also contains a means to verify communication between network devices and the server. The *shared secret* is a password configured on the network device and RADIUS server, used by each to verify communication.

To configure the shared secret for RADIUS servers, use the following command:

```
configure radius [primary | secondary] shared-secret {encrypted} [<string>]
```

Enabling and Disabling RADIUS

After server information is entered, you can start and stop RADIUS authentication as many times as necessary without needing to reconfigure server information.

To enable RADIUS authentication, use the following command:

```
enable radius
```

To disable RADIUS authentication, use the following command:

```
disable radius
```

Configuring RADIUS Accounting

Extreme switches are capable of sending RADIUS accounting information. As with RADIUS authentication, you can specify two servers for receipt of accounting information. You can configure RADIUS accounting servers to be the same as the authentication servers, but this is not required.

To specify RADIUS accounting servers, use the following command:

```
configure radius-accounting [primary | secondary] server [<ipaddress> | <hostname>]
{<udp_port>} client-ip [<ipaddress>]
```

To configure the timeout if a server fails to respond, use the following command:

```
configure radius-accounting timeout <seconds>
```

RADIUS accounting also makes use of the shared secret password mechanism to validate communication between network access devices and RADIUS accounting servers.

To specify shared secret passwords for RADIUS accounting servers, use the following command:

```
configure radius-accounting [primary | secondary] shared-secret {encrypted} [<string>]
```

After you configure RADIUS accounting server information, you must enable accounting before the switch begins transmitting the information. You must enable RADIUS authentication for accounting information to be generated. You can enable and disable accounting without affecting the current state of RADIUS authentication.

To enable RADIUS accounting, use the following command:

```
enable radius-accounting
```

To disable RADIUS accounting, use the following command:

```
disable radius-accounting
```

Per-Command Authentication Using RADIUS

The RADIUS implementation can be used to perform per-command authentication. Per-command authentication allows you to define several levels of user capabilities by controlling the permitted command sets based on the RADIUS username and password. You do not need to configure any additional switch parameters to take advantage of this capability. The RADIUS server implementation automatically negotiates the per-command authentication capability with the switch. For examples on per-command RADIUS configurations, see the next section.

Configuring RADIUS Client

You can define primary and secondary server communication information, and for each RADIUS server, the RADIUS port number to use when talking to the RADIUS server. The default port value is 1645. The client IP address is the IP address used by the RADIUS server for communicating back to the switch.

RADIUS RFC 2138 Attributes

The RADIUS RFC 2138 optional attributes supported are as follows:

- User-Name
- User-Password
- Service-Type
- Login-IP-Host

Using RADIUS Servers with Extreme Switches

Extreme Networks switches have two levels of user privilege:

- Read-only
- Read-write

Because there are no CLI commands available to modify the privilege level, access rights are determined when you log in. For a RADIUS server to identify the administrative privileges of a user, Extreme switches expect a RADIUS server to transmit the Service-Type attribute in the Access-Accept packet, after successfully authenticating the user.

Extreme switches grant a RADIUS-authenticated user read-write privilege if a Service-Type value of 6 is transmitted as part of the Access-Accept message from the Radius server. Other Service-Type values, or no value, result in the switch granting read-only access to the user. Different implementations of RADIUS handle attribute transmission differently. You should consult the documentation for your specific implementation of RADIUS when you configure users for read-write access.

Cistron RADIUS

Cistron RADIUS is a popular server, distributed under GPL. Cistron RADIUS can be found at:

http://www.miquels.cistron.nl/radius/

When you configure the Cistron server for use with Extreme switches, you must pay close attention to the users file setup. The Cistron RADIUS dictionary associates the word Administrative-User with Service-Type value 6, and expects the Service-Type entry to appear alone on one line with a leading tab character.

The following is a user file example for read-write access:

```
adminuser   Auth-Type = System
            Service-Type = Administrative-User,
            Filter-Id = “unlim”
```

Livingston (Lucent) RADIUS

Livingston RADIUS is produced by Lucent Technologies primarily for use with their portmaster products. Version 2.1 is released under a BSD license agreement and can be found at ftp://ftp.livingston.com/pub/le/radius/radius21.tar.Z. As with Cistron RADIUS, the Livingston server default dictionary associates Administrative-User with Service-Type value 6. The administrative users file entry example for Cistron RADIUS also works with Livingston RADIUS.

RSA Ace

For users of their SecureID product, RSA offers RADIUS capability as part of their ACE server software. With some versions of ACE, the RADIUS shared-secret is incorrectly sent to the switch resulting in an inability to authenticate. As a work around, do *not* configure a shared-secret for RADIUS accounting and authentication servers on the switch.

Limiting Max-Concurrent Sessions with Funk Software’s Steel Belted Radius

For users who have Funk Software’s Steel Belted Radius (SBR) server, it is possible to limit the number of concurrent login sessions using the same user account. This feature allows the use of shared user accounts, but limits the number of simultaneous logins to a defined value. Using this feature requires Funk Software Steel-Belted-Radius for Radius Authentication & Accounting.

Complete the following two steps to limit the maximum concurrent login sessions under the same user account:

1. Configure Radius and Radius-Accounting on the switch

   The Radius and Radius-Accounting servers used for this feature must reside on the same physical Radius server. Standard Radius and Radius-Accounting configuration is required as described earlier in this chapter.

2. Modify the Funk SBR ‘vendor.ini’ file and user accounts

   To configure the Funk SBR server, the file ‘***vendor.ini***’ must be modified to change the Extreme Networks configuration value of ‘***ignore-ports***’ to yes as shown in the example below:

   ```
   vendor-product       = Extreme Networks
   dictionary           = Extreme
   ignore-ports         = yes
   port-number-usage    = per-port-type
   help-id              = 2000
   ```

   After modifying the ‘vendor.ini’ file, the desired user accounts must be configured for the Max-Concurrent connections. Using the SBR Administrator application, enable the check box for ‘Max-Concurrent connections’ and fill in the desired number of maximum sessions.

Extreme RADIUS

Extreme Networks provides its users, free of charge, a radius server based on Merit RADIUS. Extreme RADIUS provides per-command authentication capabilities in addition to the standard set of radius features. Source code for Extreme RADIUS can be obtained from the Extreme Networks Technical Assistance Center and has been tested on Red Hat Linux and Solaris.

When Extreme RADIUS is up and running, the two most commonly changed files will be users and profiles. The users file contains entries specifying login names and the profiles used for per-command authentication after they have logged in. Sending a HUP signal to the RADIUS process is sufficient to get changes in the users file to take place. Extreme RADIUS uses the file named profiles to specify command lists that are either permitted or denied to a user based on their login identity. Changes to the profiles file require the RADIUS server to be shutdown and restarted. Sending a HUP signal to the RADIUS process is not enough to force changes to the profiles file to take effect.

When you create command profiles, you can use an asterisk to indicate any possible ending to any particular command. The asterisk cannot be used as the beginning of a command. Reserved words for commands are matched exactly to those in the profiles file. Due to the exact match, it is not enough to simply enter “sh” for “show” in the profiles file, the complete word must be used. Commands can still be entered in the switch in partial format.

When you use per-command authentication, you must ensure that communication between the switch(es) and radius server(s) is not lost. If the RADIUS server crashes while users are logged in, they will have full administrative access to the switch until they log out. Using two RADIUS servers and enabling idle timeouts on all switches will greatly reduce the chance of a user gaining elevated access due to RADIUS server problems.

RADIUS Server Configuration Example (Merit)

Many implementations of RADIUS server use the publicly available Merit© AAA server application, available on the World Wide Web at:

http://www.merit.edu/aaa

Included below are excerpts from relevant portions of a sample Merit RADIUS server implementation. The example shows excerpts from the client and user configuration files. The client configuration file (`ClientCfg.txt`) defines the authorized source machine, source name, and access level. The user configuration file (`users`) defines username, password, and service type information.

```
ClientCfg.txt

#Client Name        Key             [type]          [version]   [prefix]
#----------------   ---------------  --------------  ---------   --------
#10.1.2.3:256       test             type = nas      v2          pfx
#pm1                %^$%#*(&!(*&)+   type=nas                    pm1.
#pm2                :-):-(;^):-}!    type nas                    pm2.
#merit.edu/homeless hmoemreilte.ses
#homeless           testing          type proxy      v1
#xyz.merit.edu      moretesting      type=Ascend:NAS v1
#anyoldthing:1234   whoknows?        type=NAS+RAD_RFC+ACCT_RFC
10.202.1.3          andrew-linux     type=nas
10.203.1.41         eric             type=nas
10.203.1.42         eric             type=nas
10.0.52.14          samf             type=nas

users

user    Password = ""
     Filter-Id = "unlim"
admin   Password = "", Service-Type = Administrative
```

```
     Filter-Id = "unlim"

eric    Password = "", Service-Type = Administrative
     Filter-Id = "unlim"

albert     Password = "password", Service-Type = Administrative
     Filter-Id = "unlim"

samuel  Password = "password", Service-Type = Administrative
      Filter-Id = "unlim"
```

RADIUS Per-Command Configuration Example

Building on this example configuration, you can use RADIUS to perform per-command authentication to differentiate user capabilities. To do so, use the Extreme-modified RADIUS Merit software that is available from the Extreme Networks by contacting Extreme Networks technical support. The software is available in compiled format for Solaris™ or Linux™ operating systems, as well as in source code format. For all clients that use RADIUS per-command authentication, you must add the following type to the client file:

```
type:extreme:nas + RAD_RFC + ACCT_RFC
```

Within the `users` configuration file, additional keywords are available for `Profile-Name` and `Extreme-CLI-Authorization`. To use per-command authentication, enable the CLI authorization function and indicate a profile name for that user. If authorization is enabled without specifying a valid profile, the user is unable to perform any commands.

Next, define the desired profiles in an ASCII configuration file called `profiles`. This file contains named profiles of exact or partial strings of CLI commands. A named profile is linked with a user through the `users` file. A profile with the `permit on` keywords allows use of only the listed commands. A profile with the `deny` keyword allows use of all commands *except* the listed commands.

CLI commands can be defined easily in a hierarchal manner by using an asterisk (*) to indicate any possible subsequent entry. The parser performs exact string matches on other text to validate commands. Commands are separated by a comma (,) or newline.

Looking at the following example content in profiles for the profile named `PROFILE1`, which uses the `deny` keyword, the following attributes are associated with the user of this profile:

- Cannot use any command starting with `enable`.
- Cannot issue the `disable ipforwarding` command.
- Cannot issue a `show switch` command.
- Can perform all other commands.

We know from the `users` file that this applies to the users `albert` and `lulu`. We also know that `eric` is able to log in, but is unable to perform any commands, because he has no valid profile assigned.

In `PROFILE2`, a user associated with this profile can use any `enable` command, the `clear counters` command and the `show management` command, but can perform no other functions on the switch. We also know from the `users` file that `gerald` has these capabilities.

The following lists the contents of the file `users` with support for per-command authentication:

```
user    Password = ""
        Filter-Id = "unlim"
```

```
admin   Password = "", Service-Type = Administrative
        Filter-Id = "unlim"

eric    Password = "", Service-Type = Administrative, Profile-Name = ""
        Filter-Id = "unlim"
        Extreme:Extreme-CLI-Authorization = Enabled

albert  Password = "", Service-Type = Administrative, Profile-Name =
"Profile1"
          Filter-Id = "unlim"
          Extreme:Extreme-CLI-Authorization = Enabled

lulu    Password = "", Service-Type = Administrative, Profile-Name =
"Profile1"
          Filter-Id = "unlim"
          Extreme:Extreme-CLI-Authorization = Enabled

gerald    Password = "", Service-Type = Administrative, Profile-Name "Profile2"
          Filter-Id = "unlim"
          Extreme:Extreme-CLI-Authorization = Enabled
```

Contents of the file “profiles”:

```
PROFILE1 deny
{
enable  *, disable ipforwarding
show switch
}

PROFILE2
{
enable *, clear counters
show   management
}

PROFILE3 deny
{
create vlan *, configure iproute *, disable *, show fdb
delete *, configure rip add
}
```

Configuring TACACS+

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

You can configure two TACACS+ servers, specifying the primary server address, secondary server address, and UDP port number to be used for TACACS+ sessions.

RADIUS Authentication Decoupling

It is possible to decouple the RADIUS and TACAS authentication mechanisms, thereby allowing use of TACACS+ for device management authentication while employing RADIUS for network login. This is accomplished by permitting user choice of RADIUS and TACACS+ for device management authentication.You can configure separate RADIUS servers for device management authentication (switch login) and network access authentication (Network Login, web based or 802.1x based).

If RADIUS authentication is enabled, all the CLI/WEB/802.1x logins are sent to the configured RADIUS server for authentication. Similarly, if TACACS authentication is enabled, all the logins are sent to the TACACS server for authentication.

RADIUS and TACACS can be enabled simultaneously. A RADIUS or TACACS client is invoked, depending on the configuration. If no association is configured for management/netlogin sessions, then the switch looks first for RADIUS servers and then for TACACS servers for authentication/accounting.

Remote RADIUS/TACACS authentication is also used by PPP sessions. PPP calls remote_authentication with the session type SESSION_HTTP and can be authenticated with authentication servers configured for HTTP sessions. If remote authentication is disabled for HTTP sessions, PPP sessions will be locally authenticated.

RADIUS authentication decoupling cannot be disabled. If you upgrade to a new software image with an old configuration, all the session types are automatically configured to use the configured RADIUS/TACACS server. This is done to make the switch behave similar to the older version on start-up.

Primary/Secondary Server Configuration

The following CLI commands can be used to configure single primary/secondary server and additional primary/secondary servers.

To configure RADIUS primary or secondary servers, use the following command:

```
configure radius [primary | secondary] server [<ipaddress> | <hostname>] {<udp_port>
<L4 port no>} client-ip [<ipaddress>]
```

To configure RADIUS accounting on primary or secondary servers, use the following command:

```
configure radius-accounting [primary | secondary] server [<ipaddress> | <hostname>]
{<udp_port>} client-ip [<ipaddress>]
```

To configure TACACS primary or secondary servers, use the following command:

```
configure tacacs [primary | secondary] server [<ipaddress> | <hostname>] {<tcp_port> | <L4 port no>}
client-ip <ipaddress>
```

```
configure tacacs [primary | secondary] shared-secret {encrypted} <string>
```

To configure a TACACS accounting primary or secondary servers, use the following command:

```
configure tacacs [primary | secondary] server [<ipaddress> | <hostname>] {<tcp_port> | <L4 port no>}
client-ip <ipaddress>
```

Shared Secret Configuration

The following CLI commands configure the RADIUS shared-secret for the primary/secondary servers.

To configure the shared-secret for all the configured primary or secondary RADIUS servers, use the following command:

```
configure radius [primary | secondary] shared-secret {encrypted} [<string>]
```

To configure the shared-secret of all the configured primary or secondary RADIUS accounting servers, use the following command:

```
configure radius-accounting [primary | secondary] shared-secret {encrypted} [<string>]
```

To configure the shared-secret of all the configured primary or secondary TACACS servers, use the following command:

```
configure tacacs [primary | secondary] shared-secret {encrypted} <string>
```

To configure the shared-secret of all the configured primary or secondary TACACS accounting servers, use the following command:

```
configure tacacs-accounting [primary | secondary] shared-secret {encrypted} <string>
```

To list the configuration statistics pertaining to all the configured authentication and accounting servers, use the following commands:

show radius {<ipaddress>}

```
show radius-accounting {<ipaddress>}
show tacacs {<ipaddress>}
show tacacs-accounting {<ipaddress>}
```

Configuring Timeout

Use the following commands to configure RADIUS and TACACS timeouts for the primary/secondary servers.

To configure the timeout interval for RADIUS authentication requests:

```
configure radius (primary|secondary) server <ipaddress> timeout <seconds>
```

To configure the timeout for the RADIUS accounting server, use the following command:

```
configure radius-accounting (primary|secondary) server <ipaddress> timeout <seconds>
```

To configure the timeout for the TACACS server, use the following command:

```
configure tacacs (primary |secondary) server <ipaddress> timeout <seconds>
```

To configure the timeout for the TACACS accounting server, use the following command:

```
configure tacacs-accounting (primary|secondary) server <ipaddress> timeout <seconds>
```

Display Commands

Use the following commands to display information about specific RADIUS or TACACS servers.

To display the configuration and statistics of the radius server determined by <host/ipaddress>, use the following command:

```
show radius {<ipaddress>}
```

To display the configuration and statistics of the radius-accounting server determined by <host/ipaddress>, use the following command:

```
show radius-accounting {<ipaddress>}
```

To display the configuration and statistics of the TACACS server determined by <host/ipaddress>, use the following command:

```
show tacacs {<ipaddress>}
```

To display the configuration and statistics of the tacacs-accounting server determined by <host/ipaddress>, use the following command:

```
show tacacs-accounting {<ipaddress>}
```

To display the authentication servers configured for mgmt-access/netlogin type of sessions, use the following command:

```
show auth
```

Mgmt Sessions

Use the following CLI commands to configure management sessions for primary/secondary authentication servers.

NOTE

The RADIUS or TACACS servers must be configured before using the management session configuration commands. The commands fail if the given primary and secondary radius servers are not configured.

To configure management sessions for RADIUS servers, use the following commands:

```
configure auth mgmt-access radius primary <ipaddress> [secondary <ipaddress>]
```

To configure management sessions for RADIUS accounting, use the following commands. These command returns an error if the given primary and secondary RADIUS servers are not configured or if radius authentication is not configured for management sessions:

```
configure auth mgmt-access radius-accounting primary <ipaddress> [secondary
<ipaddress>]
```

To authenticate management sessions through TACACS servers, use the following commands. By default, remote authentication will remain disabled for the given session type:

```
configure auth mgmt-access tacacs primary <ipaddress> [secondary <ipaddress>]
```

To use TACACS-accounting servers for management session accounting, use the following commands. These command returns an error if the given primary and secondary TACACS servers are not configured or if TACACS authentication is not configured for management sessions:

```
configure auth mgmt-access tacacs-accounting primary <ipaddress> [secondary
<ipaddress>]
```

To disable the remote authentication for management sessions, use the following command:

```
unconfigure auth mgmt-access
```

4.3.5Netlogin Sessions

The following CLI commands configure primary/secondary authentication servers for all the netlogin sessions. These commands are equivalent to configuring dot1x-netlogin and http-netlogin sessions.

To configure authentication for all the netlogin sessions by way of RADIUS servers, use the following commands. This command will fail if the given primary and secondary RADIUS servers are not configured:

```
configure auth netlogin radius primary <ipaddress> [secondary <ipaddress>]
```

To configure RADIUS-accounting servers to account for netlogin sessions, use the following commands. These commands return an error if the given primary and secondary radius servers are not configured or if RADIUS authentication is not configured for netlogin sessions.

```
configure auth netlogin radius-accounting primary <ipaddress> [secondary <ipaddress>]
```

To authenticate the netlogin sessions by way of TACACS servers, use the following commands. The command will fail if the given primary and secondary TACACS servers are not configured. By default, remote authentication will remain disabled for the given session type:

```
configure auth netlogin tacacs primary <ipaddres> [secondary <ipaddress>]
```

To configure to TACACS-accounting servers to account for netlogin sessions, use the following commands. This command returns an error if the given primary and secondary TACACS servers are not configured or if TACACS authentication is not configured for netlogin sessions.

```
configure auth netlogin tacacs-accounting primary <ipaddress> [secondary <ipaddress>]
```

To disable the remote authentication for netlogin sessions, use the following command:

```
unconfigure auth netlogin
```

Secure Shell 2 (SSH2)

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

The ExtremeWare SSH2 switch application is based on the Data Fellows™ SSH2 server implementation. It is highly recommended that you use the F-Secure® SSH client products from Data Fellows corporation. These applications are available for most operating systems. For more information, see the Data Fellows website at:

http://www.datafellows.com.

NOTE

SSH2 is compatible with the Data Fellows SSH2 client version 2.0.12 or above. SSH2 is not compatible with SSH1.

The ExtremeWare SSH2 switch application also works with SSH2 client and server (version 2.x or later) from SSH Communication Security, and the free SSH2 and SCP2 implementation (version 2.5 or later) from OpenSSH. The SFTP file transfer protocol is required for file transfer using SCP2.

Enabling SSH2 for Inbound Switch Access

Because SSH2 is currently under U.S. export restrictions, you must first obtain a security-enabled version of the ExtremeWare software from Extreme Networks before you can enable SSH2. The procedure for obtaining a security-enabled version of the ExtremeWare software is described in Chapter 1.

You must enable SSH2 on the switch before you can connect to it using an external SSH2 client. Enabling SSH2 involves two steps:

- Enabling SSH2 access, which may include specifying a list of clients that can access the switch, and specifying a TCP port to be used for communication.

  By default, if you have a security license, SSH2 is enabled using TCP port 22, with no restrictions on client access.
- Generating or specifying an authentication key for the SSH2 session.

To enable SSH2, use the following command:

```
enable ssh2 {access-profile [<access profile> | none]} {port <tcp_port_number>}
```

You can specify a list of predefined clients that are allowed SSH2 access to the switch. To do this, you must create an access profile that contains a list of allowed IP addresses.

You can also specify a TCP port number to be used for SSH2 communication. By default the TCP port number is 22.

The supported ciphers are 3DES-CBC and Blowfish. The supported key exchange is DSA.

An authentication key must be generated before the switch can accept incoming SSH2 sessions. This can be done automatically by the switch, or you can enter a previously generated key. To have the key generated by the switch, use the following command:

```
configure ssh2 key
```

You are prompted to enter information to be used in generating the key. The key generation process takes approximately ten minutes. Once the key has been generated, you should save your configuration to preserve the key.

To use a key that has been previously created, use the following command:

```
configure ssh2 key {pregenerated}
```

You are prompted to enter the pregenerated key.

The key generation process generates the SSH2 private host key. The SSH2 public host key is derived from the private host key, and is automatically transmitted to the SSH2 client at the beginning of an SSH2 session.

Before you initiate a session from an SSH2 client, ensure that the client is configured for any nondefault access list or TCP port information that you have configured on the switch. Once these tasks are accomplished, you may establish an SSH2-encrypted session with the switch. Clients must have a valid user name and password on the switch in order to log into the switch after the SSH2 session has been established.

For additional information on the SSH protocol refer to [FIPS-186] Federal Information Processing Standards Publication (FIPSPUB) 186, Digital Signature Standard, 18 May 1994. This can be download from: ftp://ftp.cs.hut.fi/pub/ssh. General technical information is also available from:

http://www.ssh.fi

Using SCP2 from an External SSH2 Client

In ExtremeWare version 6.2.1 or later, the SCP2 protocol is supported for transferring image and configuration files to the switch from the SSH2 client, and for copying the switch configuration from the switch to an SSH2 client.

CAUTION

You can download a configuration to an Extreme Networks switch using SCP. If you do this, you cannot save this configuration. If you save this configuration and reboot the switch, the configuration will be corrupted.

The user must have administrator-level access to the switch. The switch can be specified by its switch name or IP address.

Configuration or image files stored on the system running the SSH2 client may be named as desired by the user. However, files on the switch have predefined names, as follows:

- `configuration.cfg`—The current configuration
- `incremental.cfg`—The current incremental configuration
- `primary.img`—The primary ExtremeWare image
- `secondary.img`—The secondary ExtremeWare image
- `bootrom.img`—The BootROM image

For example, to copy an image file saved as *image1.xtr* to switch with IP address 10.10.0.5 as the primary image using SCP2, you would enter the following command within your SSH2 session:

```
scp2 image1.xtr admin@10.20.0.5:primary.img
```

To copy the configuration from the switch and save it in file *config1.save* using SCP, you would enter the following command within your SSH2 session:

```
scp2 admin@10.10.0.5:configuration.cfg config1.save
```

SSH2 Client Functions on the Switch

In ExtremeWare version 6.2.1 or later, an Extreme Networks switch can function as an SSH2 client. This means you can connect from the switch to a remote device running an SSH2 server, and send commands to that device. You can also use SCP2 to transfer files to and from the remote device.

You do not need to enable SSH2 or generate an authentication key to use the SSH2 and SCP2 commands from the ExtremeWare CLI.

To send commands to a remote system using SSH2, use the following command:

```
ssh2 {cipher [3des | blowfish]} {port <portnum>} {compression [on | off]} {user
<username>} {debug <debug_level>} {<username>@} [<host> | <ipaddress>] {<remote
command>}
```

The remote commands can be any commands acceptable by the remote system. You can specify the login user name as a separate argument, or as part of the user@host specification. If the login user name for the remote system is the same as your user name on the switch, you can omit the username parameter entirely.

To initiate a file copy from a remote system to the switch using SCP2, use the following command:

```
scp2 {cipher [3des | blowfish]} {port <portnum>} {debug <debug_level>} <user>@
[<hostname> | <ipaddress>] :<remote_file> [configuration {incremental} | image
[primary | secondary] | bootrom]
```

To initiate a file copy to a remote system from the switch using SCP2, use the following command:

```
scp2 {cipher [3des | blowfish]} {port <portnum>} {debug <debug_level>} configuration
<user>@ [<hostname> | <ipaddress>]:<remote_file>
```

Part 2

Using Switching and Routing Protocols

13 Ethernet Automatic Protection Switching

This chapter describes the use of the Ethernet Automatic Protection Switching (EAPS™) protocol, and includes information on the following topics:

- Overview of the EAPS Protocol on page 349
- Fault Detection and Recovery on page 352
- Multiple EAPS Domains Per Switch on page 354
- Configuring EAPS on a Switch on page 356
- Configuring EAPS Shared Ports on page 363
- EAPS Shared Port Configuration Rules on page 369
- EAPS Shared Port Configuration Examples on page 369

Overview of the EAPS Protocol

The EAPS protocol provides fast protection switching to layer 2 switches interconnected in an Ethernet ring topology, such as a Metropolitan Area Network (MAN) or large campuses (see Figure 42).

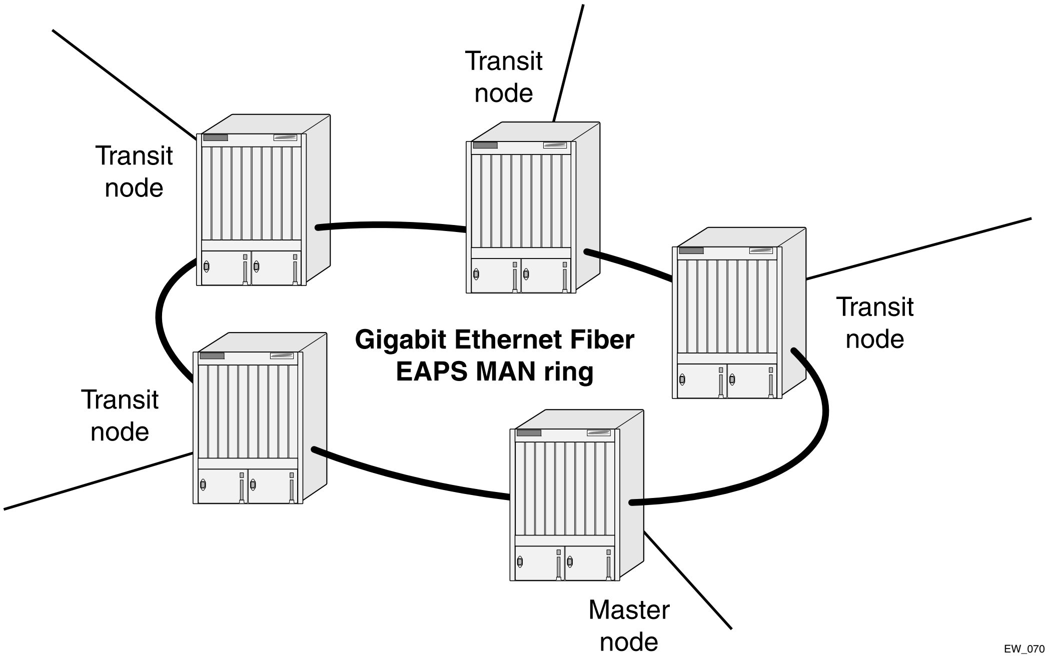
EAPS protection switching is similar to what can be achieved with the Spanning Tree Protocol (STP), but offers the advantage of converging in less than a second when a link in the ring breaks.

An Ethernet ring built using EAPS can have resilience comparable to that provided by SONET rings, at a lower cost and with fewer restraints (e.g., ring size). The EAPS technology developed by Extreme Networks to increase the availability and robustness of Ethernet rings is described in *RFC 3619: Extreme Networks' Ethernet Automatic Protection Switching (EAPS) Version 1*.

In order to use EAPS, you must enable EDP on the switch and EAPS ring ports. For more information on EDP, see Chapter 4.

EAPS operates by declaring an EAPS domain on a single ring. Any VLAN that warrants fault protection is configured on all ring ports in the ring, and is then assigned to an EAPS domain. On that ring domain, one switch, or node, is designated the *master* node (see Figure 43), while all other nodes are designated as *transit* nodes.

Figure 42: Gigabit Ethernet fiber EAPS MAN ring

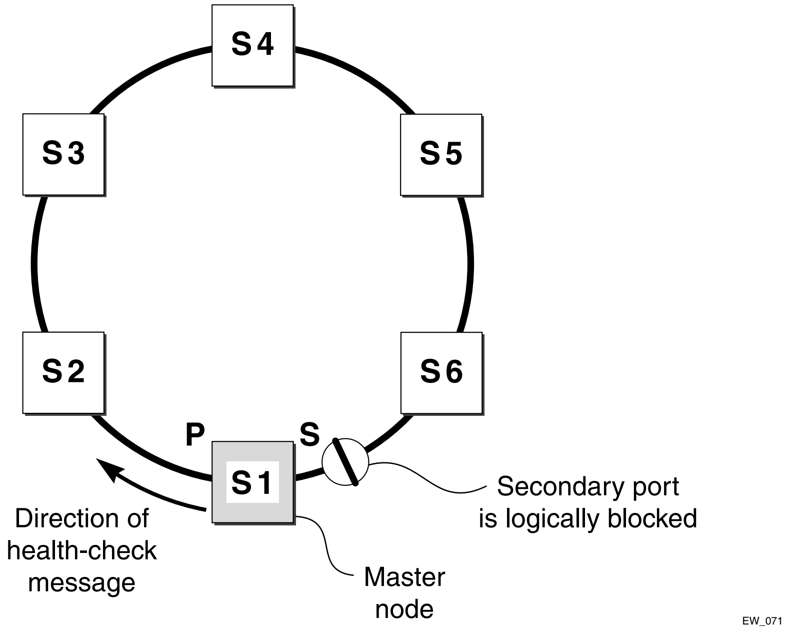


One port of the master node is designated the master node's *primary* port (P) to the ring; another port is designated as the master node's *secondary* port (S) to the ring. In normal operation, the master node blocks the secondary port for all non-control traffic belonging to this EAPS domain, thereby avoiding a loop in the ring, like STP. Layer 2 switching and learning mechanisms operate per existing standards on this ring.

NOTE

Like the master node, each transit node is also configured with a primary port and a secondary port on the ring, but the primary/secondary port distinction is ignored as long as the node is configured as a transit node.

Figure 43: EAPS operation


S4
S3
S5
S2
S6
P
S
S1
Direction of health-check message
Secondary port is logically blocked
Master node
EW_071

If the ring is complete, the master node logically blocks all data traffic in the transmit and receive directions on the secondary port to prevent a loop. If the master node detects a break in the ring, it unblocks its secondary port and allows data traffic to be transmitted and received through it.

EAPS Terms

Table 46 describes terms associated with EAPS.

Table 46: EAPS Terms

Term	Description
EAPS domain	A domain consists of a series of switches, or nodes, that comprise a single ring in a network. An EAPS domain consists of a master node, transit nodes, and on the master node, one primary port and one secondary port. EAPS operates by declaring an EAPS domain on a single ring.
EDP	Extreme Discovery Protocol. A protocol used to gather information about neighbor Extreme switches. Extreme switches use EDP to exchange topology information.
master node	A switch, or node, that is designated the master in an EAPS domain ring. The master node blocks the secondary port for all non-control traffic belonging to this EAPS domain, thereby avoiding a loop in the ring.
transit node	A switch, or node, that is not designated a master in an EAPS domain ring.
primary port	A port on the master node that is designated the primary port to the ring. The transit node ignores the primary port distinction as long as the node is configured as a transit node.
secondary port	A port on the master node that is designated the secondary port to the ring. The transit node ignores the secondary port distinction as long as the node is configured as a transit node.
control VLAN	A VLAN that sends and receives EAPS messages. You must configure one control VLAN for each EAPS domain.

Table 46: EAPS Terms (Continued)

Term	Description
protected VLAN	A VLAN that carries data traffic through an EAPS domain. You must configure one or more protected VLANs for each EAPS domain. (Also known as data VLAN)
common link	The physical link between the controller and partner nodes in a network where multiple EAPS domains share a common link between them.
controller	The end of a common link responsible for blocking ports if the common link fails thereby preventing a superloop
partner	The other end of a common link. This end does not participate in any form of blocking.

Fault Detection and Recovery

EAPS fault detection on a ring is based on a single *control* VLAN per EAPS domain. This EAPS domain provides protection to one or more data-carrying VLANs called *protected* VLANs.

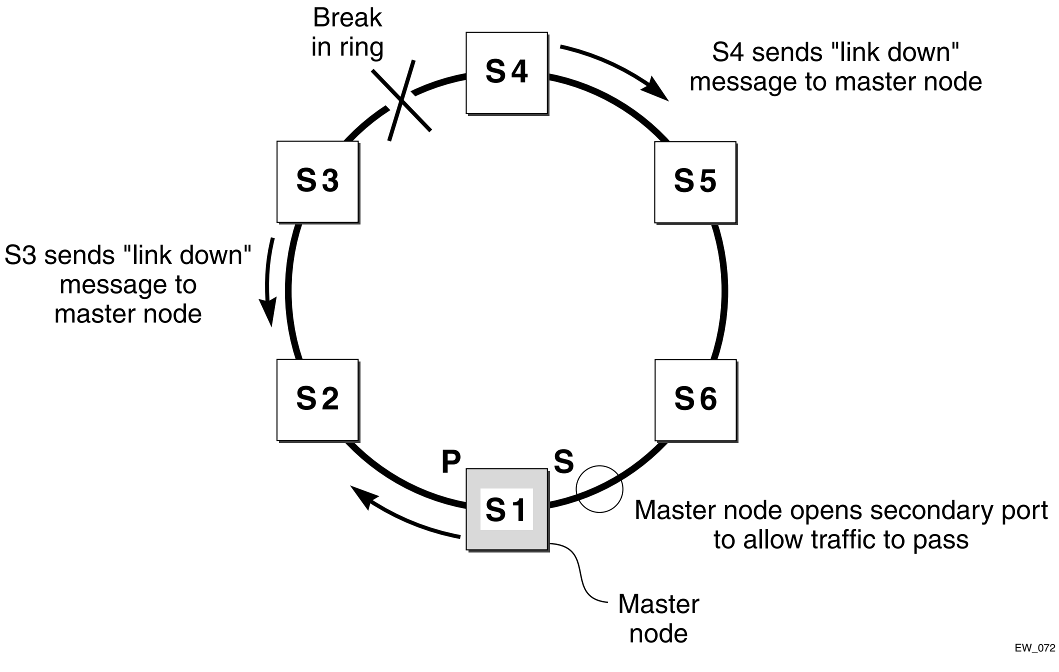
The control VLAN is used only to send and receive EAPS messages; the protected VLANs carry the actual data traffic. As long as the ring is complete, the EAPS master node blocks the protected VLANs from accessing its secondary port.

NOTE

The control VLAN is not blocked. Messages sent on the control VLAN must be allowed into the switch for the master node to determine whether the ring is complete.

To avoid loops in the network, the control VLAN must be NOT be configured with an IP address, and ONLY ring ports may be added to the VLAN.

Figure 44: EAPS fault detection and protection switching


Break in ring
S4
S4 sends "link down" message to master node
S3
S5
S3 sends "link down" message to master node
S2
S6
P
S
S1
Master node opens secondary port to allow traffic to pass
Master node
EW_072

A master node detects a ring fault in one of three ways:

- Link-down message sent by a transit node
- Ring port down event sent by hardware layers
- Polling response

Link Down Message Sent by a Transit Node

When any transit node detects a loss of link connectivity on any of its ring ports, it immediately sends a “link down” message on the control VLAN using its good link to the master node.

When the master node receives the “link down” message (see Figure 44), it immediately declares a “failed” state and opens its logically blocked secondary port on all the protected VLANs. Now, traffic can flow through the master’s secondary port. The master node also flushes its FDB and sends a message on the control VLAN to all of its associated transit nodes to flush their forwarding databases as well, so that all of the switches can learn the new paths to layer 2 end stations on the reconfigured ring topology.

Ring Port Down Event Sent by Hardware Layer

When a ring port goes down on a master node switch, it is notified by the lower hardware layer and immediately goes into a “failed” state.

If the primary ring port goes down, the secondary port is opened. The normal operation of flushing its FDB and sending a “link-down” message to all transit nodes is performed.

Polling

The master node transmits a health-check packet on the control VLAN at a user-configurable interval (see Figure 43). If the ring is complete, the master node will receive the health-check packet on its secondary port (the control VLAN is not blocked on the secondary port). When the master node receives the health-check packet, it resets its failtimer and continues normal operation.

If the master node does not receive the health-check packet before the failtimer interval expires, and the failtime expiry action is set to `open-secondary-port`, it declares a “failed” state and performs the same steps described above: it unblocks its secondary port for access by the protected VLANs, flushes its forwarding database (FDB), and sends a “flush FDB” message to its associated transit nodes.

Restoration Operations

The master node continues sending health-check packets out its primary port even when the master node is operating in the failed state. As long as there is a break in the ring, the fail-period timer of the master node will continue to expire and the master node will remain in the failed state.

When the broken link is restored, the master will receive its health-check packet back on its secondary port, and will once again declare the ring to be complete. It will logically block the protected VLANs on its secondary port, flush its FDB, and send a “flush FDB” message to its associated transit nodes.

During the time between when the transit node detects that the link is operable again and when the master node detects that the ring is complete, the secondary port on the master node is still open and data could start traversing the transit node port that just came up. To prevent the possibility of a such a temporary loop, when the transit node detects that its failed link is up again, it will perform these steps:

1. For the port that just came up, put all the protected VLANs traversing that port into a temporary blocked state.
2. Remember which port has been temporarily blocked.
3. Set the state to Preforwarding.

When the master node receives its health-check packet back on its secondary port, and detects that the ring is once again complete, it sends a message to all its associated transit nodes to flush their forwarding databases.

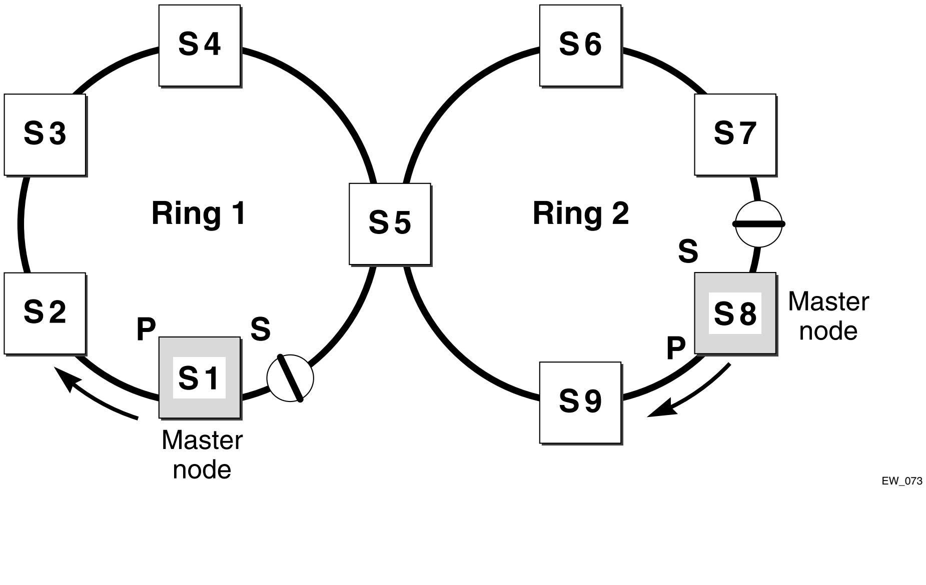
When the transit nodes receive the message to flush their forwarding databases, they perform these steps:

1. Flush their forwarding databases on the protected VLANs.
2. If the port state is set to Preforwarding, unblock all the previously blocked protected VLANs for the port.

Multiple EAPS Domains Per Switch

Figure 45 shows how a data VLAN could span two rings interconnected by a common switch—a "figure eight" topology. In this example, there is an EAPS domain with its own control VLAN running on ring 1 and another EAPS domain with its own control VLAN running on ring 2. A data VLAN that spans both rings will be added as a protected VLAN to both EAPS domains. In Figure 45, switch S5 will have two instances of EAPS domains running on it: one for each ring.

Figure 45: EAPS data VLAN spanning two rings interconnected by one switch



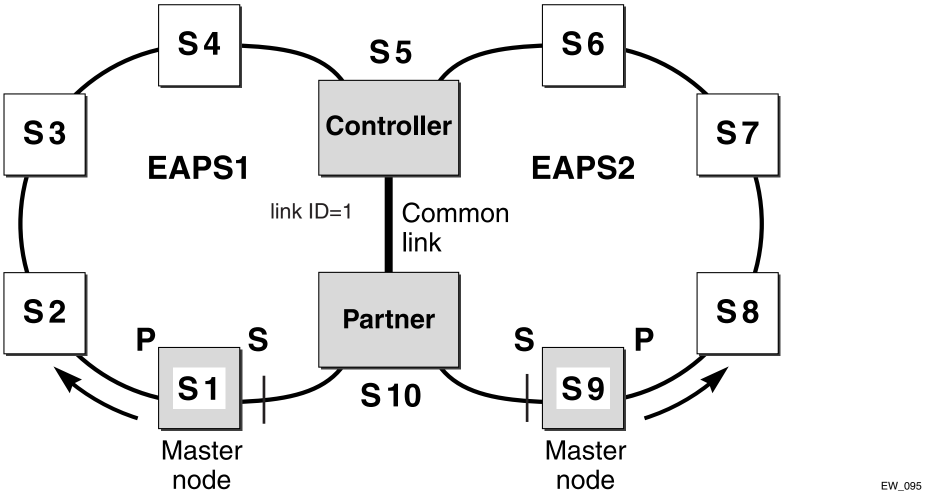
To take advantage of the Spatial Reuse technology and broaden the use of the ring's bandwidth, EAPS supports multiple EAPS domains running on the ring at the same time.

So, a single ring might have two EAPS domains running on it. Each EAPS domain would have a different EAPS master node. Each EAPS domain will protect its own set of protected VLANS.

Multiple EAPS Rings Sharing Common Links

In the example shown in Figure 45, switch S5 could be a single point of failure. If switch S5 were to go down, users on Ring 1 would not be able to communicate with users on Ring 2. To make the network more resilient, you can add another switch, S10. The link connecting S5 to S10 is knows as the *common link,* as shown in Figure 46

Figure 46: EAPS common link



The switches on either end of the common link must be configured as *controller* and a *partner*. For information about configuring common links, see "Configuring EAPS Shared Ports" on page 363.

NOTE

If the shared port is not configured and the common link goes down a superloop between the multiple EAPS domains will occur.

NOTE

In order to take advantage of the Spatial Reuse technology in a shared-port environment in this software release, you can use the existing solution of configuring EAPS plus STP.

Configuring EAPS on a Switch

This section describes how to configure EAPS on a switch.

Creating and Deleting an EAPS Domain

Each EAPS domain is identified by a unique domain name.

To create an EAPS domain, use the following command:

```
create eaps <name>
```

The `name` parameter is a character string of up to 32 characters that identifies the EAPS domain to be created. EAPS domain names and VLAN names must be unique: Do not use the same name string to identify both an EAPS domain and a VLAN.

The following command example creates an EAPS domain named “eaps_1”:

```
create eaps eaps_1
```

To delete an EAPS domain, use the following command:

```
delete eaps <name>
```

The following command example deletes the EAPS domain “eaps_1”:

```
delete eaps eaps_1
```

Defining the EAPS Mode of the Switch

To configure the EAPS node type of the switch, use the following command:

```
configure eaps <name> mode [master | transit]
```

One node on the ring must be configured as the master node for the specified domain; all other nodes on the ring are configured as transit nodes for the same domain.

The following command example identifies this switch as the master node for the EAPS domain named eaps_1.

```
configure eaps eaps_1 mode master
```

The following command example identifies this switch as a transit node for the EAPS domain named eaps_1.

```
configure eaps eaps_1 mode transit
```

Configuring EAPS Polling Timers

To set the values of the polling timers the master node uses for the EAPS health-check packet that is circulated around the ring for an EAPS domain, use the following command:

```
configure eaps <name> hellotime <seconds>
configure eaps <name> failtime [<seconds>]
```

To configure the action taken if there is a break in the ring, use the following command:

```
configure eaps <name> failtime expiry-action [ open-secondary-port | send-alert]
```

NOTE

These commands apply only to the master node. If you configure the polling timers for a transit node, they will be ignored. If you later reconfigure that transit node as the master node, the polling timer values will be used as the current values.

Use the `hellotime` keyword and its associated `seconds` parameter to specify the amount of time the master node waits between transmissions of health-check packets on the control VLAN. `seconds` must be greater than 0 when you are configuring a master node. The default value is one second.

NOTE

Increasing the `hellotime` *value keeps the processor from sending and processing too many health-check packets. Increasing the* `hellotime` *value should not affect the network convergence time, because transit nodes are already sending "link down" notifications.*

Use the `failtime` keyword and `seconds` parameters to specify the amount of time the master node waits before the failtimer expires.

The `seconds` parameter must be greater than the configured value for `hellotime`. The default value is three seconds.

You can configure the action taken when the failtimer expires by using the `configure eaps failtime expiry-action` command. Use the `send-alert` parameter to send an alert when the failtimer expires. Instead of going into a "failed" state, the master node remains in a "Complete" or "Init" state, maintains the secondary port blocking, and writes a critical error message to syslog warning the user that there is a fault in the ring. An SNMP trap is also sent.

To use the failtimer expiry action of earlier releases, use the `open-secondary-port` parameter.

NOTE

Increasing the failtime value provides more protection by waiting longer to receive a health-check packet when the network is congested.

The following command examples configure the hellotime value for the EAPS domain "eaps_1" to 2 seconds, the failtime value to 15 seconds, and the failtime expiry-action to open the secondary port if the failtimer expires:

```
configure eaps eaps_1 hellotime 2
configure eaps eaps_1 failtime 15
configure eaps eaps_1 failtimer expiry-action open-secondary-port
```

Configuring the Primary and Secondary Ports

Each node on the ring connects to the ring through two ring ports. As part of the protection switching scheme, one port must be configured as the *primary* port; the other must be configured as the *secondary* port.

If the ring is complete, the master node prevents a loop by logically blocking all data traffic in the transmit and receive directions on its secondary port. If the master node subsequently detects a break in the ring, it unblocks its secondary port and allows data traffic to be transmitted and received through it.

To configure a node port as primary or secondary, use the following command:

```
configure eaps <eaps domain> [primary | secondary] port <port number>
```

The following command example adds port 1 of the module installed in slot 8 of the BlackDiamond switch to the EAPS domain "eaps_1" as the primary port.

```
configure eaps eaps_1 primary port 8:1
```

Configuring the EAPS Control VLAN

You must configure one *control* VLAN for each EAPS domain. The control VLAN is used only to send and receive EAPS messages.

NOTE

A control VLAN cannot belong to more than one EAPS domain. If the domain is active, you cannot delete the domain or modify the configuration of the control VLAN.

To configure the EAPS control VLAN for the domain, use the following command:

```
configure eaps <name> add control vlan <vlan_name>
```

NOTE

The control VLAN must NOT be configured with an IP address. In addition, only ring ports may be added to this control VLAN. No other ports can be members of this VLAN. Failure to observe these restrictions can result in a loop in the network.

NOTE

When you configure the VLAN that will act as the control VLAN, that VLAN must be assigned a QoS profile of Qp8, and the ring ports of the control VLAN must be tagged.

By assigning the control VLAN a QoS profile of Qp8 (with the QoS profile `HighHi` priority setting), you ensure that EAPS control VLAN traffic is serviced before any other traffic and that control VLAN messages reach their intended destinations. For example, if the control VLAN is not assigned the highest priority and a broadcast storm occurs in the network, the control VLAN messages might be dropped at intermediate points. Assigning the control VLAN the highest priority prevents dropped control VLAN messages.

Because the QoS profile `HighHi` priority setting by itself should ensure that the control VLAN traffic gets through a congested port first, you should not need to set the QoS profile minimum bandwidth (minbw) or maximum bandwidth (maxbw) settings. However, if you plan to use QoS (profile priority and bandwidth settings) for other traffic, you might need to set a minbw value on Qp8 for control VLAN traffic. Whether you need to do this depends entirely on your configuration.

The following command example adds the control VLAN “keys” to the EAPS domain “eaps_1”.

```
configure eaps eaps_1 add control vlan keys
```

Configuring the EAPS Protected VLANs

You must configure one or more *protected* VLANs for each EAPS domain. The protected VLANs are the data-carrying VLANs.

NOTE

When you configure the VLAN that will act as a protected VLAN, the ring ports of the protected VLAN must be tagged (except in the case of the default VLAN).

To configure an EAPS protected VLAN, use the following command:

```
configure eaps <name> add protect vlan <vlan_name>
```

NOTE

As long as the ring is complete, the master node blocks the protected VLANs on its secondary port.

The following command example adds the protected VLAN “orchid” to the EAPS domain “eaps_1.”

```
configure eaps eaps_1 add protect vlan orchid
```

NOTE

The configuration of the Superbridge, SubBridge, and IP range control VLANs cannot be modified.

Enabling and Disabling an EAPS Domain

To enable a specific EAPS domain, use the following command:

```
enable eaps {<name>}
```

To disable a specific EAPS domain, use the following command:

```
disable eaps {<name>}
```

Enabling and Disabling EAPS

To enable the EAPS function for the entire switch, use the following command:

```
enable eaps
```

To disable the EAPS function for the entire switch, use the following command:

```
disable eaps
```

Unconfiguring an EAPS Ring Port

Unconfiguring an EAPS port sets its internal configuration state to INVALID, which causes the port to appear in the Idle state with a port status of Unknown when you use the `show eaps {<name>} {detail}` command to display the status information about the port.

To unconfigure an EAPS primary or secondary ring port for an EAPS domain, use the following command:

```
unconfigure eaps <name> [primary | secondary] port
```

The following command example unconfigures this node's EAPS primary ring port on the domain "eaps_1":

```
unconfigure eaps eaps_1 primary port
```

Displaying EAPS Status Information

To display EAPS status information, use the following command:

```
show eaps summary
```

This example displays summary EAPS information on a transit node:

```
EAPS Enabled: Yes
Number of EAPS instances: 3
EAPSD-Bridge links: 6

                                  Pri     Sec                         Vlan
Domain        State        Mo En  Port    Port     Control-Vlan (VID) count
------------  ------------ -- -- ------- -------   -----------------------
eaps4         Links-Up     T  Y    1:1     1:4     cv4         (1004)    1
eaps3         Links-Up     T  Y    1:1     1:3     cv3         (1003)    1
eaps2         Links-Up     T  Y    1:1     1:2     cv2         (1002)    1


EAPS shared-port count: 1

                         Link                 Domain Vlan       RB       RB
Shared-port  Mode        Id     Up   State      count  count  Nbr State    Id
-----------  ----------  ----   --   ---------  ------ -----  --- ------- -----
1:1          Controller  2      Y    Ready        3      1      Yes None   None
EAPS Domain list: "eaps2" "eaps3" "eaps4"
```

To display more detailed EAPS status information, use the following command:

```
show eaps {<name>} {detail}
```

If you enter the `show eaps` command without an argument or keyword, the command displays a summary of status information for all configured EAPS domains. You can use the `detail` keyword to display more detailed status information.

NOTE

The output displayed by this command depends on whether the node is a transit node or a master node. The display for a transit node contains information fields that are not shown for a master node. Also, some state values are different on a transit node than on a master node.

The following example of the `show eaps {<name>} {detail}` command displays detailed EAPS information for a transit node. Table 47 describes the fields and values in the display.

```
* Summit5iTx:39 # show eaps detail
EAPS Enabled: Yes
Number of EAPS instances: 1
EAPSD-Bridge links: 2

  Name: “eaps1” (instance=0)
  State: Links Up          [Running: Yes]
  Enabled: Yes    Mode: Transit
  Primary port: 13          Port status: Up        Tag status: Tagged
  Secondary port: 14        Port status: Up        Tag status: Tagged
  Hello Timer interval: 1 sec     Fail Timer interval: 3 sec
  Preforwarding Timer interval: 3 sec
  Last update: From Master Id 00:01:30:B9:4B:E0, at Tue May 6 12:49:25 2003
  Eaps Domain has following Controller Vlan:
       Vlan Name            VID    QosProfile
        “rhsc”              0020   QP8
  EAPS Domain has following Protected Vlan(s):
    Vlan Name            VID
    “traffic”            1001
  Number of Protected Vlans: 1
```

The following example of the `show eaps {<name>} {detail}` command displays detailed EAPS information for a single EAPS domain named “eaps2” on the master node. Table 47 describes significant fields and values in the display.

```
* Baker15:4 # show eaps2 detail
  Name: “eaps2” (instance=0)
  State: Complete        [Running: Yes]
  Enabled: Yes    Mode: Master
  Primary port: 14          Port status: Up        Tag status: Tagged
  Secondary port: 13        Port status: Blocked   Tag status: Tagged
  Hello Timer interval: 1 sec     Fail Timer interval: 3 sec
   Failtimer expiry action: Send alert
  Last update: From Master Id 00:01:30:B9:4B:E0, at Tue May 6 12:49:25 2003
  Eaps Domain has following Controller Vlan:
     Vlan Name            VID      QosProfile
      “rhsc”            0020          QP8
  EAPS Domain has following Protected Vlan(s):
    Vlan Name            VID
    “blue”               1003
    “traffic”            1001
  Number of Protected Vlans: 2
```

Table 47: show eaps Display Fields

Field	Description
EAPS Enabled:	Current state of EAPS on this switch: • Yes—EAPS is enabled on the switch. • No—EAPS is not enabled.
EAPS Fast Convergence:	Displays only when Fast Convergence is on.
Number of EAPS instances:	Number of EAPS domains created. The maximum number of EAPS domains per switch is 64.

Table 47: show eaps Display Fields (Continued)

Field	Description
EAPSD-Bridge links:	The total number of EAPS bridge links in the system. The maximum count is 8192. Each time a VLAN is added to EAPS, this count increments by 1.
Name:	The configured name for this EAPS domain.
(Instance=)	The instance number is created internally by the system.
State:	On a transit node, the command displays one of the following states: • Idle—The EAPS domain has been enabled, but the configuration is not complete. • Links-Up—This EAPS domain is running, and both its ports are up and in the FORWARDING state. • Links-Down—This EAPS domain is running, but one or both of its ports are down. • Preforwarding—This EAPS domain is running, and both of its ports are up, but one of them is in a temporary BLOCKED state. On a master node, the command displays one of the following states: • Idle—The EAPS domain has been enabled, but the configuration is not complete. • Init—The EAPS domain has started but has not yet determined the status of the ring. The secondary port is in a BLOCKED state. • Complete—The ring is in the COMPLETE state for this EAPS domain. • Failed—There is a break in the ring for this EAPS domain. • [Failtimer Expired]—When the failtimer expires and it's action is set to send-alert, this flag is set. This flag indicates there is a misconfiguration or hardware problem in the EAPS ring. The EAPS master node will continue to remain in COMPLETE or INIT state with it's secondary port blocking.
[Running: …]	• Yes—This EAPS domain is running. • No—This EAPS domain is not running.
Enabled:	Indicates whether EAPS is enabled on this domain. • Y—EAPS is enabled on this domain. • N—EAPS is not enabled.
Mode:	The configured EAPS mode for this switch: transit (T) or master (M).
Primary/Secondary port:	The port numbers assigned as the EAPS primary and secondary ports. On the master node, the port distinction indicates which port is blocked to avoid a loop.
Port status:	• Unknown—This EAPS domain is not running, so the port status has not yet been determined. • Up—The port is up and is forwarding data. • Down—The port is down. • Blocked—The port is up, but data is blocked from being forwarded.

Table 47: show eaps Display Fields (Continued)

Field	Description
Tag status:	Tagged status of the control VLAN: • Tagged—The control VLAN has this port assigned to it, and the port is tagged in the VLAN. • Untagged—The control VLAN has this port assigned to it, but the port is untagged in the control VLAN. • Undetermined—Either a VLAN has not been added as the control VLAN to this EAPS domain or this port has not been added to the control VLAN.
Hello Timer interval:	The configured value of the timer in seconds, specifying the time that the master node waits between transmissions of health-check packets.
Fail Timer interval:	The configured value of the timer in seconds, specifying the time that the master node waits before the failtimer expires.
Failtimer expiry action:	Displays the action taken when the failtimer expires: • Send-alert—Sends a critical message to the syslog when the failtimer expires. • Open-secondary-port—Opens the secondary port when the failtimer expires. Displays only for master nodes.
Preforwarding Timer interval:[1]	The configured value of the timer. This value is set internally by the EAPS software.
Last update:[1]	Displayed only for transit nodes; indicates the last time the transit node received a hello packet from the master node (identified by its MAC address).
EAPS Domain has … Controller Vlans:	Lists the assigned name and ID of the control VLAN.
EAPS Domain has … Protected Vlans:[2]	Lists the assigned names and VLAN IDs of all the protected VLANs configured on this EAPS domain.
Number of Protected Vlans:	The count of protected VLANs configured on this EAPS domain.

[1] These fields apply only to transit nodes; they are not displayed for a master node.

[2] This list is displayed when you use the `detail` keyword in the `show eaps` command.

Configuring EAPS Shared Ports

The physical link between two nodes in a multiple EAPS domain state is the *common link*. Each node is configured with a shared port to another node in an EAPS domain to create the common link. To prevent a superloop from occurring if the common link between the multiple EAPS domains fails, the switches on either end of the common link must be configured as *controller* and a *partner.*

If the common link fails, both the controller and partner go into a “blocking” state. The partner never actually does any blocking. Only the controller is responsible for blocking to prevent a superloop, while at the same time maintaining connectivity. When the common link fails, the controller keeps one of its ports in the forwarding state and mark it as “Active-Open”, and the remaining ports will be marked as “blocked”.

When the common link comes back up again, the controller goes from a “blocking” state to a ″Preforwarding″ state; it keeps the ports temporarily blocked to prevent a temporary loop.

Steady State

In steady state when the common link is up, both the controller and partner are said to be in the "ready" state. After EAPS has converged and the EAPS master node has blocked its own secondary ports, the controller puts all its ports into "forwarding", and goes back to "ready" state.

Figure 47: Multiple EAPS Domain Steady State

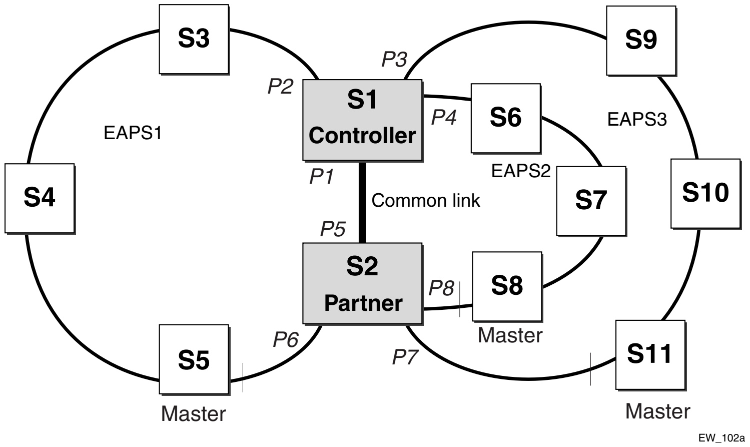


Figure 47 shows a multiple EAPS domain steady state, where:

- EAPS1 is the EAPS domain for ring S1, S3, S4, S5, and S2
- EAPS2 is the EAPS domain for ring S1, S6, S7, S8, and S2
- EAPS3 is the EAPS domain for ring S1, S9, S10, S11, and S2
- P1, P2, P3, and P4 are the ports on switch S1
- P5, P6, P7, and P8 are the ports on switch S2
- S5, S8, and S11 are the master nodes of their respective EAPS domains
- S3, S4, S6, S7, S9, and S10 are the transit nodes of their respective EAPS domains
- S1 and S2 are running EAPSv2
- S1 is the controller
- S2 is the partner
- P1 is the EAPS shared port on switch S1
- P5 is the EAPS shared port on switch S2

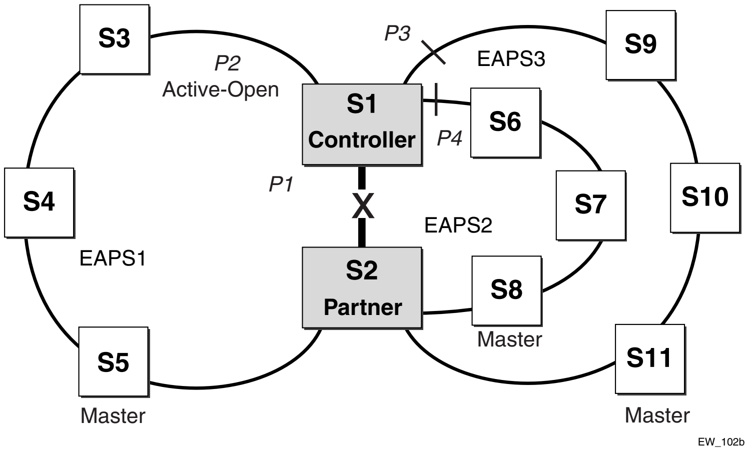
Common Link Failures

When a single common link fails the configured controller (S1) and partner (S2) take steps to prevent a superloop.

Assuming there is a single data VLAN configured on all three EAPS domains, the controller (S1) needs to keep one port open (called "Active-Open") to prevent a superloop. The remaining ports would be "blocked".

In Figure 48, P2 is the "Active-Open" port on S1. Ports P3 and P4 are "blocked". The master nodes (S5, S8, and S11) will open their secondary ports.

Figure 48: EAPS Common Link Failure



When the common link is restored, the controller goes into Preforwarding state. After it gets notification from the master nodes that they have converged and blocked their secondary ports, the controller opens all ports.

Creating and Deleting a Shared Port

To configure a common link, you must create a shared port on each switch belonging to the common link. To create a shared port, use the following command:

```
create eaps shared-port <port>
```

where *port* is the common link port.

NOTE

A switch can have a maximum of two shared ports.

To delete a shared port on the switch, use the following command:

```
delete eaps shared-port <port>
```

Defining the Mode of the Shared Port

The shared port on one end of the common link must be configured to be the *controller*. This is the end responsible for blocking ports when the common link fails thereby preventing the superloop.

The shared port on the other end of the common link must be configured to be the *partner*. This end does not participate in any form of blocking. It is responsible for only sending and receiving health-check messages.

To configure the mode of the shared port, use the following command:

```
configure eaps shared-port <port> mode <controller | partner>
```

CAUTION

The master secondary port cannot be a shared port. If the master primary port is a shared port, you must configure the partner before you configure the controller.

Configuring the Link ID of the Shared Port

Each common link in the EAPS network must have a unique link ID. The controller and partner shared ports belonging to the same common link must have *matching* link IDs. No other instance in the network should have that link ID.

To configure the link ID of the shared port, use the following command.

```
configure eaps shared-port <port> link-id <id>
```

Unconfiguring an EAPS Shared Port

To unconfigure a link ID on a shared port, use the following command:

```
unconfigure eaps shared-port <port> link-id
```

To unconfigure the mode on a shared port, use the following command:

```
unconfigure eaps shared-port <port> mode
```

To delete a shared port, use the following command:

```
delete eaps shared-port <port>
```

Displaying EAPS Shared-Port Status Information

To display EAPS shared port status information, use the following command:

```
show eaps {<name>} {detail}
```

If you enter the `show eaps shared-port` command without an argument or keyword, the command displays a summary of status information for all configured EAPS shared ports. You can use the `detail` keyword to display more detailed status information about the segments and VLANs associated with each shared port.

The following examples of the `show eaps shared-port` command displays shared port information when the EAPS domain is in a “ready” state (for example, when the common link is up).

```
BD_3_42:7 # show eaps shared-port

EAPS shared-port count: 1

                         Link                 Domain Vlan       RB   RB
Shared-port  Mode        Id    Up  State      count  count  Nbr StateId
-----------  ----------  ----  --  ---------  ------ -----  --- ------------
1:1          Controller  2     Y   Ready        3     1     Yes None None

EAPS Domain list: "eaps2" "eaps3" "eaps4"
```

The following example also displays detailed EAPS shared-port information:

```
show eaps summary
```

The results for this command are as follows:

```
EAPS Enabled: Yes
Number of EAPS instances: 3
EAPSD-Bridge links: 6

                                  Pri     Sec                          Vlan
Domain        State        Mo En  Port    Port     Control-Vlan (VID) count
------------  ------------ -- -- ------- -------   ------------------ -----
eaps4         Links-Up     T  Y    1:1     1:4     cv4         (1004)    1
eaps3         Links-Up     T  Y    1:1     1:3     cv3         (1003)    1
eaps2         Links-Up     T  Y    1:1     1:2     cv2         (1002)    1


EAPS shared-port count: 1

                         Link                 Domain Vlan       RB      RB
Shared-port  Mode        Id    Up  State      count  count  Nbr State   Id
-----------  ----------  ----  --  ---------  ------ -----  --- ------- -----
1:1          Controller  2     Y   Ready        3     1     Yes None    None
EAPS Domain list: "eaps2" "eaps3" "eaps4"
```

Table 48 describes significant fields and values in the display output of `show eaps shared-port detail` commands.

Table 48: show eaps shared-port Display Fields

Field	Description
Shared Port	Displays the port number of the shared port.
Mode	Indicates whether the switch on either end of the common link is a controller or partner. The mode is configured by the user.
Link ID	The link ID configured by the user.

Table 48: show eaps shared-port Display Fields (Continued)

Field	Description
Up	Displays one of the following states: • Yes—Indicates that the link ID and the mode are configured. • No—Indicates that the link ID or the mode is not configured.
State	Displays one of the following states: • Idle—The neighbor cannot be reached. • Ready—The EAPS domain is running, the neighbor can be reached, and the common link is *up*. • Blocking—The EAPS domain is running, the neighbor can be reached, but the common link is *down*. • Preforwarding—The EAPS domain was in a blocking state, and the common link came up. To prevent a superloop, a temporary blocking state is created before going into Ready state.
Domain Count	Indicates the number of EAPS domains sharing the common link.
VLAN Count	Indicates the total number of VLANs that are protected under the EAPS domains sharing this common link.
Nbr	Displays one of the following states: • Yes—Indicates that the EAPS instance on the other end of the common link is configured with matching link ID and opposite modes. For example, if one end of the common link is configured as a controller, the other end must be configured as a partner. • Err—Indicates that the EAPS instance on the other end of the common link is configured with a matching link ID, but the modes are configured the same (for example, both modes are configured as controller, or both modes are configured as partner. • No—Indicates one or more of the following: - The switch on the other end of the common link is not running. - The shared port has not been created. - The link IDs on each side of the common link do not match. - The common link, and any other segment between the controller and partner are not fully connected.
RB State	Displays one of the following states: • None—This EAPS shared-port is not the “root blocker”. • Active—This EAPS shared-port is the “root blocker” and is currently active. • Inactive—This EAPS shared-port is the “root blocker” but is currently inactive.
RB ID	The ID of the root blocker. If the value is none, there are not two or more common-link failures.
EAPS Domain List	Lists the EAPS domains that share the common link.

EAPS Shared Port Configuration Rules

The following rules apply to EAPS shared port configurations:

- The controller and partner shared ports on either side of a common link *must* have the same link ID.
- Each common link must have a *unique* link ID.
- The modes on either side of a common link must be different from each other; one must be a *controller* and one must be a *partner*.
- There can be only up to two shared ports per switch.
- There cannot be more that one controller on a switch.

  Valid combinations on any one switch are:
  - 1 controller
  - 1 partner
  - 1 controller and 1 partner
  - 2 partners
- A shared port cannot be configured on an EAPS master's secondary port.

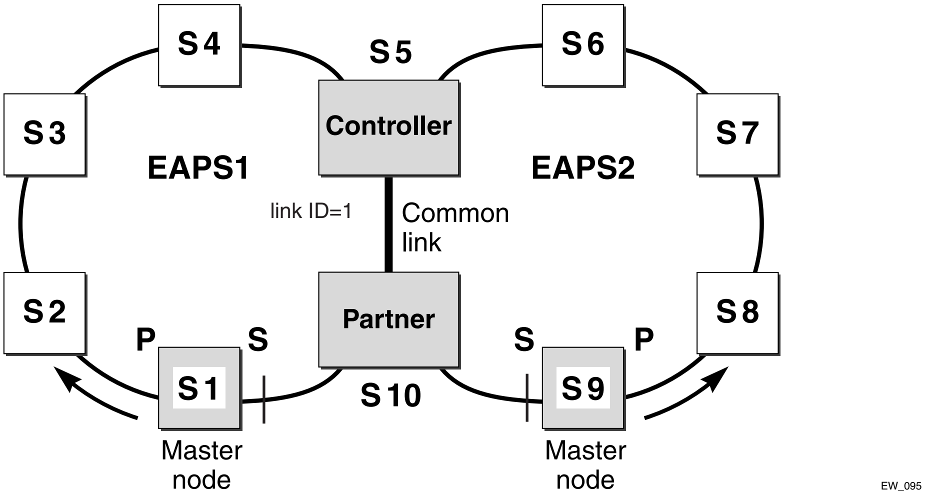
EAPS Shared Port Configuration Examples

This section provides examples of EAPS shared port configurations.

Basic Configuration

This example, shown in Figure 49, is the most basic configuration; two EAPS domains with a single common link between them.

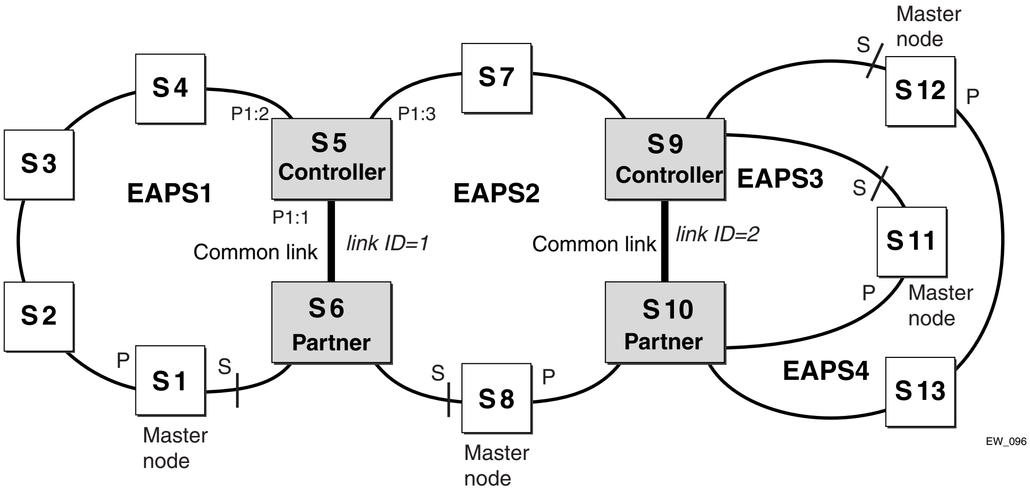
Figure 49: EAPS shared port basic configuration



Basic Core Configuration

This configuration, shown in Figure 50, shows a core with access rings. In this topology, there are two EAPS common links.

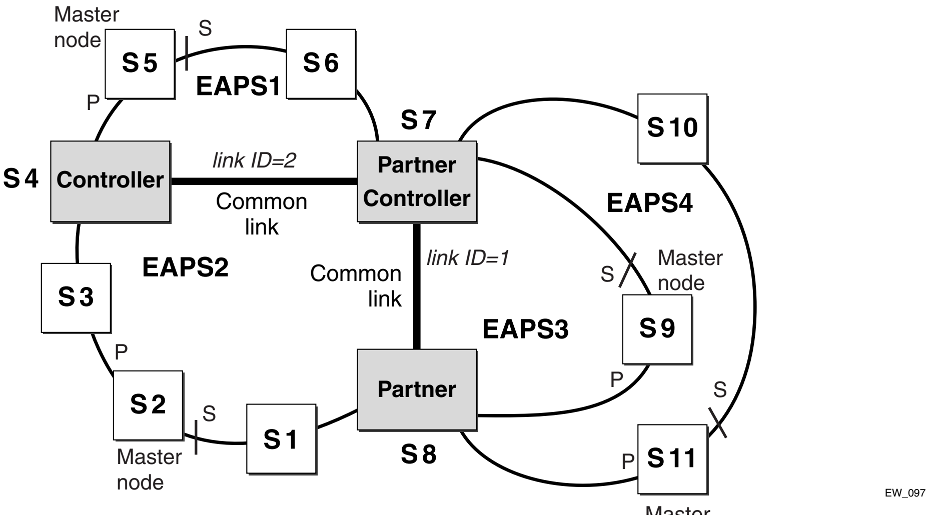
Figure 50: EAPS shared port basic core configuration



Right Angle Configuration

In this topology, there are still two EAPS common links, but the common links are adjacent to each other. To configure a right angle configuration, there must be two common links configured on one of the switches. Figure 51 shows a Right Angle configuration.

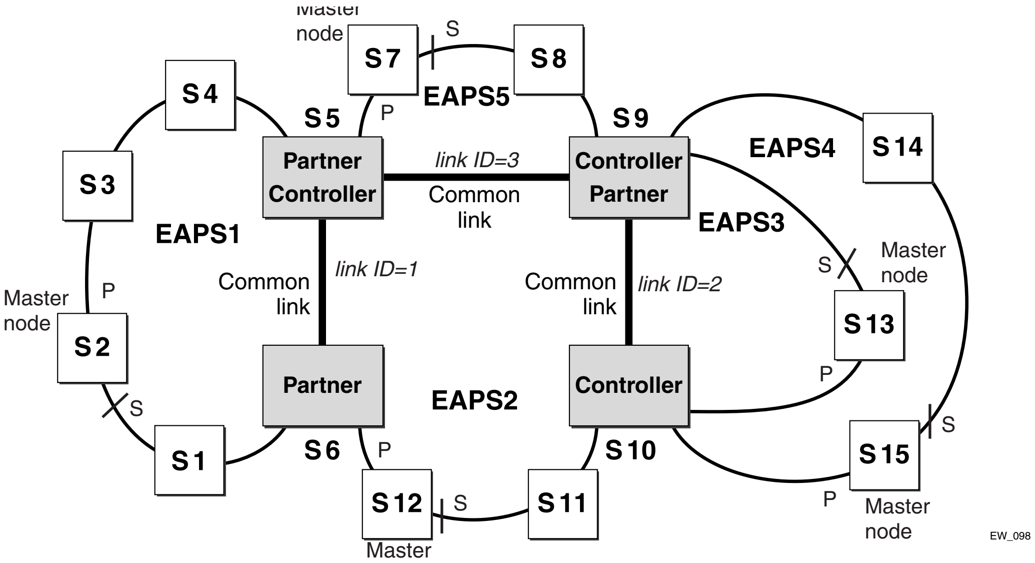
Figure 51: EAPS shared port right angle configuration



Combined Basic Core and Right Angle Configuration

Figure 52 shows a combination Basic Core and Right Angle configuration.

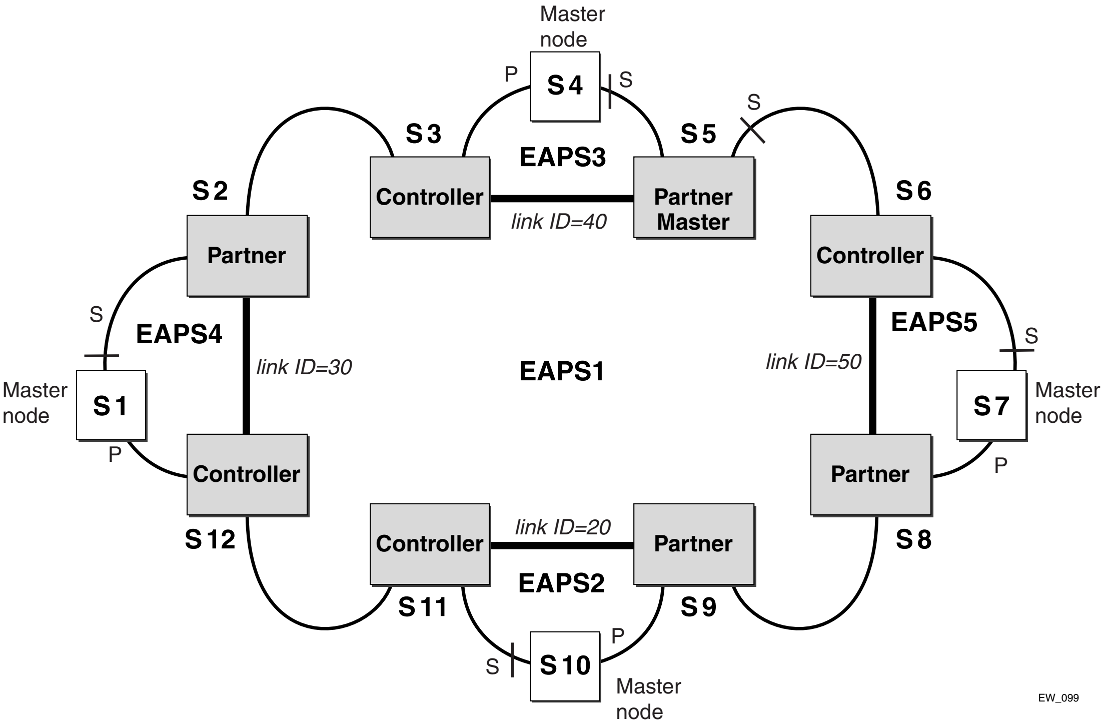
Figure 52: Basic core and right angle configuration



Large Core and Access Rings Configuration

Figure 53 shows a single large core ring with multiple access rings hanging off of it. This is an extension of a basic core configuration.

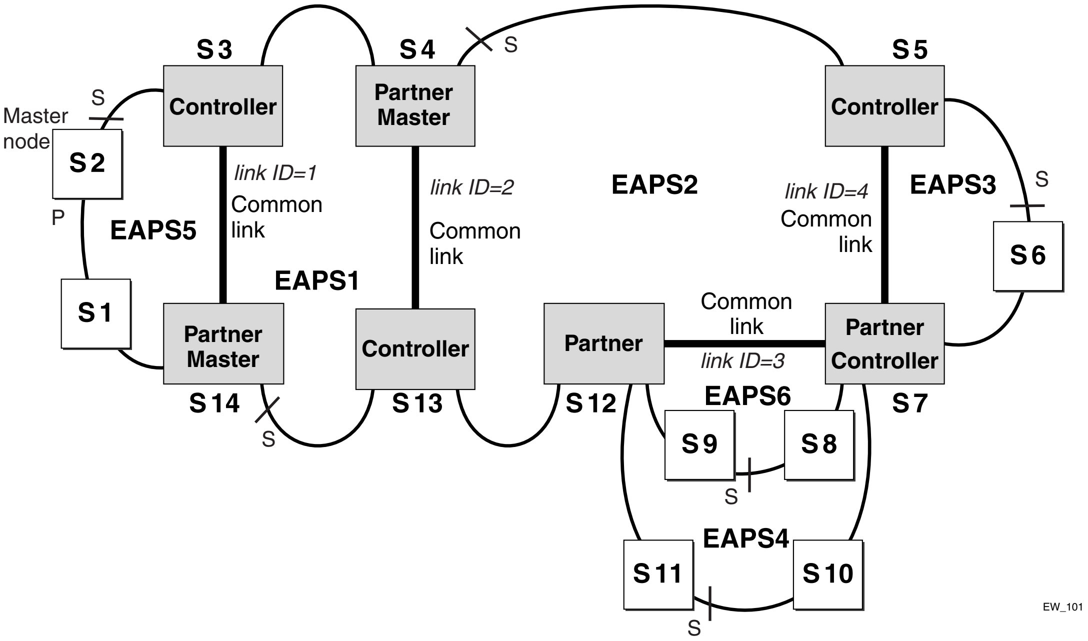
Figure 53: Large core and access ring configuration



Advanced Configuration

Figure 54 shows an extension of the Basic Core and Right Angle configuration.

Figure 54: Advanced configuration



14 Spanning Tree Protocol (STP)

This chapter covers the following topics:

- Overview of the Spanning Tree Protocol on page 373
- Spanning Tree Domains on page 374
- STP Configurations on page 376
- Per-VLAN Spanning Tree on page 382
- Rapid Spanning Tree Protocol on page 382
- STP Rules and Restrictions on page 393
- Configuring STP on the Switch on page 393
- Displaying STP Settings on page 397

Using the Spanning Tree Protocol (STP) functionality of the switch makes your network more fault tolerant. The following sections explain more about STP and the STP features supported by ExtremeWare.

NOTE

STP is a part of the 802.1d bridge specification defined by the IEEE Computer Society. To explain STP in terms used by the 802.1d specification, the switch will be referred to as a bridge.

Overview of the Spanning Tree Protocol

STP is a bridge-based mechanism for providing fault tolerance on networks. STP allows you to implement parallel paths for network traffic, and ensure that:

- Redundant paths are disabled when the main paths are operational.
- Redundant paths are enabled if the main path fails.

NOTE

STP is not supported in conjunction with ESRP.

Spanning Tree Domains

The switch can be partitioned into multiple virtual bridges. Each virtual bridge can run an independent Spanning Tree instance. Each Spanning Tree instance is called a *Spanning Tree Domain* (STPD). Each STPD has its own root bridge and active path. After an STPD is created, one or more VLANs can be assigned to it.

A port can belong to multiple STPDs. In addition, a VLAN can span multiple STPDs.

The key points to remember when configuring VLANs and STP are:

- Each VLAN forms an independent broadcast domain.
- STP blocks paths to create a loop-free environment.
- When STP blocks a path, no data can be transmitted or received on the blocked port.
- Within any given STPD, all VLANs belonging to it use the same spanning tree.

If you delete a STPD, the VLANs that were members of that STPD are also deleted. You must remove all VLANs associated with the STP before deleting the STPD.

STPD Modes

An STPD has two modes of operation

- 802.1d mode

  Use this mode for backward compatibility with previous STP versions and for compatibility with third-party switches using IEEE standard 802.1d. When configured in this mode, all rapid configuration mechanisms are disabled.
- 802.1w mode

  Use this mode for compatibility with Rapid Spanning Tree (RSTP). When configured in this mode, all rapid configuration mechanisms are enabled. This mode is available for point-to-point links only.

  RSTP is enabled or disabled on a per STPD basis only. You do not enable RSTP on a per port basis.

  For more information about RSTP and RSTP features, see “Rapid Spanning Tree Protocol” on page 382.

By default, the:

- STPD operates in 802.1d mode
- Default device configuration contains a single STPD called *s0*
- Default VLAN is a member of STPD s0

To configure the mode of operation of an STPD, use the following command:

```
configure stpd <spanning tree name> mode [dot1d | dot1w]
```

All STP parameters default to the IEEE 802.1d values, as appropriate.

Port Modes

An STP port has three modes of operation:

- 802.1d mode

  This mode is used for backward compatibility with previous STP versions and for compatibility with third-party switches using IEEE standard 802.1d. BPDUs are sent untagged in 1D mode. Because of this, on any given physical interface there can be only *one* STPD running in 1D mode.
- Extreme Multiple Instance Spanning Tree Protocol (EMISTP) mode

  EMISTP mode is an extension of STP that allows a physical port to belong to multiple STPDs by assigning the port to multiple VLANs. EMISTP adds significant flexibility to STP network design. BPDUs are sent with an 802.1Q tag having an STPD instance Identifier (StpdID) in the VLANid field.
- Per-VLAN Spanning Tree (PVST)+ mode

  This mode implements PVST+ in compatibility with third-party switches running this version of STP. The STPDs running in this mode have a one-to-one relationship with VLANs, and send and process packets in PVST+ format.

These port modes are for STP ports, not for physical ports. When a physical port belongs to multiple STPDs, it is associated with multiple STP ports. It is possible for the physical port to run in different modes for different domains to which it belongs.

STPD Identifier

An StpdID is used to identify each STP domain. You assign the StpdID when configuring the domain, and that VLAN cannot belong to another STPD.

An StpdID must be identical to the VLANid of one of the member VLANs in that STP domain.

NOTE

If an STPD contains at least one port not in 1D mode, the STPD must be configured with an StpdID.

STPD BPDU Tunneling

You can configure ExtremeWare to allow a Bridge Protocol Data Unit (BPDU) to traverse a VLAN without being processed by STP, even if STP is enabled on the port. This is known as BPDU *tunneling*.

To enable and disable BPDU tunneling on a VLAN, use one of the following commands:

```
enable ignore-bpdu vlan <vlan name>
disable ignore-bpdu vlan <vlan name>
```

If you have a known topology and have switches outside of your network within your STPD, use this feature to keep the root bridge within your network.

Rapid Root Failover

ExtremeWare supports rapid root failover for faster STP failover recovery times in STP 802.1d mode. If the active root port link goes down ExtremeWare recalculates STP and elects a new root port. Rapid root failover allows the new root port to immediately begin forwarding, skipping the standard listening and learning phases. Rapid root failover occurs only when the link goes down, and not when there is any other root port failure, such as missing BPDUs.

The default setting is disabled. To enable rapid root failover, use the following command:

```
enable stpd <spanning tree name> rapid-root-failover
```

To display the configuration, use the following command:

```
show stpd {<spanning tree name> | detail}
```

STP Configurations

When you assign VLANs to an STPD, pay careful attention to the STP configuration and its effect on the forwarding of VLAN traffic.

This section describes three types of STP configurations:

- Basic STP
- Multiple STPDs on a single port (EMISTP)
- A VLAN that spans multiple STPDs

Basic STP Configuration

This section describes a basic, 802.1D STP configuration. Figure 55 illustrates a network that uses VLAN tagging for trunk connections. The following four VLANs have been defined:

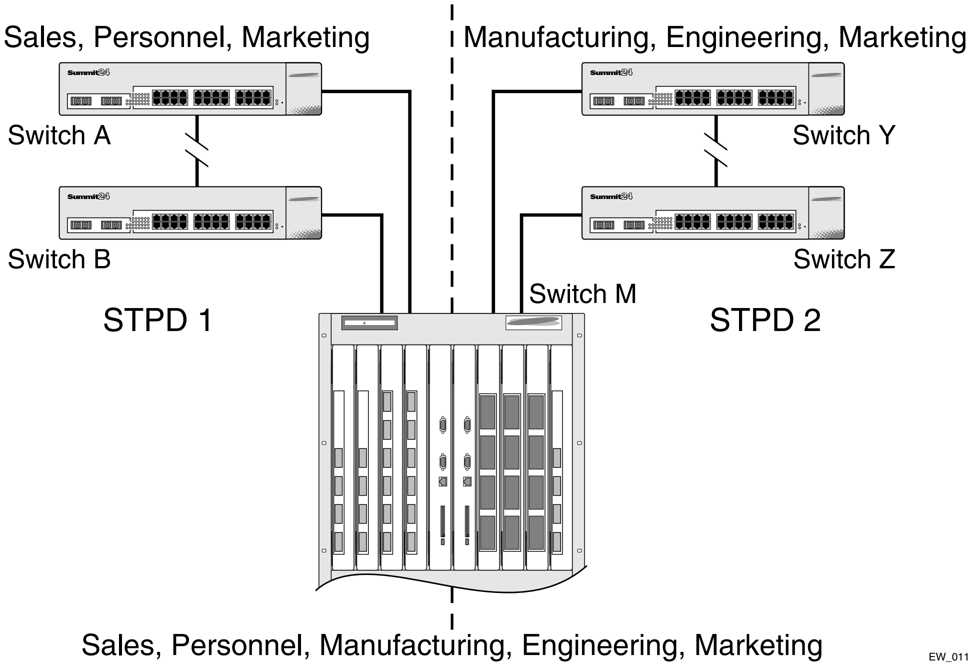
- *Sales* is defined on switch A, switch B, and switch M.
- *Personnel* is defined on switch A, switch B, and switch M.
- *Manufacturing* is defined on switch Y, switch Z, and switch M.
- *Engineering* is defined on switch Y, switch Z, and switch M.
- *Marketing* is defined on all switches (switch A, switch B, switch Y, switch Z, and switch M).

Two STPDs are defined:

- STPD1 contains VLANs *Sales* and *Personnel.*
- STPD2 contains VLANs *Manufacturing* and *Engineering.*

The VLAN *Marketing* is a member of both STPD1 and STPD2.

Figure 55: Multiple Spanning Tree Domains


Sales, Personnel, Marketing
Manufacturing, Engineering, Marketing
Switch A
Switch Y
Switch B
Switch Z
Switch M
STPD 1
STPD 2
Sales, Personnel, Manufacturing, Engineering, Marketing
EW_011

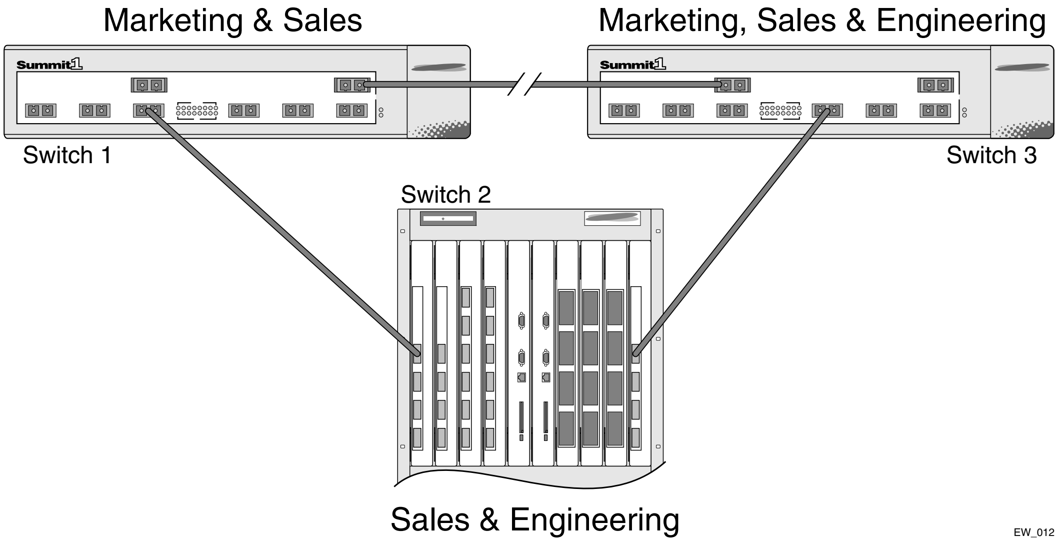
When the switches in this configuration start up, STP configures each STPD such that there are no active loops in the topology. STP could configure the topology in a number of ways to make it loop-free.

In Figure 55, the connection between switch A and switch B is put into blocking state, and the connection between switch Y and switch Z is put into blocking state. After STP converges, all the VLANs can communicate, and all bridging loops are prevented.

The VLAN *Marketing*, which has been assigned to both STPD1 and STPD2, communicates using all five switches. The topology has no loops, because STP has already blocked the port connection between switch A and switch B, and between switch Y and switch Z.

Within a single STPD, you must be extra careful when configuring your VLANs. Figure 56 illustrates a network that has been incorrectly set up using a single STPD so that the STP configuration disables the ability of the switches to forward VLAN traffic.

Figure 56: Tag-based STP configuration



The tag-based network in Figure 56 has the following configuration:

- Switch 1 contains VLAN *Marketing* and VLAN *Sales*.
- Switch 2 contains VLAN *Engineering* and VLAN *Sales*.
- Switch 3 contains VLAN *Marketing*, VLAN *Engineering*, and VLAN *Sales*.
- The tagged trunk connections for three switches form a triangular loop that is not permitted in an STP topology.
- All VLANs in each switch are members of the same STPD.

STP can block traffic between switch 1 and switch 3 by disabling the trunk ports for that connection on each switch.

Switch 2 has no ports assigned to VLAN marketing. Therefore, if the trunk for VLAN marketing on switches 1 and 3 is blocked, the traffic for VLAN marketing will not be able to traverse the switches.

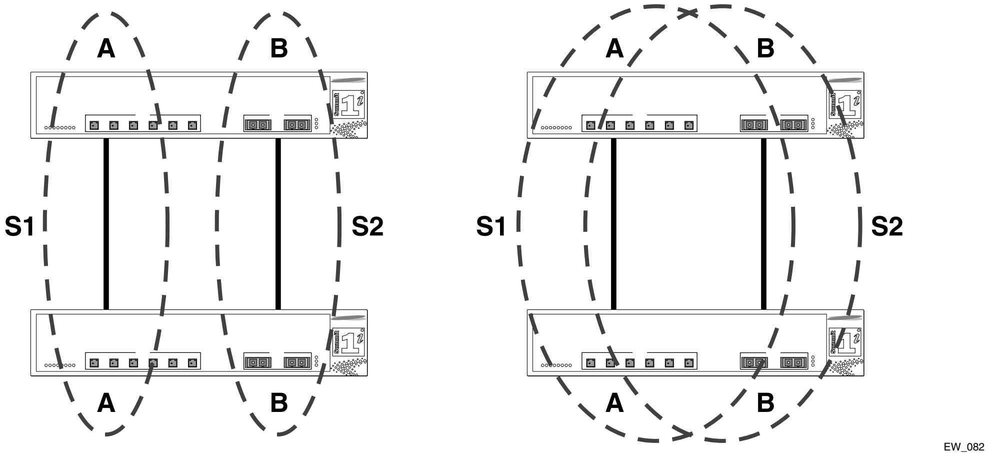
NOTE

If an STPD contains multiple VLANs, all VLANs must be configured on all ports in that domain, except for ports that connect to hosts (edge ports).

Multiple STPDs on a Port

Traditional 802.1d STP has some inherent limitations when addressing networks that have multiple VLANs and multiple STPDs. For example, consider the simple network depicted in Figure 57.

Figure 57: Limitations of Traditional STPD



The two switches are connected by a pair of parallel links. Both switches run two VLANs, A and B. To achieve load-balancing between the two links using the traditional approach, you would have to associate A and B with two different STPDs, called S1 and S2, respectively, and make the left link carry VLAN A traffic while the right link carries VLAN B traffic (or vice versa). If the right link fails, S2 is broken and VLAN B traffic is disrupted.

To optimize the solution, you can use the Extreme Multiple Instance Spanning (EMISTP) mode, which allows a port to belong to multiple STPDs. EMISTP adds significant flexibility to STP network design. Referring to Figure 57, using EMISTP, you can configure all four ports to belong to both VLANs.

Assuming that S1 and S2 still correspond to VLANs A and B, respectively, you can fine-tune STP parameters to make the left link active in S1 and blocking in S2, while the right link is active in S2 and blocking in S1. Once again, if the right link fails, the left link is elected active by the STP algorithm for S2, without affecting normal switching of data traffic.

Using EMISTP, an STPD becomes more of an abstract concept. It does not necessarily correspond to a physical domain. It is better regarded as a vehicle to carry VLANs that have STP instances. Because VLANs can overlap, so do STPDs. However, even if the different STPDs share the entire topology or part of the redundant topology, the STPDs react to topology change events in an independent fashion.

VLAN Spanning Multiple STPDs

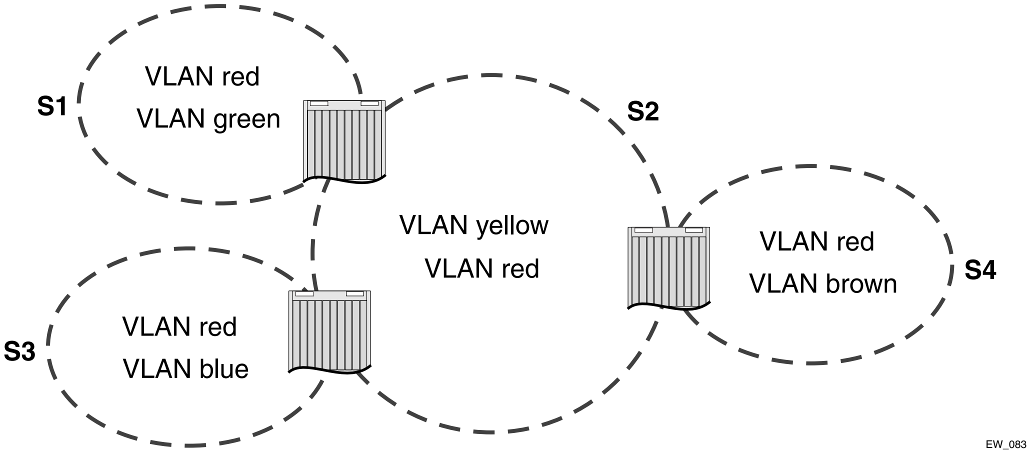
Traditionally, the mapping from VLANs to STP instances have been one-to-one, or many-to-one. In both cases, a VLAN is wholly contained in a single instance. In practical deployment there are cases in which a one-to-many mapping is desirable. In a typical large enterprise network, for example, VLANs span multiple sites and/or buildings. Each site represents a redundant looped area. However, between any two sites the topology is usually very simple.

Alternatively, the same VLAN may span multiple large geographical areas (because they belong to the same enterprise) and may traverse a great many nodes. In this case, it is desirable to have multiple STP domains operating in a single VLAN, one for each looped area. The justifications include the following:

- The complexity of the STP algorithm increases, and performance drops, with the size and complexity of the network. The 802.1d standard specifies a maximum network diameter of 7 hops. By segregating a big VLAN into multiple STPDs, you reduce complexity and enhance performance.
- Local to each site, there may be other smaller VLANs that share the same redundant looped area with the large VLAN. Some STPDs must be created to protect those VLAN. The ability to partition VLANs allows the large VLAN to be "piggybacked" in those STPDs in a site-specific fashion.

Figure 58 has five domains. VLANs green, blue, brown, and yellow are local to each domain. VLAN red spans all of the four domains. Using a VLAN that spans multiple STPDS, you do not have to create a separate domain for VLAN red. Instead, VLAN red is "piggybacked" onto those domains local to other VLANs.

Figure 58: VLAN Spanning Multiple STPDs



In addition, the configuration in Figure 58 has these features:

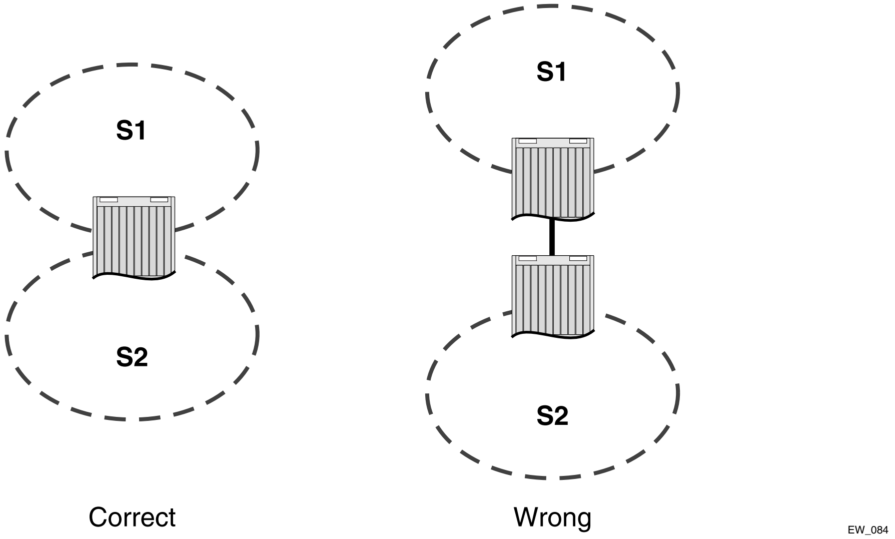
- Each site can be administered by a different organization or department within the enterprise. Having a site-specific STP implementation makes the administration more flexible and convenient.
- Between the sites the connections usually traverse distribution switches in ways that are known beforehand to be "safe" with STP. In other words, the looped areas are already well-defined.

EMISTP Deployment Constraints

While EMISTP greatly enhances STP capability, these features must deployed with care. This section discusses configuration issues that, if not followed, could lead to an improper deployment of EMISTP. This section also provides the restrictive principles to abide by in network design.

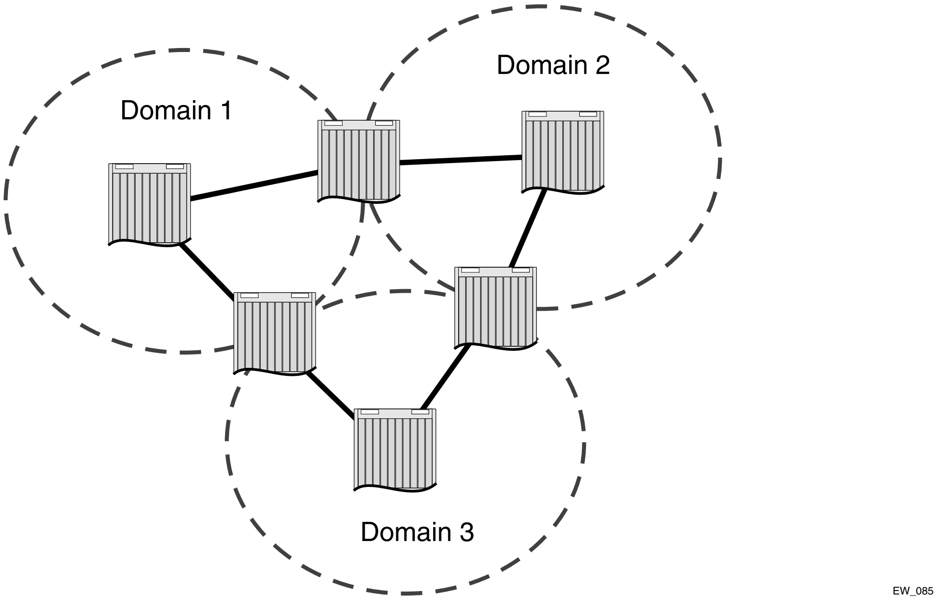
- While a physical port can belong to multiple STPDs, any VLAN on that port can be in only one domain. Put another way, a VLAN can not belong to two domains on the same physical port.
- While a VLAN can span multiple domains, any LAN segment in that VLAN must be in the same STPD. VLANs traverse domains only inside switches, not across links. On a single switch, however, bridge ports for the same VLAN can be assigned to different STPDs. This scenario is illustrated in Figure 59.

Figure 59: VLANs traverse domains inside switches



- The VLAN partition feature is deployed under the premise that the overall inter-domain topology for that VLAN is loop-free. Consider the case in Figure 60, VLAN red (the only VLAN in the figure) spans domains 1, 2, and 3. Inside each domain, STP produces a loop-free topology. However, VLAN red is still looped, because the three domains form a ring among themselves.

Figure 60: Looped VLAN topology



A necessary (but not sufficient) condition for a loop-free inter-domain topology is that every two domains only meet at a single crossing point.

NOTE

Newly created EMISTP VLANs are not associated with STPD s0 by default.

Per-VLAN Spanning Tree

Switching products that implement Per-VLAN Spanning Tree (PVST) have been in existence for many years and are widely deployed. To support STP configurations that use PVST, ExtremeWare has an operational mode called PVST+.

NOTE

In this document, PVST and PVST+ are used interchangeably. PVST+ is an enhanced version of PVST that is interoperable with 802.1Q STP. The following discussions are in regard to PVST+, if not specifically mentioned.

STPD VLAN Mapping

Each VLAN participating in PVST+ must be in a separate STPD and the VLAN number must be the same as the STPD identifier (StpdID). As a result, PVST+ VLANs can not be partitioned.

This fact does not exclude other non-PVST+ VLANs from being grouped into the same STPD. A PVST+ VLAN can be joined by multiple non-PVST+ VLANs to be in the same STP domain.

Native VLAN

In PVST+, the native VLAN must be peered with the default VLAN on Extreme devices, as both are the only VLAN allowed to send and receive untagged packets on the physical port.

Third-party PVST+ devices send VLAN 1 packets in a special manner. ExtremeWare does not support PVST+ for VLAN 1. Therefore, when the switch receives a packet for VLAN 1, the packet is dropped.

When a PVST+ instance is disabled, the fact that PVST+ uses a different packet format raises an issue. If the STPD also contains ports not in PVST+ mode, the flooded packet has an incompatible format with those ports. The packet is not recognized by the devices connected to those ports. Therefore, ExtremeWare has the following limitation:

- If an STPD contains both PVST+ and non-PVST+ ports, the STPD must not be disabled. Otherwise, the BPDUs are flooded in the format of the incoming STP port.

Rapid Spanning Tree Protocol

The Rapid Spanning Tree Protocol (RSTP; 802.1w) provides an enhanced spanning tree algorithm that improves the convergence speed of bridged networks. RSTP takes advantage of point-to-point links in the network and actively confirms that a port can safely transition to the forwarding state without relying on any timer configurations. If a network topology change or failure occurs, RSTP rapidly recovers network connectivity by confirming the change locally before propagating that change to other devices across the network. For broadcast links, there is no difference in convergence time between STP and RSTP.

RSTP supersedes legacy STP protocols, supports the existing STP parameters and configurations, and allows for seamless interoperability with legacy STP.

NOTE

RSTP is not supported in conjunction with ESRP.

RSTP Terms

Table 49 describes the terms associated with RSTP.

Table 49: RSTP Terms

Term	Description
root port	Provides the shortest path to the root bridge. All bridges except the root bridge, contain one root port. For more information about the root port, see “Port Roles” on page 383.
designated port	Provides the shortest path connection to the root bridge for the attached LAN segment. There is only one designated port on each LAN segment. For more information about the designated port, see “Port Roles” on page 383.
alternate port	Supplies an alternate path to the root bridge and the root port. For more information about the alternate port, see “Port Roles” on page 383.
backup port	Supports the designated port on the same attached LAN segment. Backup ports only exist when the bridge is connected as a self-loop or to a shared-media segment. For more information about the backup port, see “Port Roles” on page 383.
edge ports	Ports that connect to non-STP devices such as routers, endstations, and other hosts. Edge ports are not part of the RSTP configuration.
root bridge	The bridge with the best bridge identifier selected to be the root bridge. There is only one root bridge in the network. The root bridge is the only bridge in the network that does not have a root port.

RSTP Concepts

This section describes important RSTP concepts.

Port Roles

RSTP uses information from BPDUs to assign port roles for each LAN segment. Port roles are not user-configurable. Port role assignments are determined based on the following criteria:

- A unique bridge identifier (MAC address) associated with each bridge
- The path cost associated with each bridge port
- A port identifier associated with each bridge port

RSTP assigns one of four port roles to bridge ports in the network, as described in Table 50.

Table 50: RSTP port roles

Port Role	Description
Root	Provides the shortest path to the root bridge. There is only one root port per bridge; the root bridge does not have a root port. If a bridge has two or more ports with the same path cost, the port with the best port identifier becomes the root port.
Designated	Provides the shortest path connection to the root bridge for the attached LAN segment. To prevent loops in the network, there is only one designated port on each LAN segment. To select the designated port, all bridges that are connected to a particular segment listen to each other's BPDUs and agree on the bridge sending the best BPDU. The corresponding port on that bridge becomes the designated port. If there are two or more ports connected to the LAN, the port with the best port identifier (lowest MAC address) becomes the designated port.
Alternate	Provides an alternate path to the root bridge and the root port.
Backup	Supports the designated port on the same attached LAN segment. Backup ports only exist when the bridge is connected as a self-loop or to a shared-media segment.

When RSTP stabilizes, all:

- Root ports and designated ports are in the forwarding state
- Alternate ports and backup ports are in the blocking state

RSTP makes the distinction between the alternate and backup port roles to describe the rapid transition of the alternate port to the forwarding state if the root port fails.

Ports that connect to non-STP devices are edge ports. Edge ports do not participate in RSTP, and their role is not confirmed. Edge ports immediately enter the forwarding state.

Link Types

You can configure the link type of a port in an STPD. RSTP tries to rapidly move designated point-to-point links into the forwarding state when a network topology change or failure occurs. For rapid convergence to occur, the port must be configured as a point-to-point link.

Table 51 describes the link types.

Table 51: RSTP link types

Port Role	Description
Auto	Specifies the switch to automatically determine the port link type. An auto link behaves like a point-to-point link if the link is in full duplex mode or if link aggregation is enabled on the port. Otherwise, the link behaves like a broadcast link used for 802.1w configurations.
Edge	Specifies a port that does not have a bridge attached. An edge port is placed and held in the STP forwarding state unless a BPDU is received by the port.
Broadcast	Specifies a port attached to a LAN segment with more than two bridges. A port with a broadcast link type cannot participate in rapid reconfiguration. By default, all ports are broadcast links.
Point-to-point	Specifies a port attached to a LAN segment with only two bridges. A port with port-to-port link type can participate in rapid reconfiguration. Used for 802.1w configurations.

Configuring Link Types. By default, all ports are broadcast links. To configure the ports in an STPD, use the following command:

```
configure stpd <spanning tree name> ports link-type [auto | edge | broadcast |
point-to-point] <portlist>
```

- `auto`—Configures the ports as auto links. If the link is in full duplex mode, or if link aggregation is enabled on the port, an auto link behaves like a point-to-point link.
- `edge`—Configures the ports as edge ports.
- `point-to-point`—Configures the ports for an RSTP environment.

To display detailed information about the ports in an STPD, use the following command:

```
show stpd <spanning tree name> ports <portlist> {detail}
```

RSTP Timers

For RSTP to rapidly recover network connectivity, RSTP requires timer expiration. RSTP derives many of the timer values from the existing configured STP timers to meet its rapid recovery requirements rather than relying on additional timer configurations. Table 52 describes the user configurable timers, and Table 53 describes the timers that are derived from other timers and not user configurable.

Table 52: User configurable timers

Timer	Description
Hello	The root bridge uses the hello timer to send out configuration BPDUs through all of its forwarding ports at a pre-determined, regular time interval. The default value is 2 seconds. The range is 1 to 10 seconds.
Forward delay	A port moving from the blocking state to the forwarding state uses the forward delay timer to transition through the listening and learning states. In RSTP, this timer complements the rapid configuration behavior. If none of the rapid rules are in effect, the port uses legacy STP rules to move to the forwarding state. The default is 15 seconds. The range is 4 to 30 seconds.

Table 53: Derived timers

Timer	Description
TCN	The root port uses the Topology Change Notification (TCN) timer when it detects a change in the network topology. The TCN timer stops when the topology change timer expires or upon receipt of a topology change acknowledgement. The default value is the same as the value for the bridge hello timer.
Topology Change	The topology change timer determines the total time it takes the forwarding ports to send configuration BPDUs. The default value for the topology change timer depends upon the mode of the port. • 1d mode—The sum of the forward delay timer (default value is 15 seconds; range of 4 to 30 seconds) and the max age timer (default value is 20 seconds; range of 6 to 40 seconds). • 1w mode—Double the hello timer (default value is 4 seconds)
Message age	A port uses the message age timer to time out receiving BPDUs. When a port receives a superior or equal BPDU, the timer restarts. When the timer expires, the port becomes a designated port and a configuration update occurs. If the bridge operates in 1w mode and receives an inferior BPDU, the timer expires early. The default value is the same as the STPD bridge max age parameter.

Table 53: Derived timers (Continued)

Timer	Description
Hold	A port uses the hold timer to restrict the rate that successive BPDUs can be sent. The default value is the same as the value for the bridge hello timer.
Recent backup	The timer starts when a port leaves the backup role. When this timer is running, the port cannot become a root port. The default value is double the hello time (4 seconds).
Recent root	The timer starts when a port leaves the root port role. When this timer is running, another port cannot become a root port unless the associated port is put into the blocking state. The default value is the same as the forward delay time.

The Protocol migration timer is neither user-configurable nor derived; it has a set value of 3 seconds. The timer starts when a port transitions from STP (802.1d) mode to RSTP (802.1w) mode and vice versa. This timer must expire before further mode transitions can occur.

RSTP Operation

In an RSTP environment, there are two bridges on a point-to-point link LAN segment. A switch that considers itself the unique, designated bridge for the attached LAN segment sends a “propose” message to the other bridge to request a confirmation of its role. The other bridge on that LAN segment replies with an “agree” message if they agree with the proposal. The receiving bridge immediately moves its designated port into the forwarding state.

Before a bridge replies with an “agree” message, it reverts all of its designated ports into the blocking state. This introduces a temporary partition into the network. The bridge then sends another “propose” message on all of its designated ports for further confirmation. Since all of the connections are blocked, the bridge immediately sends an “agree” message to unblock the proposing port without having to wait for further confirmations to come back or without the worry of temporary loops.

Beginning with the root bridge, each bridge in the network engages in the exchange of “propose” and “agree” messages until they reach the edge ports. Edge ports connect to non-STP devices and do not participate in RSTP. Their role does not need to be confirmed. If an edge port receives a BPDU, it enters an inconsistency state. An inconsistency state puts the edge port into the blocking state and starts the message age timer. Every time the edge port receives a BPDU, the message age timer restarts. The edge port remains in the blocking state until no further BPDUs are received and the message age timer expires.

RSTP attempts to transition root ports and designated ports to the forwarding state and alternate ports and backup ports to the blocking state as rapidly as possible.

A port transitions to the forwarding state if any of the following is true. The port:

- Has been in either a root or designated port role long enough that the spanning tree information supporting this role assignment has reached all of the bridges in the network.

  NOTE

  RSTP is backward compatible with STP, so if a port does not move to the forwarding state with any of the RSTP rapid transition rules, a forward delay timer starts and STP behavior takes over.

- Is now a root port and no other ports have a recent role assignment that contradicts with its root port role.

- Is a designated port and attaches to another bridge by a point-to-point link and receives an “agree” message from the other bridge port.
- Is an edge port.

  An edge port is a port connected to a non-STP device and is in the forwarding state.

The preceding sections provide more information about RSTP behavior.

Root Port Rapid Behavior

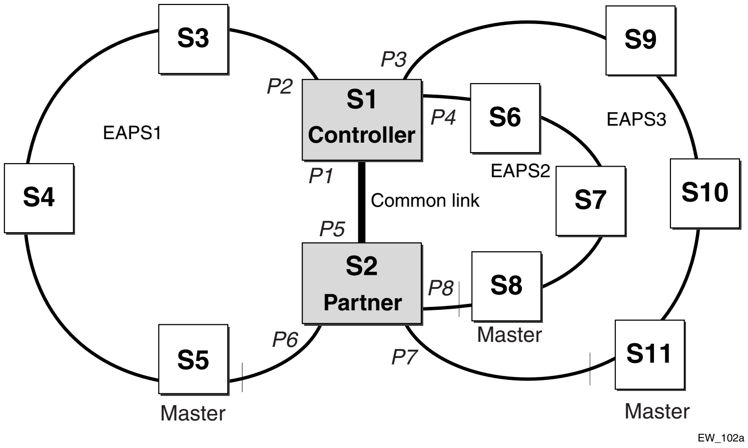
In Figure 61, the diagram on the left displays the initial network topology with a single bridge having the following:

- Two ports connected to a shared LAN segment
- One port is the designated port
- One port is the backup port

The diagram on the right displays a new bridge that:

- Is connected to the LAN segment
- Has a superior STP bridge priority
- Becomes the root bridge and sends a BPDU to the LAN that is received by both ports on the old bridge

Figure 61: Example of root port rapid behavior



If the backup port receives the BPDU first, STP processes this packet and temporarily elects this port as the new root port while the designated port’s role remains unchanged. If the new root port is immediately put into the forwarding state, there is a loop between these two ports.

To prevent this type of loop from occurring, the recent backup timer starts. The root port transition rule does not allow a new root port to be in the forwarding state until the recent backup timer expires.

Another situation may arise if you have more than one bridge, and you lower the port cost for the alternate port which makes it the new root port. The previous root port is now an alternate port. Depending on your STP implementation, STP may set the new root port to the forwarding state before setting the alternate port to the blocking state. This may cause a loop.

To prevent this type of loop from occurring, the recent root timer starts when the port leaves the root port role. The timer stops if the port enters the blocking state. RSTP requires that the recent root timer stops on the previous root port before the new root port can enter the forwarding state.

Designated Port Rapid Behavior

When a port becomes a new designated port, or the STP priority changes on an existing designated port, the port becomes an *unsynced* designated port. In order for an unsynced designated port to rapidly move into the forwarding state, the port must propose a confirmation of its role on the attached LAN segment, unless the port is an edge port. Upon receiving an “agree” message, the port immediately enters the forwarding state.

If the receiving bridge does not agree and it has a superior STP priority, the receiving bridge replies with its own BPDU. Otherwise, the receiving bridge keeps silent and the proposing port enters the forwarding state and starts the forward delay timer.

The link between the new designated port and the LAN segment must be a point-to-point link. If there is a multi-access link, the “propose” message is sent to multiple recipients. If only one of the recipients agrees with the proposal, it is possible for the port to erroneously enter the forwarding state after receiving a single “agree” message.

Receiving Bridge Behavior

The receiving bridge must decide whether or not to accept a proposal from a port. Upon receiving a proposal for a root port, the receiving bridge:

- Processes the BPDU and computes the new STP topology
- Synchronizes all of the designated ports if the receiving port is the root port of the new topology
- Puts all unsynced, designated ports into the blocking state
- Sends down further “propose” messages
- Sends back an “agree” message through the root port

If the receiving bridge receives a proposal for a designated port, the bridge replies with its own BPDU. If the proposal is for an alternate or backup port, the bridge keeps silent.

Propagating Topology Change Information

When a change occurs in the topology of the network, such events are communicated through the network.

In an RSTP environment, only non-edge ports entering the forwarding state cause a topology change. A loss of network connectivity is not considered a topology change; however, a gain in network connectivity needs to be communicated. When an RSTP bridge detects a topology change, it starts the topology change timer, sets the topology change flag on its BPDUs, floods all of the forwarding ports in the network (including the root ports), and flushes the learned MAC address entries.

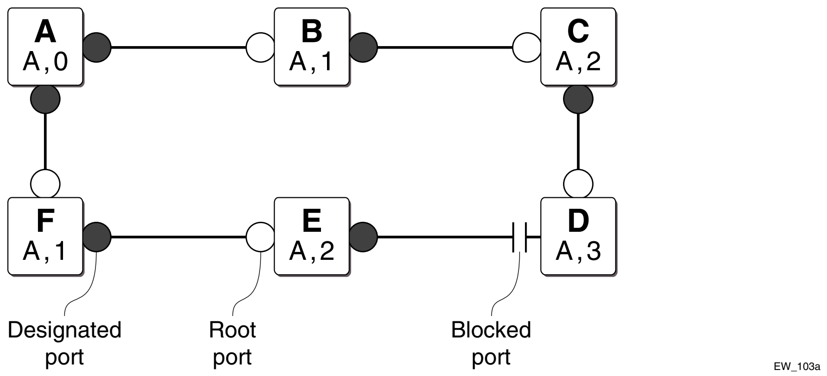
Rapid Reconvergence

This section describes the RSTP rapid behavior following a topology change. In this example, the bridge priorities are assigned based on the order of their alphabetical letters; bridge A has a higher priority than bridge F.

Suppose we have a network, as shown in Figure 62, with six bridges (bridge A through bridge F) where the following is true:

- Bridge A is the root bridge
- Bridge D contains an alternate port in the blocking state
- All other ports in the network are in the forwarding state

Figure 62: Initial network configuration



The preceding steps describe how the network reconverges.

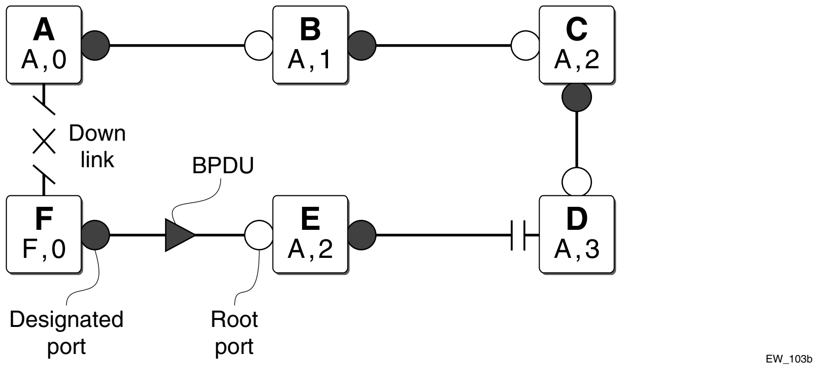
1 If the link between bridge A and bridge F goes down, bridge F detects the root port is down. At this point, bridge F:

  - Immediately deletes that port from the STP
  - Performs a configuration update

  After the configuration update, bridge F:

  - Considers itself the new root bridge
  - Sends a BPDU message on its designated port to bridge E

Figure 63: Down link detected



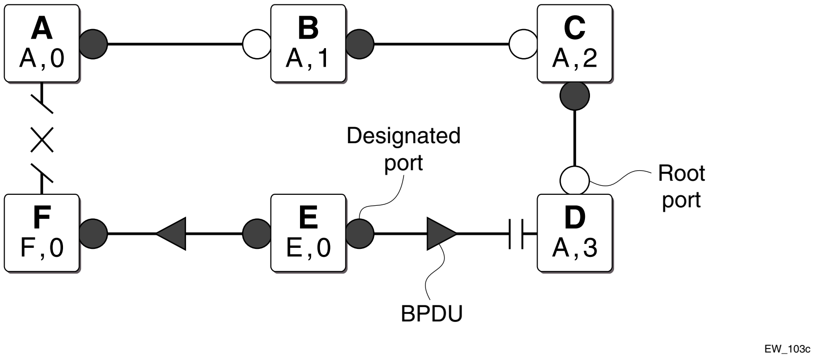
2 Bridge E believes that bridge A is the root bridge. When bridge E receives the BPDU on its root port from bridge F, bridge E:

- Determines that it received an inferior BPDU.
- Immediately begins the max age timer on its root port
- Performs a configuration update

After the configuration update, bridge E:

- Regards itself as the new root bridge
- Sends BPDU messages on both of its root ports to bridges F and D, respectively

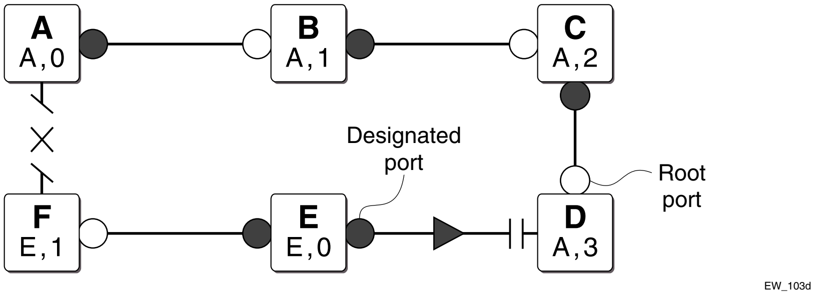
Figure 64: New root bridge selected



3 When bridge F receives the superior BPDU and configuration update from bridge E, bridge F:

- Decides that the receiving port is the root port
- Determines that bridge E is the root bridge.

Figure 65: Communicating new root bridge status to neighbors



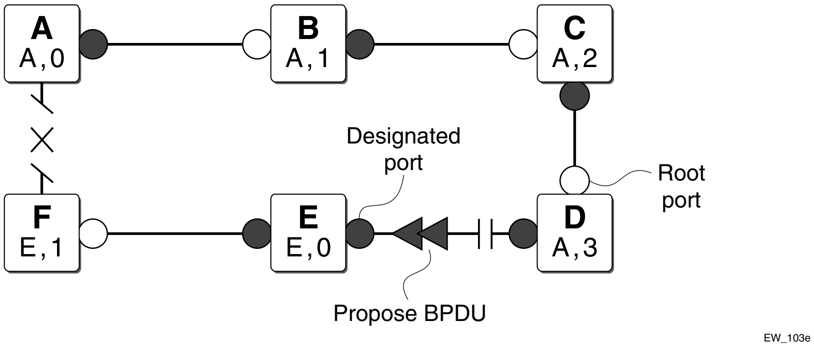
4 Bridge D believes that bridge A is the root bridge. When bridge D receives the BPDU from bridge E on its alternate port, bridge D:

- Immediately begins the max age timer on its alternate port
- Performs a configuration update

After the configuration update, bridge D:

- Moves the alternate port to a designated port
- Sends a "propose" message to bridge E to solicit confirmation of its designated role and to rapidly move the port into the designated state

Figure 66: Sending a propose message to confirm a port role



5 Upon receiving the proposal, bridge E:

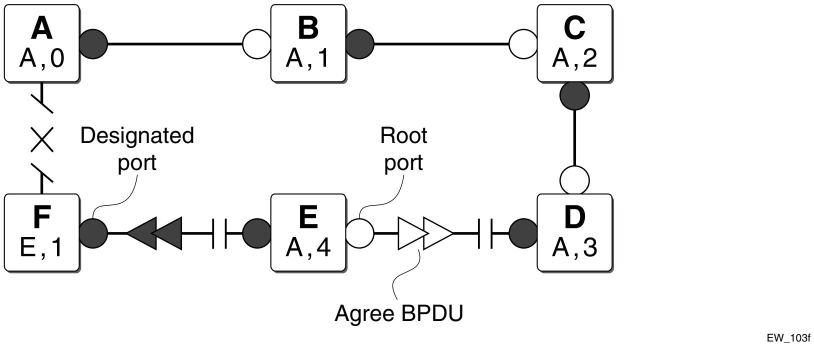
- Performs a configuration update
- Changes its receiving port to a root port

  The existing designated port enters the blocking state

Bridge E then sends:

- A "propose" message to bridge F
- An "agree" message from its root port to bridge D.

Figure 67: Communicating port status to neighbors



6 To complete the topology change, the following occurs:

- Bridge D moves the port that received the agree message into the forwarding state
- Bridge F confirms that its receiving port (the port that received the “propose” message) is the root port, and immediately replies with an “agree” message to bridge E to unblock the proposing port

Figure 68: Completing the topology change

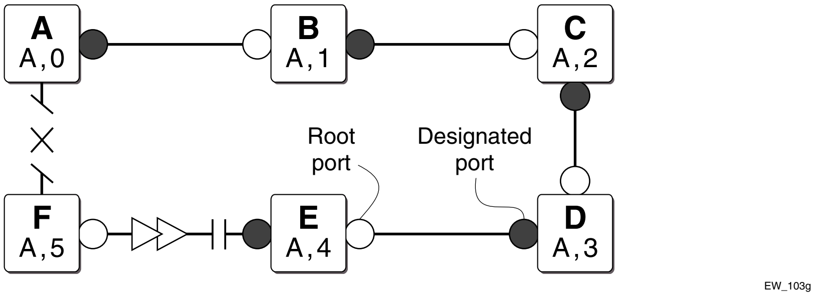
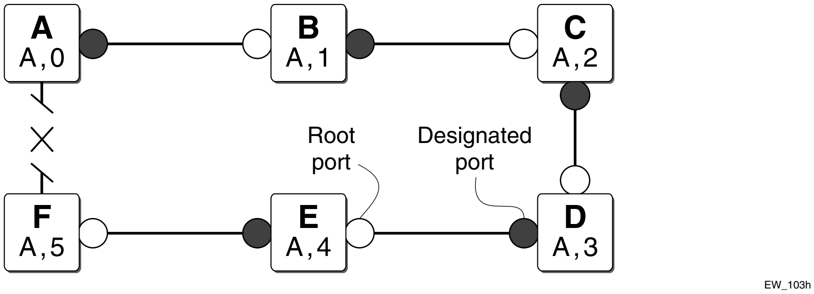


Figure 69 displays the new topology.

Figure 69: Final network configuration



Compatibility With STP (802.1d)

RSTP interoperates with legacy STP protocols; however, the rapid convergence benefits are lost when interacting with legacy STP bridges.

Each RSTP bridge contains a port protocol migration state machine to ensure that the ports in the STPD operate in the correct, configured mode. The state machine is a protocol entity within each bridge configured to run in 802.1w mode. For example, a compatibility issue occurs if you configure 802.1w mode and the bridge receives an 802.1d BPDU on a port. The receiving port starts the protocol migration timer and remains in 802.1d mode until the bridge stops receiving 802.1d BPDUs. Each time the bridge receives an 802.1d BPDU, the timer restarts. When the port migration timer expires, no more 802.1d BPDUs have been received and the bridge returns to its configured setting, 802.1w mode.

STP Rules and Restrictions

This section summarizes the rules and restrictions for configuring STP.

- The StpdID must be the VLANid of one of its member VLANs, and that VLAN can not be partitioned.
- A default VLAN can not be partitioned. If a VLAN traverses multiple STP domains, the VLAN must be tagged.
- An STPD can carry, at most, one VLAN running in PVST+ mode, and its StpdID must be identical with that VLANid. In addition, the PVST+ VLAN can not be partitioned.
- The default VLAN of a PVST+ port must be identical with the native VLAN on the PVST+ device connected to that port.
- If a port supports 802.1w-STPD, then the port must be configured with a default VLAN. If not, the BPDUs for that STPD are not flooded when the STPD is disabled.
- If an STPD contains both PVST+ and non-PVST+ ports, it must be enabled. If it is disable, the BPDUs are flooded in the format of the incoming STP port, which may be incompatible with those of the connected devices.

Configuring STP on the Switch

To configure basic STP, follow these steps:

1 Create one or more STP domains using the following command:

```
create stpd <name>
```

NOTE

STPD, VLAN, and QoS profile names must all be unique. For example, a name used to identify a VLAN cannot be used when you create an STPD or a QoS profile.

2 Add one or more VLANs to the STPD using the following command:

```
configure stpd <spanning tree name> add vlan <vlan name> {ports <portlist> [dot1d
| emistp | pvst-plus]}
```

3 Enable STP for one or more STP domains using the following command:

```
enable stpd {<spanning tree name>}
```

After you have created the STPD, you can optionally configure STP parameters for the STPD.

NOTE

You should not configure any STP parameters unless you have considerable knowledge and experience with STP. The default STP parameters are adequate for most networks.

The following parameters can be configured on each STPD:

- Hello time
- Forward delay
- Max age

- Bridge priority
- StpdID

The following parameters can be configured on each port:

- Path cost
- Port priority
- Port mode

NOTE

The device supports the RFC 1493 Bridge MIB. Parameters of only the s0 default STPD are accessible through this MIB.

NOTE

If an STPD contains at least one port not in dot1D mode, the STPD must be configured with an StpdID.

STP Configuration Examples

This section provides three configuration examples:

- Basic 802.1d STP
- EMISTP
- RSTP 802.1w

Basic 802.1d Configuration Example

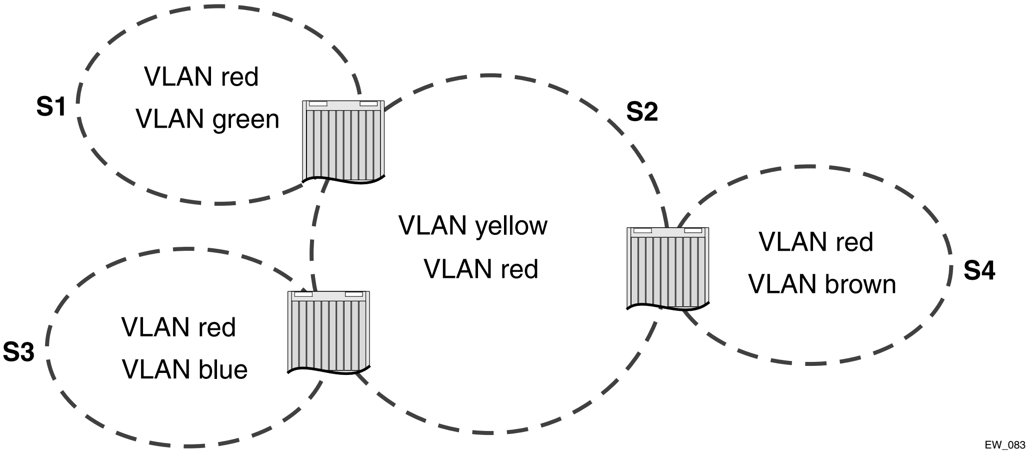
The following modular switch example creates and enables an STPD named *Backbone_st*. It assigns the *Manufacturing* VLAN to the STPD. It disables STP on slot 2, ports 1 through 7, and slot 3 port 12.

```
create stpd backbone_st
configure stpd backbone_st add vlan manufacturing
enable stpd backbone_st
disable stpd backbone_st port 2:1-2:7,3:12
```

EMISTP Configuration Example

Figure 70 is an example of EMISTP.

Figure 70: EMISTP configuration example



The following commands configure the switch located between S1 and S2:

```
create vlan red
configure red tag 100
configure red add ports 1-4 tagged

create vlan green
configure green tag 200
configure green add ports 1-2 tagged

create vlan yellow
configure yellow tag 300
configure yellow add ports 3-4 tagged

create stpd s1
configure stpd s1 add green
configure stpd s1 tag 200
configure stpd s1 add red ports 1-2 emistp

create stpd s2
configure stpd s2 add yellow
configure stpd s2 tag 300
configure stpd s2 add red ports 3-4 emistp
```

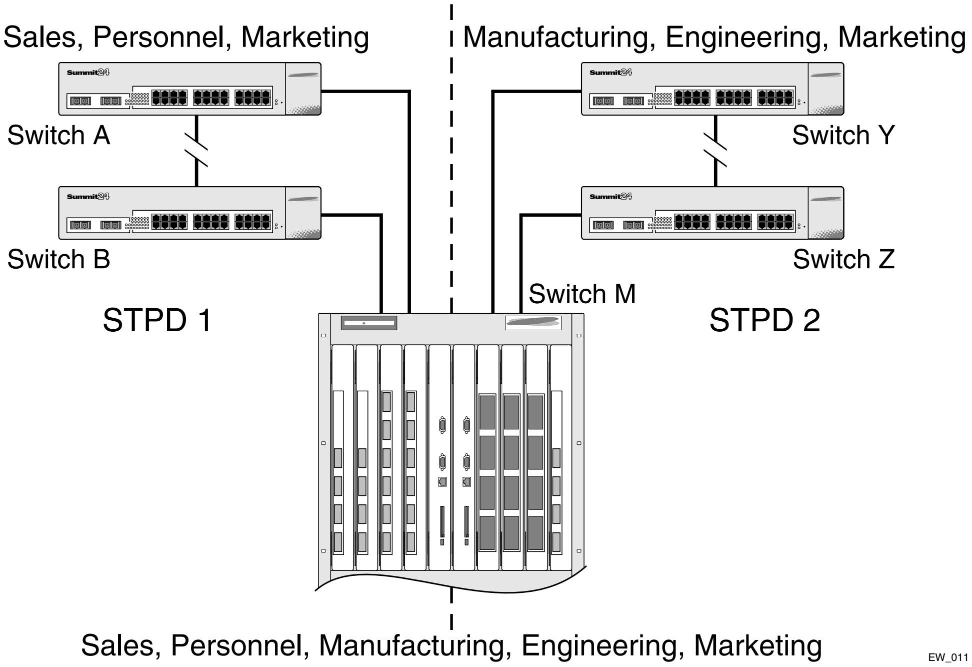
RSTP 802.1w Configuration Example

Figure 71 is an example of a network with multiple STPDs that can benefit from RSTP. For RSTP to work, you need to do the following:

- Create an STPD
- Configure the mode of operation for the STPD
- Create the VLANs and assign the ports

- Add the VLANs to the STPD
- Configure the port link types
- Enable STP

Figure 71: RSTP example


Sales, Personnel, Marketing
Manufacturing, Engineering, Marketing
Switch A
Switch Y
Switch B
Switch Z
Switch M
STPD 1
STPD 2
Sales, Personnel, Manufacturing, Engineering, Marketing
EW_011

In this example, the commands configure switch A in STPD1 for rapid reconvergence. Use the same commands to configure each switch and STPD in the network.

```
create stpd stpd1
configure stpd stpd1 mode dot1w

create vlan sales
create vlan personnel
create vlan marketing
configure vlan sales add ports 1,2 tagged
configure vlan personnel add ports 1,2 tagged
configure vlan marketing add ports 1,2 tagged

configure stpd stpd1 add vlan sales
configure stpd stpd1 add vlan personnel
configure stpd stpd1 add vlan marketing

configure stpd stpd1 ports link-type point-to-point 1,2

enable stpd stpd1
```

Displaying STP Settings

To display STP settings, use the following command:

```
show stpd {<spanning tree name> | detail}
```

This command displays the following information:

- STPD name
- STPD state
- STPD mode of operation
- Rapid Root Failover
- Tag
- Ports
- Active VLANs
- Bridge Priority
- Bridge ID
- Designated root
- STPD configuration information

To display the STP state of a port, use the following command:

```
show stpd <spanning tree name> ports <portlist> {detail}
```

This command displays the following information:

- STPD port configuration
- STPD port mode of operation
- STPD path cost
- STPD priority
- STPD state (root bridge, and so on)
- Port role (root bridge, edge port, etc.)
- STPD port state (forwarding, blocking, and so on)
- Configured port link type
- Operational port link type

If you have a VLAN that spans multiple STPDs, use the `show vlan <vlan name> stpd` command to display the STP configuration of the ports assigned to that specific VLAN.

The command displays the following:

- STPD port configuration
- STPD port mode of operation
- STPD path cost
- STPD priority
- STPD state (root bridge, and so on)
- Port role (root bridge, edge port, etc.)

- STPD port state (forwarding, blocking, and so on)
- Configured port link type
- Operational port link type

15 Extreme Standby Router Protocol

This chapter covers the following topics:

- Overview of ESRP on page 399
- ESRP Concepts on page 401
- Determining the ESRP Master on page 403
- Advanced ESRP Features on page 405
- Displaying ESRP Information on page 415
- Using ELRP with ESRP on page 416
- Using Standalone ELRP to Enable Loop Tests on page 419
- ESRP Examples on page 421
- ESRP Cautions on page 424
- Extreme Link Status Monitoring (ELSM) on page 425

Overview of ESRP

ESRP is a feature of ExtremeWare that allows multiple switches to provide redundant routing services to users. From the workstation's perspective, there is only one default router (that has one IP address and one MAC address), so ARP cache entries in client workstations do not need to be refreshed or aged-out.

In addition to providing layer 3 routing redundancy for IP and IPX, ESRP also provides for layer 2 redundancy. These "layered" redundancy features can be used in combination or independently. You do not have to configure the switch for routing to make valuable use of ESRP. The layer 2 redundancy features of ESRP offer fast failure recovery and provide for dual-homed system design. In some instances, depending on network system design, ESRP can provide better resiliency than using Spanning Tree Protocol (STP) or Virtual Router Redundancy Protocol (VRRP).

We recommended that all switches participating in ESRP run the same version of ExtremeWare. Not all ESRP features are available in all ExtremeWare software releases.

Reasons to Use ESRP

You can use ESRP when working with edge-level or aggregation-level redundancy. Deploying ESRP in this area of the network allows you to simplify your network design which is important in designing a stable network. ESRP also works well in meshed networks where layer 2 loop protection and layer 3 redundancy are simultaneously required.

ESRP Terms

Table 54 describes terms associated with ESRP.

Table 54: ESRP Terms

Term	Description
ESRP-aware	An Extreme switch that is capable of listening to EDP which is the protocol that ESRP uses to transmit information. For more information see “ESRP Concepts” on page 401.
ESRP-enabled	An Extreme switch with the ESRP feature enabled. ESRP-enabled switches include the ESRP master and slave switches.
EDP	Extreme Discovery Protocol. A protocol used by ESRP to communicate information about neighbor Extreme switches. The master and the slave utilize EDP to send hello packets that contain timers, port count, and other state information pertinent to ESRP.
master switch	The master switch is the device with the highest priority based on the election algorithm. The master is responsible for responding to clients for layer 3 routing and layer 2 switching for the VLAN. For more information about the master switch, see “Determining the ESRP Master” on page 403.
pre-master state	An ESRP switch that is ready to be master but is going through possible loop detection prior to transitioning to master. For more information about the behavior of the pre-master switch, see “Pre-Master Switch Behavior” on page 403.
slave switch	A switch participating in ESRP that is not elected or configured the master. The slave switch does not respond to ARP requests, but it does exchange EDP packets with other switches on the same VLAN. The slave switch is available to assume the responsibilities of the master switch if the master becomes unavailable or criteria for ESRP changes. For more information about the behavior of the slave switch, see “Slave Switch Behavior” on page 403.
election algorithm	A user-defined criteria to determine how the master and the slave interact with each other. The election algorithm also determines which device becomes the master or the slave and how ESRP makes those decisions. For more information about the election algorithms, see “ESRP Election Algorithms” on page 404.
priority	A user-defined field to set the priority values for ESRP. The range of the priority value is 0 to 255; a higher number has higher priority. The default priority setting is 0. A priority setting of 255 loses the election and the switch remains in slave mode. To learn more about configuring priority values for ESRP, see “Electing the Master Switch” on page 404.
tracking	ESRP uses tracking mechanisms to determine a master. Should the ESRP master lose the ability to track a selected mechanism, the ESRP slave assumes master. For more information about the tracking methods used by ESRP, see “ESRP Tracking” on page 405.
domains	Domains are a method of increasing scalability for ESRP by creating a domain master VLAN that controls ESRP election and failover criteria for member-VLANs.
domain master-VLAN	The VLAN that ESRP is enabled on and controls the member-VLANs.
domain member-VLAN	The VLAN that is controlled by the ESRP domain master-VLAN. ESRP cannot be enabled on this VLAN.

Table 54: ESRP Terms (Continued)

Term	Description
ESRP VLAN	A VLAN that has ESRP enabled.
ESRP instance	You enable ESRP on a per-VLAN basis. Each time you enable ESRP on a VLAN is an ESRP instance.

ESRP Concepts

ESRP is configured on a per-VLAN basis on each switch. A maximum of four switches can participate in providing redundant layer 3 or layer 2 services to a single VLAN. The switches exchange keep-alive packets for each VLAN independently. Only one switch (the master) can actively provide layer 3 routing and/or layer 2 switching for each VLAN. This switch handles the forwarding, ARP requests, and routing for this particular VLAN. Other participating switches for the VLAN are in slave mode waiting for an ESRP state change.

For a VLAN with ESRP enabled, each participating switch uses the same MAC address and must be configured with the same IP address or IPX NetID. It is possible for one switch to be master for one or more VLANs while being in slave for others, thus allowing the load to be split across participating switches.

NOTE

If you configure OSPF and ESRP, you must manually configure an OSPF router identifier (ID). Be sure that you configure a unique OSPF router ID on each switch running ESRP. For more information on configuring OSPF, see Chapter 18.

To have two or more switches participate in ESRP, the following must be true:

- For each VLAN to be made redundant, the switches must have the ability to exchange packets on the same layer 2 broadcast domain for that VLAN. Multiple paths of exchange can be used, and typically exist in most network system designs that take advantage of ESRP.
- For a VLAN to be recognized as participating in ESRP, the assigned IP address or the IPX NETid for the separate switches must be *identical*. Other aspects of the VLAN, including its name, are ignored.
- ESRP must be enabled on the desired VLANs for each switch.

  NOTE

  ESRP cannot be enabled on the VLAN default.

- Extreme Discovery Protocol (EDP) must be enabled on the ports that are members of the ESRP VLANs (The default setting is enabled.).

  To verify EDP status, use the following command:

  ```
  show ports {mgmt | <portlist>} [t1 | e1 | t3] info
  ```

NOTE

If you configure a domain master-VLAN for ESRP, the domain master-VLAN must contain all ports belonging to the domain member-VLANs in order to operate properly as an ESRP VLAN.

ESRP-Aware Switches

Extreme switches that are not running ESRP, but are connected on a network that has other Extreme switches running ESRP are ESRP-*aware*. When ESRP-aware switches are attached to ESRP-enabled switches, the ESRP-aware switches reliably perform fail-over and fail-back scenarios in the prescribed recovery times. No configuration of this feature is necessary.

NOTE

If you disable EDP on the switch, the switch is no longer ESRP-aware.

If Extreme switches running ESRP are connected to layer 2 switches that are not manufactured by Extreme Networks (or Extreme switches that are not running ExtremeWare 4.0 or later), the fail-over times seen for traffic local to the segment may appear longer, depending on the application involved and the FDB timer used by the other vendor's layer 2 switch. As such, ESRP can be used with layer 2 switches from other vendors, but the recovery times vary.

The VLANs associated with the ports connecting an ESRP-aware switch to an ESRP-enabled switch must be configured using an 802.1Q tag on the connecting port, or, if only a single VLAN is involved, as untagged using the protocol filter `any`. ESRP will not function correctly if the ESRP-aware switch interconnection port is configured for a protocol-sensitive VLAN using untagged traffic. You can also use port restart in this scenario. For more information about port restart, see "ESRP Port Restart" on page 410.

To display ESRP-aware information, use the following command:

```
show esrp-aware vlan <vlan name>
```

The display includes the group number, MAC address for the master of the group, and age of the information.

Linking ESRP Switches

When considering system design using ESRP, Extreme Networks recommends using a direct link. Direct links between ESRP switches are useful under the following conditions:

- A direct link can provide a more direct routed path, if the ESRP switches are routing and supporting multiple VLANs where the master/slave configuration is split such that one switch is master for some VLANs and a second switch is master for other VLANs. The direct link can contain a unique router-to-router VLAN/subnet, so that the most direct routed path between two VLANs with different master switches uses a direct link, instead of forwarding through another set of connected routers.
- A direct link can be used as a highly reliable method to exchange ESRP hellos, so that the possibility of having multiple masters for the same VLAN is lessened, should all downstream layer 2 switches fail.
- A direct link is necessary for the ESRP HA option. The direct link is used to provide layer 2 forwarding services through an ESRP slave switch.

Direct links may contain a router-to-router VLAN, along with VLANs running ESRP. If multiple VLANs are used on the direct links, use 802.1Q tagging. The direct links may be aggregated into a load-shared group, if desired. If multiple ESRP VLANs share a host port, each VLAN must be in a different ESRP group.

Determining the ESRP Master

The ESRP master switch (providing layer 3 routing and/or layer 2 switching services for a VLAN) is determined by the following default factors:

- **Active ports**—The switch that has the greatest number of active ports takes highest precedence.
- **Tracking information—**Various types of tracking are used to determine if the switch performing the master ESRP function has connectivity to the outside world. ExtremeWare supports the following types of tracking:
  - VLAN—Tracks any active port connectivity to one or more designated VLANs
  - IP route table entry—Tracks specific learned routes from the IP route table
  - Ping—Tracks ICMP ping connectivity to specified devices
  - Diagnostics—Tracks the diagnostics of the switch
  - Environment (health checks)—Tracks the environment of the switch

  If any of the configured tracking mechanisms fail, the master ESRP switch relinquishes status as master, and remains in slave mode for as long as the tracking mechanism continues to fail.
- **ESRP priority—**This is a user-defined field. The range of the priority value is 0 to 255; a higher number has higher priority. The default priority setting is 0. A priority setting of 255 makes an ESRP switch remain in slave mode and is the recommended setting for system maintenance. A switch with a priority setting of 255 will never become the master.
- **System MAC address—**The switch with the higher MAC address has higher priority.

Master Switch Behavior

If a switch is master, it actively provides layer 3 routing services to other VLANs, and layer 2 switching between all the ports of that VLAN. Additionally, the switch exchanges EDP packets with other switches that are in slave mode.

Pre-Master Switch Behavior

A pre-master switch is ready to transition to master, but is going through possible loop detection prior to changing to the master state. This temporary state avoids the possibility of having simultaneous masters.

Slave Switch Behavior

If a switch is in slave mode, it exchanges EDP packets with other switches on that same VLAN. When a switch is in slave mode, it does not perform layer 3 routing or layer 2 switching services for the VLAN. From a layer 3 routing protocol perspective (for example, RIP or OSPF), when in slave mode for the VLAN, the switch marks the router interface associated with the VLAN as down. From a layer 2 switching perspective, no forwarding occurs between the member ports of the VLAN; this prevents loops and maintains redundancy.

If you configure the switch to use the optional ESRP Host Attach configuration, the switch continues layer 2 forwarding to the master. For more information, see “ESRP Host Attach” on page 411.

Electing the Master Switch

A new master can be elected in one of the following ways:

- A communicated parameter change
- Loss of communication between master and slave(s)

If a parameter that determines the master changes (for example, link loss or priority change), the election of the new master typically occurs within one timer cycle (2 seconds by default). If a switch in slave mode loses its connection with the master, a new election (using the same precedence order indicated previously) occurs. The new election typically takes place in three times the defined timer cycle (6 seconds by default).

Before the switch transitions to the master state, the switch enters a temporary pre-master state. While in the pre-master state the VLAN does not send ESRP PDUs until the pre-master state timeout expires. When the timeout expires, the slave VLAN operates normally. Traffic is unaffected by the pre-master state because the master continues to operate normally. The pre-master state avoids the possibility of having simultaneous masters.

You can configure the pre-master state timeout using the following command:

```
configure vlan <vlan name> esrp esrp-premaster-timeout <premaster-timer (0-512, 0
restores dflt)>
```

CAUTION

Configure the pre-master state timeout only with guidance from Extreme Networks personnel. Misconfiguration can severely degrade the performance of ESRP and your switch.

Failover Time

Failover time is largely determined by the following factors:

- The ESRP timer setting.
- The routing protocol being used for inter-router connectivity if layer 3 redundancy is used. OSPF failover time is faster than RIP failover time.

The failover time associated with the ESRP protocol is dependent on the timer setting and the nature of the failure. The default timer setting is 2 seconds; the range is 1 to 255 seconds. In most cases, a non-hardware failover is 2 seconds and a hardware failover is 6 seconds.

If routing is configured, the failover of the particular routing protocol (such as RIP V1, RIP V2, or OSPF) is added to the failover time associated with ESRP.

If you use OSPF, make your OSPF configuration passive. A passive configuration acts as a stub area and helps increase the time it takes for recalculating the network. A passive configuration also maintains a stable OSPF core.

ESRP Election Algorithms

You configure the switch to use one of seven different election algorithms to select the ESRP master. Each algorithm considers the election factors in a different order of precedence, as follows:

- `ports-track-priority-mac`—Active ports, tracking information, ESRP priority, MAC address (Default)

- `ports-track-priority`—Active ports, tracking information, ESRP priority
- `track-ports-priority-mac`—Tracking information, active ports, ESRP priority, MAC address
- `track-ports-priority`—Tracking information, active ports, ESRP priority
- `priority-ports-track-mac`—ESRP priority, active ports, tracking information, MAC address
- `priority-track-ports-mac`—ESRP priority, tracking information, active ports, MAC address
- `priority-mac-only`—ESRP priority, MAC address

CAUTION

All switches in the ESRP network must use the same election algorithm, otherwise loss of connectivity, broadcast storms, or other unpredictable behavior may occur.

NOTE

Only the `ports-track-priority-mac` *election algorithm is compatible with ExtremeWare releases prior to version 6.0.*

Advanced ESRP Features

This section describes the following advanced ESRP features:

- ESRP Tracking on page 405
- ESRP Port Restart on page 410
- ESRP and VLAN Aggregation on page 410
- ESRP Host Attach on page 411
- ESRP Don’t Count on page 412
- ESRP Domains on page 412
- ESRP Groups on page 413
- Selective Forwarding on page 414

ESRP Tracking

Tracking information is used to track various forms of connectivity from the ESRP switch to the outside world. This section describes the following ESRP tracking options:

- ESRP Environment and Diagnostic Tracking on page 406
- ESRP VLAN Tracking on page 407
- ESRP Route Table Tracking on page 407
- ESRP Ping Tracking on page 407
- OSPF Tracking on page 407
- BGP Tracking on page 408
- RIP Tracking on page 408

ESRP Environment and Diagnostic Tracking

You can configure ESRP to track hardware status. If a power supply or fan fails, if the chassis is overheating, if a non-fully loaded power supply is detected, or if the diagnostics fail, the priority for the ESRP VLAN will change to the failover settings. You can track the environment, diagnostics, or both at the same time.

NOTE

Enabling environmental tracking on a BlackDiamond chassis with only one power supply unit (PSU) installed causes tracking to fail. In this case, the tracking failure occurs by design.

To configure the failover priority for ESRP VLAN, follow these steps:

1. Assign a priority to each ESRP VLAN, using the following command:

   ```
   configure vlan <vlan name> esrp priority <value>
   ```

   The range of the priority value is 0 to 254; a higher number has a higher priority. The default priority setting is 0.

   NOTE

   If you set the priority to 255, the ESRP VLAN will remain in slave mode even if the master ESRP VLAN fails.

   You will typically configure both ESRP VLANs with the same priority.

2. Assign the priority flag precedence over the active ports count, using the following command:

   ```
   configure vlan <vlan name> esrp esrp-election [ports-track-priority |
   ports-track-priority-mac | track-ports-priority | track-ports-priority-mac |
   priority-ports-track-mac | priority-track-ports-mac | priority-mac-only]
   ```

   Because the priority of both ESRP VLANs are set to the same value, ESRP will use the active ports count to determine the master ESRP VLAN.

3. Set the failover priority, using the following command:

   ```
   configure vlan <vlan name> add [track-diagnostic | track-environment | track-rip |
   track-bgp | track-ospf] failover <priority>
   ```

   Where:

   — `track-bgp` tracks for any available BGP route.

   — `track-diagnostic` tracks for any diagnostics failure.

   — `track-environment` tracks for any environmental failure.

   — `track-ospf` tracks for any available OSPF route.

   — `track-rip` tracks for any available RIP route.

   The range of the priority value is 0 to 254; a higher number has a higher priority. The default priority setting is 0.

   Typically you will set the failover priority lower than the configured priority. Then, if one of the ESRP VLANs experiences a hardware or diagnostics failure, it will become the standby VLAN.

ESRP VLAN Tracking

You can configure ESRP to track port connectivity to one or more specified VLANs as criteria for failover. The number of VLAN active ports are tracked. If the switch is no longer connected to the specified VLANs, the switch automatically relinquishes master status and remains in slave mode. You can track a maximum of four routes per VLAN.

To add or delete a tracked VLAN, use one of the following commands:

```
configure vlan <vlan name> add track-vlan <vlan_tracked>>
configure vlan <vlan name> delete track-vlan <vlan_tracked>
```

ESRP Route Table Tracking

You can configure ESRP to track specified routes in the route table as criteria for failover. If all of the configured routes are not available within the route table, the switch automatically relinquishes master status and remains in slave mode. You can track a maximum of four routes per route table.

To participate in ESRP route table tracking, all ESRP switches must run ExtremeWare version 6.0 or later.

To add or delete a tracked route, use one of the following commands:

```
configure vlan <vlan name> add track-iproute <ip address>/<masklength>
configure vlan <vlan name> delete track-iproute <ipaddress>/<masklength>
```

ESRP Ping Tracking

You can configure ESRP to track connectivity using a simple ping to any device. This may represent the default route of the switch, or any device meaningful to network connectivity of the master ESRP switch. The switch automatically relinquishes master status and remains in slave mode if a ping keepalive fails. You can configure a maximum of four ping tracks.

NOTE

The ESRP ping tracking option cannot be configured to ping an IP address within an ESRP VLAN subnet. It should be configured on some other normal VLAN across the router boundary.

To participate in ESRP ping tracking, all ESRP switches must run ExtremeWare version 6.0 or above.

To view the status of tracked devices, use the following command:

```
show esrp
```

To configure ping tracking, use the following command:

```
configure vlan <vlan name> add track-ping <ip address> frequency <seconds> miss
<number>
```

OSPF Tracking

You can configure ESRP to track any available OSPF routes as a criteria for failover. ESRP tracks the presence or non-presence of the OSPF routes in the route table. If no OSPF routes are detected, the ESRP VLAN priority steps to the failover-priority value specified.

To configure OSPF tracking, use the following command:

```
configure vlan <vlan name> add track-ping <ip address> frequency <seconds> miss
<number>
```

To disable OSPF tracking, use the following command:

```
configure vlan <vlan name> delete track-ospf
```

BGP Tracking

You can configure ESRP to track any available BGP routes as a criteria for failover. ESRP tracks the presence or non-presence of the BGP routes in the route table. If no BGP routes are detected, the ESRP VLAN priority steps to the failover-priority value specified.

To configure BGP tracking, use the following command:

```
configure vlan <vlan name> add track-bgp failover <priority>
```

To disable BGP tracking, use the following command:

```
configure vlan <vlan name> delete track-bgp
```

RIP Tracking

You can configure ESRP to track any available RIP routes as a criteria for failover. ESRP tracks the presence or non-presence of the RIP routes in the route table. If no RIP routes are detected, the ESRP VLAN priority steps to the failover-priority value specified.

To configure RIP tracking, use the following command:

```
configure vlan <vlan name> add track-rip failover <priority>
```

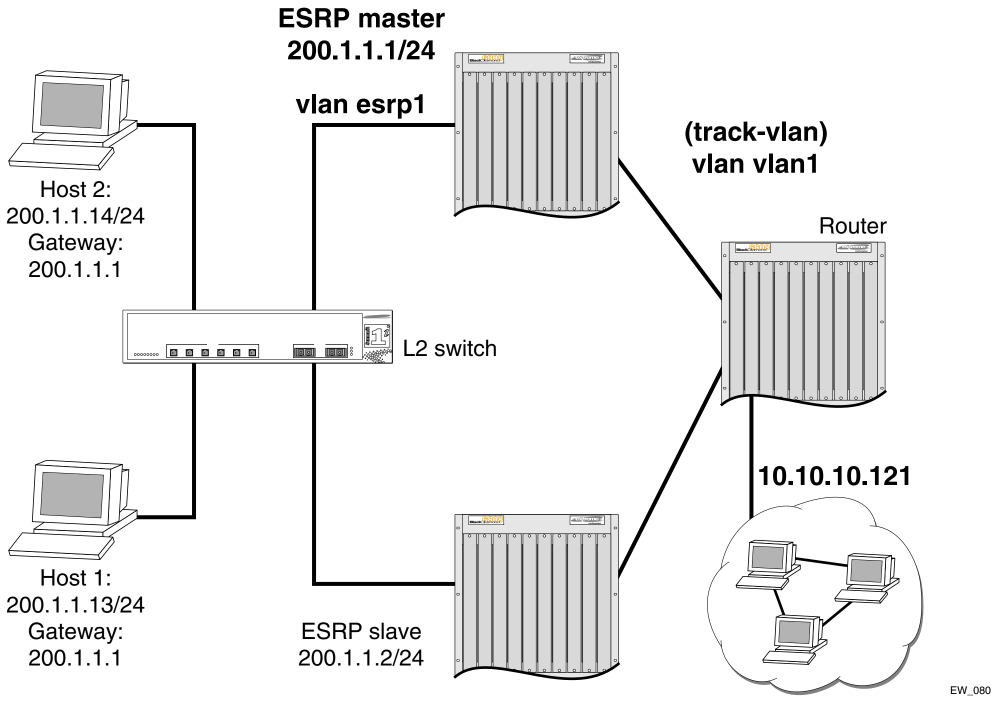
To disable RIP tracking, use the following command:

```
configure vlan <vlan name> delete track-rip
```

ESRP Tracking Example

Figure 72 is an example of ESRP tracking.

Figure 72: ESRP tracking



To configure VLAN tracking, use the following command:

```
configure vlan esrp1 add track-vlan vlan1
```

Using the tracking mechanism, if VLAN1 fails, the ESRP master realizes that there is no path to the upstream router via the Master switch and implements a failover to the slave.

To configure route table tracking, use the following command:

```
configure vlan esrp1 add track-iproute 10.10.10.0/24
```

The route specified in this command must exist in the IP routing table. When the route is no longer available, the switch implements a failover to the slave.

To configure ping tracking, use the following command:

```
configure vlan esrp1 add track-ping 10.10.10.121 2 2
```

The specified IP address is tracked. If the fail rate is exceeded the switch implements a failover to the slave.

To configure RIP tracking, use the following command:

```
configure vlan esrp1 add track-rip failover 20
```

The switch tracks RIP routes in its IP routing table. If no RIP routes are available, the switch implements a failover to failover priority 20.

To configure OSPF tracking, use the following command:

```
configure vlan esrp1 add track-ospf failover 20
```

The switch tracks OSPF routes in its IP routing table. If no OSPF routes are available, the switch implements a failover to failover priority 20.

To configure BGP tracking, use the following command:

```
configure vlan esrp1 add track-bgp failover 20
```

The switch tracks BGP routes in its IP routing table. If no BGP routes are available, the switch implements a failover to failover priority 20.

ESRP Port Restart

You can configure ESRP to restart ports in the ESRP master VLAN when the downstream switch is a non-Extreme switch. This action takes down and restarts the port link to clear and refresh the downstream ARP table. To configure port restart, use the following command:

```
configure vlan <vlan name> add ports [<portlist> | all] restart
```

To disable port restart, use the following command:

```
configure vlan <vlan name> add ports [<portlist> | all] no-restart
```

If a switch becomes a slave, ESRP takes down (disconnects) the physical links of member ports that have port restart enabled. The disconnection of these ports causes downstream devices to remove the ports from their FDB tables. This feature allows you to use ESRP in networks that include equipment from other vendors. After 3 seconds the ports re-establish connection with the ESRP switch.

To remove a port from the restart configuration, delete the port from the VLAN and re-add it.

NOTE

The port restart feature is also available for VRRP. For more information on VRRP, see Chapter 16.

ESRP and VLAN Aggregation

ESRP can be used to provide redundant default router protection to VLAN aggregation clients. ESRP is enabled on the super-VLAN *only* (not the sub-VLANs). The procedure is to add ports to the super-VLAN that is shared with the sub-VLANs. To do so, the super-VLAN should be configured with an 802.1Q tag, and added as tagged with the sub-VLAN ports to avoid a protocol conflict. Lastly, enable ESRP on the super-VLAN.

NOTE

All ports must be tagged for the super-VLAN.

The following example combines ESRP and VLAN aggregation for the super-VLAN *vsuper* and two sub-VLANs, *v1sub* and *v2sub*, that have ports 1 and 2 as members, respectively.

1 Create the VLANs and set up the super to sub-VLAN relationship.

```
create vlan v1sub
create vlan v2sub
create vlan vsuper
configure vsuper ipaddress 10.1.2.3/24
enable ipforwarding
enable ospf
configure ospf add vsuper area 0.0.0.0
configure v1sub add port 1
configure v2sub add port 2
configure vsuper add subvlan v1sub
configure vsuper add subvlan v2sub
```

2 Turn on ESRP for the VLAN *vsuper*.

```
configure vsuper tag 1234
configure vsuper add port 1,2 tagged
enable esrp vlan vsuper
```

Use the following commands to verify the configuration:

- `show vlan {<vlan name> | detail | stats {vlan} <vlan-name>}`— Displays super- and sub-VLAN relationships, IP addresses, and port membership.
- `show esrp {detail}`—Verifies ESRP is enabled and operational.

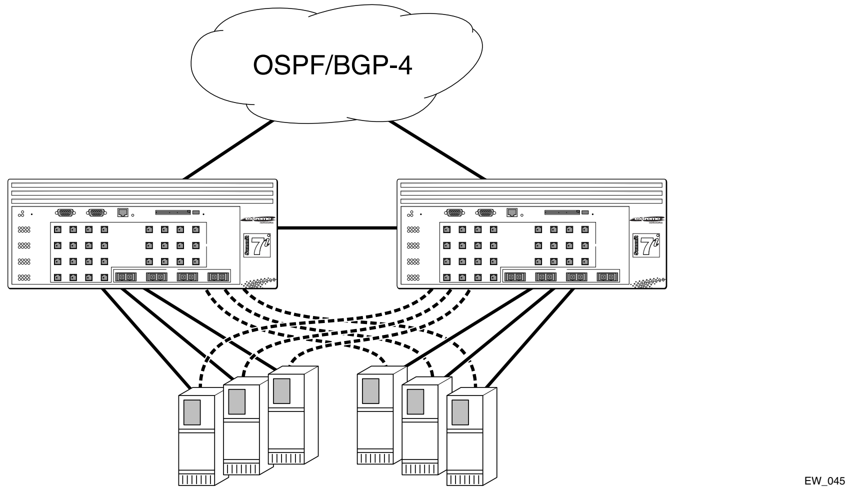
ESRP Host Attach

ESRP host attach (HA) is an optional ESRP configuration that allows you to connect active hosts directly to an ESRP master or slave switch. Normally, the layer 2 redundancy and loop prevention capabilities of ESRP do not allow packet forwarding from the slave ESRP switch. ESRP HA allows configured ports that do not represent loops to the network to continue layer 2 operation independent of their ESRP status.

ESRP HA is designed for redundancy for dual-homed server connections. HA allows the network to continue layer 2 forwarding regardless of the ESRP status. Do not use ESRP HA to interconnect devices on the slave ESRP switch instead of connecting directly to the ESRP master switch.

The ESRP HA option is useful if you are using dual-homed network interface cards (NICs) for server farms, and in conjunction with high availability server load-balancing (SLB) configurations, as shown in Figure 73. The ESRP HA option is also useful as a means to allow for high availability security where an unblocked layer 2 environment is necessary.

Figure 73: ESRP host attach



ESRP VLANs that share ESRP HA ports must be members of different ESRP groups. Each port can have a maximum of four VLANs.

When using load sharing with the ESRP HA feature, configure all ports in the same load-sharing group as host attach ports.

Other applications allow lower cost redundant routing configurations, because hosts can be directly attached to the switch involved with ESRP. The ESRP HA feature is used only on switches and I/O modules that have the "*i*" series chipset. It also requires at least one link between the master and the slave ESRP switch for carrying traffic and to exchange ESRP hello packets.

NOTE

Do not use the ESRP HA feature with the following protocols: STP, EAPS, or VRRP. A broadcast storm may occur.

ESRP Don't Count

ESRP don't count is an optional ESRP port configuration that allows the port to be part of the VLAN, but if a link failure occurs, it will not trigger a reconvergence. The don't count feature has the effect of not counting the host ports and normal ports as active ports. This has the convenience of minimal ESRP state changes due to frequent client activities like reboots and unplugging laptops.

When using load sharing with the ESRP don't count feature, configure all ports in the same load-sharing group as don't count ports.

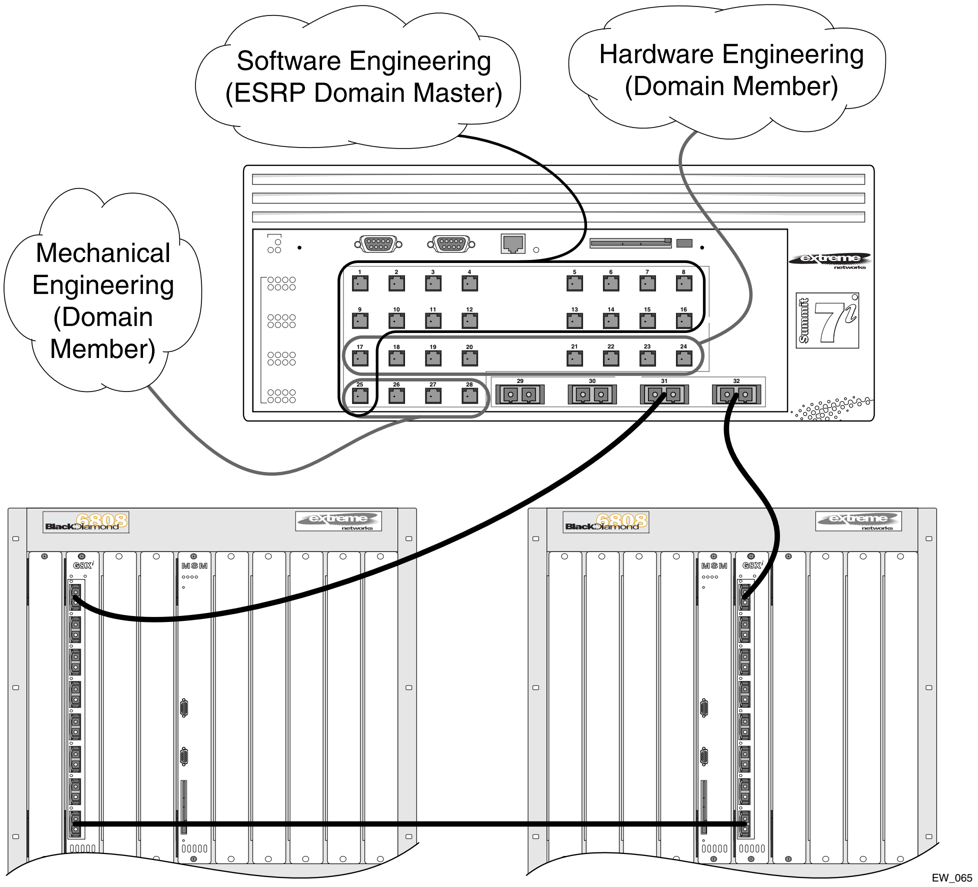
To configure don't count on either a host attach port or a normal port, use the following command:

```
configure esrp port-mode [host | normal] ports <portlist> {don't-count}
```

ESRP Domains

ESRP domains is an optional ESRP configuration that allows you to configure multiple VLANs under the control of a single instance of the ESRP protocol. By grouping multiple VLANs under one ESRP domain, the ESRP protocol can scale to provide protection to large numbers of VLANs. All VLANs within an ESRP domain simultaneously share the same active and standby router and failover, providing one port of each member VLAN belongs to the domain master, as shown in Figure 74.

Figure 74: ESRP domains



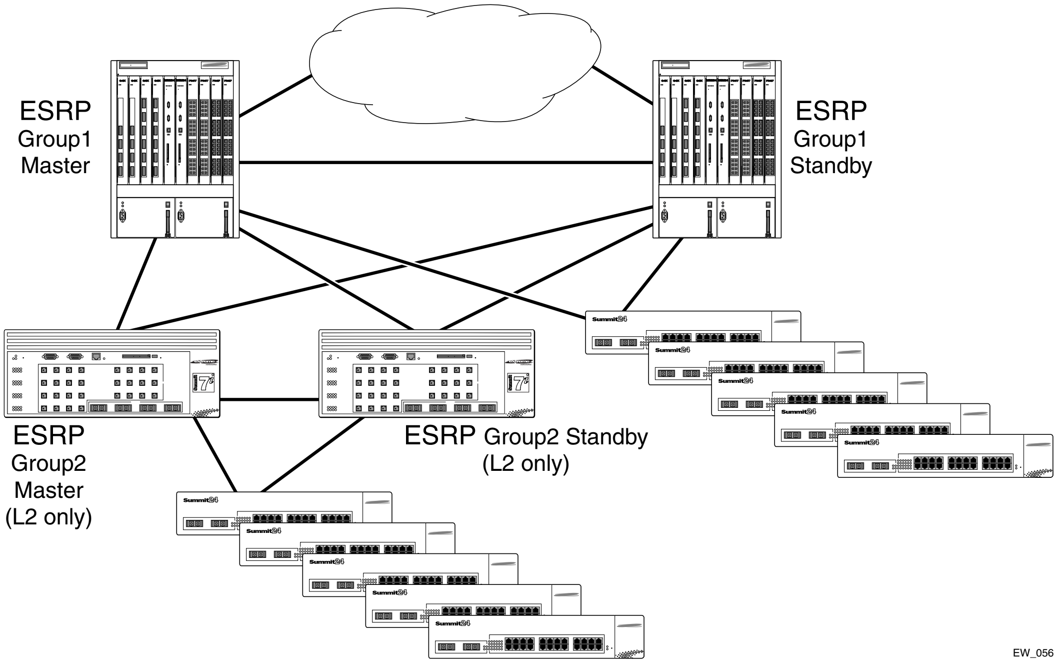
When a port in a member VLAN belongs to the domain master, the member VLAN ports are considered when determining the ESRP master. You can configure a maximum of 64 ESRP domains in a network.

ESRP Groups

ExtremeWare supports running multiple instances of ESRP within the same VLAN or broadcast domain. This functionality is called an ESRP group. Though other uses exist, the most typical application for multiple ESRP groups is when two or more sets of ESRP switches are providing fast-failover protection within a subnet. A maximum of four distinct ESRP groups can be supported on a single ESRP switch. You can configure a maximum of 32 ESRP groups in a network.

For example, two ESRP switches provide L2/L3 connectivity and redundancy for the subnet, while another two ESRP switches provide L2 connectivity and redundancy for a portion of the same subnet. Figure 75 shows ESRP groups.

Figure 75: ESRP groups



NOTE

A switch cannot perform both master and slave functions on the same VLAN for separate instances of ESRP.

An additional user for ESRP groups is ESRP Host Attach (HA), described on page 411.

Selective Forwarding

An ESRP-aware switch floods ESRP PDUs to all ports in an ESRP-aware VLAN and the CPU. This flooding increases the amount of network traffic because all ports, regardless if they are connected to switches running the same ESRP group or not, receive ESRP PDUs. To reduce the amount of traffic, you can select the ports that receive ESRP PDUs by configuring selective forwarding on an ESRP-aware VLAN. By configuring selective forwarding, you create a portlist for the ESRP groups associated with an ESRP-aware VLAN, and that portlist is used for forwarding ESRP PDUs on the relevant ports only.

You configure this feature on a per-VLAN basis, and selective forwarding is disabled by default.

NOTE

Extreme Networks recommends keeping the default settings unless you have considerable knowledge and experience with ESRP.

To configure selective forwarding, use the following command:

```
configure vlan <vlan name> esrp group <group_number> add esrp-aware-ports [all |
<portlist>]
```

where the following is true:

- `vlan name`—Specifies an ESRP-aware VLAN name.
- `group number`—Specifies the ESRP group to which this ESRP-aware VLAN belongs. The ESRP group number must be the same as the ESRP-aware VLAN number.
- `all`—Specifies all of the ports to be configured. All of the ports must be connected to switches running ESRP, and the ports must connect to the ESRP master and slave switches.
- `portlist`—Specifies the ports to be configured. The selected ports must be connected to switches running ESRP, and the ports must connect to the ESRP master and slave switches. May be in the form 1, 2, 3-5, 2:*, 2:5, 2:6-2:8.

When an ESRP-aware switch receives an ESRP PDU, the software will lookup the group to which the PDU belongs and will forward the ESRP PDU to the group's portlist and the CPU.

You cannot enable selective forwarding on an ESRP-enabled VLAN. If you try to enable selective forwarding on an ESRP-enabled VLAN, you see the following message:

```
ERROR: vlan meg is esrp enabled. Cannot enable selective forwarding on esrp vlans
```

To disable selective forwarding, use the following command:

```
configure vlan <vlan name> esrp group <group_number> delete esrp-aware-ports [all |
<portlist>]
```

where the following is true:

- `group number`—Specifies the ESRP group to which this ESRP-aware VLAN belongs. The ESRP group number must be the same number as the ESRP-aware VLAN.
- `all`—Specifies all of the ports to be disabled.
- `portlist`—Specifies the selected ports to be disabled.

Displaying Selective Forwarding Information

To display the ESRP-aware VLAN(s), the ESRP group(s), and the ESRP-aware port(s) that receive ESRP PDUs, use the following command:

```
show esrp-aware-ports {vlan <vlan name>}
```

Displaying ESRP Information

To verify the operational state of an ESRP VLAN and the state of its neighbor, use the following command:

```
show esrp {detail}
```

If you enter the `show esrp` command without a keyword, the command displays summary ESRP status information for the VLANs on the switch. Use the `detail` keyword to display more detailed status information.

To view tracking information about a particular VLAN, including the VLANs tracked by it and a list of the VLANs tracking it, use the following command:

```
show vlann
```

To view ESRP configuration information for a specific VLAN, use the following command:

```
show esrp vlan
```

To view ESRP counter information for a specific VLAN, use the following command:

```
show esrp vlan <vlan name> {counters}}
```

To view ESRP-aware information for a specific VLAN, including:

- Group number
- MAC address for the master of the group
- Age of the information

use the following command:

```
show esrp-aware vlan <vlan name>
```

For more information about any of the commands used to enable, disable, or configure ESRP, refer to the *ExtremeWare Software Command Reference Guide*.

Using ELRP with ESRP

Extreme Loop Recovery Protocol (ELRP) is a feature of ExtremeWare that allows you to prevent, detect, and recover from layer 2 loops in the network. You can use ELRP with other protocols such as ESRP.

With ELRP, each switch, except for the sender, treats the ELRP PDU as a layer 2 multicast packet. The sender uses the source and destination MAC addresses to identify the packet it sends and receives. When the sender receives its original packet back, that triggers loop detection and prevention. Once a loop is detected, the loop recovery agent is notified of the event and takes the necessary actions to recover from the loop. ELRP operates only on the sending switch; therefore, ELRP operates transparently across the network.

How a loop recovers is dependent upon the protocol that uses the loop detection services provided by ELRP. If you are using ELRP in an ESRP environment, ESRP may recover by transitioning the VLAN state from master to slave. This section describes how ESRP uses ELRP to recover from a loop and the switch behavior.

ELRP Terms

Table 55 describes terms associated with ELRP.

Table 55: ELRP Terms

Term	Description
Loop detection	The process ELRP uses to detect a loop in the network. The switch sending the ELRP PDU waits to receive its original PDU back. If the switch receives the PDU, there is a loop in the network.

Table 55: ELRP Terms (Continued)

Term	Description
ELRP PDU	Extreme Loop Recovery Protocol Protocol Data Unit. A layer 2 multicast packet that helps the sending switch determine if there is a loop in the network. The sender uses the source and destination MAC addresses to identify the packet it sends and receives. When the sender receives its original packet back, that triggers loop detection and prevention. (Also known as loop-detect packets.)

Using ELRP with ESRP to Recover Loops

ELRP sends loop-detect packets to notify ESRP about loops in the network. In an ESRP environment, when the current master goes down, one of the slaves becomes the master and continues to forward layer 2 and layer 3 traffic for the ESRP VLAN. If a situation occurs when a slave incorrectly concludes that the master is down, the slave incorrectly assumes the role of master. This introduces more than one master on the VLAN which causes temporary loops and disruption in the network.

NOTE

Because ELRP introduces the pre-master state to ESRP, you must upgrade all ESRP-enabled switches within an ESRP domain to ExtremeWare 6.2.2b134 (or later) for ESRP to operate correctly. Earlier ExtremeWare releases do not recognize the pre-master state.

ELRP on ESRP Pre-Master Switch Behavior

A pre-master switch is an ESRP switch that is ready to transition to master, but is going through possible loop detection. A pre-master periodically sends out ELRP loop-detect packets (ELRP PDUs) for a specified number of times and waits to make sure that none of the sent ELRP PDUs are received. Transition to master occurs only after this additional check is completed. If any of the ELRP PDUs are received, the switch transitions from pre-master to slave state. You configure pre-master ELRP loop detection on a per VLAN basis.

ELRP on ESRP Master Switch Behavior

A master switch is an ESRP switch that sends ELRP PDUs on its VLAN ports. If the master switch receives an ELRP PDU that it sent, the master transitions to the slave. While in the slave state, the switch transitions to the pre-master state and periodically checks for loops prior to transitioning to the master. The pre-master process is described in "ELRP on ESRP Pre-Master Switch Behavior" on page 417. You configure the master ELRP loop detection on a per VLAN basis.

Configuring ELRP

This section describes the commands used to configure ELRP for use with ESRP. By default, ELRP is disabled.

Configuring the Pre-Master

If you enable the use of ELRP by ESRP in the pre-master state, ESRP requests ELRP packets sent to ensure that there is no loop in the network prior to changing to the master state. If no packets are received, there is no loop in the network. By default, the use of ELRP by ESRP in the pre-master state is disabled.

To enable the use of ELRP by ESRP in the pre-master state on a per-VLAN basis, and to configure how often and how many ELRP PDUs are sent in the pre-master state, use the following command:

```
configure vlan <vlan name> esrp elrp-premaster-poll enable {count <number> | interval
<seconds>}
```

where the following is true:

- `vlan name`—Specifies an ESRP-enabled VLAN name.
- `number`—Specifies the number of times the switch sends ELRP PDUs. The default is 3, and the range is 1 to 32.
- `seconds`—Specifies how often, in seconds, the ELRP PDUs are sent. The default is 1 seconds, and the range is 1 to 32 seconds.

To disable the use of ELRP by ESRP in the pre-master state, use the following command:

```
configure vlan <vlan name> esrp elrp-premaster-poll disable
```

Configuring the Master

If you enable the use of ELRP by ESRP in the master state, ESRP requests that ELRP packets are periodically sent to ensure that there is no loop in the network while ESRP is in the master state. By default, the use of ELRP by ESRP in the master state is disabled.

To enable the use of ELRP by ESRP in the master state on a per-VLAN basis, and to configure how often the master checks for loops in the network, use the following command:

```
configure vlan <vlan name> esrp elrp-master-poll enable {interval <seconds>}
```

where the following is true:

- `vlan name`—Specifies and ESRP-enabled VLAN name.
- `seconds`—Specifies how often, in seconds, successive ELRP packets are sent. The default is 1 second, and the range is 1 to 32 seconds.

To disable the use of ELRP by ESRP in the master state, use the following command:

```
configure vlan <vlan name> esrp elrp-master-poll disable
```

Configuring Ports

You can configure one or more ports of a VLAN where ELRP packet transmission is requested by ESRP. This allows the ports in your network that might experience loops, such as ports that connect to the master, slave, or ESRP-aware switches, to receive ELRP packets. You do not need to send ELRP packets to host ports.

By default, all ports of the VLAN where ESRP is enabled also has ELRP transmission enabled on the ports.

If you change your network configuration, and a port no longer connects to a master, slave, or ESRP-aware switch, you can disable ELRP transmission on that port. To disable ELRP transmission, use the following command:

```
configure vlan <vlan name> delete elrp-poll ports [<portlist> | all]
```

To enable ELRP transmission on a port, use the following command:

```
configure vlan <vlan name> add elrp-poll ports [<portlist> | all]
```

Displaying ELRP Information

To display summary ELRP information, use the following command:

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

If you enter the `show elrp` command without a keyword, the command displays the total number of:

- Clients registered with ELRP
- ELRP packets transmitted
- ELRP packets received

Use the `vlan name` parameter to display information specific to a VLAN, and the `detail` keyword to display more detailed status information for VLANs in the master and pre-master states.

For more detailed information about the output associated with the `show elrp` command, see the *ExtremeWare Command Reference Guide*.

Using Standalone ELRP to Enable Loop Tests

Having a tool to determine if the network has any loops is extremely useful. There are various other protocols that can exploit this tool to prevent network loops. There are also situations where you might want to check the topology for the existence or absence of a loop.

Extreme Loop Recovery Protocol (ELRP) is a feature of ExtremeWare that allows you to prevent, detect, and recover from layer 2 loops in the network. You can use ELRP with other protocols such as Extreme Standby Router Protocol (ESRP), as described in “Using ELRP with ESRP”. EAPS protocol requires that a network have a ring topology to operate. In this case ELRP can be used to ensure that the network has ring topology.

ELRP is used to detect network loops in a layer-2 network. A switch running ELRP transmits multicast packets with special MAC destination address out of some or all of the ports belonging to a VLAN. All the other switches in the network treat this packet as a regular, multicast packet and flood it to all the ports belonging to the VLAN. If the packets transmitted by a switch are received back by that switch, this indicates a loop in the layer-2 network.

Once a loop is detected through ELRP, different recovery actions can be taken such as blocking certain ports to prevent loop or log a message to system log. The action taken is largely dependent on the protocol using ELRP to detect loops in the network.

The preceding “Using ELRP with ESRP” section describes an implementation of ExtremeWare in which Extreme Loop Recovery Protocol (ELRP) is used by ESRP. In ESRP, two or more switches provide redundant connectivity to the network. One of these switches acts as a master and performs active forwarding of L2 and L3 data. All the other switches operate in standby mode and transition to master only under certain trigger conditions (for example: the master switch fails, or the standby switch performance improves according to the master election criteria). However, in ESRP protocol, there is a possibility that a slave switch can prematurely assume that the master has gone away and transition its state to master. This causes a loop in the network.

Using ELRP with ESRP is one way ELRP can be put to use. Another way to use ELRP is to invoke “standalone” ELRP commands to determine whether a network has an L2 loop or not.

About Standalone ELRP

Standalone ELRP gives you the ability to send ELRP packets, either periodically or on an ad hoc “one-shot” basis on a specified subset of VLAN ports. If any of these transmitted packets is received back then standalone ELRP can perform a configured action such as sending a log message to the system log file or sending a trap to the SNMP manager.

Standalone ELRP allows you to:

- Configure ELRP packet transmission on specified VLANs.
- Specify some or all the ports of VLAN for packet transmission.

NOTE

Reception of packets is not limited to any specific ports of the VLAN and cannot be configured.

- Configure transmission of ELRP packets on specified ports of a VLAN periodically with the added ability to configure the interval between consecutive timings.
- Save and restore standalone ELRP configuration across reboots.
- Request periodic or non-periodic transmission of ELRP packets on specified ports of a VLAN.

  For **non-periodic** ELRP requests:

  - You can specify the number of times ELRP packets must be transmitted and the interval between consecutive transmissions.
  - A message is printed to the console and logged into the system log file indicating detection of network loop when ELRP packets are received back or no packets are received within the specified duration.
  - There is no need to trap to the SNMP manager.

  For **periodic** ELRP requests:

  - If ELRP packets are received back, a message is printed to the system log file and a trap is sent to the SNMP manager indicating detection of a network loop.

Configuring Standalone ELRP

This section describes configuring ELRP packet transmission to detect network loops.

The ELRP client (standalone ELRP) must be enabled globally in order for it to work on any VLANs. To globally enable the ELRP client use the following command:

```
enable elrp-client
```

The ELRP client can be disabled globally so that none of the ELRP VLAN configurations take effect. Use the following command to globally disable the ELRP client:

```
disable elrp-client
```

To start one-time, non-periodic ELRP packet transmission on specified ports of a VLAN using a particular count and interval, use the following command:

```
configure elrp-client one-shot <vlan name> timeout <interval> retry <count> ports
<port-mask> action [log | trap | log-and-trap]
```

This command starts one-time, non-periodic ELRP packet transmission on the specified ports of the VLAN using the specified count and interval. If any of these transmitted packets is returned, indicating loopback detection, the ELRP client can perform a configured action such as logging a message in the system log file or printing a log message to the console. There is no need to trap to the SNMP manager for non-periodic requests.

To start periodic ELRP packet transmission on specified ports of a VLAN using a particular interval, use the following command:

```
configure elrp-client periodic <vlan name> timeout <interval> ports <port-mask> action
[log | trap | log-and-trap]
```

This command starts periodic ELRP packet transmission on the specified ports of the VLAN using the specified interval. If any of these transmitted packets is returned, indicating loopback detection, the ELRP client can perform a configured action such as logging a message in the system log file and/or sending a trap to the SNMP manager.

To disable a pending one-shot or periodic ELRP request for a specified VLAN use the following command:

```
unconfigure elrp-client <vlan name>
```

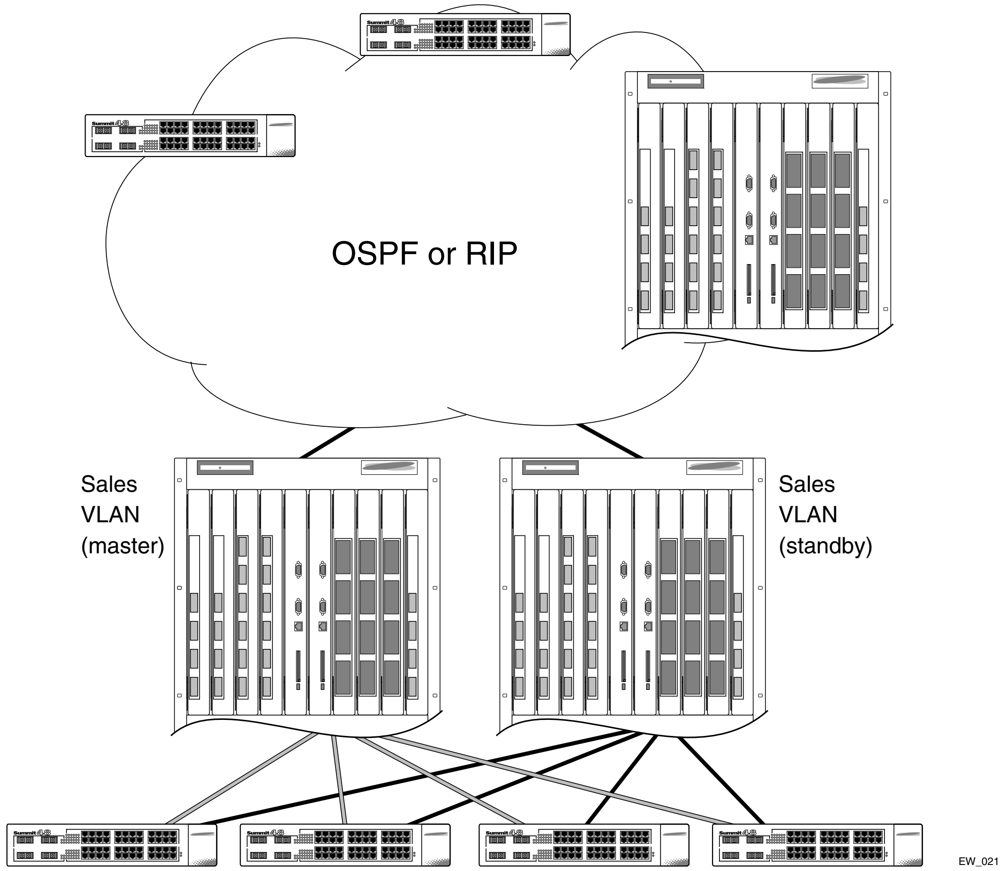
ESRP Examples

This section provides examples of ESRP configurations.

Single VLAN Using Layer 2 and Layer 3 Redundancy

This example, shown in Figure 76, uses a number of Summit switches that perform layer 2 switching for VLAN *Sales*. The Summit switches are dual-homed to the BlackDiamond switches. The BlackDiamond switches perform layer 2 switching between the Summit switches and layer 3 routing to the outside world. Each Summit switch is dual-homed using active ports to two BlackDiamond switches (as many as four could be used). ESRP is enabled on each BlackDiamond switch only for the VLAN that interconnects to the Summit switches. Each BlackDiamond switch has the VLAN *Sales* configured using the identical IP address. The BlackDiamond switches then connect to the routed enterprise normally, using the desired routing protocol (for example RIP or OSPF).

Figure 76: ESRP example using layer 2 and layer 3 redundancy



The BlackDiamond switch, acting as master for VLAN *Sales*, performs both layer 2 switching and layer 3 routing services for VLAN *Sales*. The BlackDiamond switch in slave mode for VLAN *Sales* performs neither, thus preventing bridging loops in the VLAN. The BlackDiamond switch in slave mode does, however, exchange EDP packets with the master BlackDiamond switch.

There are four paths between the BlackDiamond switches on VLAN *Sales*. All the paths are used to send EDP packets, allowing for four redundant paths for communication. The Summit switches, being ESRP-aware, allow traffic within the VLAN to fail-over quickly, as they will sense when a master/slave transition occurs and flush FDB entries associated with the uplinks to the ESRP-enabled BlackDiamond switches.

The following commands are used to configure both BlackDiamond switches. The assumption is that the inter-router backbone is running OSPF, with other routed VLANs already properly configured. Similar commands would be used to configure a switch on a network running RIP. The primary requirement is that the IP address for the VLAN(s) running ESRP must be identical. In this scenario, the master is determined by the programmed MAC address of the switch, because the number of active links for the VLAN and the priority are identical to both switches.

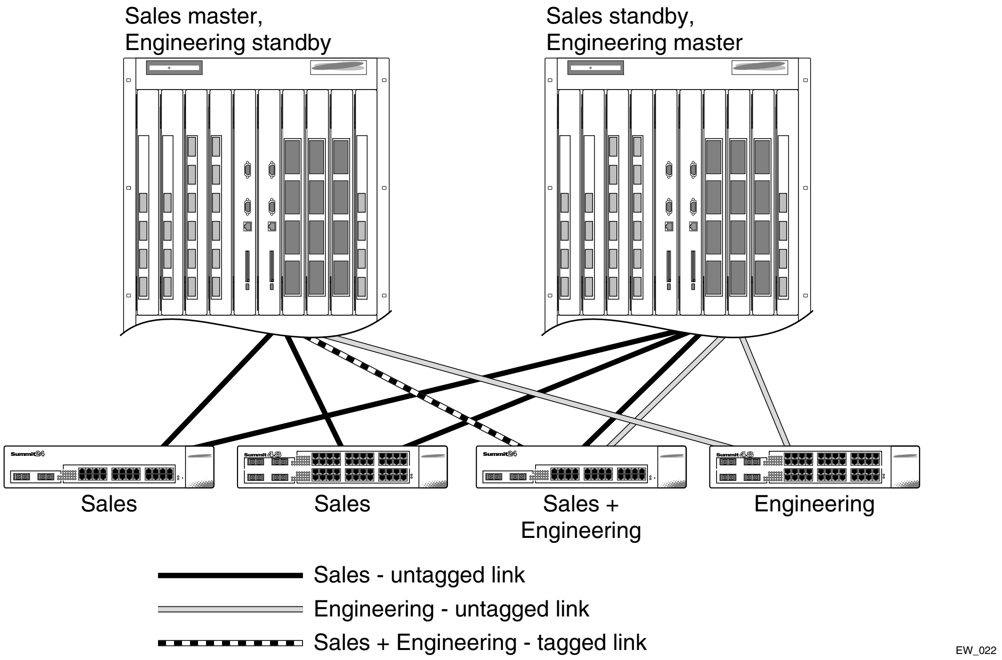
The commands used to configure the BlackDiamond switches are as follows:

```
create vlan sales
configure sales add port 1:1-1:4
configure sales ipaddr 10.1.2.3/24
enable ipforwarding
enable esrp sales
enable edp ports all
configure ospf add vlan sales
enable ospf
```

Multiple VLANs Using Layer 2 Redundancy

The example shown in Figure 77 illustrates an ESRP configuration that has multiple VLANs using layer 2 redundancy.

Figure 77: ESRP example using layer 2 redundancy



This example builds on the previous example, but eliminates the requirement of layer 3 redundancy. It has the following features:

- An additional VLAN, *Engineering*, is added that uses layer 2 redundancy.
- The VLAN *Sales* uses three active links to each BlackDiamond switch.
- The VLAN *Engineering* has two active links to each BlackDiamond switch.
- The third Summit switch carries traffic for both VLANs.
- The link between the third Summit switch and the first BlackDiamond switch uses 802.1Q tagging to carry traffic from both VLANs traffic on one link. The BlackDiamond switch counts the link active for each VLAN.
- The second BlackDiamond switch has a separate physical port for each VLAN connected to the third Summit switch.

In this example, the BlackDiamond switches are configured for ESRP such that the VLAN *Sales* normally uses the first BlackDiamond switch and the VLAN *Engineering* normally uses the second BlackDiamond switch. This is accomplished by manipulating the ESRP priority setting for each VLAN for the particular BlackDiamond switch.

Configuration commands for the first BlackDiamond switch are as follows:

```
create vlan sales
configure sales tag 10
configure sales add port 1:1-1:2
configure sales add port 1:3 tagged
configure sales ipaddr 10.1.2.3/24
create vlan eng
configure eng tag 20
configure eng add port 1:4
configure eng add port 1:3 tagged
configure eng ipaddr 10.4.5.6/24
enable esrp sales
enable esrp eng
enable edp ports all
configure sales esrp priority 5
```

Configuration commands for the second BlackDiamond switch are as follows:

```
create vlan sales
configure sales add port 1:1-1:3
configure sales ipaddr 10.1.2.3/24
create vlan eng
configure eng add port 1:4, 2:1
configure eng ipaddr 10.4.5.6/24
enable esrp sales
enable esrp eng
configure eng esrp priority 5
```

ESRP Cautions

This section describes important details to be aware of when configuring ESRP.

Configuring ESRP and Multinetting

When configuring ESRP and IP multinetting on the same switch, the parameters that affect the determination of the ESRP master must be configured identically for all the VLANs involved with IP multinetting. For example, the number of links in your configuration, the priority settings, and timer settings must be identical for all affected VLANs.

ESRP and Spanning Tree

A switch running ESRP should not simultaneously participate in the Spanning Tree Protocol (STP) for the same VLAN(s). Other switches in the VLAN being protected by ESRP may run STP and the switch running ESRP forwards, but does not filter, STP BPDUs. Therefore, you can combine ESRP and STP on a network and a VLAN, but you must do so on separate devices. You should be careful to maintain ESRP connectivity between ESRP master and slave switches when you design a network that uses ESRP and STP.

Extreme Link Status Monitoring (ELSM)

The Extreme Link Status Monitoring (ELSM) protocol allows you to detect remote CPU failures in the network. A software or hardware fault might prevent the CPU from transmitting or receiving, leading to the sudden failure of the CPU. If the CPU cannot process or send packets, ELSM isolates the connections to the faulty switch from the rest of the network. If the switch fabric continues to send packets during a CPU failure, the switch may appear to be healthy when it is not.

An Extreme Networks device with ELSM enabled can detect remote CPU failures by exchanging hello packets between two ELSM peers. When ELSM detects a CPU failure as a result of not hearing from its neighbor, it brings down the connection to the neighbor. ELSM operates on a point-to-point basis; you only configure ELSM on the ports that connect to other devices within the network, but you must configure ELSM on both sides of the peer connections.

ELSM ports use hello packets to communicate information about the health of the network to peer ports. The hello packets are received and transmitted by an ELSM-enabled port. The port expects a response from its neighbor after it sends a hello packet.

Enabling ELSM

To enable ELSM, use the following command:

```
enable elsm ports <portlist>
```

When you enable ELSM on the specified ports, the ports participate in ELSM with their peers and begin exchanging ELSM hellos.

ELSM works between two connected ports, and each ELSM instance is based on a single port.

Disabling ELSM

To disable ELSM, use the following command:

```
disable elsm ports <portlist>
```

When you disable ELSM on the specified ports, the ports no longer send ELSM hellos to its peer and no longer maintain ELSM states.

Configuring ELSM

ELSM uses two types of hello packets to communicate the health of the network to other ELSM ports.

- Hello+ — The device receives a hello from the neighbor device, and no problem is detected
- Hello- — The device does not receive a hello from the neighbor device, or the device has experienced a critical event.

Table 56 describes the ELSM user-configurable parameters.

Table 56: ELSM user-configurable parameters

Timer	Description
Hello	Specifies the time, in seconds, between consecutive ELSM hellos. Use the same value for the hello interval on peer ports. The default is 1. The range is 1 to 128.
Hold	Specifies the number of packets required to transition out of the Down-Wait state to the Up state. A hold threshold of 1 means the ELSM port must receive at least one Hello+ packet to transition from the Down-Wait state to the Up state. The default is 2. The range is 1 to 3.

To configure the hello timer, use the following command:

```
configure elsm hellotime <1-128> ports <portlist>
```

To configure the hold threshold, use the following command:

```
configure elsm hold-threshold <1-3> ports <portlist>
```

ELSM Timers

Table 57 describes the ELSM timers that are derived from other timers and are not user-configurable.

Table 57: Derived ELSM timers

Timer	Description
Down	Specifies the time it takes for the ELSM receive port to cycle through the following states: • Down • Down-Wait • Up If the Hello timer is set to 1 seconds, it takes 4 seconds for the ELSM receive port to cycle through the states. After the timer expires, the port checks the number of Hello+ packets against the hold threshold. If the number of Hello+ packets received is greater than or equal to the configured hold threshold, the ELSM receive port moves from the Down-Wait state to the Up state. If the number of Hello(+) packets received is less than the configured hold threshold, the ELSM receive port moves from the Down-Wait state to the Down state. The down timer is 4 times the Hello timer.
Up	When an ELSM-enabled port enters the Up state, the Up timer begins. The timer restarts each time the port receives a Hello+ packet. The Up timer is 6 times the Hello timer.
HelloRx	Specifies the time in which a Hello packet is expected, otherwise the ELSM transmit state changes from HelloRx+ to HelloRx-. The HelloRx timer is 6 times the Hello timer.

ELSM Receive Port

The ELSM receive port receives hello messages from its peer. The ELSM receive states are:

- Down—Port is down.

When you enable ELSM, the starting state is Up. If it does not receive a Hello message from its neighbor before the Up timeout, it transitions to the Down state. When ELSM is down, data packets are neither received nor transmitted out of that port.

- Down-Wait—Transitional state.

  When the port enters the Down-Wait state, the Down timer begins. After the timer expires, the port checks the number of Hello+ packets received against the configured down threshold. If the Hello+ packets are greater than or equal to the threshold, the port transitions to the Up state. If the Hello+ packets are less than the threshold, the port returns to the Down state and begins the process again.

- Up—Beginning state, port is up.

  If ELSM is enabled and the port enters the Up state, the Up timer begins. Each time the port receives a Hello+ packet, the timer restarts and remains in the Up state.

  If the port no longer receives hello packets for Up-timer seconds, or receives a hello- packet, the port transitions to either the Down or Down-Stuck state.

- Down-Stuck —Port stays down and requires manual intervention.

  If you have ELSM automatic restart enabled and the port goes down, ELSM automatically brings up the port if it receives the Hello packets from its neighbor.

  If you do not have automatic restart enabled, the port goes through the Up, Down, Down-Wait process once. When you first enable ELSM or if you reboot the switch, it goes through the process twice. After it is done with the cycle (or cycles), the port enters the Down-Stuck state.

  To enable automatic restart, use the following command:

  ```
  enable elsm auto-restart ports <portlist>
  ```

  To disable automatic restart, use the following command:

  ```
  disable elsm auto-restart ports <portlist>
  ```

  To get out of the Down-Stuck state and enter the Down state, you can use one of the following commands:

  ```
  clear elsm auto-restart ports <portlist>
  enable elsm auto-restart ports <portlist>
  ```

ELSM Transmit Port

The ELSM transmit port sends hello messages to its peer. The ELSM transmit states are.

- Init—No ELSM activity, the initial transmit state. The port remains in this state until ELSM is enabled on the port.
- HelloRx- —Transitions from Init when ELSM is enabled.

  When you enable ELSM, the port transitions from the Init state to the HelloRx- state. During the HelloRx- state, the port waits to receive neighbor hello messages. Depending on what happens to the port, the following occurs:

  — Hello+ packet received: The port actively receives hello messages from its neighbor and the network is healthy. The port transitions to the Hello Rx+ state.

  — Hello- packet received: The neighbor has not received the Hello packet sent by this switch. The switch transitions to HelloRx+ state.

- HelloRx+ —Up and receives hello messages.

  In this state, the port receives hello messages from its neighbor and the following occurs:

- — Hello+ packet received: The port actively receives hello messages from its neighbor and the network is healthy. The port remains in the Hello Rx+ state and the HelloRx timer is restarted.
- — Hello- packet received: The neighbor has not received the Hello sent by this switch. The switch stays in the HelloRx+ state.
- — HelloRX timer: If the HelloRx timer expires, the port returns to the HelloRx- state.

- CriticalEvent—A critical event occurs in the software.

  A critical event occurs when a critical task crash occurs in the software. When the critical event clears, the port returns to the HelloRx- state. As long as the port is in the CriticalEvent state, Hello - packets are sent to the neighboring device.

Using ELSM With ESRP

You can use ELSM with ESRP to improve the recovery of layer 2 loops in the network. A sudden failure in the switch CPU may cause the hardware to continue forwarding traffic. This may cause ESRP to select a second device for forwarding traffic and create a layer 2 loop in the network. With ELSM, if the CPU fails, ELSM closes the connection to faulty device in the network to prevent loops.

Monitoring ELSM

To verify the operational state of ELSM on a particular port or all ports on a switch, use the following command:

```
show elsm ports <portlist>
```

Following is the output from this command:

```
ELSM Info Port 9
          Admin                         : Enabled
          Upper Layer Link Status       : Down
          Rx State                      : Down
          Tx State                      : HelloRx(-)
          Hello Time                    : 1 (second)
          Hold Threshold                : 2
          Auto Restart                  : Enabled
          Rx Hello+                     : 0
          Rx Hello-                     : 0
          Tx Hello+                     : 0
          Tx Hello-                     : 0
          ELSM Up/Down Count            : Up 0 Down 0
```

Following is the output from the `show elsm` command:

```
          Port     Rx State                Hello Time
          9         Up                         1
```

The following ELSM data is displayed by the switch:

- Admin state—enabled or disabled

- Upper layer link status—up or down
- Receive State—up, down, down-wait, or down-stuck
- Transmit state—HelloRx+, HelloRx-, Critical Event, Init
- Hello time
- Hold threshold
- Auto-restart
- Receive Hello and Transmit Hello packet counters
- ELSM up/down count

If ELSM is disabled, only the admin (enabled/disabled) information is displayed.

To clear the statistics gathered by ELSM, use the following command:

```
clear elsm counters ports <portlist>
```

Configuring ELSM Debug Tracing

To configure debug tracing for ELSM ports, use the following command:

```
configure debug elsm-port <level> <port number>
```

The levels provide the following information:

- Level 1 is information.
- Level 2 is trace, and is used to trace the path of code execution.
- Levels 3 and above are not used.

To disable debug tracing, set the level to 0.

To configure ELSM debug tracing for the entire system, use the following command:

```
configure debug elsm-system <level>
```

The levels provide the following information:

- Level 1 is information.
- Level 2 is trace, and is used to trace the path of code execution.
- Levels 3 and above are not used.

To disable debug tracing, set the level to 0.

16 Virtual Router Redundancy Protocol

This chapter covers the following topics:

- Overview on page 431
- Determining the VRRP Master on page 432
- Additional VRRP Highlights on page 435
- VRRP Operation on page 436
- VRRP Configuration Parameters on page 439
- VRRP Examples on page 440

This chapter assumes that you are already familiar with the Virtual Router Redundancy Protocol (VRRP). If not, refer to the following publications for additional information:

- RFC 2338—*Virtual Router Redundancy Protocol (VRRP)*
- RFC 2787—*Definitions of Managed Objects for the Virtual Router Redundancy Protocol*

Overview

Like ESRP, VRRP is a protocol that allows multiple switches to provide redundant routing services to users. VRRP is used to eliminate the single point of failure associated with manually configuring a default gateway address on each host in a network. Without using VRRP, if the configured default gateway fails, you must reconfigure each host on the network to use a different router as the default gateway. VRRP provides a redundant path for the hosts. If the default gateway fails, the backup router assumes forwarding responsibilities.

VRRP Terms

Table 58 describes terms associated with VRRP.

Table 58: VRRP Terms

Term	Description
virtual router	A VRRP router is a group of one or more physical devices that acts as the default gateway for hosts on the network. The virtual router is identified by a virtual router identifier (VRID) and an IP address.
VRRP router	Any router that is running VRRP. A VRRP router can participate in one or more virtual routers. A VRRP router can be a backup router for one more master routers.
IP address owner	A single VRRP router that has the IP address of the virtual router configured as its real interface address. The IP address owner responds to TCP/IP packets addressed to the virtual router IP address. The IP address owner is optional in a VRRP configuration.
master router	The physical device (router) in the virtual router that is responsible for forwarding packets sent to the virtual router, and responding to ARP requests. The master router sends out periodic advertisements that let backup routers on the network know that it is alive. If the IP address owner is identified, it always becomes the master.
backup router	Any VRRP router in the virtual router that is not elected as the master. The backup router is available to assume forwarding responsibility if the master becomes unavailable.
VRID	Virtual router identifier. Each virtual router is given a unique VRID. All of the VRRP routers that participate in the virtual router are assigned the same VRID.
virtual router MAC address	RFC 2338 assigns a static MAC address for the first 5 octets of the virtual router. These octets are set to 00-00-5E-00-01. When you configure the VRID, the last octet of the MAC address is dynamically assigned the VRID number.

Determining the VRRP Master

The VRRP master is determined by the following factors:

- **IP address—**If a router is configured with the IP address of the virtual IP address, it becomes the master.
- **VRRP priority—**This is a user-defined field. The range of the priority value is 1 to 254; a higher number has higher priority. The value of 255 is reserved for a router that is configured with the virtual router IP address. A value of 0 is reserved for the master router, to indicate it is releasing responsibility for the virtual router. The default value is 100.
- **Higher IP address—**If the routers have the same configured priority, the router with the higher IP address becomes the master.

VRRP Tracking

Tracking information is used to track various forms of connectivity from the VRRP router to the outside world. This section describes the following VRRP tracking options:

- VRRP VLAN tracking
- VRRP route table tracking
- VRRP ping tracking

VRRP VLAN Tracking

You can configure VRRP to track connectivity to one or more specified VLANs as criteria for failover. If no active ports remain on the specified VLANs, the router automatically relinquishes master status and remains in backup mode.

To add or delete a tracked VLAN, use one of the following commands:

```
configure vlan <vlan name> add track-vlan <vlan_tracked>
configure vlan <vlan name> delete track-vlan <vlan_tracked>
```

VRRP Route Table Tracking

You can configure VRRP to track specified routes in the route table as criteria for failover. If any of the configured routes are not available within the route table, the router automatically relinquishes master status and remains in backup mode.

To add or delete a tracked route, use the following command:

```
configure vlan <vlan name> add track-iproute <ip address>/<masklength>
```

VRRP Ping Tracking

You can configure VRRP to track connectivity using a simple ping to any outside responder. The responder may represent the default route of the router, or any device meaningful to network connectivity of the master VRRP router. The router automatically relinquishes master status and remains in backup mode if a ping keepalive fails three consecutive times.

To add or delete a tracked route, use one of the following commands:

```
configure vlan <vlan name> add track-ping <ip address> frequency <seconds> miss
<number>
configure vlan <vlan name> delete track-ping <ipaddress>
```

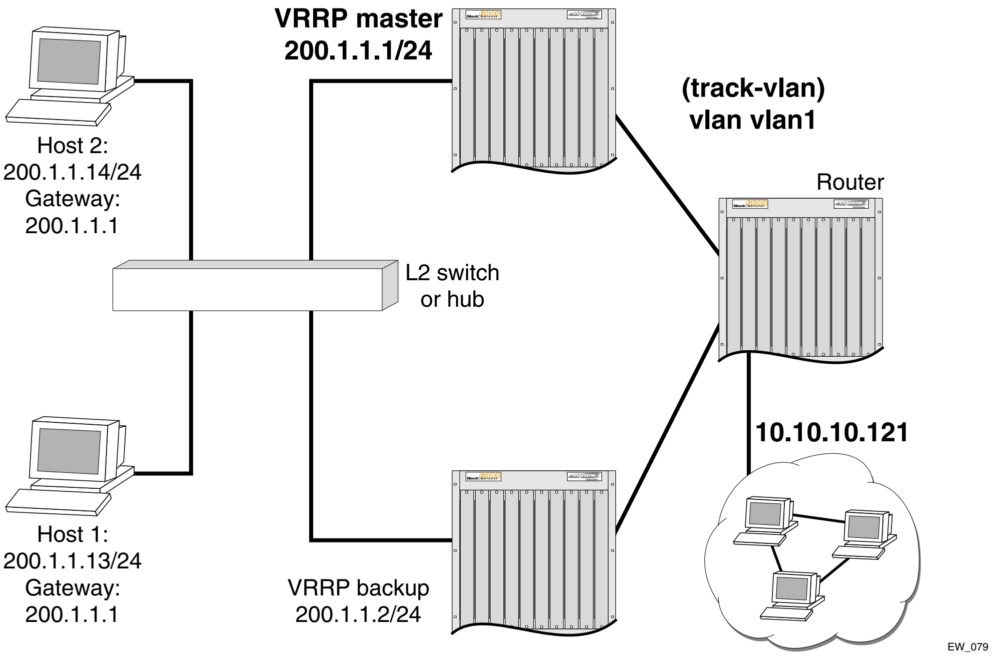
To view the status of tracked devices, use the following command:

```
show vrrp [vlan <vlan name> | all] {detail}
```

VRRP Tracking Example

Figure 78 is an example of VRRP tracking.

Figure 78: VRRP tracking



To configure VLAN tracking, as shown in Figure 78, use the following command:

```
Configure vlan vrrp1 add track-vlan vlan1
```

Using the tracking mechanism, if VLAN1 fails, the VRRP master realizes that there is no path to upstream router via the Master switch and implements a failover to the backup.

To configure route table tracking, as shown in Figure 78, use the following command:

```
configure vlan vrrp1 add track-iproute 10.10.10.0/24
```

The route specified in this command must exist in the IP routing table. When the route is no longer available, the switch implements a failover to the backup.

To configure ping tracking, as shown in Figure 78, use the following command:

```
configure vlan vrrp1 add track-ping 10.10.10.121 2 2
```

The specified IP address is tracked. If the fail rate is exceeded the switch implements a failover to the backup.

Electing the Master Router

VRRP uses an election algorithm to dynamically assign responsibility for the master router to one of the VRRP routers on the network. A VRRP router is elected master if one of the following is true:

- The router is the IP address owner.
- The router is configured with the highest priority (the range is 3 - 255).

If the master router becomes unavailable, the election process provides dynamic failover and the backup router that has the highest priority assumes the role of master.

A new master is elected when one of the following things happen:

- VRRP is disabled on the master router.
- Loss of communication between master and backup router(s).

When VRRP is disabled on the master interface, the master router sends an advertisement with the priority set to 0 to all backup routers. This signals the backup routers that they do not need to wait for the master down interval to expire, and the master election process for a new master can begin immediately.

The master down interval is set as follows:

3 * advertisement interval + skew time

Where:

- The advertisement interval is a user-configurable option.
- The skew time is (256-priority/256).

NOTE

An extremely busy CPU can create a short dual master situation. To avoid this, increase the advertisement interval.

Additional VRRP Highlights

The following additional points pertain to VRRP:

- VRRP packets are encapsulated IP packets.
- The VRRP multicast address is 224.0.0.18.
- The virtual router MAC address is `00 00 5E 00 01 <vrid>`
- Duplicate virtual router IDs are allowed on the router, but not on the same interface.
- The maximum number of supported VRIDs per interface is 4.
- An interconnect link between VRRP routers should not be used, except when VRRP routers have hosts directly attached.
- A maximum of 64 VRID instances are supported on the router.
- Up to 4 unique VRIDs can be configured on the router. VRIDs can be re-used, but not on the same interface.

- VRRP and Spanning Tree can be simultaneously enabled on the same switch.

VRRP Port Restart

You can configure VRRP to restart ports if those ports are members of a VLAN that becomes a backup. To configure port restart, use the following command:

```
configure vlan <vlan name> add ports [<portlist> | all] restart
```

To disable port restart, use the following command:

```
configure vlan <vlan name> add ports [<portlist> | all] no-restart
```

If a VLAN becomes a backup, VRRP disconnects member ports that have port restart enabled. The disconnection of these ports causes downstream devices to remove the ports from their FDB tables. This feature allows you to use VRRP in networks that include equipment from other vendors. After 3 seconds the ports re-establish connection with the VRRP switch.

To remove a port from the restart configuration, delete the port from the VLAN and re-add it.

NOTE

The port restart feature is also available for ESRP. For more information on ESRP, see Chapter 15.

VRRP Operation

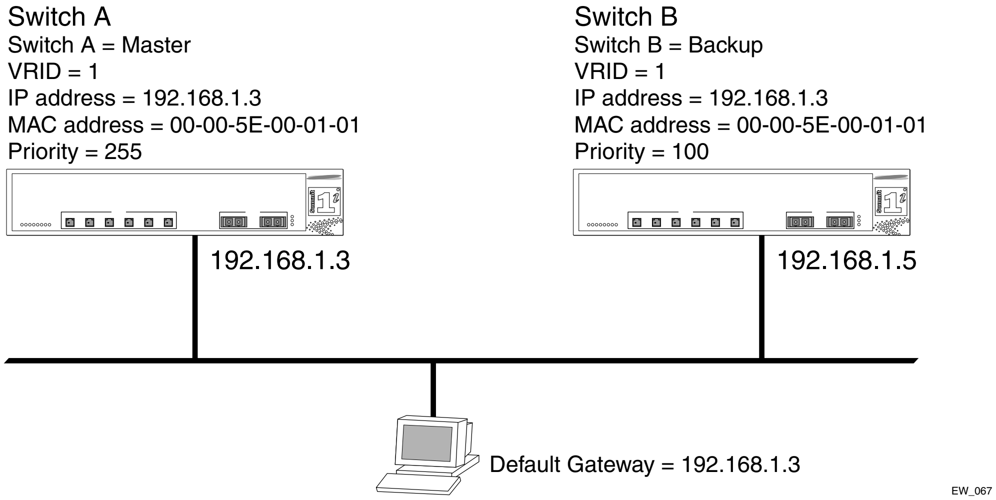
This section describes two VRRP network configuration:

- A simple VRRP network
- A fully-redundant VRRP network

Simple VRRP Network Configuration

Figure 79 shows a simple VRRP network.

Figure 79: Simple VRRP network



In Figure 79, a virtual router is configured on Switch A and Switch B using these parameters:

- VRID is 1.
- MAC address is 00-00-5E-00-01-01.
- IP address is 192.168.1.3.

Switch A is configured with a priority of 255. This priority indicates that it is the master router. Switch B is configured with a priority of 100. This indicates that it is a backup router.

The master router is responsible for forwarding packets sent to the virtual router. When the VRRP network becomes active, the master router broadcasts an ARP request that contains the virtual router MAC address (in this case, 00-00-5E-00-01-01) for each IP address associated with the virtual router. Hosts on the network use the virtual router MAC address when they send traffic to the default gateway.

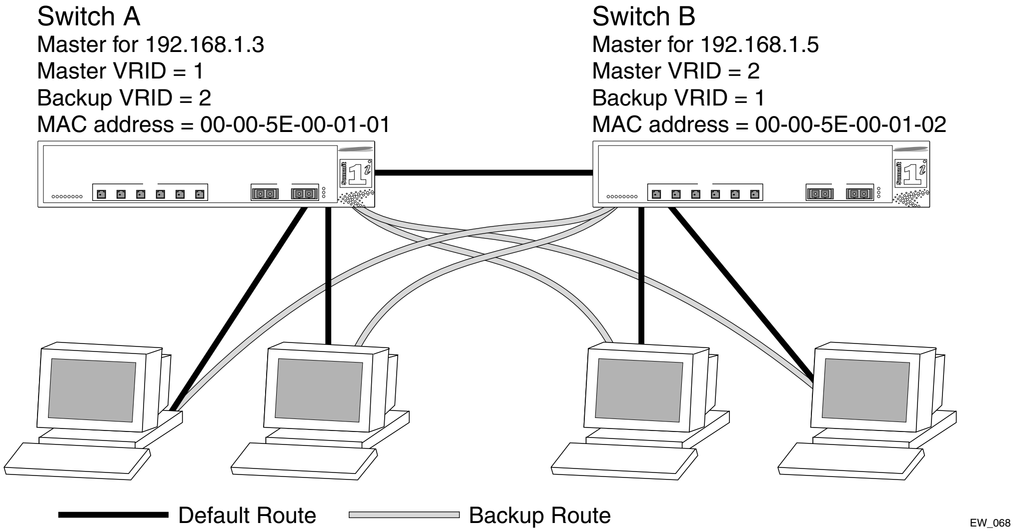
The virtual router IP address is configured to be the real interface address of the IP address owner. The IP address owner is usually the master router. The virtual router IP address is also configured on each backup router. However, in the case of the backup router, this IP address is not associated with a physical interface. Each physical interface on each backup router must have a unique IP address. The virtual router IP address is also used as the default gateway address for each host on the network.

If the master router fails, the backup router assumes forwarding responsibility for traffic addressed to the virtual router MAC address. However, because the IP address associated with the master router is not physically located on the backup router, the backup router cannot reply to TCP/IP messages (such as pings) sent to the virtual router.

Fully-Redundant VRRP Network

You can use two or more VRRP-enabled switches to provide a fully-redundant VRRP configuration on your network. Figure 80 shows a fully-redundant VRRP configuration.

Figure 80: Fully-redundant VRRP configuration



In Figure 80, switch A is configured as follows:

- IP address 192.168.1.3
- Master router for VRID 1
- Backup router for VRID 2
- MAC address 00-00-5E-00-01-01

Switch B is configured as follows:

- IP address 192.168.1.5
- Master router for VRID 2
- Backup router for VRID 1
- MAC address 00-00-5E-00-01-02

Both virtual routers are simultaneously operational. The traffic load from the four hosts is split between them. Host 1 and host 2 are configured to use VRID 1 on switch A as their default gateway. Host 3 and host 4 are configured to use VRID 2 on switch B as their default gateway. In the event that either switch fails, the backup router configured is standing by to resume normal operation.

VRRP Configuration Parameters

Table 59 lists the parameters that are configured on a VRRP router.

Table 59: VRRP Configuration Parameters

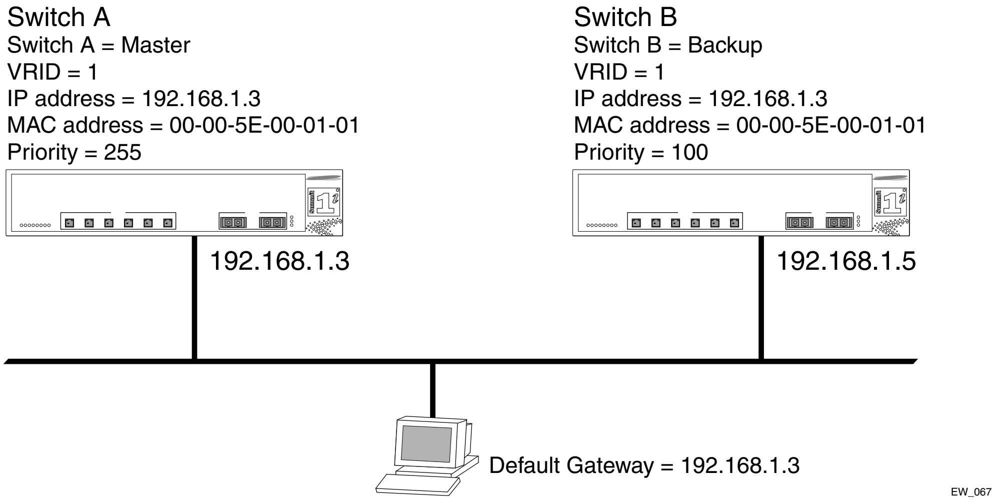
Parameter	Description
vrid	Virtual router identifier. Configured item in the range of 1- 255. This parameter has no default value.
priority	Priority value to be used by this VRRP router in the master election process. A value of 255 is reserved for a router that is configured with the virtual router IP address. A value of 0 is reserved for the master router to indicate it is releasing responsibility for the virtual router. The range is 1 - 254. The default value is 100.
ip_address	One or more IP addresses associated with this virtual router. This parameter has no default value.
advertisement_interval	Time interval between advertisements, in seconds. The range is 1 - 255. The default value is 1 second.
skew_time	Time to skew master_down_interval, in seconds. This value is calculated as ((256-priority)/256).
master_down_interval	Time interval for backup router to declare master down, in seconds. This value is calculated as ((3 * advertisement_interval) + skew_time).
preempt_mode	Controls whether a higher priority backup router preempts a lower priority master. A value of true allows preemption. A value of false prohibits preemption. The default setting is true. **NOTE** *The router that owns the virtual router IP address always preempts, independent of the setting of this parameter.*

VRRP Examples

This section provides the configuration syntax for the two VRRP networks discussed in this chapter.

Configuring the Simple VRRP Network

The following illustration shows the simple VRRP network described in Figure 79.



The configuration commands for switch A are as follows:

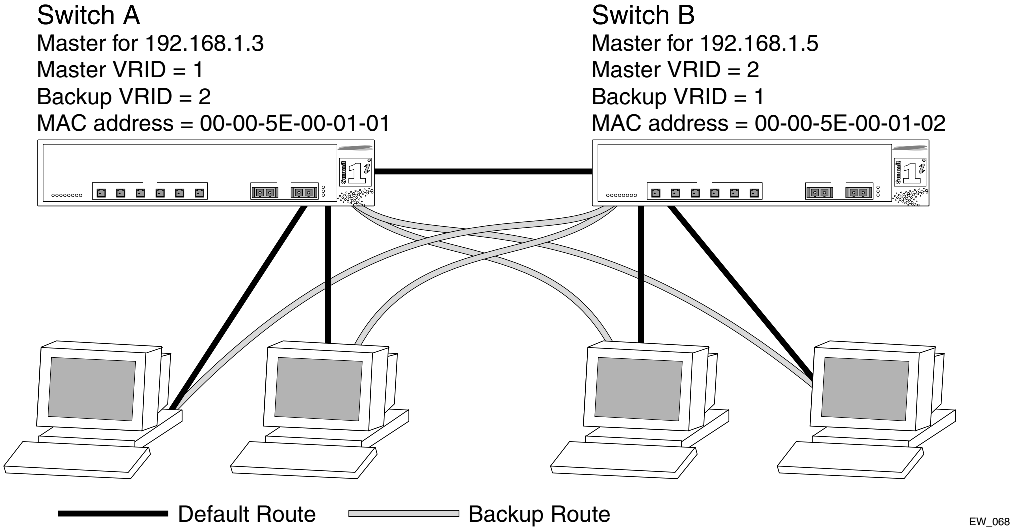
```
configure vlan vlan1 ipaddress 192.168.1.3/24
configure vrrp add vlan vlan2
configure vrrp vlan vlan1 add master vrid 1 192.168.1.3
enable vrrp
```

The configuration commands for switch B are as follows:

```
configure vlan vlan1 ipaddress 192.168.1.5/24
configure vrrp add vlan vlan1
configure vrrp vlan vlan1 add backup vrid 1 192.168.1.3
enable vrrp
```

Configuring the Fully-Redundant VRRP Network

The following illustration shows the fully-redundant VRRP network configuration described in Figure 80.



The configuration commands for switch A are as follows:

```
configure vlan vlan1 ipaddress 192.168.1.3/24
configure vrrp vlan vlan1 add master vrid 1 192.168.1.3
configure vrrp vlan vlan1 add backup vrid 2 192.168.1.5
configure vrrp add vlan vlan1
enable vrrp
```

The configuration commands for switch B are as follows:

```
configure vlan vlan1 ipaddress 192.168.1.5/24
configure vrrp vlan vlan1 add master vrid 2 192.168.1.5
configure vrrp vlan vlan1 add backup vrid 1 192.168.1.3
configure vrrp add vlan vlan1
enable vrrp
```

17 IP Unicast Routing

This chapter describes the following topics:

- Overview of IP Unicast Routing on page 443
- Proxy ARP on page 447
- Relative Route Priorities on page 448
- Configuring IP Unicast Routing on page 449
- Routing Configuration Example on page 449
- IP Multinetting on page 451
- Configuring DHCP/BOOTP Relay on page 459
- UDP-Forwarding on page 460
- VLAN Aggregation on page 462

This chapter assumes that you are already familiar with IP unicast routing. If not, refer to the following publications for additional information:

- RFC 1256—*ICMP Router Discovery Messages*
- RFC 1812—*Requirements for IP Version 4 Routers*

NOTE

For more information on interior gateway protocols, see Chapter 18. For information on exterior gateway protocols, see Chapter 19.

Overview of IP Unicast Routing

The switch provides full layer 3, IP unicast routing. It exchanges routing information with other routers on the network using either the Routing Information Protocol (RIP) or the Open Shortest Path First (OSPF) protocol. The switch dynamically builds and maintains a routing table, and determines the best path for each of its routes.

Each host using the IP unicast routing functionality of the switch must have a unique IP address assigned. In addition, the default gateway assigned to the host must be the IP address of the router interface.

Router Interfaces

The routing software and hardware routes IP traffic between router interfaces. A router interface is simply a VLAN that has an IP address assigned to it.

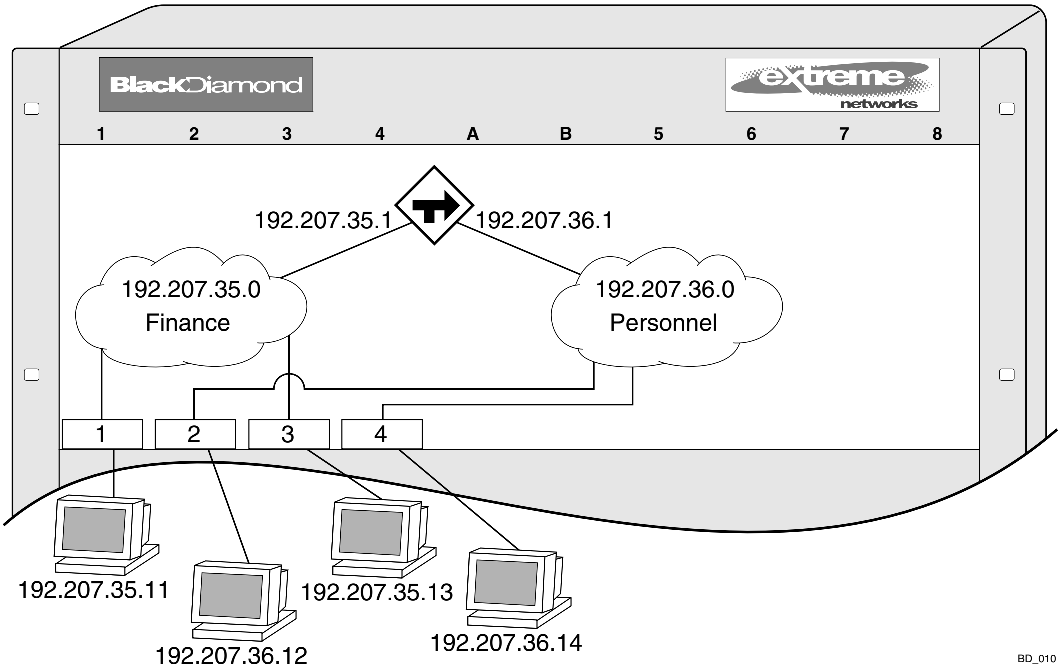
As you create VLANs with IP addresses belonging to different IP subnets, you can also choose to route between the VLANs. Both the VLAN switching and IP routing function occur within the switch.

NOTE

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

In Figure 81, a BlackDiamond switch is depicted with two VLANs defined; *Finance* and *Personnel*. All ports on slots 1 and 3 are assigned to *Finance*; all ports on slots 2 and 4 are assigned to *Personnel*. *Finance* belongs to the IP network 192.207.35.0; the router interface for *Finance* is assigned the IP address 192.206.35.1. *Personnel* belongs to the IP network 192.207.36.0; its router interface is assigned IP address 192.207.36.1. Traffic within each VLAN is switched using the Ethernet MAC addresses. Traffic between the two VLANs is routed using the IP addresses.

Figure 81: Routing between VLANs



Populating the Routing Table

The switch maintains an IP routing table for both network routes and host routes. The table is populated from the following sources:

- Dynamically, by way of routing protocol packets or by ICMP redirects exchanged with other routers
- Statically, by way of routes entered by the administrator
  - — Default routes, configured by the administrator

— Locally, by way of interface addresses assigned to the system

— By other static routes, as configured by the administrator

NOTE

If you define a default route, and subsequently delete the VLAN on the subnet associated with the default route, the invalid default route entry remains. You must manually delete the configured default route.

Dynamic Routes

Dynamic routes are typically learned by way of RIP or OSPF. Routers that use RIP or OSPF exchange information in their routing tables in the form of advertisements. Using dynamic routes, the routing table contains only networks that are reachable.

Dynamic routes are aged out of the table when an update for the network is not received for a period of time, as determined by the routing protocol.

Static Routes

Static routes are manually entered into the routing table. Static routes are used to reach networks not advertised by routers.

Static routes can also be used for security reasons, to control which routes you want advertised by the router. You can decide if you want all static routes to be advertised, using one of the following commands:

- `enable rip export static` or `disable rip export static`
- `enable ospf export static [cost <metric> [ase-type-1 | ase-type-2] {tag <number>} | <route map>]` or `disable ospf export [bgp | direct | e-bgp | i-bgp | isis | isis-level-1 | isis-level-1-external | isis-level-2 | isis-level-2-external | rip | static | vip]`

The default setting is disabled. Static routes are never aged out of the routing table.

A static route must be associated with a valid IP subnet. An IP subnet is associated with a single VLAN by its IP address and subnet mask. If the VLAN is subsequently deleted, the static route entries using that subnet must be deleted manually.

Multiple Routes

When there are multiple, conflicting choices of a route to a particular destination, the router picks the route with the longest matching network mask. If these are still equal, the router picks the route using the following criteria (in the order specified):

- Directly attached network interfaces
- ICMP redirects
- Static routes
- Directly attached network interfaces that are not active.

NOTE

If you define multiple default routes, the route that has the lowest metric is used. If multiple default routes have the same lowest metric, the system picks one of the routes.

You can also configure *blackhole* routes—traffic to these destinations is silently dropped.

IP Route Sharing

IP route sharing allows multiple equal-cost routes to be used concurrently. IP route sharing can be used with static routes or with OSPF routes. In OSPF, this capability is referred to as *equal cost multipath* (ECMP) routing. To use IP route sharing, use the following command:

```
enable iproute sharing
```

Next, configure static routes and/or OSPF as you would normally. ExtremeWare supports unlimited route sharing across static routes and up to 12 ECMP routes for OSPF.

Route sharing is useful only in instances where you are constrained for bandwidth. This is typically not the case using Extreme switches. Using route sharing makes router troubleshooting more difficult because of the complexity in predicting the path over which the traffic will travel.

Route Maps

Route maps for IP routing can be configured based on the route origin. When routes are added to the IP routing table from various source, the route map configured for the origin of the route is applied to the route. After matching on specified characteristics, the characteristics for the route can be modified using the route maps. The characteristics that can be matched and modified are dependent on the origin of the route. Route maps for IP routing can be dynamically changed. In the case of direct and static route origins, the changes are reflected immediately. In the case of routes that are sourced from other origin, the changes are reflected within 30 seconds.

To configure route maps for IP routing, use the following command:

```
configure iproute route-map [bgp | direct | e-bgp | i-bgp | ospf | ospf-extern1 |
ospf-extern2 | ospf-inter | ospf-intra | rip | static] [<route map> | none]
```

To view the route maps for IP routing, use the following command:

```
show iproute route-map
```

Subnet-Directed Broadcast Forwarding

You can enable or disable the hardware forwarding of subnet-directed broadcast IP packets. This allows the switch to forward subnet-directed broadcast packets at wire-speed.

To enable or disable hardware forwarding, use one the following commands:

```
[enable | disable] ipforwarding fast-direct-broadcast [vlan <vlan_name>]
```

The entries are added to the IP forwarding table as standard entries and you can view them using the `show ipfdb` command.

You can also configure the VLAN router interface to either forward and process all subnet-directed broadcast packets, or to simply forward these packets after they have been added to the IP forwarding database. The latter option allows you to improve CPU forwarding performance by having upper layers, such as UDP and TCP, ignore broadcast packet processing (for example, if the packets have IP-options configured).

To enable or disable broadcast packet processing, use the following command:

```
[enable | disable] ipforwarding ignore-broadcast vlan <vlan_name>
```

Using these commands together, you can achieve a 30-50% reduction in system processing cycles in forwarding subnet-directed broadcast traffic on a BlackDiamond switch, and a 100% reduction on the Alpine and Summit switches.

NOTE

Although forwarding performance is improved in the BlackDiamond switch, the CPU continues to observe the subnet-directed broadcast packets and does not ignore such packets when traversing modules in a BlackDiamond switch. Only I/O modules containing the "i" series chipset support this command on the BlackDiamond switch.

Proxy ARP

Proxy Address Resolution Protocol (ARP) was first invented so that ARP-capable devices could respond to ARP Request packets on behalf of ARP-incapable devices. Proxy ARP can also be used to achieve router redundancy and simplify IP client configuration. The switch supports proxy ARP for this type of network configuration. The section describes some example of how to use proxy ARP with the switch.

ARP-Incapable Devices

To configure the switch to respond to ARP Requests on behalf of devices that are incapable of doing so, you must configure the IP address and MAC address of the ARP-incapable device using the use the following command:

```
configure iparp add proxy <ip address> {<mask>} {<mac_address>} {always}
```

Once configured, the system responds to ARP Requests on behalf of the device as long as the following conditions are satisfied:

- The valid IP ARP Request is received on a router interface.
- The target IP address matches the IP address configured in the proxy ARP table.
- The proxy ARP table entry indicates that the system should always answer this ARP Request, regardless of the ingress VLAN (the `always` parameter must be applied).

Once all the proxy ARP conditions are met, the switch formulates an ARP Response using the configured MAC address in the packet.

Proxy ARP Between Subnets

In some networks, it is desirable to configure the IP host with a wider subnet than the actual subnet mask of the segment. Proxy ARP can be used so that the router answers ARP Requests for devices outside of the subnet. As a result, the host communicates as if all devices are local. In reality, communication with devices outside of the subnet are proxied by the router.

For example, an IP host is configured with a class B address of 100.101.102.103 and a mask of 255.255.0.0. The switch is configured with the IP address 100.101.102.1 and a mask of 255.255.255.0. The switch is also configured with a proxy ARP entry of IP address 100.101.0.0 and mask 255.255.0.0, *without* the `always` parameter.

When the IP host tries to communicate with the host at address 100.101.45.67, the IP hosts communicates as if the two hosts are on the same subnet, and sends out an IP ARP Request. The switch answers on behalf of the device at address 100.101.45.67, using its own MAC address. All subsequent data packets from 100.101.102.103 are sent to the switch, and the switch routes the packets to 100.101.45.67.

Relative Route Priorities

Table 60 lists the relative priorities assigned to routes depending upon the learned source of the route.

NOTE

Although these priorities can be changed, do not attempt any manipulation unless you are expertly familiar with the possible consequences.

Table 60: Relative Route Priorities

Route Origin	Priority
Direct	10
BlackHole	50
SLB_VIP	1000
Static	1100
ICMP	1200
EBGP	1700
IBGP	2100
OSPF	1200
OSPFIntra	2200
OSPFInter	2300
ISIS	2350
ISISL1	2360
ISISL2	2370
RIP	2400
OSPFAsExt	3100
OSPFExtern1	3200
OSPFExtern2	3300
ISISL1Ext	3400
ISISL2Ext	3500
BOOTP	5000

To change the relative route priority, use the following command:

```
configure iproute priority [rip | bootp | icmp | static | ospf-intra | ospf-inter |
ospf-as-external | ospf-extern1 | ospf-extern2] <priority>
```

Configuring IP Unicast Routing

This section describes the commands associated with configuring IP unicast routing on the switch. To configure routing, follow these steps:

1. Create and configure two or more VLANs.
2. Assign each VLAN that will be using routing an IP address using the following command:

   ```
   configure vlan <vlan name> ipaddress <ipaddress> {<netmask> | <mask length>}
   ```

   Ensure that each VLAN has a unique IP address.
3. Configure a default route using the following command:

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

   Default routes are used when the router has no other dynamic or static route to the requested destination.
4. Turn on IP routing for one or all VLANs using the following command:

   ```
   enable ipforwarding {[broadcast | fast-direct-broadcast | ignore-broadcast]} {vlan
   <vlan name>}
   ```
5. Turn on RIP or OSPF using one of the following commands:

   ```
   enable rip
   ```

   ```
   enable ospf
   ```

Verifying the IP Unicast Routing Configuration

Use the `show iproute` command to display the current configuration of IP unicast routing for the switch, and for each VLAN. The `show iproute` command displays the currently configured routes, and includes how each route was learned.

Additional verification commands include:

- `show iparp`—Displays the IP ARP table of the system.
- `show ipfdb`—Displays the hosts that have been transmitting or receiving packets, and the port and VLAN for each host.
- `show ipconfig`—Displays configuration information for one or more VLANs.

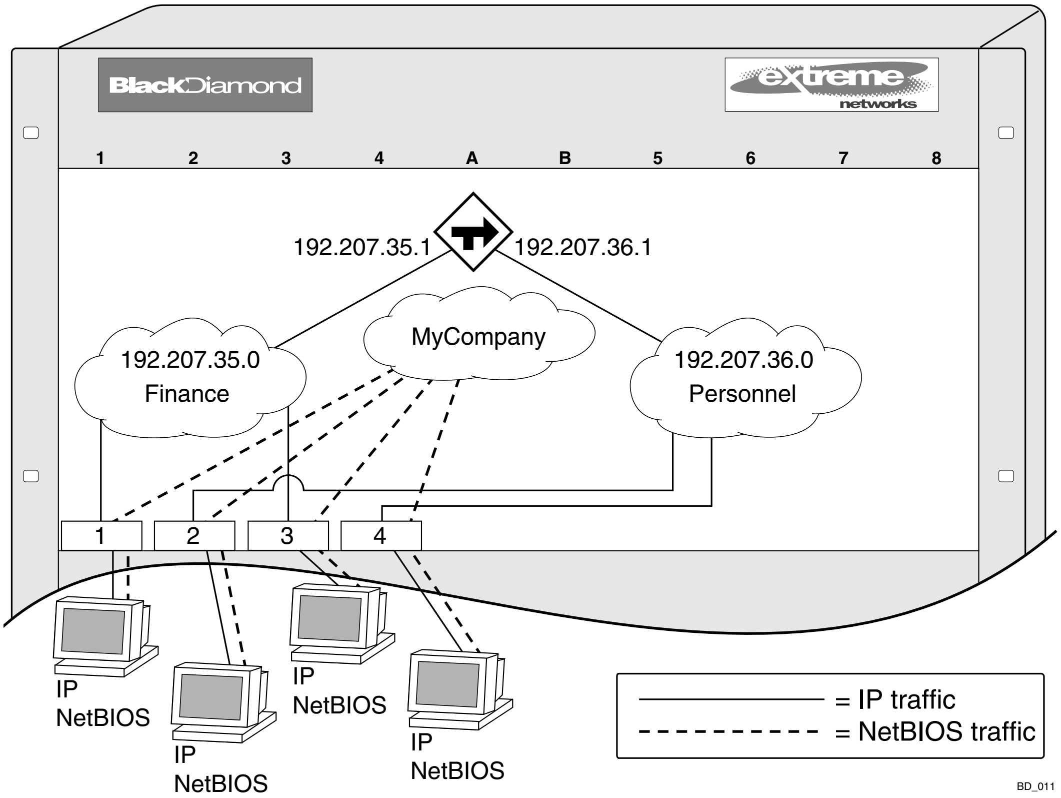
Routing Configuration Example

Figure 82 illustrates a BlackDiamond switch that has three VLANs defined as follows:

- *Finance*
  - — Protocol-sensitive VLAN using the IP protocol.
  - — All ports on slots 1 and 3 have been assigned.
  - — IP address 192.207.35.1.

- *Personnel*
  - — Protocol-sensitive VLAN using the IP protocol.
  - — All ports on slots 2 and 4 have been assigned.
  - — IP address 192.207.36.1.
- *MyCompany*
  - — Port-based VLAN.
  - — All ports on slots 1 through 4 have been assigned.

Figure 82: Unicast routing configuration example



The stations connected to the system generate a combination of IP traffic and NetBIOS traffic. The IP traffic is filtered by the protocol-sensitive VLANs. All other traffic is directed to the VLAN *MyCompany*.

In this configuration, all IP traffic from stations connected to slots 1 and 3 have access to the router by way of the VLAN *Finance*. Ports on slots 2 and 4 reach the router by way of the VLAN *Personnel*. All other traffic (NetBIOS) is part of the VLAN *MyCompany*.

The example in Figure 82 is configured as follows:

```
create vlan Finance
create vlan Personnel
create vlan MyCompany

configure Finance protocol ip
configure Personnel protocol ip
configure Finance add port 1:*,3:*
configure Personnel add port 2:*,4:*
configure MyCompany add port all

configure Finance ipaddress 192.207.35.1
configure Personnel ipaddress 192.207.36.1

configure rip add vlan Finance
configure rip add vlan Personnel

enable ipforwarding
enable rip
```

IP Multinetting

IP multinetting refers to having multiple IP networks on the same bridging domain (VLAN). The hosts connected to the same physical segment can belong to any one of the networks, so multiple subnets can overlap onto the same physical segment. Any routing between the hosts in different networks is done through the interface of the router. Typically, different IP networks will be placed on different physical segments, but IP multinetting does not require this arrangement.

Multinetting can be a critical element in a transition strategy, allowing a legacy assignment of IP addresses to coexist with newly configured hosts. However, due to the additional constraints introduced in troubleshooting and bandwidth, it is recommended that multinetting be used as a transitional tactic only, and not as a long-term network design strategy.

ExtremeWare offers two types of IP multinetting:

- IP Standard Multinetting
- IP Proprietary Multinetting

ExtremeWare releases prior to version 7.3.0 supported a “proprietary” multinetting implementation that required separate VLANs to be created for each secondary subnet. ExtremeWare 7.3.0 and later releases also support the “standard” form of Multinetting. In the standard scheme, a VLAN is created and multiple IP addresses (belonging to different subnets) assigned. This scheme of multinetting implementation is referred to as “Standard Multinetting” in ExtremeWare 7.3.0

NOTE

Proprietary multinetting and standard multinetting cannot be enabled concurrently.

The following sections describe the characteristics of both the standard and proprietary forms of IP multinetting in ExtremeWare.

IP Standard Multinetting

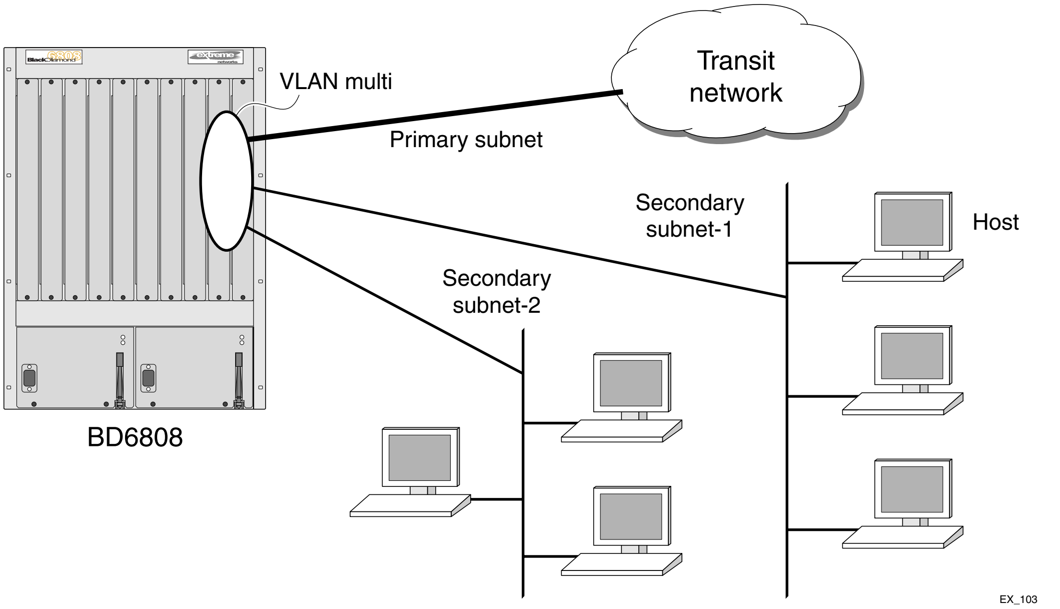
This section focusses on the issues related to the standard multinetting.

Multinetting Topology

For an IP multinetted interface, one of the IP networks on the interface acts as the transit network for the traffic that is routed by this interface. The transit network is the primary subnet for the interface. The remaining multinetted subnets, called *secondary* subnets, must be stub networks. This restriction is required because it is not possible to associate the source of the incoming routed traffic to a particular network. IP routing occurs between the different subnets of the same VLAN (one-arm routing), and also between subnets of different VLANs.

An example of a multinetted VLAN named *multi* is shown in Figure 83. VLAN *multi* has three IP subnets; therefore, three IP addresses have been configured for the VLAN. One of the subnets is the *primary subnet* and can be connected to any transit network (for example, the Internet). The remaining two *secondary subnets* are stub networks. Multiple hosts such as management stations, user PCs, and file servers can be connected to the stub networks.

Figure 83: Multinetted Network Topology



To avoid routing loops, do not place any additional routing or switching devices in the secondary subnets. Figure 83 shows the subnets on separate physical segments; however, multinetting can also support hosts from different IP subnets on the same physical segment.

IP Unicast Routing

When multinetting is configured on a VLAN, the switch can be reached using any of the subnet addresses (primary or secondary) assigned to VLAN. This means that operations like ping, Telnet, HTTP, TFTP, SSH, and others can be done to the switch from a host residing in either the primary or the secondary subnet of the VLAN.

How Multinetting Impacts Other Features

IP Standard Multinetting impacts some other features in ExtremeWare. This section describes how multinetting affects both layer 2 and layer 3 features.

Unicast Routing Protocols. There is no way to configure a routing protocol on an individual primary or secondary interface. Configuring a protocol parameter on a VLAN automatically configures the parameter on all its associated primary and secondary interfaces. The same logic applies to configuring IP forwarding, for example, on a VLAN.

Routing protocols in the multinetted environment advertise the secondary subnets to their peers in their protocol exchange process. For example, for OSPF the secondary subnets are advertised as stub networks in router LSAs. RIP also advertises secondary subnets to its peers residing on the primary subnet.

- **BGP**

  There are no behavioral changes in BGP in an IP multinetting environment. This section describes a set of recommendations for using BGP with IP Multinetting:

  — BGP neighbors must not be created with neighbors in secondary subnets.

  — Secondary interface addresses cannot be used as the source interface for a BGP neighbor.

  — Direct routes corresponding to secondary interfaces can be exported into the BGP domain (by enabling export of direct routes).

- **OSPF**

  Direct routes corresponding to secondary interfaces can be exported into the OSPF domain (by enabling export of direct routes), if OSPF is not enabled on the container VLAN.

- **RIP**

  This section describes the behavior of RIP in an IP Multinetting environment:

  — RIP will not send any routing information update on the secondary interfaces. However, RIP will advertise networks corresponding to secondary interfaces in its routing information packet to the primary interface.

  — Any inbound RIP control packets from secondary interfaces will be dropped.

  — Direct routes corresponding to secondary interfaces can be exported into the RIP domain (by enabling export of direct routes), if RIP is not enabled on the container VLAN.

- **IGMP Snooping and IGMP**

  In this ExtremeWare 7.3 beta release IGMP Snooping and IGMP are not supported for the hosts in the secondary subnets.

Multicast Routing Protocols. This section describes the impact of standard multinetting on various multicast routing protocols.

- **PIM**

  IPIM support for receiving data packets/membership information from secondary subnets is not supported.

- **EAPS, ESRP, and STP**

  Control protocols like EAPS, ESRP, and STP treat the VLAN as an interface. If the protocol control packets are exchanged as layer 3 packets, then the source address in the packet is validated against the IP networks configured on that interface.

- **DHCP Server**

  DHCP Server in ExtremeWare supports allocating addresses from the primary, secondary subnets and also from the remote subnets. Allocation of IP addresses for the remote subnets is useful when the DHCP Server co-operates with a DHCP relay for IP address allocation/assignment. The appropriate remote subnet in such a case is identified by the usage of GIADDR field in the incoming DHCP packets.

- **DHCP Relay**

  When the switch is configured as a DHCP relay agent, it will forward the DHCP request received from a client to the DHCP server. When doing so, it sets the GIADDR field in the DHCP request packet to the primary IP address of the ingress VLAN. This means that the DHCP server that resides on a remote subnet, will allocate an IP address for the client in the primary subnet range.

- **VRRP**

  VRRP protection can be provided for the primary as well as for the secondary IP addresses of a VLAN. For multinetting, the IP address assigned to a VRRP VRID (virtual router identifier) can be either the primary or the secondary IP addresses of the corresponding VLAN.

  For example, assume a VLAN named *v1* with two IP addresses, a primary IP address of 10.0.0.1/24, and a secondary IP address of 20.0.0.1/24. To provide VRRP protection to such a VLAN, one of the following configuration tasks needs to be performed:

  — Configure VRRP in VLAN *v1* with two VRRP VRIDs. One VRID will have the master IP address 10.0.0.1/24, and the other VRID will have the master IP address 20.0.0.1/24. The other VRRP router, the one configured to act as backup, should be configured similarly.

  or

  — Configure VRRP in VLAN *v1* with two VRRP VRIDs. One VRID will have the backup IP address as 10.0.0.1/24, and the other VRID will have the backup IP address as 20.0.0.1/24.

  In ExtremeWare a VRID on a VLAN can have only one IP address assigned to it.

- **Flow Redirection**

  IP addresses in secondary subnets can be configured as *flow redirect nexthops*.

  For example, in the command `configure flow-redirect <flow redirect> add next-hop <ip address>`, (where `<flow redirect>` refers to the flow redirect rule) the nexthop `<ip address>` value can belong to either a primary local subnet or a secondary local subnet.

  The following example shows a simple flow-redirection configuration with a secondary and a primary subnet:

```
create vlan test0
config vlan test0 ipaddress 50.36.11.107/24
enable multinetting standard
config vlan test0 add secondary-ip 60.36.11.107/24
enable ipforwarding test0

create flow-redirect flrule any destination any source 20.0.0.0/16
config flow-redirect flrule add nexthop 60.36.11.108
config flow-redirect flrule add nexthop 50.36.11.108
```

- **Server Load Balancing**

  The IP standard multinetting allows SLB Pool and Virtual Server IP configuration to belong to the primary as well as the secondary subnets.

  The following example shows a simple SLB pool/VIP configuration belonging in the secondary subnet:

```
create vlan test0
config vlan test0 ipaddress 50.36.11.107/24
enable multinetting standard
config vlan test0 add secondary-ip 60.36.11.107/24
enable ipforwarding test0
enable slb

create slb pool mypool
config slb pool mypool add 60.36.11.108:80

create slb vip myvip mypool mode transparent 60.36.11.144:80
```

- **VLAN Aggregation**

  With IP standard multinetting it is possible to configure a super-VLAN with multiple IP subnets (primary/secondary subnets). Also it is possible to configure a sub-vlan address range either in the primary or in the secondary subnet.

  The following configuration shows one simple configuration of VLAN aggregation with primary/secondary subnets:

```
create vlan test0
create vlan test0 ipaddress 50.36.11.107/24
enable multinetting standard
config vlan test0 add secondary-ip 60.36.11.107/24
enable ipforwarding test0

create vlan subtest0
create vlan subtest1
config vlan default delete ports all
config vlan subtest0 add ports 1:5
config vlan subtest1 add ports 5:5

config vlan test0 add subvlan subtest0
config vlan test0 add subvlan subtest1

configure vlan subtest0 subvlan-address-range 60.36.11.109 - 60.36.11.120
```

Configuring IP Multinetting

Configuring IP multinetting is accomplished by adding a secondary IP address to a vlan. The secondary address is a /32 IP address that is the same subnet as the primary subnet of the interface. Use the following command to add a secondary IP address:

```
configure vlan <vlan-name> add secondary-ip <sec-ip-address> {<sec-ip-mask> |
<mask-length>}
```

To change the secondary IP address once it has been added, it must first be deleted. Use the following command to delete secondary IP addresses:

```
configure vlan <vlan-name> delete secondary-ip {<sec-ip-address> | all}
```

Secondary IP addresses cannot be deleted if there are VRRP VRIDs, Flow Redirect Nexthops, and SLB VIPs dependant on these secondary subnets. Deletion of a secondary IP address automatically clears the static ARP entries/DHCP address configuration associated with that secondary subnet.

NOTE

The secondary address is not exported to routing protocols in ExtremeWare releases older than 7.3.0. The secondary address has been used primarily for tracking the reachability of the interface. If you are using the secondary IP address in an ExtremeWare release older than 7.3.0, and you upgrade to 7.3.0, you will lose the ability to track interface reachability using the secondary interface. Therefore, it is *recommended that you use the primary address to track interface reachability. Upon rebooting the switch after upgrading, the following syslog error message will be generated: "WARNING: Secondary IP Address x.x.x.x/32 will not be used."*

IP Multinetting Examples

The following example configures a switch to have one multinetted segment (port 5:5) that contains three subnets (192.168.34.0/24, 192.168.35.0/24, and 192.168.37.0/24).

```
configure default delete port 5:5
create vlan test
configure test ipaddress 192.168.34.1
enable multinetting standard
configure test add secondary-ip 192.168.35.1
configure test add secondary-ip 192.168.37.1
configure test add port 5:5
enable ipforwarding
```

The following example configures a switch to have one multinetted segment (port 5:5) that contains three subnets (192.168.34.0, 192.168.35.0, and 192.168.37.0). It also configures a second multinetted segment consisting of two subnets (192.168.36.0 and 172.16.45.0). The second multinetted segment spans three ports (1:8, 2:9, and 3:10). RIP is enabled on both multinetted segments.

```
configure default delete port 5:5
create vlan test
configure test ipaddress 192.168.34.1
enable multinetting standard
configure test add secondary-ip 192.168.35.1
configure test add secondary-ip 192.168.37.1
configure test add port 5:5
configure default delete port 1:8, 2:9, 3:10
create vlan multinet_2
configure multinet_2 ipaddress 192.168.36.1
configure multinet_2 add secondary-ip 172.16.45.1
configure multinet_2 add port 1:8, 2:9, 3:10
configure rip add vlan test
configure rip add vlan multinet_2
enable rip
enable ipforwarding
```

Proprietary IP Multinetting

IP multinetting is used in many legacy IP networks when there is need to overlap multiple subnets onto the same physical segment. Though it can be a critical element in a transition strategy, due to the additional constraints introduced in troubleshooting and bandwidth, it is recommended that multinetting be used as a transitional tactic, and not as a long-term network design strategy.

On the switch, each subnet is represented by a different VLAN, and each of those VLANs has its own IP address. All of the VLANs share the same physical port(s). The switch routes IP traffic from one subnet to another, all within the same physical port(s).

The following rules and comments apply when you are configuring IP multinetting:

- Multinetting is enabled by default. If you have disabled multinetting, enable it after configuring.
- Multiple VLANs share the same physical ports; each of the VLANs is configured with an IP address.

- A maximum of four subnets (or VLANs) on multinetted ports is recommended.
- All VLANs used in the multinetting application must share the same port assignment.
- One VLAN is configured to use an IP protocol filter. This is considered the “primary” VLAN interface for the multinetted group.
- The “secondary” multinetted VLANs can be exported using the `export direct` command.
- The FDB aging timer is automatically set to 3,000 seconds (50 minutes).
- If you are using a UDP or DHCP relay function, only the “primary” VLAN that is configured with the IP protocol filter is capable of servicing these requests.
- The VLAN *default* should not be used for multinetting.

IP Multinetting Operation

To use IP multinetting, follow these steps:

1. Select a slot (modular switches only) and port on which IP multinetting is to run.

   For example, slot 1, port 2 on a modular switch, or port 2 on a stand-alone switch.

2. Remove the port from the default VLAN using the following command:

   `configure default delete port 1:2` (modular switch)

   or

   `configure default delete port 2` (stand-alone switch)

3. Create a dummy protocol by using the following command:

   ```
   create protocol mnet
   ```

4. Create the multinetted subnets using the following commands:

   ```
   create vlan net21
   create vlan net22
   ```

5. Assign IP addresses to the net VLANs using the following commands:

   ```
   configure net21 ipaddress 123.45.21.1 255.255.255.0
   configure net22 ipaddress 192.24.22.1 255.255.255.0
   ```

6. Assign one of the subnets to the IP protocol using the following command:

   ```
   configure net21 protocol ip
   ```

7. Assign the other subnets to the dummy protocol using the following command:

   ```
   configure net22 protocol mnet
   ```

8. Assign the subnets to a physical port using the following commands:

   ```
   configure net21 add port 1:2
   configure net22 add port 1:2
   ```

9. Enable IP forwarding on the subnets using the following command:

   ```
   enable ipforwarding
   ```

10. Enable IP multinetting using the following command:

    ```
    enable multinetting
    ```

11. If you are using RIP, disable RIP on the dummy VLANs using the following command:

    ```
    configure rip delete net22
    ```

NOTE

Multinetted VLAN groups must contain identical port assignments.

IP Multinetting Examples

The following example configures a modular switch to have one multinetted segment (slot 5, port 5) that contains three subnets (192.67.34.0, 192.67.35.0, and 192.67.37.0).

```
configure default delete port 5:5
create protocol mnet
create vlan net34
create vlan net35
create vlan net37
configure net34 ipaddress 192.67.34.1
configure net35 ipaddress 192.67.35.1
configure net37 ipaddress 192.67.37.1
configure net34 protocol ip
configure net35 protocol mnet
configure net37 protocol mnet
configure net34 add port 5:5
configure net35 add port 5:5
configure net37 add port 5:5
enable ipforwarding
```

The following example configures a modular switch to have one multinetted segment (slot 5: port 5) that contains three subnets (192.67.34.0, 192.67.35.0, and 192.67.37.0). It also configures a second multinetted segment consisting of two subnets (192.67.36.0 and 192.99.45.0). The second multinetted segment spans three ports (slot1:port 8, slot2:port 9, and slot3:port 10). RIP is enabled on both multinetted segments.

```
configure default delete port 5:5
create protocol mnet
create vlan net34
create vlan net35
create vlan net37
configure net34 ipaddress 192.67.34.1
configure net35 ipaddress 192.67.35.1
configure net37 ipaddress 192.67.37.1
configure net34 protocol ip
configure net35 protocol mnet
configure net37 protocol mnet
configure net34 add port 5:5
configure net35 add port 5:5
configure net37 add port 5:5
configure default delete port 1:8, 2:9, 3:10
create vlan net36
create vlan net45
configure net36 ipaddress 192.67.36.1
configure net45 ipaddress 192.99.45.1
configure net36 protocol ip
configure net45 protocol mnet
configure net36 add port 1:8, 2:9, 3:10
configure net45 add port 1:8, 2:9, 3:10
configure rip add vlan net34
configure rip add vlan net36
enable rip
enable ipforwarding
```

Configuring DHCP/BOOTP Relay

Once IP unicast routing is configured, you can configure the switch to forward Dynamic Host Configuration Protocol (DHCP) or BOOTP requests coming from clients on subnets being serviced by the switch and going to hosts on different subnets. This feature can be used in various applications, including DHCP services between Windows NT servers and clients running Windows 95. To configure the relay function, follow these steps:

1. Configure VLANs and IP unicast routing.
2. Enable the DHCP or BOOTP relay function, using the following command:

   ```
   enable bootprelay
   ```
3. Configure the addresses to which DHCP or BOOTP requests should be directed, using the following command:

   ```
   configure bootprelay add <ip address>
   ```

To delete a BOOTP relay entry, use the following command:

```
configure bootprelay delete [<ip address> | all]
```

Configuring the DHCP Relay Agent Option (Option 82)

After configuring and enabling the DHCP/BOOTP relay feature, you can enable the DHCP relay agent option feature. This feature inserts a piece of information, called option 82, into any DHCP request packet that is to be relayed by the switch. Similarly, if a DHCP reply received by the switch contains a valid relay agent option, the option will be stripped from the packet before it is relayed to the client.

The DHCP relay agent option consists of two pieces of data, called sub-options. The first is the agent circuit ID sub-option, and the second is the agent remote ID sub-option. When the DHCP relay agent option is enabled on switches running ExtremeWare, the value of these sub-options is set as follows:

- **Agent circuit ID sub-option**: Contains the ID of the port on which the original DHCP request packet was received. This ID is encoded as ((*slot_number* * 1000) + *port_number*). For example, if the DHCP request were received on port 3:12, the agent circuit ID value would be 3012. On non-slot-based switches, the agent circuit ID value is simply the port number.
- **Agent remote ID sub-option**: Always contains the Ethernet MAC address of the relaying switch. You can display the Ethernet MAC address of the switch by issuing the `show switch` command.

To enable the DHCP relay agent option, use the following command after configuring the DHCP/BOOTP relay function:

```
configure bootprelay dhcp-agent information option
```

To disable the DHCP relay agent option, use the following command:

```
unconfigure bootprelay dhcp-agent information option
```

In some instances, a DHCP server may not properly handle a DHCP request packet containing a relay agent option. To prevent DHCP reply packets with invalid or missing relay agent options from being forwarded to the client, use the following command:

```
configure bootprelay dhcp-agent information check
```

To disable checking of DHCP replies, use this command:

```
unconfigure bootprelay dhcp-agent information check
```

A DHCP relay agent may receive a client DHCP packet that has been forwarded from another relay agent. If this relayed packet already contains a relay agent option, then the switch will handle this packet according to the configured DHCP relay agent option policy. To configure this policy, use the following command:

```
configure bootprelay dhcp-agent information policy <policy>
```

where `<policy>` must be one of the following values: `replace`, `keep`, or `drop`. The default relay policy is `replace`. To configure the policy to the default, use this command:

```
unconfigure bootprelay dhcp-agent information policy
```

For more general information about the DHCP relay agent information option, refer to RFC 3046.

Verifying the DHCP/BOOTP Relay Configuration

To verify the DHCP/BOOTP relay configuration, use the following command:

```
show ipconfig
```

This command displays the configuration of the BOOTP relay service, and the addresses that are currently configured.

UDP-Forwarding

UDP-forwarding is a flexible and generalized routing utility for handling the directed forwarding of broadcast UDP packets. UDP-forwarding allows applications, such as multiple DHCP relay services from differing sets of VLANs, to be directed to different DHCP servers. The following rules apply to UDP broadcast packets handled by this feature:

- If the UDP profile includes BOOTP or DHCP, it is handled according to guidelines in RFC 1542.
- If the UDP profile includes other types of traffic, these packets have the IP destination address modified as configured, and changes are made to the IP and UDP checksums and decrements to the TTL field, as appropriate.

If the UDP-forwarding is used for BOOTP or DHCP forwarding purposes, do not configure or use the existing `bootprelay` function. However, if the previous `bootprelay` functions are adequate, you may continue to use them.

NOTE

UDP-forwarding only works across a layer 3 boundary.

Configuring UDP-Forwarding

To configure UDP-forwarding, the first thing you must do is create a UDP-forward destination profile. The profile describes the types of UDP packets (by port number) that are used, and where they are to be forwarded. You must give the profile a unique name, in the same manner as a VLAN, protocol filter, or Spanning Tree Domain.

Next, configure a VLAN to make use of the UDP-forwarding profile. As a result, all incoming traffic from the VLAN that matches the UDP profile is handled as specified in the UDP-forwarding profile.

A maximum of ten UDP-forwarding profiles can be defined. Each named profile may contain a maximum of eight "rules" defining the UDP port, and destination IP address or VLAN. A VLAN can make use of a single UDP-forwarding profile. UDP packets directed toward a VLAN use an all-ones broadcast on that VLAN.

UDP-Forwarding Example

In this example, the VLAN *Marketing* and the VLAN *Operations* are pointed toward a specific backbone DHCP server (with IP address 10.1.1.1) and a backup server (with IP address 10.1.1.2). Additionally, the VLAN *LabUser* is configured to use any responding DHCP server on a separate VLAN called *LabSvrs*.

The commands for this configuration are as follows:

```
create udp-profile backbonedhcp
create udp-profile labdhcp
configure backbonedhcp add 67 ipaddress 10.1.1.1
configure backbonedhcp add 67 ipaddress 10.1.1.2
configure labdhcp add 67 vlan labsvrs
configure marketing udp-profile backbonedhcp
configure operations udp-profile backbonedhcp
configure labuser udp-profile labdhcp
```

ICMP Packet Processing

As ICMP packets are routed or generated, you can take various actions to control distribution. For ICMP packets typically generated or observed as part of the routing function, you can assert control on a per-type, per-VLAN basis. You would alter the default settings for security reasons: to restrict the success of tools that can be used to find an important application, host, or topology information. The controls include the disabling of transmitting ICMP messages associated with unreachables, port-unreachables, time-exceeded, parameter-problems, redirects, time-stamp, and address-mask requests.

For ICMP packets that are typically routed, you can apply access lists to restrict forwarding behavior. Access lists are described in Chapter 12.

UDP Echo Server

You can use UDP Echo packets to measure the transit time for data between the transmitting and receiving end.

To enable UDP echo server support, use the following command:

```
enable udp-echo-server
```

To disable UDP echo server support, use the following command:

```
disable udp-echo-server
```

VLAN Aggregation

VLAN aggregation is an ExtremeWare feature aimed primarily at service providers. The purpose of VLAN aggregation is to increase the efficiency of IP address space usage. It does this by allowing clients within the same IP subnet to use different broadcast domains while still using the same default router.

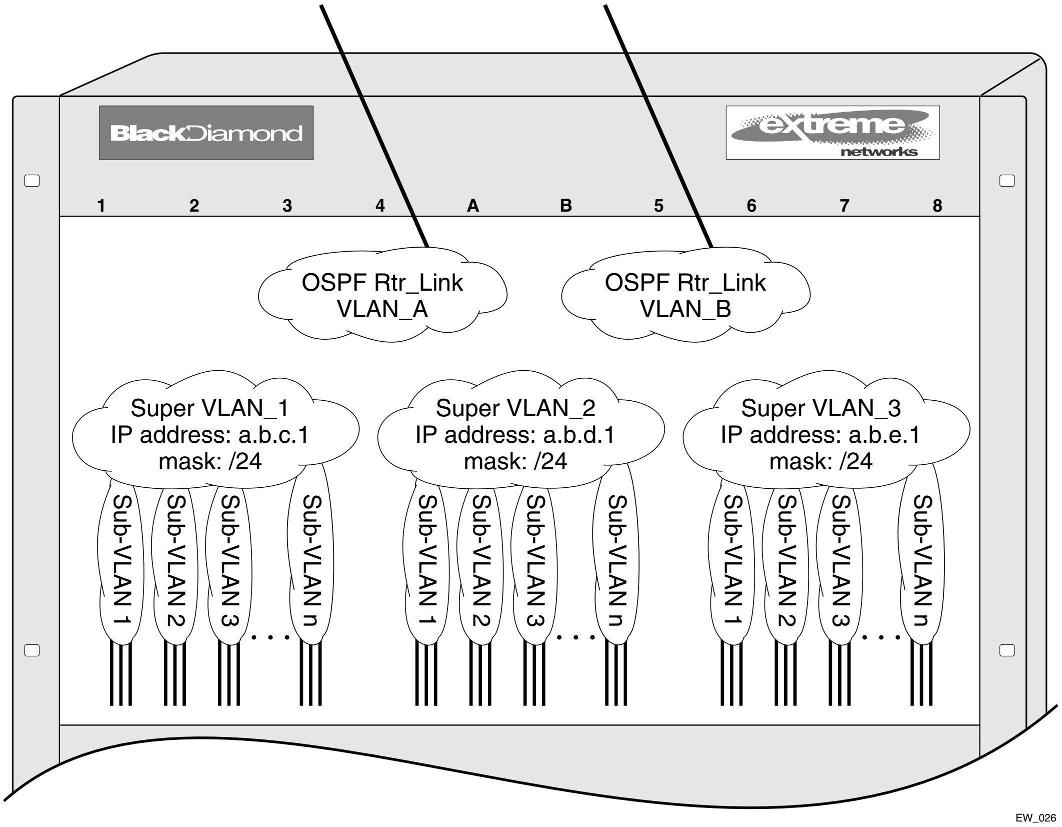
Using VLAN aggregation, a *super-VLAN* is defined with the desired IP address, but without any member ports (unless it is running ESRP). The sub-VLANs use the IP address of the super-VLAN as the default router address. Groups of clients are then assigned to sub-VLANs that have no IP address, but are members of the super-VLAN. In addition, clients can be informally allocated any valid IP addresses within the subnet. Optionally, you can prevent communication between sub-VLANs for isolation purposes. As a result, sub-VLANs can be quite small, but allow for growth without re-defining subnet boundaries.

Without using VLAN aggregation, each VLAN has a default router address, and you need to use large subnet masks. The result of this is more unused IP address space.

Multiple secondary IP addresses can be assigned to the super-VLAN. These IP addresses are *only* used to respond to ICMP ping packets to verify connectivity.

Figure 84 illustrates VLAN aggregation.

Figure 84: VLAN aggregation


BlackDiamond
extreme networks
1
2
3
4
A
B
5
6
7
8
OSPF Rtr_Link VLAN_A
OSPF Rtr_Link VLAN_B
Super VLAN_1 IP address: a.b.c.1 mask: /24
Super VLAN_2 IP address: a.b.d.1 mask: /24
Super VLAN_3 IP address: a.b.e.1 mask: /24
Sub-VLAN 1
Sub-VLAN 2
Sub-VLAN 3
Sub-VLAN n
EW_026

In Figure 84, all stations are configured to use the address 10.3.2.1 for the default router.

VLAN Aggregation Properties

VLAN aggregation is a very specific application, and the following properties apply to its operation:

- All broadcast and unknown traffic remains local to the sub-VLAN and does not cross the sub-VLAN boundary. All traffic within the sub-VLAN is switched by the sub-VLAN, allowing traffic separation between sub-VLANs (while using the same default router address among the sub-VLANs).
- Hosts are located on the sub-VLAN. Each host can assume any IP address within the address range of the super-VLAN router interface. Hosts on the sub-VLAN are expected to have the same network mask as the super-VLAN and have their default router set to the IP address or the super-VLAN.
- All traffic (IP unicast and IP multicast) between sub-VLANs is routed through the super-VLAN. For example, no ICMP redirects are generated for traffic between sub-VLANs, because the super-VLAN is responsible for sub-VLAN routing. Unicast IP traffic across the sub-VLANs is facilitated by the automatic addition of an ARP entry (similar to a proxy ARP entry) when a sub-VLAN is added to a super-VLAN. This feature can be disabled for security purposes.
- IP multicast traffic between sub-VLANs is routed when an IP multicast routing protocol is enabled on the super-VLAN.

VLAN Aggregation Limitations

The following limitations apply to VLAN aggregation:

- No additional routers may be located in a sub-VLAN. This feature is only applicable for "leaves" of a network.
- A sub-VLAN cannot be a super-VLAN, and vice-versa.
- Sub-VLANs are not assigned an IP address.
- Typically, a super-VLAN has no ports associated with it, except in the case of running ESRP.

VLAN Aggregation SubVLAN Address Range Checking

You can configure subVLAN address ranges on each subVLAN to prohibit the entry of IP addresses from hosts outside of the configured range.

To configure a subVLAN range, use the following command:

```
configure vlan <vlan name> subvlan-address-range <ip address1> - <ip address2>
```

To remove a subVLAN address range, use the following command:

```
configure vlan <name> subvlan-address-range 0.0.0.0 - 0.0.0.0
```

To view the subVLAN address range, use the following command:

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

There is no error checking to prevent the configuration of overlapping subVLAN address ranges between multiple subVLANs. Doing so can result in unexpected behavior of ARP within the superVLAN and associated subVLANs.

Isolation Option for Communication Between Sub-VLANs

To facilitate communication between sub-VLANs, by default, an entry is made in the IP ARP table of the super-VLAN that performs a proxy ARP function. This allows clients on one sub-VLAN to communicate with clients on another sub-VLAN. In certain circumstances, intra-sub-VLAN communication may not be desired for isolation reasons.

To prevent normal communication between sub-VLANs, disable the automatic addition of the IP ARP entries on the super-VLAN using the following command:

```
disable subvlan-proxy-arp vlan [<super-vlan name> | all]
```

NOTE

The isolation option works for normal, dynamic, ARP-based client communication.

VLAN Aggregation Example

The follow example illustrates how to configure VLAN aggregation. The VLAN *vsuper* is created as a super-VLAN, and sub-VLANs, *vsub1*, *vsub2*, and *vsub3* are added to it.

1. Create and assign an IP address to a VLAN designated as the super-VLAN. This VLAN should have no member ports. Be sure to enable IP forwarding, and any desired routing protocol, on the switch.

   ```
   create vlan vsuper
   configure vsuper ipaddress 192.201.3.1/24
   enable ipforwarding
   enable ospf
   configure ospf add vsuper
   ```

2. Create and add ports to the sub-VLANs.

   ```
   create vlan vsub1
   con vsub1 add port 10-12
   create vlan vsub2
   configure vsub2 add po 13-15
   create vlan vsub3
   configure vsub3 add po 16-18
   ```

3. Configure the super-VLAN by adding the sub-VLANs.

   ```
   configure vsuper add subvlan vsub1
   configure vsuper add subvlan vsub2
   configure vsuper add subvlan vsub3
   ```

4. Optionally, disable communication among sub-VLANs.

   ```
   disable subvlan-proxy-arp vlan [<super-vlan name> | all]
   ```

Verifying the VLAN Aggregation Configuration

The following commands can be used to verify proper VLAN aggregation configuration.

- `show vlan`—Indicates the membership of a sub-VLANs in a super-VLAN.
- `show iparp`—Indicates an ARP entry that contains sub-VLAN information. Communication with a client on a sub-VLAN must have occurred in order for an entry to be made in the ARP table.

18 Interior Gateway Protocols

This chapter describes the following topics:

- Overview on page 468
- Overview of RIP on page 469
- Overview of OSPF on page 470
- Route Re-Distribution on page 475
- RIP Configuration Example on page 478
- Configuring OSPF on page 480
- OSPF Configuration Example on page 481
- Displaying OSPF Settings on page 483
- Overview of IS-IS on page 484
- Implementing IS-IS Routing on page 485

This chapter assumes that you are already familiar with IP unicast routing. If not, refer to the following publications for additional information:

- RFC 1058—*Routing Information Protocol (RIP)*
- RFC 1195—*Use of OSI IS-IS for Routing in TCP/IP and Dual Environments*
- ISO 10589—*OSI IS-IS Intra-Domain Routing Protocol* (also available as RFC 1142)
- RFC 1723—*RIP Version 2*
- RFC 2178—*OSPF Version 2*
- *Interconnections: Bridges and Routers*
  by Radia Perlman
  ISBN 0-201-56332-0
  Published by Addison-Wesley Publishing Company

Overview

The switch supports the use of three interior gateway protocols (IGPs); the Routing Information Protocol (RIP), the Open Shortest Path First (OSPF) protocol, and the Integrated Intermediate System-to-Intermediate System (IS-IS) dynamic routing protocol for IP unicast routing.

RIP is a distance-vector protocol, based on the Bellman-Ford (or distance-vector) algorithm. The distance-vector algorithm has been in use for many years, and is widely deployed and understood.

OSPF is a link-state protocol, based on the Dijkstra link-state algorithm. OSPF is a newer Interior Gateway Protocol (IGP), and solves a number of problems associated with using RIP on today's complex networks.

The IS-IS routing protocol is very similar to OSPF. OSPF was derived from the IS-IS protocol. IS-IS also is a link-state protocol, based on the Dijkstra link-state algorithm. As originally implemented, IS-IS can support both IP and ISO routing in mixed environments. ExtremeWare Integrated IS-IS supports IP-only routing.

NOTE

RIP, OSPF, and IS-IS can be enabled on a single VLAN.

RIP Versus Either OSPF or IS-IS

The distinction between RIP and OSPF or IS-IS lies in the fundamental differences between distance-vector protocols and link-state protocols. Using a distance-vector protocol, each router creates a unique routing table from summarized information obtained from neighboring routers. Using a link-state protocol, every router maintains an identical routing table created from information obtained from all routers in the autonomous system. Each router builds a shortest path tree, using itself as the root. The link-state protocol ensures that updates sent to neighboring routers are acknowledged by the neighbors, verifying that all routers have a consistent network map.

The biggest advantage of using RIP is that it is relatively simple to understand and implement, and it has been the *de facto* routing standard for many years.

RIP has a number of limitations that can cause problems in large networks, including:

- A limit of 15 hops between the source and destination networks.
- A large amount of bandwidth taken up by periodic broadcasts of the entire routing table.
- Slow convergence.
- Routing decisions based on hop count; no concept of link costs or delay.
- Flat networks; no concept of areas or boundaries.

OSPF and IS-IS offers many advantages over RIP, including:

- No limitation on hop count.
- Route updates multicast only when changes occur.
- Faster convergence.
- Support for load balancing to multiple routers based on the actual cost of the link.
- Support for hierarchical topologies where the network is divided into areas.

The details of RIP, OSPF, and IS-IS are explained later in this chapter.

Overview of RIP

RIP is an Interior Gateway Protocol (IGP) first used in computer routing in the Advanced Research Projects Agency Network (ARPAnet) as early as 1969. It is primarily intended for use in homogeneous networks of moderate size.

To determine the best path to a distant network, a router using RIP always selects the path that has the least number of hops. Each router that data must traverse is considered to be one hop.

Routing Table

The routing table in a router using RIP contains an entry for every known destination network. Each routing table entry contains the following information:

- IP address of the destination network
- Metric (hop count) to the destination network
- IP address of the next router
- Timer that tracks the amount of time since the entry was last updated

The router exchanges an update message with each neighbor every 30 seconds (default value), or if there is a change to the overall routed topology (also called *triggered updates*). If a router does not receive an update message from its neighbor within the route timeout period (180 seconds by default), the router assumes the connection between it and its neighbor is no longer available.

Split Horizon

Split horizon is a scheme for avoiding problems caused by including routes in updates sent to the router from which the route was learned. Split horizon omits routes learned from a neighbor in updates sent to that neighbor.

Poison Reverse

Like split horizon, poison reverse is a scheme for eliminating the possibility of loops in the routed topology. In this case, a router advertises a route over the same interface that supplied the route, but the route uses a hop count of 16, defining it as unreachable.

Triggered Updates

Triggered updates occur whenever a router changes the metric for a route, and it is required to send an update message immediately, even if it is not yet time for a regular update message to be sent. This will generally result in faster convergence, but may also result in more RIP-related traffic.

Route Advertisement of VLANs

VLANs that are configured with an IP address, but are configured to not route IP or are not configured to run RIP, do not have their subnets advertised by RIP. Only those VLANs that are configured with an IP address and are configured to route IP and run RIP have their subnets advertised.

RIP Version 1 Versus RIP Version 2

A new version of RIP, called RIP version 2, expands the functionality of RIP version 1 to include:

- Variable-Length Subnet Masks (VLSMs).
- Support for next-hop addresses, which allows for optimization of routes in certain environments.
- Multicasting.

  RIP version 2 packets can be multicast instead of being broadcast, reducing the load on hosts that do not support routing protocols.

NOTE

If you are using RIP with supernetting/Classless Inter-Domain Routing (CIDR), you must use RIPv2 only. In addition, RIP route aggregation must be turned off.

Overview of OSPF

OSPF is a link-state protocol that distributes routing information between routers belonging to a single IP domain, also known as an *autonomous system* (AS). In a link-state routing protocol, each router maintains a database describing the topology of the autonomous system. Each participating router has an identical database maintained from the perspective of that router.

From the link-state database (LSDB), each router constructs a tree of shortest paths, using itself as the root. The shortest path tree provides the route to each destination in the autonomous system. When several equal-cost routes to a destination exist, traffic can be distributed among them. The cost of a route is described by a single metric.

Link-State Database

Upon initialization, each router transmits a link-state advertisement (LSA) on each of its interfaces. LSAs are collected by each router and entered into the LSDB of each router. Once all LSAs are received, the router uses the LSDB to calculate the best routes for use in the IP routing table. OSPF uses flooding to distribute LSAs between routers. Any change in routing information is sent to all of the routers in the network. All routers within an area have the exact same LSDB. Table 61 describes LSA type numbers.

Table 61: LSA Type Numbers

Type Number	Description
1	Router LSA
2	Network LSA
3	Summary LSA
4	AS summary LSA

Table 61: LSA Type Numbers (Continued)

Type Number	Description
5	AS external LSA
7	NSSA external LSA
9	Link local—Opaque
10	Area scoping—Opaque
11	AS scoping—Opaque

OSPF passive adds the interface to the Type 1 LSA, but it does not send hellos or establish adjancencies on that interface.

Database Overflow

The OSPF database overflow feature allows you to limit the size of the LSDB and to maintain a consistent LSDB across all the routers in the domain, which ensures that all routers have a consistent view of the network.

Consistency is achieved by:

- Limiting the number of external LSAs in the database of each router.
- Ensuring that all routers have identical LSAs.

To configure OSPF database overflow, use the following command:

```
configure ospf ase-limit <number> {timeout <seconds>}
```

where:

- `<number>`—Specifies the number of external LSAs that the system supports before it goes into overflow state. A limit value of zero disables the functionality.

  When the LSDB size limit is reached, OSPF database overflow flushes LSAs from the LSDB. OSPF database overflow flushes the same LSAs from all the routers, which maintains consistency.
- `timeout`—Specifies the timeout, in seconds, after which the system ceases to be in overflow state. A timeout value of zero leaves the system in overflow state until OSPF is disabled and re-enabled.

Opaque LSAs

Opaque LSAs are a generic OSPF mechanism used to carry auxiliary information in the OSPF database. Opaque LSAs are most commonly used to support OSPF traffic engineering.

Normally, support for opaque LSAs is auto-negotiated between OSPF neighbors. In the event that you experience interoperability problems, you can disable opaque LSAs across the entire system using the following command:

```
disable ospf capability opaque-lsa
```

To re-enable opaque LSAs across the entire system, use the following command:

```
enable ospf capability opaque-lsa
```

If your network uses opaque LSAs, we recommend that all routers on your OSPF network support opaque LSAs. Routers that do not support opaque LSAs do not store or flood them. At minimum a well-interconnected subsection of your OSPF network needs to support opaque LSAs to maintain reliability of their transmission.

On an OSPF broadcast network, the designated router (DR) must support opaque LSAs or none of the other routers on that broadcast network will reliably receive them. You can use the OSPF priority feature to give preference to an opaque-capable router, so that it becomes the elected DR.

For transmission to continue reliably across the network, the backup designated router (BDR) must also support opaque LSAs.

NOTE

Opaque LSAs are supported in ExtremeWare version 6.2 and above.

Areas

OSPF allows parts of a network to be grouped together into *areas*. The topology within an area is hidden from the rest of the autonomous system. Hiding this information enables a significant reduction in LSA traffic, and reduces the computations needed to maintain the LSDB. Routing within the area is determined only by the topology of the area.

The three types of routers defined by OSPF are as follows:

- **Internal Router (IR)—**An internal router has all of its interfaces within the same area.
- **Area Border Router (ABR)—**An ABR has interfaces in multiple areas. It is responsible for exchanging summary advertisements with other ABRs. You can create a maximum of 7 non-zero areas.
- **Autonomous System Border Router (ASBR)—**An ASBR acts as a gateway between OSPF and other routing protocols, or other autonomous systems.

Backbone Area (Area 0.0.0.0)

Any OSPF network that contains more than one area is required to have an area configured as area 0.0.0.0, also called the *backbone*. All areas in an autonomous system must be connected to the backbone. When designing networks, you should start with area 0.0.0.0, and then expand into other areas.

NOTE

Area 0.0.0.0 exists by default and cannot be deleted or changed.

The backbone allows summary information to be exchanged between ABRs. Every ABR hears the area summaries from all other ABRs. The ABR then forms a picture of the distance to all networks outside of its area by examining the collected advertisements, and adding in the backbone distance to each advertising router.

When a VLAN is configured to run OSPF, you must configure the area for the VLAN. If you want to configure the VLAN to be part of a different OSPF area, use the following command:

```
configure ospf vlan area
```

If this is the first instance of the OSPF area being used, you must create the area first using the following command:

```
create ospf area
```

Stub Areas

OSPF allows certain areas to be configured as *stub areas*. A stub area is connected to only one other area. The area that connects to a stub area can be the backbone area. External route information is not distributed into stub areas. Stub areas are used to reduce memory consumption and computation requirements on OSPF routers. Use the following command to configure an OSPF area as a stub area:

```
configure ospf area stub stub-default-cost
```

Not-So-Stubby-Areas (NSSA)

NSSAs are similar to the existing OSPF stub area configuration option, but have the following two additional capabilities:

- External routes originating from an ASBR connected to the NSSA can be advertised within the NSSA.
- External routes originating from the NSSA can be propagated to other areas, including the backbone area.

The CLI command to control the NSSA function is similar to the command used for configuring a stub area, as follows:

```
configure ospf area nssa stub-default-cost
```

The `translate` option determines whether type 7 LSAs are translated into type 5 LSAs. When configuring an OSPF area as an NSSA, the `translate` should only be used on NSSA border routers, where translation is to be enforced. If `translate` is not used on any NSSA border router in a NSSA, one of the ABRs for that NSSA is elected to perform translation (as indicated in the NSSA specification). The option should not be used on NSSA internal routers. Doing so inhibits correct operation of the election algorithm.

Normal Area

A normal area is an area that is not:

- Area 0.
- Stub area.
- NSSA.

Virtual links can be configured through normal areas. External routes can be distributed into normal areas.

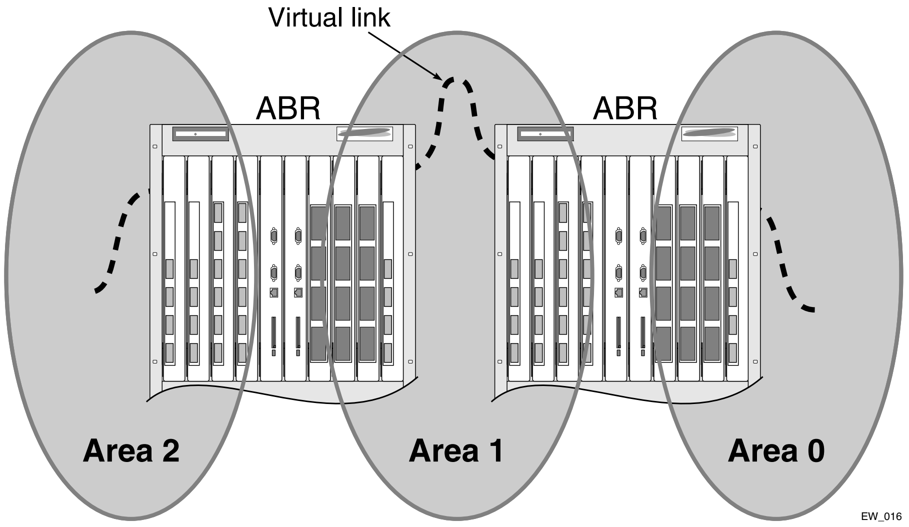
Virtual Links

In the situation when a new area is introduced that does not have a direct physical attachment to the backbone, a *virtual link* is used. A virtual link provides a logical path between the ABR of the disconnected area and the ABR of the normal area that connects to the backbone. A virtual link must be established between two ABRs that have a common area, with one ABR connected to the backbone. Figure 85 illustrates a virtual link.

NOTE

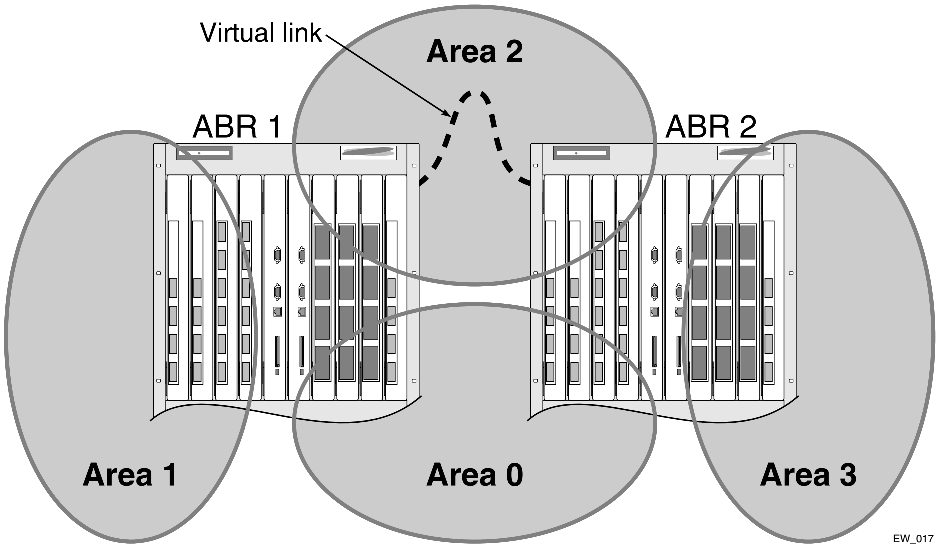
Virtual links can not be configured through a stub or NSSA area.

Figure 85: Virtual link using Area 1 as a transit area



Virtual links are also used to repair a discontiguous backbone area. For example, in Figure 86, if the connection between ABR1 and the backbone fails, the connection using ABR2 provides redundancy so that the discontiguous area can continue to communicate with the backbone using the virtual link.

Figure 86: Virtual link providing redundancy



Point-to-Point Support

You can manually configure the OSPF link type for a VLAN. Table 62 describes the link types.

Table 62: OSPF Link Types

Link Type	Number of Routers	Description
Auto	Varies	ExtremeWare automatically determines the OSPF link type based on the interface type. This is the default setting.
Broadcast	Any	Routers must elect a designated router (DR) and a backup designated router (BDR) during synchronization. Ethernet is an example of a broadcast link.
Point-to-point	Up to 2	Synchronizes faster than a broadcast link because routers do not elect a DR or BDR. Does not operate with more than two routers on the same VLAN. PPP is an example of a point-to-point link. An OSPF point-to-point link supports only zero to two OSPF routers and does not elect a DR or BDR. If you have three or more routers on the VLAN, OSPF will fail to synchronize if the neighbor is not configured.
Passive		A passive link does not send or receive OSPF packets.

NOTE

The number of routers in an OSPF point-to-point link is determined per-VLAN, not per-link.

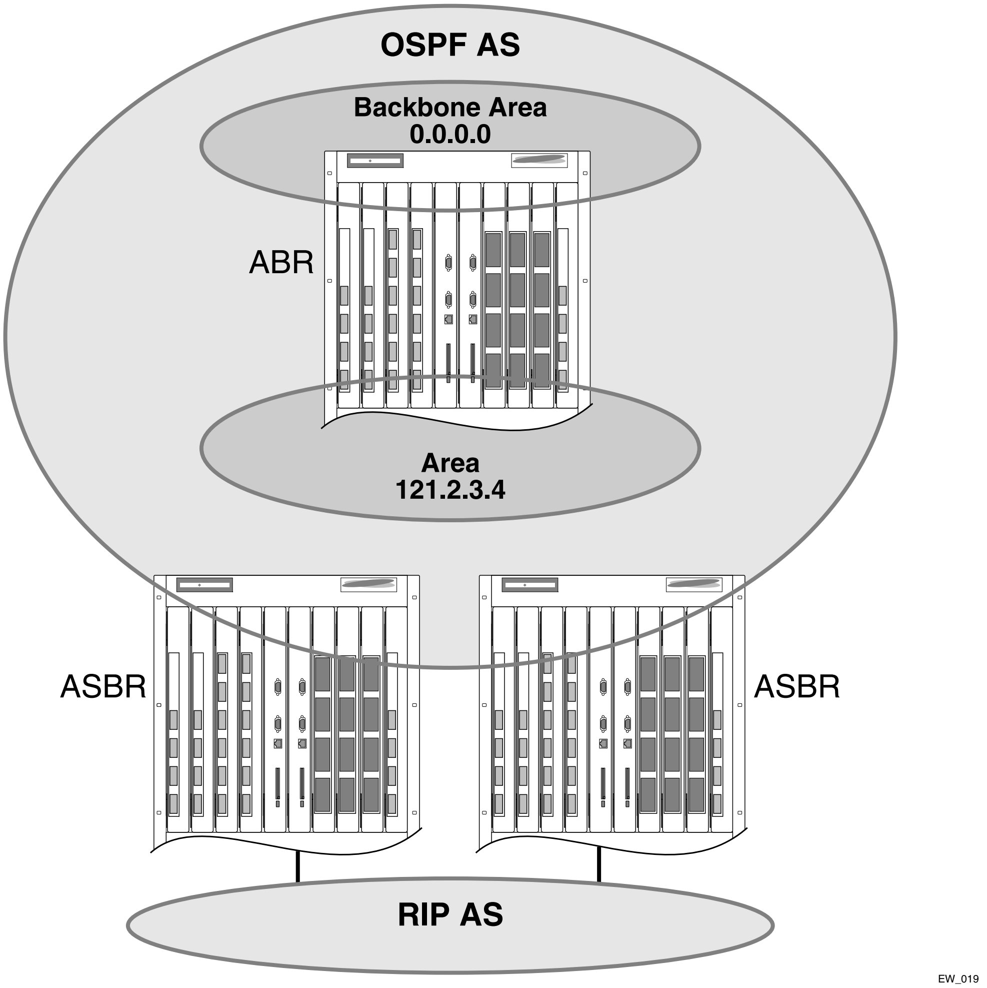
NOTE

All routers in the VLAN must have the same OSPF link type. If there is a mismatch, OSPF attempts to operate, but may not be reliable.

Route Re-Distribution

RIP, OSPF and IS-IS can be enabled simultaneously on the switch. Route re-distribution allows the switch to exchange routes, including static routes, between the three routing protocols. Figure 87 is an example of route re-distribution between an OSPF autonomous system and a RIP autonomous system.

Figure 87: Route re-distribution



Configuring Route Re-Distribution

Exporting routes from one protocol to another, and from that protocol to the first one, are discreet configuration functions. For example, to run OSPF and RIP simultaneously, you must first configure both protocols and then verify the independent operation of each. Then you can configure the routes to export from OSPF to RIP and the routes to export from RIP to OSPF. Likewise, for any other combinations of protocols, you must separately configure each to export routes to the other.

Re-Distributing Routes into OSPF

Enable or disable the exporting of BGP, RIP, IS-IS, VIP, static, and direct (interface) routes to OSPF using the following commands:

```
enable ospf export
```

```
disable ospf export
```

These commands enable or disable the exporting of RIP, static, and direct routes by way of LSA to other OSPF routers as AS-external type 1 or type 2 routes. The default setting is disabled.

The cost metric is inserted for all BGP, RIP, IS-IS, VIP, static, and direct routes injected into OSPF. If the cost metric is set to 0, the cost is inserted from the route. The tag value is used only by special routing applications. Use 0 if you do not have specific requirements for using a tag. The tag value in this instance has no relationship with 802.1Q VLAN tagging.

The same cost, type, and tag values can be inserted for all the export routes, or route maps can be used for selective insertion. When a route map is associated with the export command, the route map is applied on every exported route. The exported routes can also be filtered using route maps. Routes filtered with a route map will be exported as ase-type-1.

Enable or disable the export of virtual IP addresses to other OSPF routers using the following commands:

```
enable ospf export vip
```

```
disable ospf export vip
```

Verify the configuration using the command:

```
show ospf
```

Previous Release Issues with OSPF Re-Distribution

In versions of ExtremeWare prior to release 6.0, direct routes corresponding to the interfaces on which RIP was enabled were exported into OSPF as part of RIP routes, using the command `enable ospf export rip`. Using ExtremeWare 6.0 and above, you must configure ExtremeWare to export these direct routes to OSPF. You can use an access profile to filter unnecessary direct routes, using the command:

```
configure ospf direct-filter
```

Re-Distributing Routes into RIP

Enable or disable the exporting of static, direct, IS-IS, VIP, and OSPF-learned routes into the RIP domain using the following commands:

```
enable rip export cost
```

```
disable rip export
```

These commands enable or disable the exporting of static, direct, and OSPF-learned routes into the RIP domain. You can choose which types of OSPF routes are injected, or you can simply choose `ospf`, which will inject all learned OSPF routes regardless of type. The default setting is disabled.

OSPF Timers and Authentication

Configuring OSPF timers and authentication on a per-area basis is a shorthand for applying the timers and authentication to each VLAN in the area at the time of configuration. If you add more VLANs to the area, you must configure the timers and authentication for the new VLANs explicitly. Use the command:

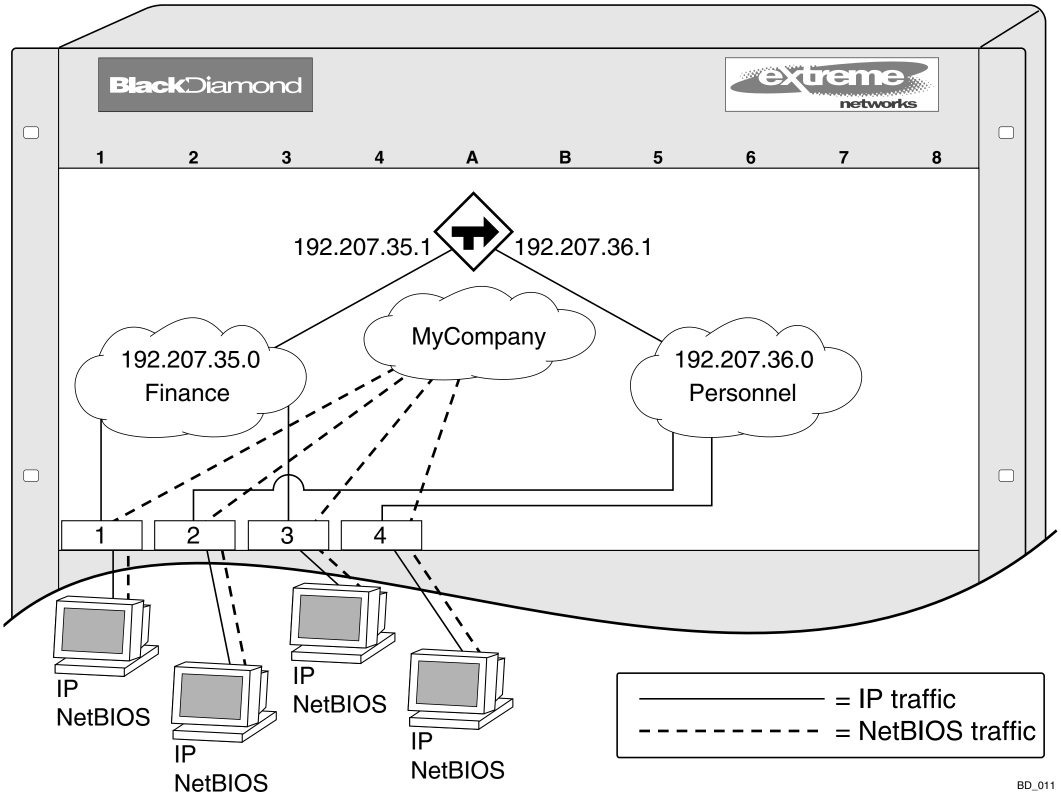
```
configure ospf vlan timer
```

RIP Configuration Example

Figure 88 illustrates a BlackDiamond switch that has three VLANs defined as follows:

- *Finance*
  - — Protocol-sensitive VLAN using the IP protocol.
  - — All ports on slots 1 and 3 have been assigned.
  - — IP address 192.207.35.1.
- *Personnel*
  - — Protocol-sensitive VLAN using the IP protocol.
  - — All ports on slots 2 and 4 have been assigned.
  - — IP address 192.207.36.1.
- *MyCompany*
  - — Port-based VLAN.
  - — All ports on slots 1 through 4 have been assigned.

Figure 88: RIP configuration example



The stations connected to the system generate a combination of IP traffic and NetBIOS traffic. The IP traffic is filtered by the protocol-sensitive VLANs. All other traffic is directed to the VLAN *MyCompany*.

In this configuration, all IP traffic from stations connected to slots 1 and 3 have access to the router by way of the VLAN *Finance*. Ports on slots 2 and 4 reach the router by way of the VLAN *Personnel*. All other traffic (NetBIOS) is part of the VLAN *MyCompany*.

The example in Figure 88 is configured as follows:

```
create vlan Finance
create vlan Personnel
create vlan MyCompany

configure Finance protocol ip
configure Personnel protocol ip

configure Finance add port 1:*,3:*
configure Personnel add port 2:*,4:*
configure MyCompany add port all

configure Finance ipaddress 192.207.35.1
configure Personnel ipaddress 192.207.36.1

enable ipforwarding
configure rip add vlan all
enable rip
```

Configuring OSPF

Each switch that is configured to run OSPF must have a unique router ID. It is recommended that you manually set the router ID of the switches participating in OSPF, instead of having the switch automatically choose its router ID based on the highest interface IP address. Not performing this configuration in larger, dynamic environments could result in an older link state database remaining in use.

Configuring OSPF Wait Interval

ExtremeWare allows you to configure the OSPF wait interval, rather than using the router dead interval.

CAUTION

Do not configure OSPF timers unless you are comfortable exceeding OSPF specifications. Non-standard settings might not be reliable under all circumstances.

To specify the timer intervals, use the following command:

```
configure ospf vlan timer
```

You can configure the following parameters:

- **Retransmit interval**—The length of time that the router waits before retransmitting an LSA that is not acknowledged. If you set an interval that is too short, unnecessary retransmissions will result. The default value is 5 seconds.
- **Transit delay**—The length of time it takes to transmit an LSA packet over the interface. The transit delay must be greater than 0.
- **Hello interval**—The interval at which routers send hello packets. Smaller times allow routers to discover each other more quickly, but also increase network traffic. The default value is 10 seconds.
- **Dead router wait interval (Dead Interval)**—The interval after which a neighboring router is declared down due to the fact that hello packets are no longer received from the neighbor. This interval should be a multiple of the hello interval. The default value is 40 seconds.
- **Router wait interval (Wait Timer Interval)**—The interval between the interface coming up and the election of the DR and BDR. This interval should be greater than the hello interval. If it is close to the hello interval, the network synchronizes very quickly, but might not elect the correct DR or BDR. The default value is equal to the dead router wait interval.

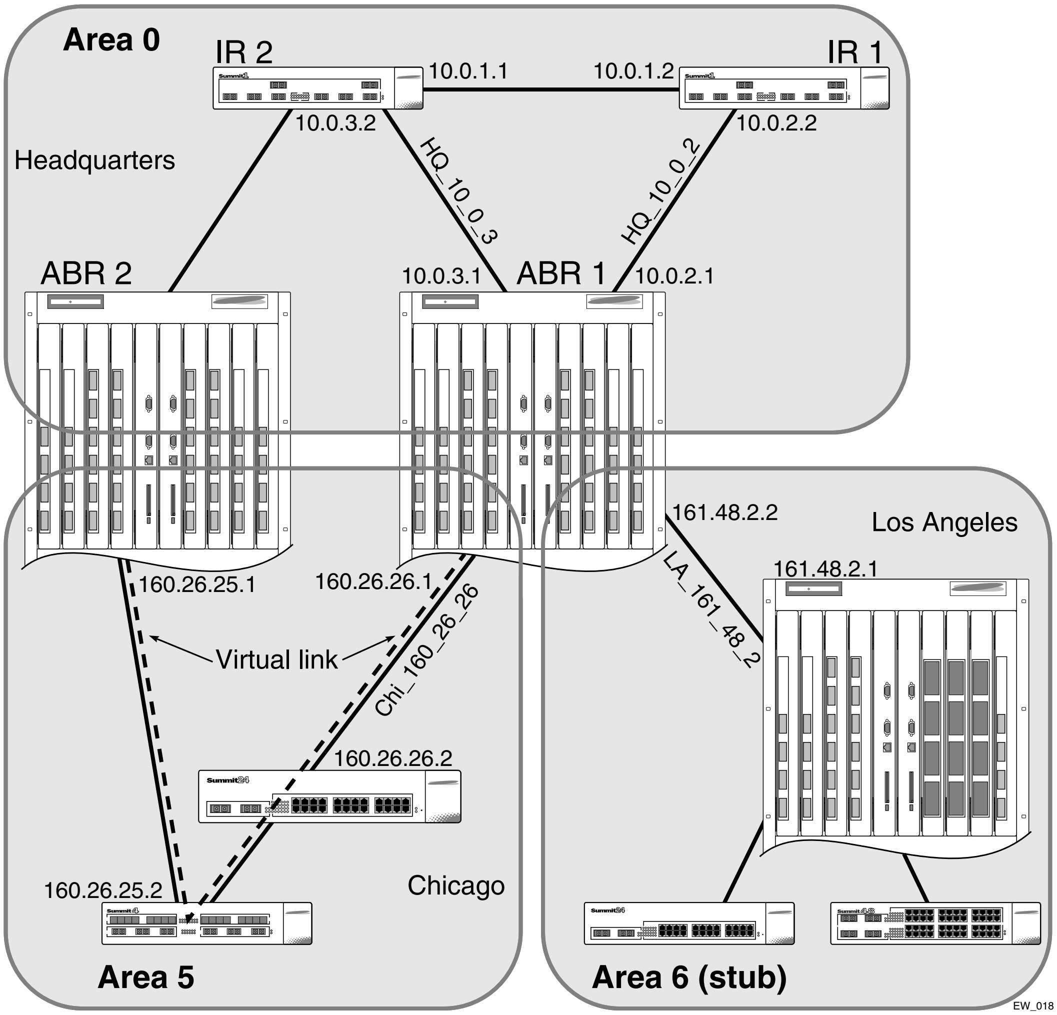
NOTE

The OSPF standard specifies that wait times are equal to the dead router wait interval.

OSPF Configuration Example

Figure 89 is an example of an autonomous system using OSPF routers. The details of this network follow.

Figure 89: OSPF configuration example



Area 0 is the backbone area. It is located at the headquarters and has the following characteristics:

- Two internal routers (IR1 and IR2)
- Two area border routers (ABR1 and ABR2)
- Network number 10.0.x.x
- Two identified VLANs (HQ_10_0_2 and HQ_10_0_3)

Area 5 is connected to the backbone area by way of ABR1 and ABR2. It is located in Chicago and has the following characteristics:

- Network number 160.26.x.x

- One identified VLAN (Chi_160_26_26)
- Two internal routers

Area 6 is a stub area connected to the backbone by way of ABR1. It is located in Los Angeles and has the following characteristics:

- Network number 161.48.x.x
- One identified VLAN (LA_161_48_2)
- Three internal routers
- Uses default routes for inter-area routing

Two router configurations for the example in Figure 89 are provided in the following section.

Configuration for ABR1

The router labeled ABR1 has the following configuration:

```
create vlan HQ_10_0_2
create vlan HQ_10_0_3
create vlan LA_161_48_2
create vlan Chi_160_26_26

configure vlan HQ_10_0_2 ipaddress 10.0.2.1 255.255.255.0
configure vlan HQ_10_0_3 ipaddress 10.0.3.1 255.255.255.0
configure vlan LA_161_48_26 ipaddress 161.48.2.26 255.255.255.0
configure vlan Chi_160_26_26 ipaddress 160.26.2.1 255.255.255.0

create ospf area 0.0.0.5
create ospf area 0.0.0.6

enable ipforwarding

configure ospf area 0.0.0.6 stub nosummary stub-default-cost 10
configure ospf add vlan LA_161_48_2 area 0.0.0.6
configure ospf add vlan Chi_160_26_26 area 0.0.0.5
configure ospf add vlan all area 0.0.0.0

enable ospf
```

Configuration for IR1

The router labeled IR1 has the following configuration:

```
configure vlan HQ_10_0_1 ipaddress 10.0.1.2 255.255.255.0
configure vlan HQ_10_0_2 ipaddress 10.0.2.2 255.255.255.0
enable ipforwarding
configure ospf add vlan all area 0.0.0.0
enable ospf
```

Displaying OSPF Settings

There are a number of commands you can use to display settings for OSPF. To show global OSPF information, use the `show ospf` command with no options.

To display information about one or all OSPF areas, use the following command:

```
show ospf area <area identifier>
```

The `detail` option displays information about all OSPF areas in a detail format.

To display information about OSPF interfaces for an area, a VLAN, or for all interfaces, use the following command:

```
show ospf interfaces {vlan <vlan name> | area <area identifier>}
```

The `detail` option displays information about all OSPF interfaces in a detail format.

OSPF LSDB Display

ExtremeWare provides several filtering criteria for the `show ospf lsdb` command. You can specify multiple search criteria and only results matching all of the criteria are displayed. This allows you to control the displayed entries in large routing tables.

To display the current link-state database, use the following command:

```
show ospf lsdb area [all | <area identifier>[/<len>] | detail | interface | lsid
<id>[/<len>] | lstype [all | as-external | external-type7 | network | opaque-area |
opaque-global | opaque-local | router | summary-asb |summary-net| routerid
<id>[/<len>] | stats | summary | vlan <vlan name>]
```

The `detail` option displays all fields of matching LSAs in a multi-line format. The `summary` option displays several important fields of matching LSAs, one line per LSA. The `stats` option displays the number of matching LSAs, but not any of their contents. If not specified, the default is to display in the summary format.

A common use of this command is to omit all optional parameters, resulting in the following shortened form:

```
show ospf lsdb
```

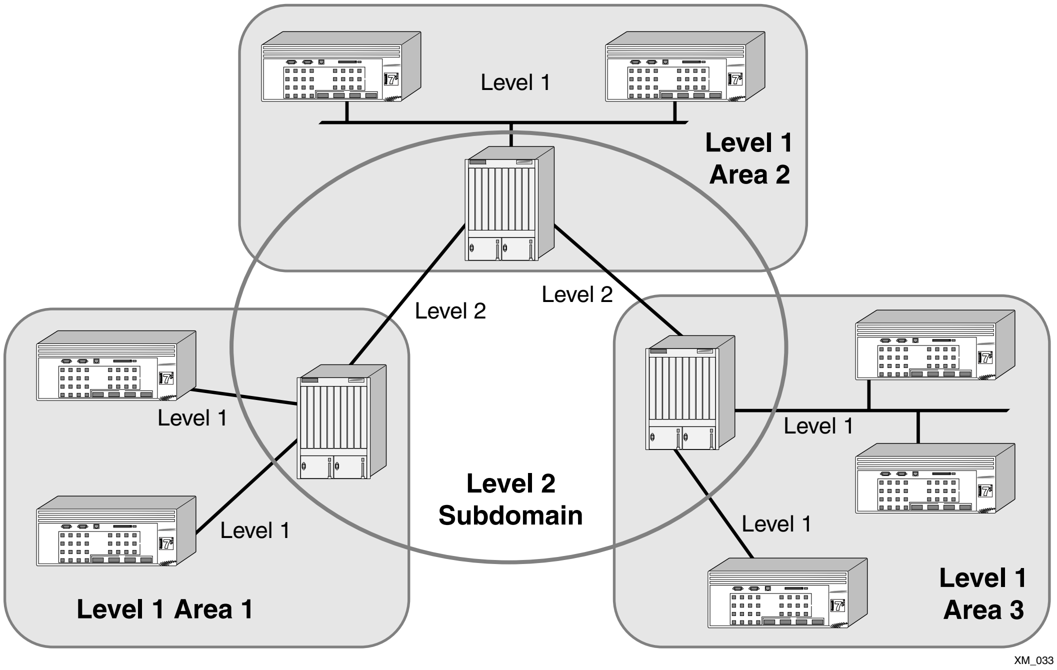
The shortened form displays all areas and all types in a summary format.

Overview of IS-IS

The IS-IS routing protocol provides transport-independent routing. IS-IS partitions the network into "routing domains." Routing domain boundaries are defined by interior and exterior links. Interior links are part of the IS-IS routing domain; exterior links are not. No IS-IS routing messages are sent on exterior links.

A routing domain is partitioned into areas, as shown in Figure 90. IS-IS routing uses two levels of hierarchical routing: level 1 and level 2.

Figure 90: Basic IS-IS network



Level 1 routers know the topology in their area, including all routers and end systems. Level 1 routers do not know the identity of routers or end systems outside of their area. Level 1 routers forward all traffic for destinations outside of their area to a level 2 router in their area.

Level 2 routers know the level 2 topology in their area, and know which addresses are reachable via each level 2 router. However, level 2 routers do not know the level 1 topology within any area, except to the extent that level 2 routers might also be level 1 routers within an area. Level 2 routers that are also level 1 routers are also called level 1/2 routers.

Overview of Integrated IS-IS

Integrated IS-IS allows a single routing protocol to route both IP and OSI packets. The protocol allows for mixing of IP-only, OSI-only, and dual (IP and OSI) routers.

- **IP-only**—An IP-only IS-IS router is a router that uses IS-IS as the routing protocol for IP and does not support OSI protocols. The ExtremeWare integrated IS-IS implementation is IP-only.
- **OSI-only**—An OSI-only router is a router that uses IS-IS as the routing protocol for OSI.

- **Dual**—A dual IS-IS router is a router that uses IS-IS as a single integrated routing protocol for both IP and OSI.

The IS-IS protocol uses the existing IS-IS packets and adds IP-specific fields containing the following:

- Authentication information
- The protocols supported by each router, as well as each router's IP addresses (specified in IS-IS Hello and Link State Packets (LSPs))
- Internally and externally reachable IP addresses (specified in all Link State Packets)

The same two-level hierarchy is used for both IP and OSI routing. Each area is specified as IP-only, OSI-only, or dual. The protocol does not allow for partial overlap of OSI and IP areas.

Within an area, level 1 routers exchange link state packets, which identify the IP addresses reachable by each router. Specifically, zero or more combinations of IP address, subnet mask, and metric can be included in each link state packet. Each level 1 router is manually configured with the combinations that are reachable on each interface. A level 1 router routes as follows:

1. If a specified destination address matches a combination reachable within the area, the packet is routed via level 1 routing.
2. If a specified destination address does not match any combination listed as reachable within the area, the packet is routed towards the nearest level 2 router by ISO routing or the packet is routed by the originate default route.

Flexible use of the limited IP address space is important in order to cope with the anticipated growth of IP environments. Thus an area (and by implication a routing domain) can simultaneously use a variety of different address masks for different subnets in the area (or domain). Generally, if a specified destination address matches more than one IP address and subnet mask pair, the more specific address (the one with more "1" bits in the mask, known as "best match" routing) is the one routed towards.

Level 2 routers include in their level 2 LSPs a complete list of combinations specifying all IP addresses reachable in their area. In addition, both level 1 and level 2 routers can report external reachability information, corresponding to addresses that can be reached via routers in other routing domains.

Typically, small IS-IS networks are a single area that includes all the routers in the network. As the network grows, that single area is usually reorganized into a backbone area made up of the connected set of all level 2 routers from all areas, which in turn connect to local areas.

Implementing IS-IS Routing

To implement integrated IS-IS routing, perform these basic steps:

1. Create IS-IS areas using the following command:

   ```
   create isis area
   ```

2. Add area addresses to level 1 using the following command:

   ```
   configure isis area add
   ```

3. Add interfaces to level 1 using the following command:

   ```
   configure isis add vlan level-1 area
   ```

4. Add area addresses to level 2 using the following command:

   ```
   configure isis level-2 add
   ```

5 Add interfaces to level 2 using the following command:

```
configure isis add vlan level-2-only
```

6 Enable ISIS using the following command:

```
enable isis
```

ExtremeWare 6.1.8 IS-IS supports integrated IS-IS as specified in ISO/IEC 10589 and RFC 1195. The IS-IS implementation allows the switches to act as an IP-only IS-IS router. No OSI routes are calculated, as there is no support for network layer forwarding of OSI traffic in Extreme switches. ExtremeWare IS-IS does not support OSI.

Integrated IS-IS is supported over VLANs containing Ethernet and PoS interfaces. VLANs containing Ethernet interfaces or a mixture of Ethernet and PoS interfaces are treated as broadcast subnetworks. VLANs containing PoS interfaces are treated as either broadcast or point-to-point subnetworks based on the PPP mode enabled on the PoS interfaces.

Currently, you can create one level 1 area. A level 2 subdomain is the domain that contains all of the level 2 routers. A level 2 subdomain is always present in every system. When you enable IS-IS on an interface, you configure the type of the interface. Depending on the type, the interface is part of a level 1 area, level 2 subdomain, or both. The presence of an interface in a level 1 area or level 2 subdomain determines the type of the router.

The IP routes that are generated as a result of running shortest-path-first (SPF) calculations on the information received from all the routers in the subdomain or area is installed in the IP routing table as IS-IS Level 1 Internal, IS-IS Level 1 External, IS-IS Level 2 Internal, and IS-IS Level 2 External routes.

Basic IS-IS includes the following features:

- Authentication
- Summarizing level 1 routing information
- Filtering level 1 routing information
- External route redistribution
- Originating default route
- Overload bit
- Metric size

Authentication

Authentication is supported at two different levels: interface, and domain or area.

- **Interface authentication**—prevents unauthorized routers from forming adjacency. This is achieved by inserting authentication information in the Hello PDUs and validating them on the received Hello PDUs. You can configure authentication separately for level 1 and level 2.
- **Domain or area authentication**—prevents intruders from injecting invalid routing information into this router. Similar to interface authentication, this is achieved by inserting the authentication information using LSP, CSNP, and PSNP PDUs and validating them on receipt. You can configure authentication separately for level 1 and level 2.

At each of the above levels two different authentication methods are supported: simple password as specified in ISO/IEC 10589, and HMAC-MD5 as specified in draft-ietf-isis-hmac-00.txt.

Summarizing Level 1 IP Routing Information

Level 2 routers include in their level 2 LSPs a list of all combinations (IP address, subnet mask, and metric) reachable in the level 1 area attached to them. This information is gathered from the level 1 LSPs from all routers in the area. By default the combinations from all the level 1 routers are included in the level 2 LSPs. Summarization of the level 1 combinations reduces the amount of information stored on the level 2 router and helps in scaling to a large routing domain.

You can configure the level 1 areas with one or more combinations for announcement in their level 2 LSPs. The level 1 IP routing information is matched against the summary addresses configured on the level 1 area. Matches are included in the level 2 LSP.

You can also configure the level 2 router to disregard the summary information. This effectively acts as a filter, preventing reachability information from being included in the level 2 LSP.

Filtering Level 1 IP Routing Information

Level 2 routers include in their level 2 LSPs a list of all combinations (IP address, subnet mask, and metric) reachable in the level 1 area attached to them. This information is gathered from the level 1 LSPs from all routers in the area. By default the combinations from all the level 1 routers are included in the level 2 LSPs. Filtering the level 1 combinations prevents the advertisement of the information to other parts of the domain. This creates a network that is reachable only from routers within the area.

You can configure the level 1 areas in the router with an IP access profile. The level 1 IP routing information in the level 2 LSP is matched against the access profile, and if the result is a deny, the information is not included in the level 2 LSP.

External Route Redistribution

This feature injects routing information learned from other IP routing protocols into an IS-IS domain, thereby advertising their reachability in the IS-IS domain. These are included as combinations (IP address, subnet mask, and metric) in the locally originated LSPs.

Redistribution of the routes into the level 1 areas or level 2 subdomain can be controlled based on the protocol originating the routing information. The metric and the type of the metric are also configured. You can also associate a route map, which can selectively assign metric, metric type, and filter routes.

You can also configure an Access Profile to filter out unwanted external routes.

Originating Default Route

This feature injects IP routing information for the default route in the LSP originated by the router, thereby advertising the router as the default gateway.

Injection of the default route into the level 2 subdomain and level 1 area can be controlled individually. You can configure the metric and metric type associated with the default route. You can also configure the default to be automatically generated based on the presence of a default route in the kernel routing table.

Overload Bit

This feature forces the router to set the overload bit (also known as the hippity bit) in its non-pseudo node link-state packets. Normally the setting of the overload bit is allowed only when a router runs into problems. For example, when a router has a memory shortage, it might be that the Link State database is not complete, resulting in an incomplete or inaccurate routing table. By setting the overload bit in its LSPs, other routers can ignore the unreliable router in their SPF calculations until the router has recovered from its problems.

Set the overload bit when you want to prevent traffic flow.

Metric Size

Normally, IS-IS metrics can have values up to 63. IS-IS generates two type, length, and value (TLV) codings, one for an IS-IS adjacency (code, length, and value (CLV) 2) and the second for an IP prefix (CLV 128 and CLV 130). During SPF, if the total cost of the path to a destination exceeds 1023, then according to ISO/IEC 10587, the path is ignored.

To overcome these restrictions, a second pair of TLVs is available, one for IP prefixes (CLV 135) and the second for IS-IS adjacency (CLV 22). With these TLVs, IS-IS metrics can have values up 16,777,215 and the maximum path metric allowed is 4,261,412,864. This allows more flexibility while designing a domain. These metrics are “wide” metrics.

You can configure a router to originate LSPs with regular metrics, wide metrics, or both.

Default Routes to Nearest Level 1/2 Switch for Level 1 Only Switches

When one router is a level 1 switch, the route to the nearest level 1/2 switch which attaches to a level 2 backbone network may be installed in the kernel routing table of the level 1 switch.

There are three kinds of level 1 only switches:

- a switch that does not attach to any level 1/2 switch; it is part of a level 1 only network
- a switch that attaches to at least one level 1/2 switch, but none of the level 1/2 switches are attached to a level 2 backbone network. Here the level 1 non-pseudo node LSP of the level 1/2 switches should set the attach bit to 0. A level 1 only switch will not install the default routes based on the unattached level 1/2 switch’s LSP information.
- a switch that attaches to at least one level 1/2 switch, and at least one of the level 1/2 switches is attached to the level 2 backbone network. Here the level 1 non-pseudo node LSP of the level 1/2 switch should set the attach bit to 1. A level 1 only switch will install the default routes based on the attached level 1/2 switch’s LSP information.

The level 1/2 switch that is attached to the level 2 backbone network when at least one of area addresses of level 2 LSP received from other level 2 or level 1/2 switches is not in the list of the level 1 union area address set.

When IS-IS installs default routes based on the attached bit, the routes should have a lower priority than originated default routes. Default routes based on the attached bit can only be installed when an originated default route does not exist. The metric installed should be 2047(e1) for the regular metric and 4,261,412,864 (i1) for the wide metric. A maximum of eight equal default routes is supported.

This feature is enabled by default. The level 1 router installs default routes based on the attach bit. To disable this feature, the attach bit must be ignored. The following command disables this feature by configuring the router to ignore the attach bit:

```
enable isis ignore-attached-bit
```

To enable this feature use the following command:

```
disable isis ignore-attached-bit
```

19 Exterior Gateway Routing Protocols

This chapter covers the following topics:

- Overview on page 491
- BGP Attributes on page 492
- BGP Communities on page 492
- BGP Features on page 492

This chapter describes how to configure the Border Gateway Protocol (BGP), an exterior routing protocol available on the switch.

For more information on BGP, refer to the following documents:

- RFC 1771—*Border Gateway Protocol version 4 (BGP-4)*
- RFC 1965—*Autonomous System Confederations for BGP*
- RFC 1966—*BGP Route Reflection*
- RFC 1997—*BGP Communities Attribute*
- RFC 1745—*BGP/OSPF Interaction*
- RFC 2439—*BGP Route Flap Damping*

NOTE

ExtremeWare supports BGP version 4 only.

Overview

BGP is an exterior routing protocol that was developed for use in TCP/IP networks. The primary function of BGP is to allow different autonomous systems (ASs) to exchange network reachability information.

An autonomous system is a set of routers that are under a single technical administration. This set of routers uses a different routing protocol (such as OSPF) for intra-AS routing. One or more routers in the AS are configured to be border routers, exchanging information with other border routers (in different autonomous systems) on behalf of all of the intra-AS routers.

BGP can be used as an exterior gateway protocol (E-BGP), or it can be used within an AS as an interior gateway protocol (I-BGP).

BGP Attributes

The following well-known BGP attributes are supported by the switch:

- Origin – Defines the origin of the route. Possible values are IGP, EGP, and incomplete.
- AS_Path – The list of ASs that are traversed for this route.
- Next_hop – The IP address of the next hop BGP router to reach the destination listed in the NLRI field.
- Multi_Exit_Discriminator – Used to select a particular border router in another AS when multiple border routers exist.
- Local_Preference – Used to advertise this router's degree of preference to other routers within the AS.
- Atomic_aggregate – Indicates that the sending border router has used a route aggregate prefix in the route update.
- Aggregator – Identifies the BGP router AS number and IP address that performed route aggregation.
- Community – Identifies a group of destinations that share one or more common attributes.
- Cluster_ID – Specifies a 4-byte field used by a route reflector to recognize updates from other route reflectors in the same cluster, helping to detect loops.
- Originator_ID – Specifies the router ID of the originator of the route in the AS in the same cluster.

BGP Communities

A BGP community is a group of BGP destinations that require common handling. ExtremeWare supports the following well-known BGP community attributes:

- no-export
- no-advertise
- no-export-subconfed

BGP Features

This section describes the following BGP features supported by ExtremeWare:

- Route Reflectors on page 493
- Route Confederations on page 493
- Route Aggregation on page 496
- IGP Synchronization on page 497
- Using the Loopback Interface on page 497
- BGP Peer Groups on page 497

- BGP Route Flap Dampening on page 498

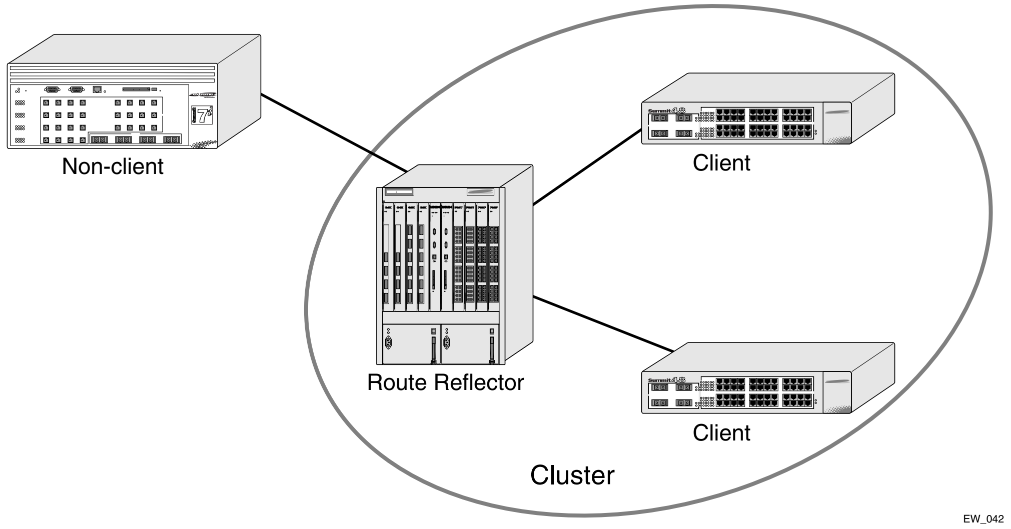
Route Reflectors

Another way to overcome the difficulties of creating a fully-meshed AS is to use *route reflectors*. Route reflectors allow a single router to serve as a central routing point for the AS or sub-AS.

A *cluster* is formed by the route reflector and its client routers. Peer routers that are not part of the cluster must be fully meshed according to the rules of BGP.

A BGP cluster, including the route reflector and its clients, is shown in Figure 91.

Figure 91: Route reflectors



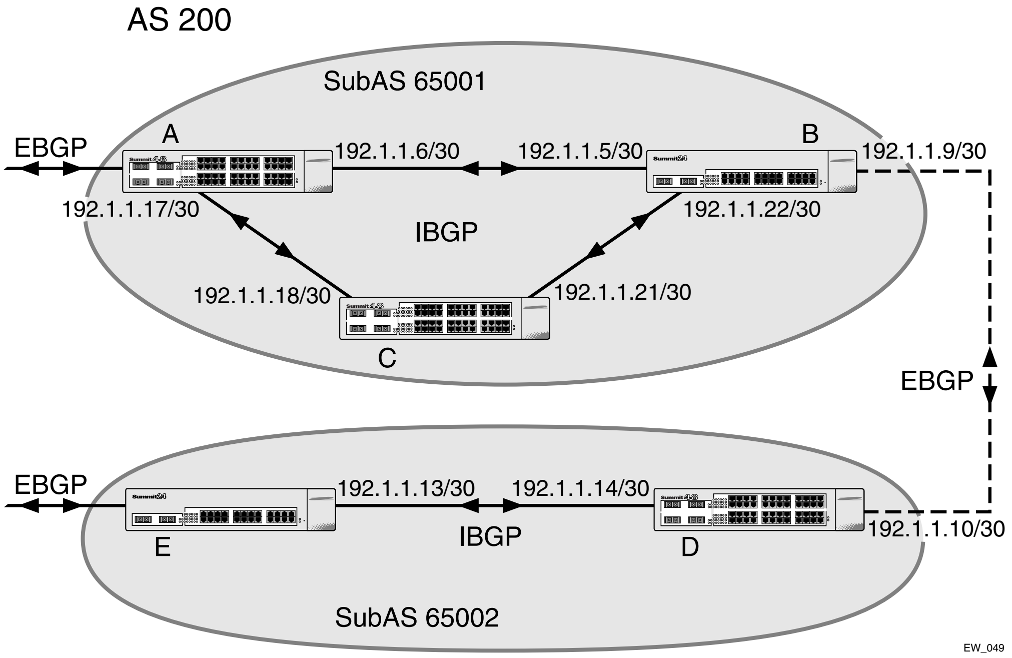
Route Confederations

BGP requires networks to use a fully-meshed router configuration. This requirement does not scale well, especially when BGP is used as an interior gateway protocol. One way to reduce the size of a fully-meshed AS is to divide the AS into multiple sub-autonomous systems and group them into a *routing confederation*. Within the confederation, each sub-AS must be fully-meshed. The confederation is advertised to other networks as a single AS.

Route Confederation Example

Figure 92 shows an example of a confederation.

Figure 92: Routing confederation



In this example, AS 200 has five BGP speakers. Without a confederation, BGP would require that the routes in AS 200 be fully meshed. Using the confederation, AS 200 is split into two sub-ASs: AS65001 and AS65002. Each sub-AS is fully meshed, and IBGP is running among its members. EBGP is used between sub-AS 65001 and sub-AS 65002. Router B and router D are EBGP peers. EBGP is also used between the confederation and outside ASs.

To configure router A, use the following commands:

```
create vlan ab
configure vlan ab add port 1
configure vlan ab ipaddress 192.1.1.6/30
enable ipforwarding vlan ab
configure ospf add vlan ab area 0.0.0.0

create vlan ac
configure vlan ac add port 2
configure vlan ac ipaddress 192.1.1.17/30
enable ipforwarding vlan ac
configure ospf add vlan ac area 0.0.0.0

disable bgp
configure bgp as-number 65001
configure bgp routerid 192.1.1.17
configure bgp confederation-id 200
enable bgp
```

```
create bgp neighbor 192.1.1.5 as-number remote-AS-number 65001
create bgp neighbor 192.1.1.18 as-number remote-AS-number 65001
enable bgp neighbor all
```

To configure router B, use the following commands:

```
create vlan ba
configure vlan ba add port 1
configure vlan ba ipaddress 192.1.1.5/30
enable ipforwarding vlan ba
configure ospf add vlan ba area 0.0.0.0

create vlan bc
configure vlan bc add port 2
configure vlan bc ipaddress 192.1.1.22/30
enable ipforwarding vlan bc
configure ospf add vlan bc area 0.0.0.0

create vlan bd
configure vlan bd add port  3
configure vlan bd ipaddress 192.1.1.9/30
enable ipforwarding vlan bd
configure ospf add vlan bd area 0.0.0.0

disable bgp
configure bgp as-number 65001
configure bgp routerid 192.1.1.22
configure bgp confederation-id 200
enable bgp

create bgp neighbor 192.1.1.6 as-number remote-AS-number 65001
create bgp neighbor 192.1.1.21 as-number remote-AS-number 65001
create bgp neighbor 192.1.1.10 as-number remote-AS-number 65002
configure bgp add confederation-peer sub-AS-number 65002
enable bgp neighbor all
```

To configure router C, use the following commands:

```
create vlan  ca
configure vlan ca add port 1
configure vlan ca ipaddress 192.1.1.18/30
enable ipforwarding vlan ca
configure ospf add vlan ca area 0.0.0.0

create vlan cb
configure vlan cb add port 2
configure vlan cb ipaddress 192.1.1.21/30
enable ipforwarding vlan cb
configure ospf add vlan cb area 0.0.0.0

disable bgp
configure bgp as-number 65001
configure bgp routerid 192.1.1.21
configure bgp confederation-id 200
enable bgp

create bgp neighbor 192.1.1.22 as-number remote-AS-number 65001
create bgp neighbor 192.1.1.17 as-number remote-AS-number 65001
enable bgp neighbor all
```

To configure router D, use the following commands:

```
create vlan db
configure vlan db add port 1
configure vlan db ipaddress 192.1.1.10/30
enable ipforwarding vlan db
configure ospf add vlan db area 0.0.0.0

create vlan de
configure vlan de add port 2
configure vlan de ipaddress 192.1.1.14/30
enable ipforwarding vlan de
configure ospf add vlan de area 0.0.0.0

disable bgp
configure bgp as-number 65002
configure bgp routerid 192.1.1.14
configure bgp confederation-id 200
enable bgp

create bgp neighbor 192.1.1.9 as-number remote-AS-number 65001
create bgp neighbor 192.1.1.13 as-number remote-AS-number 65002
configure bgp add confederation-peer sub-AS-number 65001
enable bgp neighbor all
```

To configure router E, use the following commands:

```
create vlan ed
configure vlan ed add port  1
configure vlan ed ipaddress 192.1.1.13/30
enable ipforwarding vlan ed
configure ospf add vlan ed area 0.0.0.0

disable bgp
configure bgp as-number 65002
configure bgp routerid 192.1.1.13
configure bgp confederation-id 200
enable bgp

create bgp neighbor 192.1.1.14 as-number remote-AS-number 65002
enable bgp neighbor 192.1.1.14
```

Route Aggregation

Route aggregation is the process of combining the characteristics of several routes so that they are advertised as a single route. Aggregation reduces the amount of information that a BGP speaker must store and exchange with other BGP speakers. Reducing the information that is stored and exchanged also reduces the size of the routing table.

Using Route Aggregation

To use BGP route aggregation, follow these steps:

1. Enable aggregation using the following command:

   ```
   enable bgp aggregation
   ```

2. Create an aggregate route using the following commands:

   ```
   configure bgp add aggregate-address <ip address>/<mask length> {as-set | as-match}
   {summary-only} {advertise-route-map <route-map>} {attribute-route-map <route-map>}
   ```

IGP Synchronization

You can configure an AS to be a transit AS, so that it can pass traffic through from one AS to a third AS. When you configure a transit AS, it is important that the routes advertised by BGP are consistent with the routes that are available within the AS using its interior gateway protocol. To ensure consistency, BGP should be synchronized with the IGP used within the AS. This will ensure that the routes advertised by BGP are, in fact, reachable within the AS. IGP synchronization is enabled by default.

Using the Loopback Interface

If you are using BGP as your interior gateway protocol, you may decide to advertise the interface as available, regardless of the status of any particular interface. The loopback interface can also be used for EBGP multihop. Using the loopback interface eliminates multiple, unnecessary route changes.

BGP Peer Groups

You can use BGP peer groups to group together up to 128 BGP neighbors. All neighbors within the peer group inherit the parameters of the BGP peer group. The following mandatory parameters are shared by all neighbors in a peer group:

- remote AS
- source-interface
- out-nlri-filter
- out-aspath-filter
- out-route-map
- send-community
- next-hop-self

Each BGP peer group is assigned a unique name when it is created. To create or delete peer groups, use the following command:

```
create bgp peer-group <name>
delete bgp peer-group <peer group>
```

Changes made to the parameters of a peer group are applied to all neighbors in the peer group. Modifying the following parameters will automatically disable and enable the neighbors before changes take effect:

- remote-as
- timer

- source-interface
- soft-in-reset
- password

Adding Neighbors to a BGP Peer Group

To create a new neighbor and add it to a BGP peer group, use the following command:

```
create bgp neighbor <ip address> peer-group <peer group> {multi-hop}
```

The new neighbor is created as part of the peer group and inherits all of the existing parameters of the peer group. The peer group must have remote AS configured.

To add an existing neighbor to a peer group, use the following command:

```
configure bgp neighbor [<ip address> | all] peer-group <peer group> {acquire-all}
```

If you do not specify acquire-all, only the mandatory parameters are inherited from the peer group. If you specify acquire-all, all of the parameters of the peer group are inherited. This command disables the neighbor before adding it to the peer group.

To remove a neighbor from a peer group, use the following command:

```
configure bgp neighbor [<ip address> | all] peer-group none
```

When you remove a neighbor from a peer group, it retains the parameter settings of the group. The parameter values are not reset to those the neighbor had before it inherited the peer group values.

BGP Route Flap Dampening

Route flap dampening is a BGP feature designed to minimize the propagation of flapping routes across an internetwork. A route is considered to be flapping when it is repeatedly available, then unavailable, then available, then unavailable, and so on. When a route becomes unavailable, a Withdrawal message is sent to other connected routers, which in turn propagate the Withdrawal message to other routers. As the route becomes available again, an Advertisement message is sent and propagated throughout the network. As a route repeatedly changes from available to unavailable, large numbers of messages propagate throughout the network. This is a problem in an internetwork connected to the Internet because a route flap in the Internet backbone usually involves many routes.

Minimizing the Route Flap

The route flap dampening feature minimizes the flapping problem as follows. Suppose that the route to network 172.25.0.0 flaps. The router (in which route dampening is enabled) assigns network 172.25.0.0 a penalty of 1000 and moves it to a “history” state in which the penalty value is monitored. The router continues to advertise the status of the route to neighbors. The penalties are cumulative. When the route flaps so often that the penalty exceeds a configurable suppress limit, the router stops advertising the route to network 172.25.0.0, regardless of how many times it flaps. Thus, the route is dampened.

The penalty placed on network 172.25.0.0 is decayed until the reuse limit is reached, upon which the route is once again advertised. At half of the reuse limit, the dampening information for the route to network 172.25.0.0 is removed.

The penalty is decayed by reducing the penalty value by one-half at the end of a configurable time period, called the half-life. Routes that flap many times may reach a maximum penalty level, or ceiling, after which no additional penalty is added. The ceiling value is not directly configurable, but the configuration parameter used in practice is the maximum route suppression time. No matter how often a route has flapped, once it stops flapping, it will again be advertised after the maximum route suppression time.

Configuring Route Flap Dampening

BGP route flap dampening can be enabled on a per BGP peer session basis, for a BGP peer group, or for a set of routes, using a route map.

Use the following command to enable route flap dampening over BGP peer sessions:

```
configure bgp neighbor [<ip address> | all] dampening {{<half-life> {<reuse>
<suppress> <max-suppress> }} | {route-map <route map>}}
```

Use the following command to enable route flap dampening for a BGP peer group:

```
configure bgp neighbor [<ip address> | all] dampening {{<half-life> {<reuse>
<suppress> <max-suppress> }} | {route-map <route map>}}
```

You can supply the dampening parameters through the route map or directly in the CLI command, but not both (these are mutually exclusive).

For route maps there is a set operation to configure dampening parameters. Use the following command to add a set statement to a route map for dampening:

```
configure route-map <route map> <sequence number> add set dampening <half-life>
<reuse-limit> <suppress-limit> <max-suppress>
```

Disabling Route Flap Dampening

Use the following command to disable route flap dampening for a BGP neighbor (disabling the dampening will also delete all the configured dampening parameters):

```
configure bgp neighbor [<ipaddress> | all] no-dampening
```

Use the following command to disable route flap dampening for a BGP peer group:

```
configure bgp peer-group <name> no-dampening
```

Viewing the Route Flap Dampening Configuration

Use the following command to view the configured values of the route flap dampening parameters for a BGP neighbor:

```
show bgp neighbor <ip address> {[accepted-routes | flap-statistics | received-routes |
rejected-routes | suppressed-routes | transmitted-routes] {detail} [community
[access-profile <access profile> | no-advertise | no-export | no-export-subconfed |
number <community number> | <autonomous system id>:<bgp community>] | as-path
[<as-path-expression> | access-profile <access profile>] | route-map <route map> |
network <ip address>/<mask> {exact} | all]}
```

Use the following command to view the configured values of the route flap dampening parameters for a BGP peer group:

```
show bgp peer-group {detail | <peer group> {detail}}
```

Viewing Route Flap Statistics

Use the following command to view the flap statistics of a particular route from BGP neighbor:

```
show bgp neighbor  <ip address> flap-statistics network <ip address>/<mask> {exact}
```

Use the following command to view the flap statistics of all the routes from a particular BGP neighbor:

```
show bgp neighbor <ip address> flap-statistics {detail} all
```

Use the following command to view the flap statistics of all the routes which matches a route map filter from a particular BGP neighbor:

```
show bgp neighbor <ip address> flap-statistics {detail} route-map <route map>
```

Use the following command to view the flap statistics of all the routes which matches a community criteria from a particular BGP neighbor:

```
show bgp neighbor <ip address> flap-statistics {detail} [community [access-profile
<access-profile> | <autonomous-system-id>:<bgp-community> | number <community_number>
| no-advertise | no-export | no-export-subconfed]
```

Use the following command to view the flap statistics of all the routes which matches a AS-PATH criteria from a particular BGP neighbor:

```
show bgp neighbor <ip address> flap-statistics {detail} as-path [access-profile
<access-profile> | <path-expression]
```

Clearing Route Flap Statistics

Use the following command to delete the flap statistics of a particular route from BGP neighbor:

```
clear bgp neighbor  <ip address> flap-statistics network <ip address>/<mask> {exact}
```

Use the following command to delete the flap statistics of all the routes from a particular BGP neighbor:

```
clear bgp neighbor <ip address> flap-statistics all
```

Use the following command to delete the flap statistics of all the routes which matches a route map filter from a particular BGP neighbor:

```
clear bgp neighbor <ip address> flap-statistics route-map <route map>
```

Use the following command to delete the flap statistics of all the routes which matches a community criteria from a particular BGP neighbor:

```
clear bgp neighbor <ip address> flap-statistics [community [access-profile
<access-profile> | <autonomous-system-id>:<bgp-community> | number <community_number>
| no-advertise | no-export | no-export-subconfed]
```

Use the following command to delete the flap statistics of all the routes which matches a AS-PATH criteria from a particular BGP neighbor

```
clear bgp neighbor <ip address> flap-statistics {detail} as-path [access-profile
<access-profile> | <path-expression]
```

Viewing Suppressed Routes

Use the following command to view a particular suppressed route from BGP neighbor

```
show bgp neighbor  <ip address> suppressed-routes network <ip address>/<mask> {exact}
```

Use the following command to view all the suppressed routes from a particular BGP neighbor

```
show bgp neighbor  <ip address> suppressed-routes {detail} all
```

Use the following command to view all the suppressed routes which matches a route-map filter from a particular BGP neighbor

```
show bgp neighbor  <ip address> suppressed-routes {detail} route-map <route map>
```

Use the following command to view all the suppressed routes which matches a community criteria from a particular BGP neighbor

```
show bgp neighbor <ip address> suppressed-routes {detail} [community [access-profile
<access-profile> | <autonomous-system-id>:<bgp-community> | number <community_number>
| no-advertise | no-export | no-export-subconfed]
```

Use the following command to view all the suppressed routes which matches a AS-PATH criteria from a particular BGP neighbor

```
show bgp neighbor <ip address> suppressed-routes {detail} as-path [access-profile
<access-profile> | <path-expression]
```

BGP Route Selection

BGP will select routes based on the following precedence (from highest to lowest):

- higher weight
- higher local preference
- shortest length (shortest AS path)
- lowest origin code
- lowest MED
- route from external peer
- lowest cost to Next Hop
- lowest routerID

Stripping Out Private AS Numbers from Route Updates

Private AS numbers are AS numbers in the range 64512 through 65534. You can remove private AS numbers from the AS path attribute in updates that are sent to external BGP (EBGP) neighbors. Possible reasons for using private AS numbers include:

- The remote AS does not have officially allocated AS numbers.
- You want to conserve AS numbers if you are multi-homed to the local AS.

Private AS numbers should not be advertised on the Internet. Private AS numbers can only be used locally within an administrative domain. Therefore, when routes are advertised out to the Internet, the routes can be stripped out from the AS Paths of the advertised routes using this feature.

To configure private AS numbers to be removed from updates, use the following command:

```
enable bgp neighbor [<ip address> | all] remove-private-AS-numbers
```

To disable this feature, use the following command:

```
disable bgp neighbor [<ip address> | all] remove-private-AS-numbers
```

Route Re-Distribution

BGP, OSPF, and RIP can be enabled simultaneously on the switch. Route re-distribution allows the switch to exchange routes, including static, direct, and VIP routes, between any two routing protocols.

Exporting routes from OSPF to BGP, and from BGP to OSPF, are discreet configuration functions. To run OSPF and BGP simultaneously, you must first configure both protocols and then verify the independent operation of each. Then you can configure the routes to export from OSPF to BGP and the routes to export from BGP to OSPF.

Configuring Route Re-Distribution

Exporting routes between any two routing protocols are discreet configuration functions. For example, you must configure the switch to export routes from OSPF to BGP and, if desired, you must configure the switch to export routes from BGP to OSPF. You must first configure both protocols and then verify the independent operation of each. Then you can configure the routes to export from OSPF to BGP and the routes to export from BGP to OSPF.

You can use route maps to associate BGP attributes including Community, NextHop, MED, Origin, and Local Preference with the routes. Route maps can also be used to filter out exported routes.

To enable or disable the exporting of OSPF, IS-IS, RIP, static, direct (interface), and VIP routes to BGP, use the following commands:

```
enable bgp export [[direct | ospf | ospf-extern1 | ospf-extern2 | ospf-inter |
ospf-intra | isis | isis-level-1 | isis-level-1-external | isis-level-2 |
isis-level-2-external | rip | static | vip] {<route map>}

disable bgp export [direct | ospf | ospf-extern1 | ospf-extern2 | ospf-inter |
ospf-intra | isis | isis-level-1 | isis-level-1-external | isis-level-2 |
isis-level-2-external | rip | static | vip]
```

Using the `export` command to redistribute routes complements the redistribution of routes using the `configure bgp add network` command. The `configure bgp add network` command adds the route to BGP only if the route is present in the routing table. The `enable bgp export` command redistributes an individual route from the routing table to BGP. If you use both commands to redistribute routes, the routes redistributed using the `network` command take precedence over routes redistributed using the `export` command.

20 IP Multicast Routing

This chapter covers the following topics:

- Overview on page 503
  - — DVMRP Overview on page 504
  - — PIM Overview on page 504
  - — IGMP Overview on page 508
  - — Multicast Tools on page 509
- Configuring IP Multicasting Routing on page 510
- Configuration Examples on page 512

For more information on IP multicasting, refer to the following publications:

- RFC 1112 – *Host Extension for IP Multicasting*
- RFC 2236 – *Internet Group Management Protocol, Version 2*
- DVMRP Version 3 – *draft_ietf_dvmrp_v3_07*
- PIM-DM Version 2 – *draft_ietf_pim_v2_dm_03*
- PIM-SM Version 2 – *draft_ietf_pim_sm_v2_new_04*

The following URLs point to the Web sites for the IETF Working Groups:

IETF DVMRP Working Group:

http://www.ietf.org/html.charters/idmr-charter.html

IEFT PIM Working Group:

http://www.ietf.org/html.charters/pim-charter.html

Overview

IP multicast routing is a function that allows a single IP host to send a packet to a group of IP hosts. This group of hosts can include devices that reside on the local network, within a private network, or outside of the local network.

IP multicast routing consists of the following functions:

- A router that can forward IP multicast packets.
- A router-to-router multicast routing protocol (for example, Distance Vector Multicast Routing Protocol (DVMRP) or Protocol Independent Multicast (PIM)).
- A method for the IP host to communicate its multicast group membership to a router (for example, Internet Group Management Protocol (IGMP)).

NOTE

You should configure IP unicast routing before you configure IP multicast routing.

DVMRP Overview

DVMRP is a distance vector protocol that is used to exchange routing and multicast information between routers. Like RIP, DVMRP periodically sends the entire routing table to its neighbors.

DVMRP has a mechanism that allows it to prune and graft multicast trees to reduce the bandwidth consumed by IP multicast traffic.

PIM Overview

The switch supports both dense mode and sparse mode operation. You can configure dense mode or sparse mode on a per-interface basis. Once enabled, some interfaces can run dense mode, while others run sparse mode.

PIM Dense Mode

Protocol Independent Multicast-Dense Mode (PIM-DM) is a multicast routing protocol that is similar to DVMRP. PIM-DM routers perform reverse path multicasting (RPM). However, instead of exchanging its own unicast route tables for the RPM algorithm, PIM-DM uses the existing unicast route table for the reverse path. As a result, PIM-DM requires less system memory.

PIM-DM is a broadcast and prune protocol. Using PIM-DM, multicast routes are pruned and grafted in a way similar to DVMRP.

PIM Sparse Mode (PIM-SM)

Unlike PIM-DM, PIM-SM is an explicit join and prune protocol, and it supports shared trees as well as shortest path trees (SPTs). The routers must explicitly join the group(s) in which they are interested in becoming a member, which is beneficial for large networks that have group members who are sparsely distributed.

Using PIM-SM, the router sends a join message to the rendezvous point (RP). The RP is a central multicast router that is responsible for receiving and distributing multicast packets. By default, the user configured RP is dynamic. You can also define a static RP in your network.

When a router has a multicast packet to distribute, it encapsulates the packet in a unicast message and sends it to the RP. The RP decapsulates the multicast packet and distributes it among all member routers.

When a router determines that the multicast rate has exceeded a configured threshold, that router can send an explicit join to the originating router. Once this occurs, the receiving router gets the multicast directly from the sending router, and bypasses the RP.

NOTE

You can run either PIM-DM or PIM-SM per VLAN.

PIM Mode Interoperation

An Extreme Networks switch can function as a PIM multicast border router (PMBR). A PMBR integrates PIM-SM and PIM-DM traffic.

When forwarding PIM-DM traffic into a PIM-SM network, the PMBR notifies the RP that the PIM-DM network exists. The PMBR forwards PIM-DM multicast packets to the RP, which, in turn, forwards the packets to those routers that have joined the multicast group.

The PMBR also forwards PIM-SM traffic to a PIM-DM network, based on the (*.*.RP) entry. The PMBR sends a join message to the RP and the PMBR forwards traffic from the RP into the PIM-DM network.

No commands are required to enable PIM mode interoperation. PIM mode interoperation is automatically enabled when a dense mode interface and a sparse mode interface are enabled on the same switch.

PIM Snooping

PIM snooping handles multicast traffic on shared media networks, in current networks where routers are connected to an L2 switch, and where multicast traffic is essentially treated as broadcast traffic. When switch ports are flooded with multicast packets, PIM snooping addresses this flooding behavior by efficiently replicating multicast traffic only onto ports which advertise the group membership requests.

Extreme devices that support PIM snooping are capable of intercepting PIM hello and join/prune messages without impacting the L2 forwarding rules. These devices can set up hardware entries based on the snooped join/prunes per VLAN, limiting the scope of the multicast traffic only to the ports that are attached to receivers for that group.

An Extreme switch snoops on the PIM JOIN/PRUNE control packets received from the PIM routers connected to the switch and builds a multicast traffic distribution database. This database is used to limit the multicast traffic onto only those ports that received the membership requests.

The following figures illustrate data traffic flow with and without PIM snooping enabled.

Figure 93: Data traffic flow without PIM snooping enabled

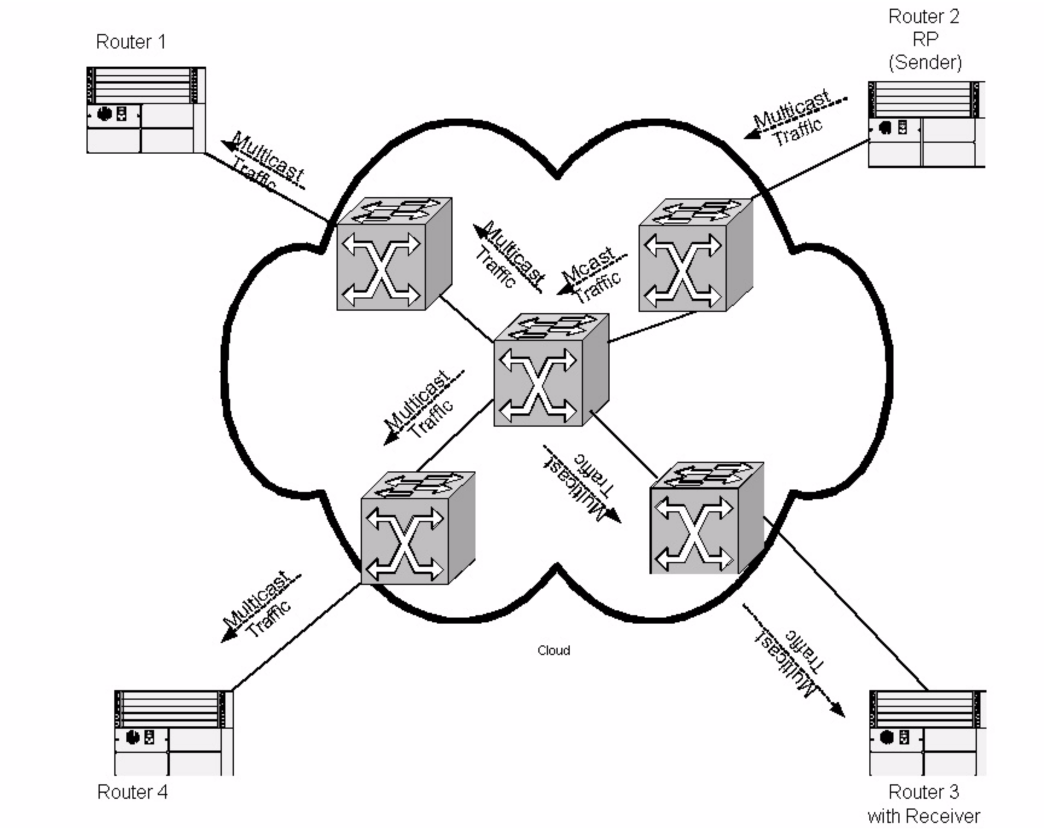
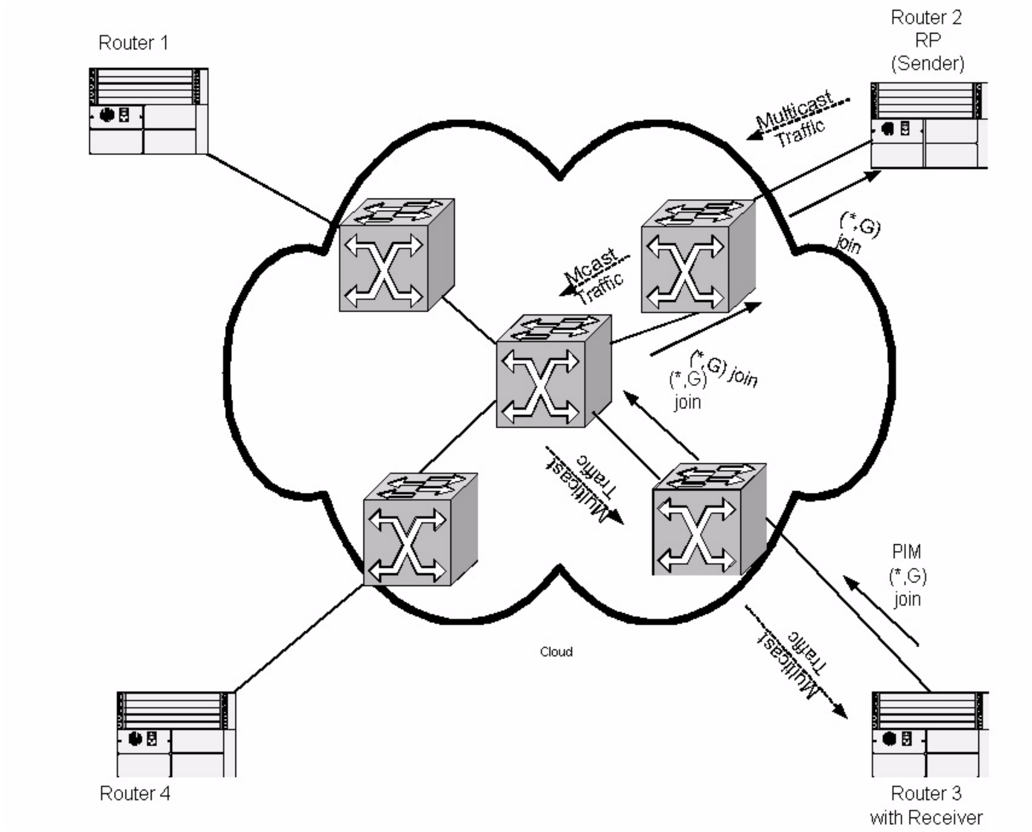


Figure 94: Data traffic flow with PIM snooping enabled



With PIM snooping enabled it not only restricts the mutlicast traffic flow only to relevant ports but also will provide some amount of security, restricting the scope of the traffic which can be snooped by a malicious user, making it hard to guess the PIM control plane.

With PIM snooping enabled, multicast traffic flow is restricted only to relevant ports, providing some additional security. Restricting the scope of traffic that can be snooped by a malicious user makes it difficult to guess the PIM control plane.

Configuring PIM Snooping. Use the following command to enable PIM snooping for a selected VLAN:

```
enable pim snooping {vlan <vlan name>}
```

To enable PIM snooping on a single VLAN, specify the VLAN name. If no VLAN name is specified, PIM snooping is enabled on all VLANs.

Use the following command to disable PIM snooping for a selected VLAN:

```
disable pim snooping {vlan <vlan name>}
```

To disable PIM snooping on a single VLAN, specify the VLAN name. If no VLAN name is specified, PIM snooping is disabled on all VLANs.

Use the following command to display PIM snooping information for a selected VLAN:

```
show pim snooping {vlan <vlan name>}
```

To display PIM snooping for a single VLAN, specify the VLAN name. If no VLAN name is specified, PIM snooping information is displayed for all VLANs

IGMP Overview

IGMP is a protocol used by an IP host to register its IP multicast group membership with a router. Periodically, the router queries the multicast group to see if the group is still in use. If the group is still active, a single IP host responds to the query, and group registration is maintained.

IGMP is enabled by default on the switch. However, the switch can be configured to disable the generation of periodic IGMP query packets. IGMP should be enabled when the switch is configured to perform IP unicast or IP multicast routing. IGMP must be enabled if the switch is configured for DVMRP.

IGMP Snooping

IGMP snooping is a layer 2 function of the switch. It does not require multicast routing to be enabled. In IGMP snooping, the layer 2 switch keeps track of IGMP requests, and only forwards multicast traffic to the part of the local network that requires it. IGMP snooping optimizes the usage of network bandwidth, and prevents multicast traffic from being flooded to parts of the local network that do not need it. The switch does not reduce any IP multicast traffic in the local multicast domain (224.0.0.x).

IGMP snooping is enabled by default on the switch. If IGMP snooping is disabled, all IGMP and IP multicast traffic floods within a given VLAN. IGMP snooping expects at least one device on every VLAN to periodically generate IGMP query messages. The static IGMP snooping entries do not require periodic query. An optional optimization for IGMP snooping is the strict recognition of multicast routers only if the remote devices have joined the DVMRP (224.0.0.4) or PIM (244.0.0.13) multicast groups.

When a port sends an IGMP leave message, the switch removes the IGMP snooping entry after 1000 milli-seconds (the leave time is configurable, ranging from 0 to 10000 ms). The switch sends a query to determine which ports want to remain in the multicast group. If other members of the VLAN want to remain in the multicast group, the router ignores the leave message, but the port that requests removal is removed from the IGMP snooping table.

If the last port within a VLAN sends an IGMP leave message, then the router will not receive any responses to the query, and the router immediately will remove the VLAN from the multicast group.

Static IGMP

In order to receive multicast traffic, a host needs to explicitly join a multicast group by sending an IGMP request, then the traffic is forwarded to that host. There are situations where you would like multicast traffic to be forwarded to a port where a multicast enabled host is not available (for example, testing multicast configurations). Static IGMP emulates a host or router attached to a switch port, so that multicast traffic will be forwarded to that port. Emulate a host to forward a particular multicast group to a port; emulate a router to forward all multicast groups to a port. Use the following command to emulate a host on a port:

```
configure igmp snooping vlan <vlan name> ports <portlist> add static group <ip
address>
```

Use the following command to emulate a multicast router on a port:

```
configure igmp snooping vlan <vlan name> ports <portlist> add static router
```

To remove these entries, use the corresponding command:

```
configure igmp snooping vlan <vlan name> ports <portlist> delete static group [<ip
address> | all]
configure igmp snooping vlan <vlan name> ports <portlist> delete static router
```

To display the IGMP snooping static groups, use the following command:

```
show igmp snooping {vlan <vlan name>} static group
```

IGMP Snooping Filters

IGMP snooping filters allow you to configure an access profile on a port to allow or deny IGMP report and leave packets coming into the port. For details on creating access profiles, see the section, “Routing Access Profiles” on page 308. For the access profiles used as IGMP snooping filters, all the profile entries should IP address type entries, and the IP address of each entry must be in the class-D multicast address space, but should not be in the multicast control subnet range (224.0.0.x/24). After you have created an access profile, use the following command to associate the access profile and filter with a set of ports:

```
configure igmp snooping vlan <vlan name> ports <portlist> filter [<access profile> |
none]
```

To remove the filter, use the `none` option as shown in tyhe following example:

```
configure igmp snooping vlan <vlan name> ports <portlist> filter none
```

To display the IGMP snooping filters, use the following command:

```
show igmp snooping {vlan <vlan name>} filter
```

Multicast Tools

ExtremeWare provides two commonly available tools to monitor and troubleshoot IP multicast, `mrinfo` and `mtrace`.

Mrinfo

The multicast router information tool, (mrinfo), uses the facility provided in DVMRP for requesting information from a router that could be used for tracing and troubleshooting. A request is sent to a multicast router, and the router responds with the following information:

- code version
- system multicast information
- interface information
  - — interface IP address
  - — interface multicast capabilities
  - — metric configured on the interface
  - — threshold configured on the interface
  - — count and IP address of the neighbors discovered on the interface

Use the following command to send an `mrinfo` request:

```
mrinfo <ip address> {from <ip address>} {timeout <seconds>}
```

Mtrace

Multicast trace (mtrace) relies on a feature of multicast routers that is accessed using the IGMP protocol. Since multicast uses reverse path forwarding, a multicast trace is run from the destination to the source. A query packet is sent to the last-hop multicast router. This router builds a trace response packet, fills in a report for its hop, and forwards the packet to the next upstream router. As the request is forwarded, each router in turn adds its own report to the trace response. When the request reaches the first-hop router, the filled in request is sent back to the system requesting the trace. The request will also be returned if the maximum hop limit is reached.

If a router does not support the mtrace functionality, it will silently drop the request packet and no information will be returned. For this situation, you could send the trace with a small number of maximum hops allowed, increasing the number of hops as the stream is traced.

The group IP address must be in the class-D multicast address space, but should not be in the multicast control subnet range (224.0.0.x/24).

Use the following command to trace a multicast stream:

```
mtrace source <ip address> {destination <ip address>} {group <ip address>} {from <ip
address>} {gateway <ip address >} {timeout <seconds>} {maximum-hops <number>}
```

Performance Enhancements for the BlackDiamond Switch

The BlackDiamond switch can optimize multicast data forwarding performance for modules that use the "i" series chipset. To increase the performance of multicast applications, you can disable I/O modules in the system that do not use the "i" series chipset.

In addition, you can modify the backplane load-sharing policy for more robust support of multicast streams.

NOTE

The round-robin algorithm is not supported on non-"i" series I/O modules. The default backplane loadsharing policy is "port-based".

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

```
configure backplane-ls-policy [address-based | port-based | round-robin]
```

NOTE

For more information on load sharing, see Chapter 4.

Configuring IP Multicasting Routing

To configure IP multicast routing, you must do the following:

1 Configure the system for IP unicast routing.

2 Enable multicast routing on the interface using the following command:

```
enable ipmcforwarding {vlan <vlan name>}
```

3 Enable DVMRP or PIM on all IP multicast routing interfaces using one of the following commands:

```
configure dvmrp add vlan [<vlan name> | all]
```

```
configure pim add vlan [<vlan name> | all] {dense | sparse}
```

4 Enable DVMRP or PIM on the router using one of the following commands:

`enable dvmrp rxmode vlan [<vlan name> | all]` or `enable dvmrp txmode vlan [vlan <vlan name> | all]`

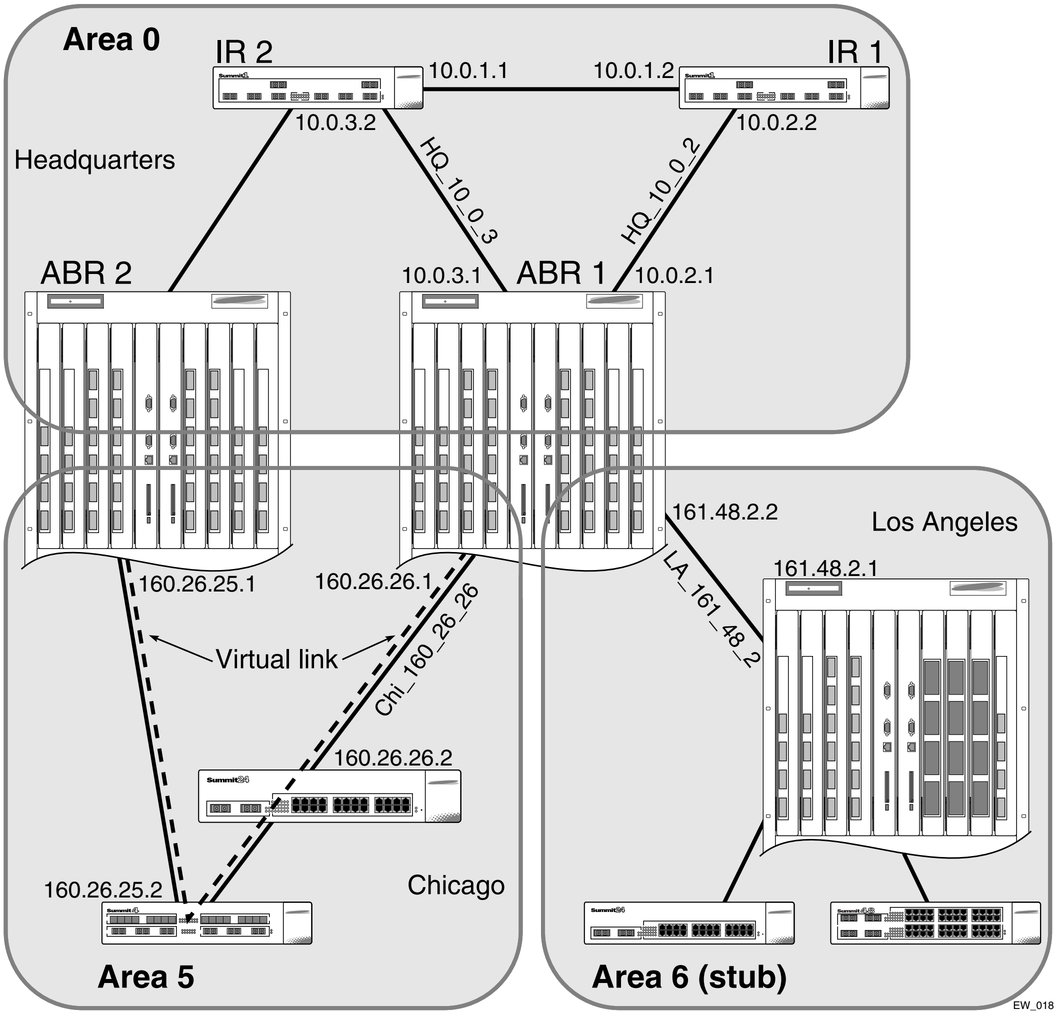
```
enable pim
```

Configuration Examples

Figure 95 andFigure 96 are used in Chapter 18 to describe the OSPF configuration on a switch. Refer to Chapter 18 for more information about configuring OSPF. In the first example, the system labeled IR1 is configured for IP multicast routing, using PIM-DM. In the second example, the system labeled ABR1 is configured for IP multicast routing using PIM-SM.

PIM-DM Configuration Example

Figure 95: IP multicast routing using PIM-DM configuration example



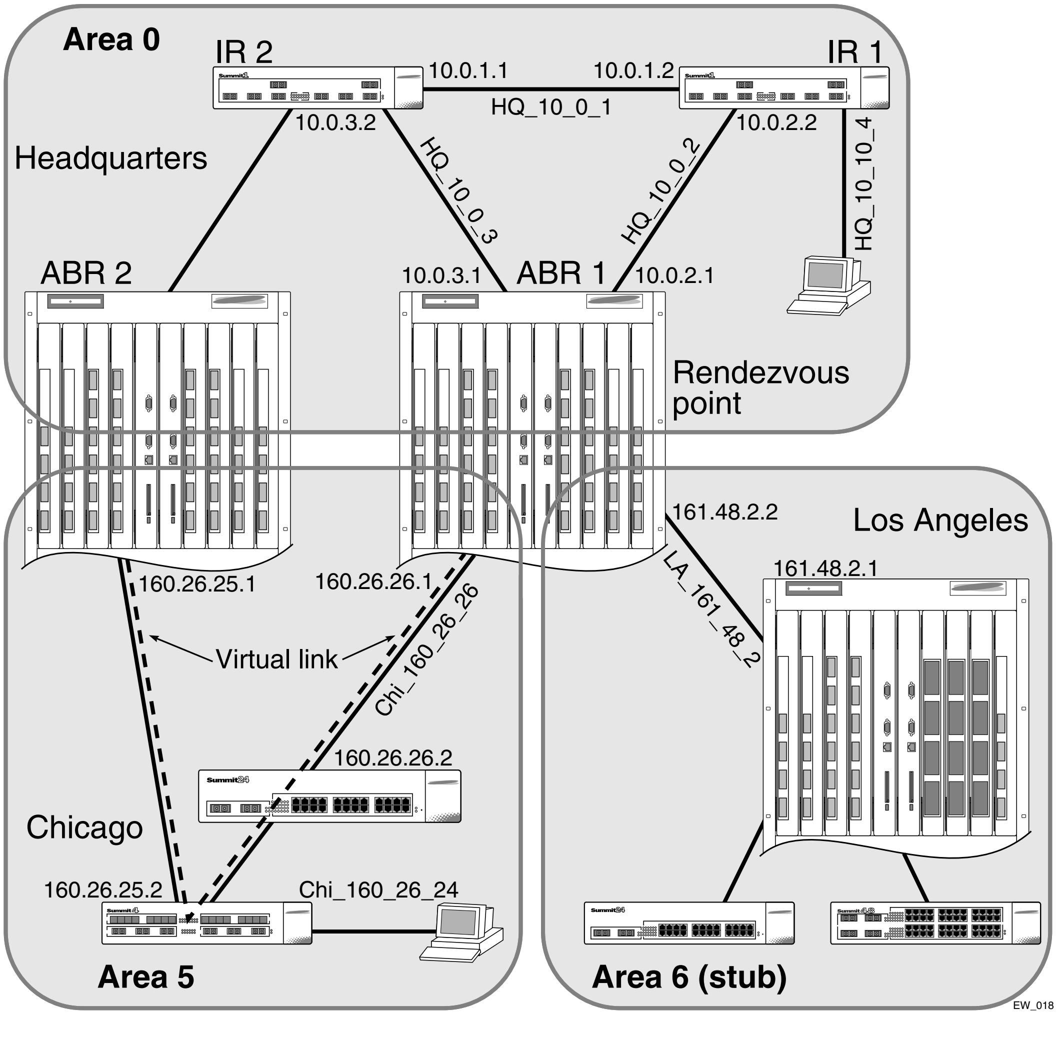
Configuration for IR1

The router labeled IR1 has the following configuration:

```
configure vlan HQ_10_0_1 ipaddress 10.0.1.2 255.255.255.0
configure vlan HQ_10_0_2 ipaddress 10.0.2.2 255.255.255.0
configure ospf add vlan all
enable ipforwarding
enable ospf
enable ipmcforwarding
configure pim add vlan all dense
enable pim
```

The following example configures PIM-SM.

Figure 96: IP multicast routing using PIM-SM configuration example



Configuration for ABR1

The router labeled ABR1 has the following configuration:

```
configure vlan HQ_10_0_2 ipaddress 10.0.2.1 255.255.255.0
configure vlan HQ_10_0_3 ipaddress 10.0.3.1 255.255.255.0
configure vlan LA_161_48_2 ipaddress 161.48.2.2 255.255.255.0
configure vlan CHI_160_26_26 ipaddress 160.26.26.1 255.255.255.0
configure ospf add vlan all
enable ipforwarding
enable ipmcforwarding
configure pim add vlan all sparse
create access-profile rp-list ipaddress
configure rp-list add ipaddress 224.0.0.0 240.0.0.0
enable loopback HQ_10_0_3
configure pim crp HQ_10_0_3 rp-list 30
configure pim cbsr HQ_10_0_3 30

configure pim spt-threshold 16 8
```

Configuring Static Multicasting Routing

To configure static multicast routing use the following command to add a static multicast route to the static multicast routing table:

```
configure mroute add <source>/<mask> {<protocol>} <rpf-address> {<distance>}
```

Use the following command to delete a static multicast route from the static multicast routing table:

```
configure mroute delete <source>/<mask> {<protocol>} <rpf-address> {<distance>}
```

To display the static multicast routing table, use the following command:

```
show mroute
```

This command displays the static multicast table entries in the order defined with the `configure mroute add` command.

21 IPX Routing

This chapter describes the following topics:

- Overview of IPX on page 515
- IPX/RIP Routing on page 518
- Configuring IPX on page 519
- IPX Configuration Example on page 521

This chapter assumes that you are already familiar with IPX. If not, refer to your Novell™ documentation.

Overview of IPX

The switch provides support for the IPX, IPX/RIP, and IPX/SAP protocols. The switch dynamically builds and maintains an IPX routing table and an IPX service table.

Router Interfaces

The routing software and hardware routes IPX traffic between IPX router interfaces. A router interface is simply a VLAN that has an IPX network identifier (NetID) and IPX encapsulation type assigned to it.

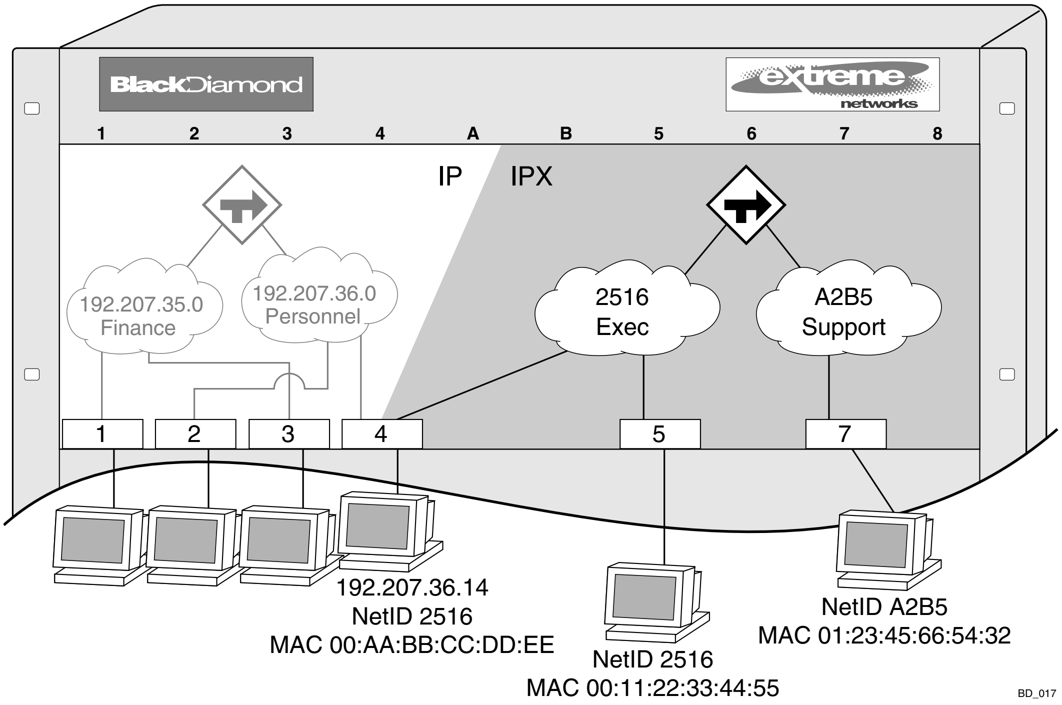
As you create VLANs with different IPX NetIDs the switch automatically routes between them. Both the VLAN switching and IPX routing function occur within the switch.###

Extreme switches support these IPX routing features:

- Separate routing interfaces for IP and IPX traffic on the same VLAN
- Load sharing of IPX routed traffic
- 802.1Q tagged packets on a routed IPX VLAN

Figure 97 shows the same BlackDiamond switch discussed in earlier chapters. In Figure 97, IPX routing has been added to the BlackDiamond switch, and two additional VLANs have been defined; *Exec* and *Support*. Both VLANs have been configured as protocol-specific VLANs, using IPX.

Figure 97: IPX VLAN configuration



Exec has been assigned the IPX NetID 2516. *Support* has been assigned the IPX NetID A2B5. All ports on slot 5 are assigned to *Exec*; all ports on slot 7 are assigned to *Support*. In addition, all ports on slot 4 have been assigned to *Exec*. Thus, the ports on slot 4 belong to both the *Personnel* VLAN (running IP) and the *Exec* VLAN (running IPX).

Traffic within each VLAN is switched using the Ethernet MAC address. Traffic between *Exec* and *Support* is routed using the IPX NetID. Traffic cannot be sent between the IP VLANs (*Finance* and *Personnel*) and the IPX VLANs (*Exec* and *Support*).

IPX Routing Performance

Extreme switches are capable of performing IPX routing at wire-speed.

IPX Load Sharing

ExtremeWare supports IPX load sharing on all products that use the “i” chipset. No additional configuration is required to support this function, simply configure load sharing as you would normally.

NOTE

For more information on load sharing, see Chapter 4.

IPX Encapsulation Types

Novell NetWare™ supports four types of frame encapsulation. The ExtremeWare term for each type is described in Table 63.

Table 63: IPX Encapsulation Types

Name	Description
ENET_II	The frame uses the standard Ethernet 2 header.
ENET_8023	The frame includes the IEEE 802.3 length field, but does not include the IEEE 802.2 Logical Link Control (LLC) header. This encapsulation is used by NetWare version 2.x and the original 3.x version.
ENET_8022	The frame uses the standard IEEE format and includes the IEEE 802.2 LLC header. This encapsulation is used by NetWare version 3.12 and 4.x.
ENET_SNAP	The frame adds a Subnetwork Access Protocol (SNAP) header to the IEEE 802.2 LLC header.

To configure a VLAN to use a particular encapsulation type, use the following command:

```
configure vlan <vlan name> xnetid <netid> [enet_ii | enet_8023 | enet_8022 |
enet_snap]
```

Tagged IPX VLANs

ExtremeWare supports tagged 802.1Q traffic on an IPX VLAN that is performing routing. Tagging is most commonly used to create VLANs that span multiple switches. Using VLAN tags, multiple VLANs can span multiple switches using one or more trunks. In a port-based VLAN, each VLAN requires its own pair of trunk ports.

Another benefit of tagged VLANs is the ability to have a port be a member of multiple VLANs. This is particularly useful if you have a device (such as a server) that must belong to multiple VLANs. A single port can be a member of only one port-based VLAN. All additional VLAN memberships for that port must be configured with tags.

To configure a tagged IPX VLAN, assign a tag to the VLAN using the following command:

```
configure vlan <vlan name> tag <vlan tag>
```

The valid range is from 1 to 4095.

To assign tagged ports to the VLAN, use the following command:

```
configure vlan <vlan name> add ports <portlist> {tagged | untagged} {nobroadcast}
{soft-rate-limit}
```

To display your VLAN settings, use the following command:

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

Populating the Routing Table

The switch builds and maintains an IPX routing table. As in the case of IP, the table is populated using dynamic and static entries.

Dynamic Routes

Dynamic routes are typically learned by way of IPX/RIP. Routers that use IPX/RIP exchange information in their routing tables in the form of advertisements. Using dynamic routes, the routing table contains only networks that are reachable.

Dynamic routes are aged out of the table when an update for the network is not received for a period of time, as determined by the routing protocol.

Static Routes

Static routes are manually entered into the routing table. Static routes are used to reach networks not advertised by routers. You can configure up to 64 static IPX routes on the switch. Static routes are never aged out of the routing table. Static routes are advertised to the network using IPX/RIP.

IPX/RIP Routing

The switch supports the use of IPX/RIP for unicast routing. IPX/RIP is different from IP/RIP. However, many of the concepts are the same. ExtremeWare supports the following IPX/RIP features:

- Split horizon
- Poison reverse
- Triggered Updates

Route information is entered into the IPX route table in one of the following two ways:

- Dynamically, by way of RIP
- Statically, using the command:

  ```
  configure ipxroute add [<dest_netid> | default] <next_hop_id> <next_hop_node_addr>
  <hops> <tics>
  ```

IPX/RIP is automatically enabled when a NetID is assigned to the VLAN. To remove the advertisement of an IPX VLAN, use the command:

```
configure ipxrip delete vlan [<vlan name> | all]
```

GNS Support

ExtremeWare supports the Get Nearest Server (GNS) reply function. When a NetID is assigned to the switch, the GNS reply service is automatically enabled. When a station requests a particular service on the network (for example, locating a print server), the station sends a GNS request and the switch responds to the request. If GNS-reply is disabled, the switch drops the request.

To disable GNS-reply, use the following command:

```
disable ipxsap gns-reply {vlan <vlan name>}
```

Routing SAP Advertisements

The switch contains an IPX Service Table, and propagates SAP advertisements to other IPX routers on the network. Each SAP advertisement contains the following:

- Service type
- Server name
- Server NetID
- Server node address

The service information is entered into the IPX Service Table in one of the following two ways:

- Dynamically, by way of SAP
- Statically, using the following command:

  ```
  configure ipxservice add <service_type> <service_name> <netid> <mac_address>
  <socket> <hops>
  ```

Configuring IPX

This section describes the commands associated with configuring IPX, IPX/RIP, and IPX/SAP on the switch. To configure IPX routing, follow these steps:

1. Create at least two VLANs.
2. If you are combining an IPX VLAN with another VLAN on the same port(s), you must use a protocol filter on one of the VLANs, or use 802.1Q tagging.
3. Assign each VLAN a NetID and encapsulation type using the following command:

   ```
   configure vlan <vlan name> xnetid <netid> [enet_ii | enet_8023 | enet_8022 |
   enet_snap]
   ```

   Ensure that each VLAN has a unique IPX NetID and that the encapsulation type matches the VLAN protocol.

   Every IPX VLAN has an internal VLAN ID that is created automatically. Every MAC address learned from the port associated with the IPX VLAN has two forwarding database (FDB) entries:

   — external VLAN ID entry

   — internal VLAN ID entry

Once you configure the IPX VLAN information, IPX forwarding automatically begins to function. Specifically, configuring the IPX VLAN automatically enables the IPX/RIP, IPX/SAP, and SAP GNS services.

Verifying IPX Router Configuration

You can use the following commands to verify the IPX routing configuration:

- `show vlan`—In addition to other information, this command displays the IPX NetID setting and encapsulation type.
- `show ipxconfig`—This command is analogous to the `show ipconfig` command for the IP protocol. It displays summary global IPX configuration information followed by per-VLAN information. Information includes enable/disable status for IPX/RIP, IPX/SAP, IPX route sharing, IPX service sharing, and so on.
- `show ipxroute`—This command is analogous to the `show iproute` command for the IP protocol. It displays static and learned routes, along with information about the VLAN that uses the route, hop count, age of the route, and so on.
- `show ipxsap`—This command displays the enable status of IPX/SAP for the VLAN, and its operational and administrative status (including the GNS reply service). It also lists any identified IPX/SAP neighbors, SAP packet statistics, and several other timer settings.
- `show ipxrip`—This command displays the enable status of IPX/RIP for the VLAN, including operational and administrative status. It also lists any identified IPX/RIP neighbors, RIP packet statistics, and several other timer settings.
- `show ipxservice`—This command displays the contents of the IPX Service Table.

Protocol-Based VLANs for IPX

When combining IPX VLANs with other VLANs on the same physical port, it may be necessary to assign a protocol filter to the VLAN. This is especially true if it is not possible to use 802.1Q VLAN tagging. For convenience, IPX-specific protocol filters have been defined and named in the default configuration of the switch. Each filter is associated with a protocol encapsulation type. The IPX-specific protocol filters and the associated encapsulation type of each are described in Table 64.

Table 64: IPX Protocol Filters and Encapsulation Types

Protocol Name	Protocol Filter	Used for Filtering IPX Encapsulation Type
IPX	eypte 0x8137	enet_ii
IPX_8022	llc 0xe0e0	enet_802_2
IPX_snap	SNAP 0x8137	enet_snap

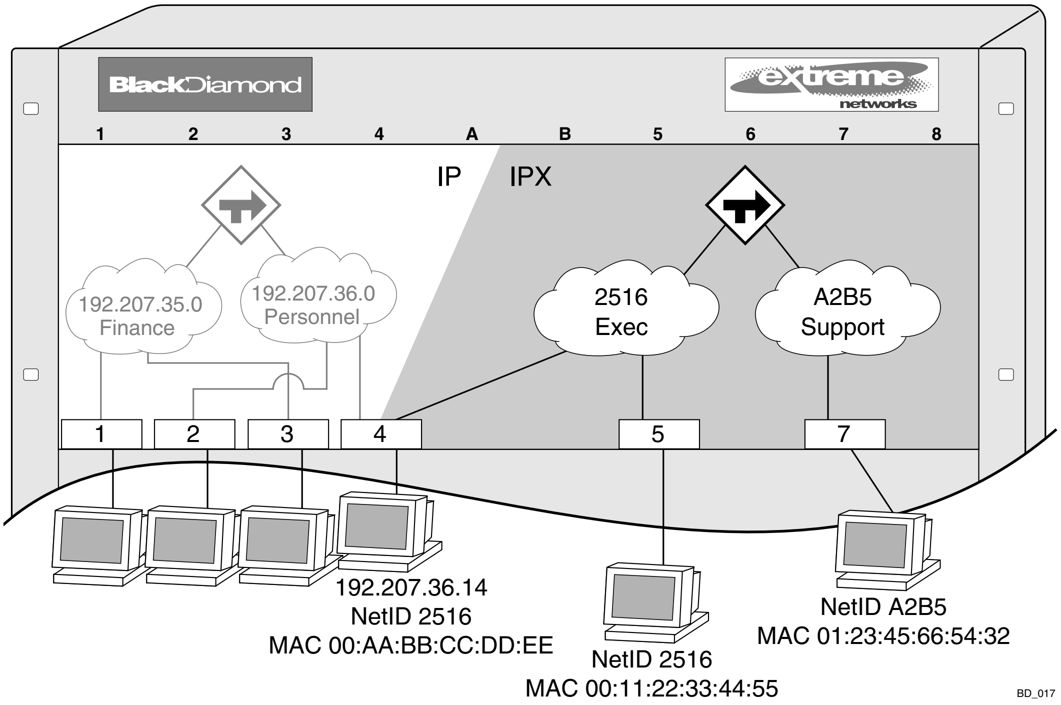
It is not possible to define a protocol-sensitive VLAN for filtering the IPX `enet_8023` encapsulation type. Instead, use a protocol-sensitive filter on the other VLANs that share the same ports, leaving the `enet_8023` encapsulation VLAN configured using the `any` protocol.

IPX Configuration Example

Figure 98 builds on the example showing the IP/RIP configuration that was used in earlier chapters. Now, in addition to having IP VLANs configured, this example illustrates a switch that has the following IPX VLANs defined:

- *Exec*
  - — Protocol-sensitive VLAN using the IPX protocol with the filter IPX_8022.
  - — All ports on slot 4 and slot 5 have been assigned to *Exec.*
  - — *Exec* is configured for IPX NetID 2516 and IPX encapsulation type 802.2.
- *Support*
  - — All ports on slot 7 have been assigned to *Support.*
  - — *Support* is configured for IPX NetID A2B5 and IPX encapsulation type 802.2.

Figure 98: IPX routing configuration example



The stations connected to the system generate a combination of IP traffic and IPX traffic. The IP traffic is filtered by the IP VLANs. IPX traffic is filtered by the IPX VLANs.

In this configuration, all IP traffic from stations connected to slots 1 and 3 have access to the IP router by way of the VLAN *Finance*. IP traffic on ports on slots 2 and 4 reach the IP router by way of the VLAN *Personnel*.

Similarly, IPX traffic from stations connected to slots 4 and 5 have access to the IPX router by way of the VLAN *Exec*. IPX traffic on ports on slot 7 reach the IPX router by way of the VLAN *Support*. Both *Exec* and *Support* use enet_8022 as the encapsulation type.

The IPX configuration shown in example in Figure 98 is as follows:

```
create vlan Exec
create vlan Support

configure Exec protocol ipx_8022

configure Exec add port 4:*,5:*
configure Support add port 7:*

configure Exec xnetid 2516 enet_8022
configure Support xnetid A2B5 enet_8022
```

Part 3
Configuring Modules

22 Accounting and Routing Module (ARM)

The Accounting and Routing Module (ARM) is a self-contained module for the BlackDiamond 6800 series chassis-based system. Unlike most other BlackDiamond modules, there are no external network interfaces on the ARM. Instead, the ARM provides advanced IP services for the other input/output (I/O) modules installed in the chassis. The ARM contains a powerful set of packet processing resources that operate in a one-armed fashion: receiving frames from the switch fabric, processing the frames, and transmitting the frames back into the switch fabric. More specifically, the accounting feature is used to track and record IP unicast packets. This enables you to create custom billing rates for your customers.

This chapter covers the following topics:

- Summary of Features on page 525
- Configuring the ARM on page 529
- ARM Configuration Examples on page 535
- Retrieving Accounting Statistics on page 544
- Diagnostics Commands on page 545
- Layer 2 and Layer 3 Switching Attributes on page 546
- Debug Trace Commands on page 546

Summary of Features

The ARM includes the following features:

- **Selective Longest Prefix Match—**IP unicast packets are routed in the ARM hardware using a longest prefix match (LPM) algorithm. This differs from the BlackDiamond switch fabric, which uses an exact match algorithm. The BlackDiamond switch fabric has great forwarding capacity, but the ARM module has better handling of large numbers (hundreds of thousands) of destination IP addresses to match each packet's destination IP address. To take advantage of the BlackDiamond switch fabric forwarding capacity and the ARM module's scalability, the ARM module can be configured to use the BlackDiamond switch fabric for some routes and the ARM's LPM for others. This feature is called Selective Longest Prefix Match (Selective-LPM).
- **Destination-Sensitive Accounting—**Destination Sensitive Accounting gives you the flexibility to bill your customers at predetermined and different rates. The rates are based on the customers' IP unicast packet destinations.

The accounting feature categorizes IP unicast packets using two parameters, input VLAN ID and accounting bin number. The VLAN ID is used to identify from which customer the packet is received. The accounting bin number is associated with the route used to forward the packet. External billing application servers can correlate the accounting bin number to a specific billing rate.

ARM Module Limitations

The following limitations apply to the ARM module:

- SLB is a mutually exclusive function with ARM
- Selective LPM is not supported when Accounting is enabled (all IP traffic is LPM routed)
- Flows are not redirected if the flow redirection rule destination matches a subnet that is LPM enabled
- IPX routing is not supported
- PoS/ATM bridging is not compatible with ARM when two MSMs are installed
- ARM and MPLS modules cannot be installed in the same switch
- Commands with port parameters are not directly applicable to the ARM

About IP Unicast Forwarding

IP unicast forwarding is performed on the ARM to facilitate implementation of accounting. When `lpm` or `accounting` is enabled, the ARM, rather than the switch fabric hardware, performs some or all of the layer-3 IP unicast forwarding. Layer-2 switching and layer-3 IP multicast forwarding are unaffected.

The ExtremeWare software distributes its IP unicast routing table, ARP table, and interface IP addresses to each ARM so that every ARM contains the same IP routing database.

Each ARM has sufficient capacity to support 239 K IP longest prefix match lookup route entries. Each route entry also supports up to four equal-cost paths, providing a maximum routing database capacity of 958 K routes. IP forwarding is configurable per VLAN.

Each ARM IP routing database provides an aggregate IP forwarding throughput of up to 4 Gbps. The total forwarding throughput for a single BlackDiamond chassis can be scaled up to 16 Gbps by adding up to three ARMs. ARMs interface to the BlackDiamond switch fabric via four 1 Gbps internal links. IP unicast traffic is internally forwarded from the BlackDiamond I/O modules using one of three backplane load sharing policies: port-based, address-based, or round-robin. The default backplane load-sharing policy is port-based. The round-robin load sharing backplane is not recommended because packet ordering is not guaranteed.

About Selective Longest Prefix Match

Selective Longest Prefix Match (SLPM) provides control over the method by which IP unicast packets are routed. The routing method can be specified for individual VLANs and routes. Packets may either be routed using the Longest Prefix Match (LPM) algorithm, or they may be routed using an IP address-caching method. To configure SLPM on a per VLAN basis, the ExtremeWare `enable ipforwarding lpm-routing` and `disable ipforwarding lpm-routing` commands are used. To configure SLPM on a per route basis, the ExtremeWare `route-map` command is used.

The LPM algorithm is supported in two ways on the BlackDiamond. The first method is implemented by the ExtremeWare software and runs on the MSM's CPU. The second method is implemented in hardware on either the MPLS module or the ARM. When one or more MPLS modules or ARMs are installed and active, LPM processing is performed on those modules. Packets destined to VLANs or routes that are configured for LPM are forwarded to the MPLS modules or ARMs for processing when SLPM is enabled. The term for packets forwarded in this manner is "LPM routing."

The IP address-caching method is implemented in hardware on both the MSM and many of the I/O modules. On Extreme Networks products, this IP address cache is called the IP Forwarding Database (IP FDB). Packets destined to VLANs or routes that are not configured for LPM routing will not be sent to the MPLS module or ARM for processing. The term for packets forwarded in this manner is "IP host routing." The default forwarding behavior for IP unicast packets is IP host routing.

Due to the nature of the IP FDB, the overall system performance can suffer under adverse conditions. Under heavy traffic loads with a large number of destination IP addresses, updating IP FDB entries can tax the system's CPU resources. Similarly, network topology changes can cause large numbers of IP FDB entries to be added or deleted, taxing the system's CPU. Enabling LPM routing can allow forwarding decisions for one or more traffic flows to bypass the IP FDB and reduce the load on the CPU.

SLPM, when enabled, also augments the performance of "slow path" forwarding. Under normal circumstances, if an IP packet received by the system has a destination IP address that cannot be found in the IP FDB, the CPU must forward that packet. Inserting an MPLS module or ARM, and enabling SLPM allows slow path processing to be performed by the module's hardware at a greatly accelerated rate.

The choice of when to configure LPM routing versus IP host routing depends on two criteria:

- The ratio of destination IP addresses to IP routes.
- Bandwidth requirements for IP traffic flows.

When the ratio of destination IP addresses to IP routes is extremely high, as is usually the case for a switch connected to the Internet, LPM routing should be considered. Typically, LPM routing would be enabled for any VLAN containing ports that connect to the Internet. However, LPM routing can be beneficial in any circumstance where the number of IP addresses in a destination network greatly exceeds the number of routes being advertised by that network. For example, LPM routing could be enabled for a network consisting mainly of end-user computers or one consisting of dial-up customers.

The amount of bandwidth required by specific IP traffic flows needs to considered as well. LPM routing is performed by hardware on the MPLS modules or ARMs installed in the system. Each module is capable of processing 4 Gbps of traffic at maximum, and a maximum of four modules can be installed. This places an upper limit of 16 Gbps of throughput for traffic being LPM routed. If the aggregate bandwidth for a set of IP traffic flows exceeds the LPM routing bandwidth, then IP host routing should be used. An example where IP host routing is beneficial is a core router connecting multiple campus networks to each other.

A special set of commands is used to configure the SLPM function. Table describes the commands added to the ExtremeWare software for configuring SLPM.

Table 65: SLPM Commands

Command	Description of Change
configure iproute route-map [bgp | direct | e-bgp | i-bgp | ospf | ospf-extern1 | ospf-extern2 | ospf-inter | ospf-intra | rip | static] [<route map> | none]	Configures how the specified route map is to be applied to IP routing tables. If none is selected, it disassociates the route map from the routing protocol.
configure route-map <route-map> <sequence-number> [add | delete] set iphost-routing	Configures IP host routing for the specified route map entry.

Table 65: SLPM Commands (Continued)

Command	Description of Change
configure route-map <route-map> <sequence-number> [add | delete] set lpm-routing	Configures LPM routing for the specified route map entry.
disable ipforwarding lpm-routing {vlan <vlan name>}	Disable the LPM routing feature for the specified VLAN. If no VLAN is specified, LPM routing is disabled for all VLANs except the management VLAN.
disable lpm	Disables the SLPM function.
enable ipforwarding lpm-routing {vlan <vlan name>}	Enables the LPM routing feature for the specified VLAN. If no VLAN is specified, LPM routing is enabled for all VLANs except the management VLAN.
enable lpm	Enables the SLPM function.
show lpm	Indicates if SLPM is currently enabled or disabled.

NOTE

SLB, Selective-LPM and DSA are mutually exclusive functions and cannot be simultaneously enabled.

About Destination-Sensitive Accounting

Destination-sensitive accounting (DSA) collects statistics that are maintained for forwarded IP traffic to support billing on a destination basis. To configure destination-sensitive accounting, a bin number can be assigned to one or more IP route entries using the ExtremeWare `route-map` command.

Bin numbers are integers that range from 0-7 and their only intrinsic meaning is to identify a particular set of accounting statistics. Each bin contains a 64-bit count of the number of packets that have been forwarded and a 64-bit count of the number of bytes that have been forwarded. When the MPLS/ARM module forwards an IP packet, the bin number from the forwarding database entry for the IP destination is used to identify the set of counters to be updated. Packets forwarded to the MSM CPU are not counted.

Eight unique bins are maintained for each of the possible 4096 VLAN IDs. Logically, the bins are organized as a two-dimensional array, with the row index being a VLAN ID and the column index being a bin number. Thus, when an IP frame is forwarded, the input VLAN ID selects the row and the bin number from the forwarding database entry selects the column. The use of input VLAN ID enables billing statistics to be maintained on a per customer basis where the VLAN ID identifies the customer.

DSA can run on either an MPLS or ARM module.

You use a special set of commands to configure the accounting function. Table 66 describes the commands added to the ExtremeWare software for configuring accounting.

Table 66: Accounting Commands

Command	Description of Change
clear accounting counters	Clears (zeroes out) all of the accounting statistics.
configure iproute route-map [ospf-intra | ospf-inter | ospf-extern1 | ospf-extern2 | ospf | rip | static | e-bgp | i-bgp | bgp | direct] <route-map> | none	Configures how the specified route map is to be applied to IP routing tables. If none is selected, it disassociates the route map from the routing protocol.

Table 66: Accounting Commands (Continued)

Command	Description of Change
configure route-map <route-map> <sequence_number> [add | delete] set accounting-index 1 value <bin_number>	Configures the accounting bin number to be associated with the specified route map entry. The accounting-index value is always set to 1 for destination-sensitive accounting.
disable accounting	Disables the destination-sensitive accounting function.
enable accounting	Enables the destination-sensitive accounting function.
show accounting {vlan <vlan name>}	Displays accounting statistics for the specified VLAN. If no VLAN is specified, statistics for all VLANs are displayed.

NOTE

SLB, Selective-LPM and DSA are mutually exclusive functions and cannot be simultaneously enabled.

Configuring the ARM

This section describes the ExtremeWare commands that support the ARM. For hardware installation information on the BlackDiamond 6800 series switch, see the *Extreme Networks Consolidated "i" Series Hardware Installation Guide*.

NOTE

Documentation for Extreme Networks products is available on the World Wide Web at the Extreme Networks home page at http://www.extremenetworks.com.

This section includes information on the following topics:

- Basic Accounting Configuration Information on page 529
- Basic SLPM Configuration Information on page 531
- Using Route Maps on page 533

Basic Accounting Configuration Information

This section uses several typical usage and configuration schemes to provide a brief overview of the accounting configuration process as a general context for the detailed command description sections that follow.

In the most basic terms, to enable the accounting function, you must enable the accounting feature, create a customer VLAN ID, enable IP forwarding, and configure the accounting bin using the route map feature.

You use a special set of commands to configure the accounting function. Due to the redirection of all incoming IP unicast packets to the ARM, the accounting feature is incompatible with ExtremeWare Server Load Balancing, and Selective-LPM. These features cannot be enabled simultaneously.

The following sections describe how to create a customer VLAN ID, how to enable and disable IP forwarding, how to configure the accounting bin, and how to display destination-based accounting statistics.

Creating Customer VLAN IDs

A unique VLAN ID is used to identify each of your customers. You create a VLAN ID to identify each customer and retrieve the accounting bin count for that customer. To create a customer VLAN ID, use the following commands:

```
create vlan <vlan name>
configure vlan <vlan name> tag <vlan tag>
configure vlan <vlan name> add ports <portlist> {tagged | untagged} {nobroadcast}
{soft-rate-limit}
```

The `name` parameter is the name of the VLAN you created.

The `vlanid` parameter is the number assigned to the VLAN. The valid numerical range for a VLAN ID is from 1 to 4095.

The `portlist` parameter specifies one or more ports assigned to the VLAN.

The `tagged | untagged` keyword configures the ports as tagged or untagged.

The `nobroadcast` keyword prevents the switch from forwarding broadcast, multicast, and unknown unicast traffic.

The following command example creates a customer VLAN named `acme` with a VLAN ID of 100. Ports 1 and 2 in slot 6 are assigned to the VLAN.

```
create vlan acme
configure vlan acme tag 100
configure vlan acme add ports 6:1-6:2 tagged
```

See Chapter 6 for more information.

Enabling and Disabling IP Forwarding

ExtremeWare allows IP forwarding to be enabled on a per-VLAN basis. To enable IP forwarding on a specific VLAN, use the following command:

```
enable ipforwarding {[broadcast | fast-direct-broadcast | ignore-broadcast]} {vlan
<vlan name>}
```

The `name` parameter is the name of the VLAN you created.

The following command example enables IP forwarding on a VLAN named `acme`:

```
enable ipforwarding acme
```

To disable IP forwarding on a specific VLAN, use the following command:

```
disable ipforwarding {[broadcast | fast-direct-broadcast | ignore-broadcast]} {vlan
<vlan name>}
```

The following command example disables IP forwarding on a VLAN named `acme`:

```
disable ipforwarding acme
```

Configuring the Accounting Bin

Destination Sensitive Accounting collects statistics that are maintained for forwarded IP traffic to support billing on a destination basis. To configure Destination Sensitive Accounting, a bin number may be assigned to one or more IP route entries using the ExtremeWare `route-map` command.

Bin numbers are integers that range from 0-7 and their only intrinsic meaning is to identify a particular set of accounting statistics. Each bin contains a 64-bit count of the number of packets that have been forwarded and a 64-bit count of the number of bytes that have been forwarded. When the ARM forwards an IP packet, the bin number from the forwarding database entry for the IP destination is used to identify the set of counters to be updated.

Eight unique bins are maintained for each of the possible 4096 VLAN IDs. Logically, the bins are organized as a 2-dimensional array, with the row index being a VLAN ID and the column index being a bin number. Thus, when an IP frame is forwarded, the input VLAN ID selects the row and the bin number from the forwarding database entry selects the column. The use of input VLAN ID enables billing statistics to be maintained on a per customer basis where the VLAN ID identifies the customer.

Displaying Accounting Statistics

To display accounting statistics, use the following command:

```
show accounting {vlan <vlan name>}
```

If you specify the optional `vlan` parameter, traffic statistics for that VLAN are displayed. If you do not specify the `vlan` parameter, traffic statistics for all VLANS are displayed. The statistics include eight bins per VLAN, where each bin includes the number of packets and bytes forwarded and IP destinations associated with the bin.

Basic SLPM Configuration Information

This section provides a brief overview of the SLPM configuration process as a general context for the detailed command description sections that follow.

In the most basic terms, to enable the SLPM function, you must configure LPM and IP host routing for the configured VLANs, optionally configure LPM and IP host routing using route maps, and enable the SLPM feature.

You use a special set of commands to configure the SLPM function. Due to the selective redirection of incoming IP unicast packets to the MPLS module or ARM, the SLPM feature is incompatible with ExtremeWare Server Load Balancing, and Destination Sensitive Accounting. These features cannot be enabled simultaneously.

The following sections describe how to configure LPM and IP host routing for the configured VLANs, how to configure LPM and IP host routing using route maps, how to enable and disable SLPM, and how to display information about SLPM.

Configuring VLAN-Based LPM and IP Host Routing

Selecting a routing method for a VLAN will cause all packets forwarded to that VLAN to use the specified routing method. To configure LPM routing for a VLAN, use the following command:

```
enable ipforwarding lpm-routing {vlan <vlan name>}
```

To configure IP host routing for a VLAN, use the following command:

```
disable ipforwarding lpm-routing {vlan <vlan name>}
```

For both commands, if a VLAN is specified, the command applies only to that VLAN. If no VLAN is specified, then all VLANs except for the management VLAN are affected. This command only affects VLANs that exist at the time the command is issued.

If neither of these commands is issued, then the default selection is to use IP host routing for all VLANs.

The following command example enables LPM routing for the VLAN named customer1 and disables LPM routing (selecting IP host routing) for the VLAN named srvr-farm.

```
enable ipforwarding lpm-routing customer1
disable ipforwarding lpm-routing srvr-farm
```

Configuring Route-Based LPM and IP Host Routing

In some circumstances, a finer grain of control is required when selecting a routing method. To select LPM or IP host routing for one or more IP route entries, use the ExtremeWare route map commands, for example, `create route-map` and `configure route-map add`.

When configuring LPM or IP host routing using route maps, be aware that the routing method specified in the route map entries overrides the routing method configured for a VLAN. This override only applies to IP route entries that match the route map criteria. This feature allows packets destined to a specific route to, for example, be IP host routed, while all other packets forwarded to the same VLAN are LPM routed.

Enabling and Disabling the SLPM Feature

Once LPM and IP host routing have been configured for both VLANs and IP route entries, the SLPM feature must be enabled. To enable SLPM, use the following command:

```
enable lpm
```

To disable SLPM, use the following command:

```
disable lpm
```

It is allowable to enable the SLPM feature even though LPM routing has not been configured for any VLAN or IP route entry. In this case, the MPLS module or ARM takes over “slow path” forwarding from the MSM CPU. Any packet received by the system whose destination IP address cannot be found in the IP FDB, is forwarded using the slow path. The MPLS module or ARM, when SLPM is enabled, augments the performance of the slow path, providing a greatly accelerated forwarding rate.

Displaying SLPM Information

To determine if the SLPM feature has been enabled, use the following command:

```
show lpm
```

This command will report if SLPM is enabled or disabled.

The ExtremeWare show vlan and show iproute commands have been modified to indicate which VLANs and IP route entries have been enabled for LPM routing. A VLAN for which LPM routing has been enabled will display an “I” (capital “i”) in the flags field of the show vlan command output. An IP route entry for which LPM routing has been enabled will display a “P” in the flags field of the show iproute command.

Configuring Access Profiles

The ExtremeWare `route-map` command is used for configuring LPM routing and assigning accounting bin numbers to specific destinations. To configure route map access policies, it may be necessary to define an access profile.

For more information about access profiles, see Chapter 12.

Using Route Maps

Route maps are used to conditionally configure LPM routing and also to conditionally assign accounting bin numbers to route destinations. Route maps are used in conjunction with the match and set operations. A match operation specifies a criteria that must be matched. A set operation specifies a change that is made to the route when the match operation is successful.

Configuring the Accounting Bin Number for Route Map Entry

To configure an accounting bin number associated with a specified route map entry, use the following command:

```
configure route-map <route-map> <sequence_number> [add | delete] set accounting-index
1 value <bin_number>
```

Where the following is true:

- The `route-map` parameter identifies a particular route map.
- The `sequence_number` parameter identifies a specific entry in that route map. The sequence number must be associated with a match statement.
- The `set accounting-index 1 value` keyword phrase indicates that the following parameter is an accounting bin number.
- The `bin_number` parameter is an integer between 0—7, and allows you to define the accounting bin number.

Configuring the Routing Method for Route Map Entry

To the configure the routing method associated with a specified route map entry, use the following commands:

```
configure route-map <route-map> <sequence-number> [add | delete ] set iphost-routing
configure route-map <route-map> <sequence-number> [add | delete ] set lpm-routing
```

Where the following is true:

- The `route-map` parameter identifies a particular route map.
- The `sequence_number` parameter identifies a specific entry in that route map. The sequence number must be associated with a match statement.
- The `set iphost-routing` keyword phrase indicates that IP host routing is to be used for IP route entries matching this route map entry's criteria.
- The `set lpm-routing` keyword phrase indicates that LPM routing is to be used for IP route entries matching this route map entry's criteria.

Applying the Route Map to the IP Routing Table

To configure how the specified route map is applied to IP routing table entries, use the following command:

```
configure iproute route-map [bgp | direct | e-bgp | i-bgp | ospf | ospf-extern1 |
ospf-extern2 | ospf-inter | ospf-intra | rip | static] [<route map> | none]
```

Where the following is true:

- The `ospf-intra` (intra-area), `ospf-inter` (inter-area), `ospf-extern1` (external type 1), `ospf-extern2` (external type 2), `ospf`, `rip`, `static`, `e-bgp` (exterior gateway protocol), `i-bgp` (interior gateway protocol), `bgp` (border gateway protocol), and `direct` (directly connected subnets) are keywords that identify route sources that are inserted into the IP routing table.

The configured route map is applied when routes of the specified source type are entered into the routing table. If there is a match between a route map entry and routing table entry, then the specified action is taken. For accounting, the configured bin number is associated with the matching routing table entry. If there is no match, the bin number 0 is assigned to the routing table entry. For SLPM, the configured routing method is selected for the matching routing table entry. If there is no match, the routing method selected will be based on the routing method for the VLAN associated with the routing table entry's next-hop.

Displaying the Configured Route Maps for the IP Route Table

To display the configured route maps for the IP route table, use the following command:

```
show iproute route-map
```

The following command displays the route map associated with each IP route protocol:

```
show iproute route-map
Route Origin Route-Map
Direct       dsb1
Static       dsb1
OSPFIntra    dsb2
OSPFInter    dsb2
RIP          dsb1
OSPFExt1     dsb2
OSPFExt2     dsb2
EBGP         dsb2
```

```
IBGP         dsb2
```

If a route map is excluded from the IP routing table, the route origins for that specific route map are not displayed. For example, if you exclude `ospf` from the iproute configuration command `configure iproute route-map ospf none`, OSPF information is not displayed in the `show iproute route-map` command:

```
show iproute route-map
Route Origin Route-Map
Direct       dsb1
Static       dsb1
RIP          dsb1
EBGP         dsb2
IBGP         dsb2
```

ARM Configuration Examples

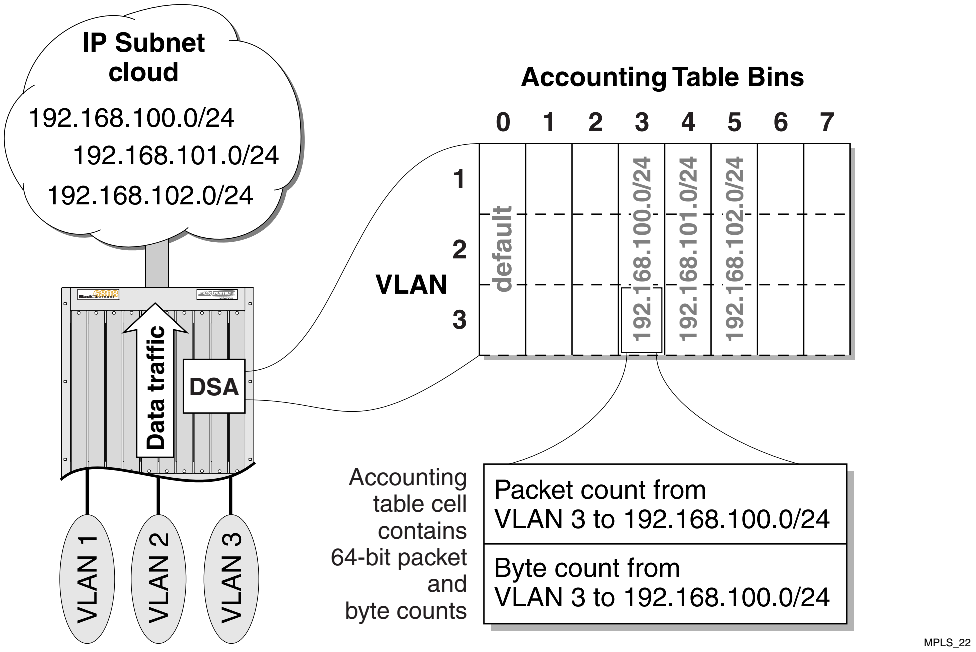
This section provides the following examples:

- Configuring Destination-Sensitive Accounting Based on Destination IP Subnets on page 535
- Configuring Destination-Sensitive Accounting Based on BGP Community Strings on page 539
- Configuring Routing Using SLPM on page 541

Configuring Destination-Sensitive Accounting Based on Destination IP Subnets

The following section gives an example of destination-sensitive accounting based on destination IP subnets, as shown in Figure 99. It depicts a core router in a network services provider environment. VLANs vlan1, vlan2, and vlan3 represent provider customers. The IP subnet cloud represents the provider's internal network where services are hosted. Three classes of service are defined, with each class residing on its own IP subnet.

Figure 99: Destination Sensitive Accounting Based on IP Subnets



In this example, all IP unicast traffic is forwarded by the BlackDiamond switch to one of three subnets. Each IP subnet is mapped to a different accounting bin.

Configure the accounting feature by following these steps:

1 Create VLANs for each attached IP subnet by using the following commands to configure the customer network interfaces as well as the provider's internal network interface. In this example, the provider is using OSPF to advertise network service IP subnets.

```
create vlan vlan1
configure vlan1 ipaddress 192.168.200.1/24
configure vlan1 add ports 8:1

create vlan vlan2
configure vlan2 ipaddress 192.168.201.1/24
configure vlan2 add ports 8:2

create vlan vlan3
configure vlan3 ipaddress 192.168.202.1/24
configure vlan3 add ports 8:3

create vlan backbone
configure backbone ipaddress 192.168.10.1/30
configure backbone add ports 7:1

enable ipforwarding

configure ospf add backbone area 0.0.0.0
enable ospf
```

2 Create access profiles for each destination subnet by using the following commands to create three different profiles: service1, service2, and service3. Each profile is defined to be type ipaddress. Each subnet is then assigned to one of the profiles.

```
create access-profile service1 type ipaddress
configure service1 add ipaddress 192.168.100.0/24

create access-profile service2 type ipaddress
configure service2 add ipaddress 192.168.101.0/24

create access-profile service3 type ipaddress
configure service3 add ipaddress 192.168.102.0/24
```

3 Create a route map named `service_example` by using the following commands:

```
create route-map service_example

configure service_example add 10 permit
configure service_example 10 add match nlri-list service1

configure service_example add 20 permit
configure service_example 20 add match nlri-list service2

configure service_example add 30 permit
configure service_example 30 add match nlri-list service3
```

4 Assign bin numbers to each route map entry by using the following commands:

```
configure service_example 10 add set accounting-index 1 value 3
configure service_example 20 add set accounting-index 1 value 4
configure service_example 30 add set accounting-index 1 value 5
```

5 Correlate the route map to OSPF intra-area routes by using the following command:

```
configure iproute route-map ospf-intra service_example
```

6. Enable the accounting feature by using the following command:

```
enable accounting
```

The `show iproute detail` command displays the bin number, if any, that is associated with a particular route. This command is useful for verifying that bin number configurations are correct.

Below is an excerpt from the output of the `show iproute detail` command for this example configuration

```
Destination: 192.168.100.0/24
Gateway: 192.168.10.2     Metric: 14          Origin: *OSPFIntra
Flags: UG-----umP-        Acct-1: 3           Duration: 0d:1h:07m:43s
Use: 0       M-Use: 0     VLAN: backbone

Destination: 192.168.101.0/24
Gateway: 192.168.10.2     Metric: 14          Origin: *OSPFIntra
Flags: UG-----umP-        Acct-1: 4           Duration: 0d:1h:07m:43s
Use: 0       M-Use: 0     VLAN: backbone

Destination: 192.168.102.0/24
Gateway: 192.168.10.2     Metric: 14          Origin: *OSPFIntra
Flags: UG-----umP-        Acct-1: 5           Duration: 0d:1h:07m:43s
Use: 0       M-Use: 0     VLAN: backbone
```

```
Origin(OR): (b) BlackHole, (be) EBGP, (bg) BGP, (bi) IBGP, (bo) BOOTP
            (ct) CBT, (d) Direct, (df) DownIF, (dv) DVMRP, (e1) ISISL1Ext
            (e2) ISISL2Ext, (h) Hardcoded, (i) ICMP, (i1) ISISL1
            (i2) ISISL2, (ma) MPLSIntra, (mr) MPLSInter, (mo) MOSPF
            (o) OSPF, (o1) OSPFExt1, (o2) OSPFExt2, (oa) OSPFIntra
            (oe) OSPFAsExt, (or) OSPFInter, (pd) PIM-DM, (ps) PIM-SM
            (r) RIP, (ra) RtAdvrt, (s) Static, (sv) SLB_VIP, (un) UnKnown
            (*) Preferred route

Flags: (B) BlackHole, (D) Dynamic, (G) Gateway, (H) Host Route
       (L) Direct LDP LSP, (l) Indirect LDP LSP, (m) Multicast
       (P) LPM-routing, (R) Modified, (S) Static, (T) Direct RSVP-TE LSP
       (t) Indirect RSVP-TE LSP, (u) Unicast, (U) Up

Mask distribution:
    1 routes at length  8           8 routes at length 24
    2 routes at length 30

Route origin distribution:
    6 routes from Direct            3 routes from OSPFIntra
    2 routes from EBGP

Total number of routes = 11.
```

The `show accounting` command lists the packet and octect counts for each bin number per VLAN. Bin 0 is always the default bin and is used to maintain traffic statistics for packets that do not match any of the route map profiles. Bins that have the same packet and octect counts are grouped together. All maintained statistics are 64-bit values.

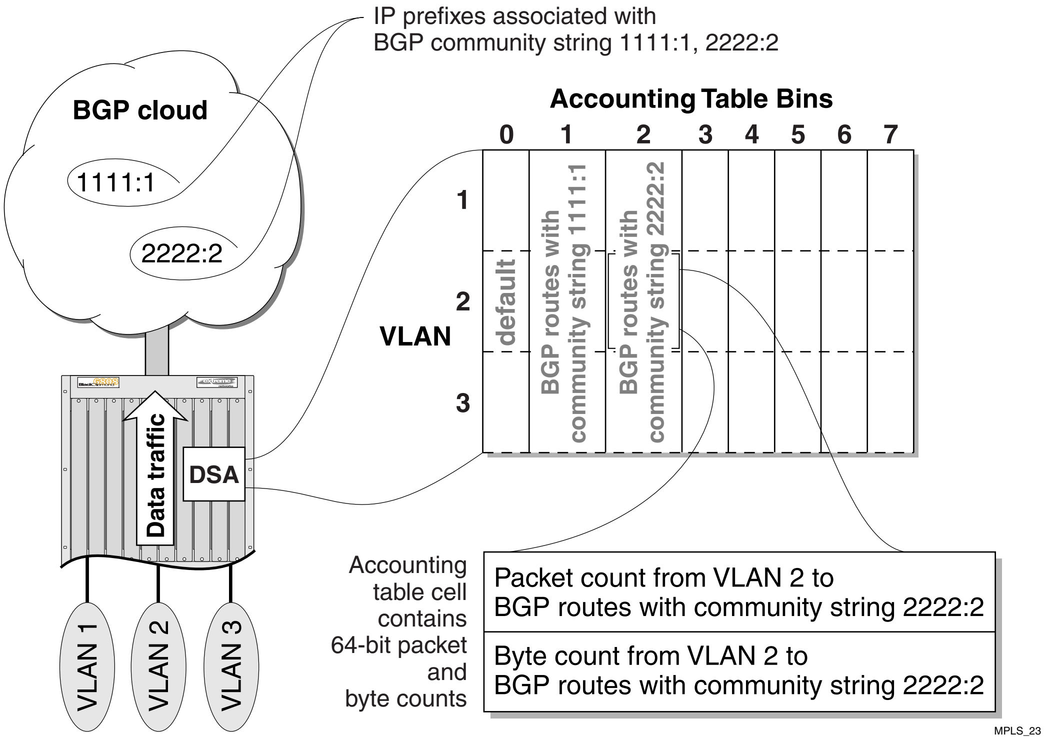
Below is an excerpt of the `show accounting` command. It is assumed that 1000 64-byte packets have been received for each service from each customer.

```
       VLAN Name(   ID)  Bins                 Packets                 Octets
----------------------  ----   ----------------------   ----------------------
         Default(    1)  0-7                        0                        0
 MacVlanDiscover(4095)  0-7                        0                        0
            Mgmt(4094)  0-7                        0                        0
           vlan1(4093)  0-2                        0                        0
                         3-5                     1000                    46000
                         6-7                        0                        0
           vlan2(4092)  0-2                        0                        0
                         3-5                     1000                    46000
                         6-7                        0                        0
           vlan3(4091)  0-2                        0                        0
                         3-5                     1000                    46000
                         6-7                        0                        0
        backbone(4090)  0-7                        0                        0
```

Configuring Destination-Sensitive Accounting Based on BGP Community Strings

The following section gives an example of destination-sensitive accounting based on BGP community strings, as shown in Figure 100. It depicts a core router in an internet service provider environment. VLANs vlan1, vlan2, and vlan3 represent provider customers. The BGP cloud represents the ISP's upstream network connections to the Internet. Two BGP communities are defined to represent two classes of bandwidth service.

Figure 100: Destination Sensitive Accounting Based on BGP


IP prefixes associated with
BGP community string 1111:1, 2222:2
BGP cloud
1111:1
2222:2
Accounting Table Bins
0
1
2
3
4
5
6
7
VLAN
1
2
3
default
BGP routes with community string 1111:1
BGP routes with community string 2222:2
Data traffic
DSA
VLAN 1
VLAN 2
VLAN 3
Accounting table cell contains 64-bit packet and byte counts
Packet count from VLAN 2 to BGP routes with community string 2222:2
Byte count from VLAN 2 to BGP routes with community string 2222:2
MPLS_23

In this example, all IP unicast traffic forwarded by the BlackDiamond switch to one of two BGP communities is counted. Each IP subnet associated with the configured BGP community is mapped to a different accounting bin.

Configure the accounting feature by following these steps:

1 Create VLANs for each attached IP subnet by using the following commands to configure the customer network interfaces as well as the provider's Internet uplink:

```
create vlan vlan1
configure vlan1 ipaddress 192.168.200.1/24
configure vlan1 add ports 8:1

create vlan vlan2
configure vlan2 ipaddress 192.168.201.1/24
configure vlan2 add ports 8:2

create vlan vlan3
configure vlan3 ipaddress 192.168.202.1/24
configure vlan3 add ports 8:3

create vlan to-internet
configure to-internet ipaddress 192.168.20.1/30
configure to-internet add ports 7:2

enable ipforwarding

configure bgp routerid 192.168.20.1
configure bgp AS-number 65001
create bgp neighbor 192.168.20.2 remote-AS-number 65002
enable bgp neighbor all
enable bgp
```

2 Create the route map `bgp_example`, map the communities 1111:1 and 2222:2 to the newly created route map and assign a bin number to each BGP community by using the following commands:

```
create route-map bgp_example

configure bgp_example add 10 permit
configure bgp_example 10 add match community 1111:1
configure bgp_example 10 add set accounting-index 1 value 1

configure bgp_example add 20 permit
configure bgp_example 20 add match community 2222:2
configure bgp_example 20 add set accounting-index 1 value 2
```

3 Apply the route map to external BGP routes by using the following commands:

```
configure iproute route-map e-bgp bgp_example
```

4 Enable the accounting feature by using the following command:

```
enable accounting
```

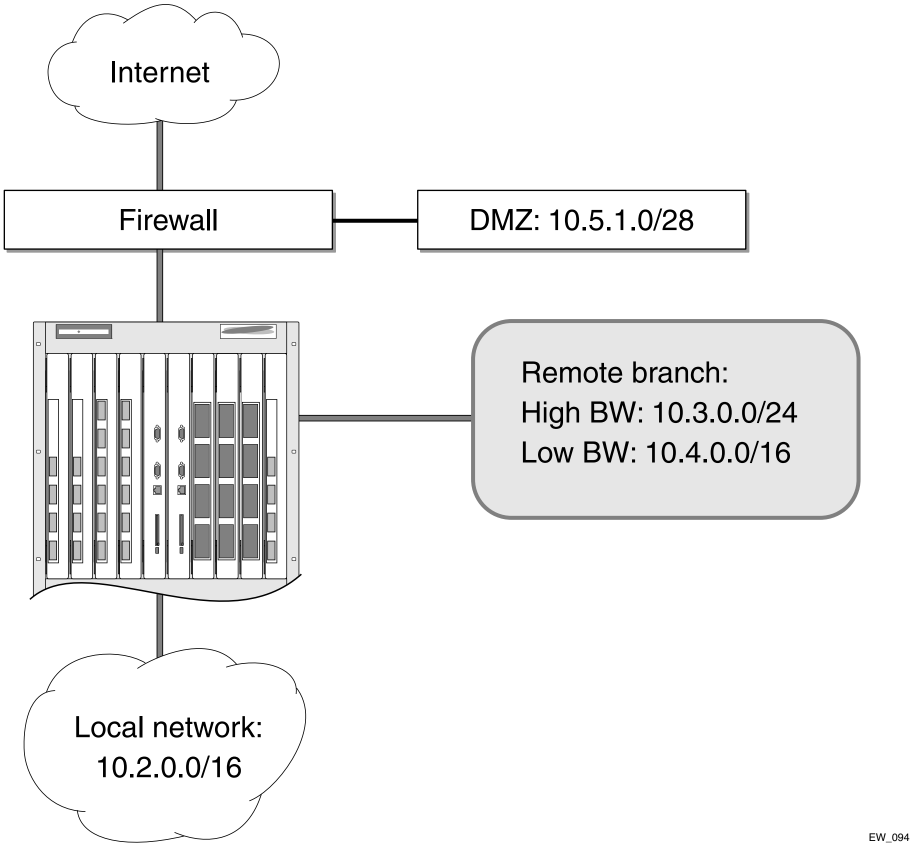
Below is an excerpt of `show accounting` command. It is assumed that 1000 64-byte packets have been received for each service from each customer.

```
       VLAN Name(  ID)  Bins                  Packets                 Octets
----------------------  ----   ----------------------   ----------------------
         Default(   1)  0-7                         0                      0
 MacVlanDiscover(4095)  0-7                         0                      0
            Mgmt(4094)  0-7                         0                      0
           vlan1(4093)  0                           0                      0
                        1-2                      1000                  46000
                        3-7                         0                      0
           vlan2(4092)  0                           0                      0
                        1-2                      1000                  46000
                        3-7                         0                      0
           vlan3(4091)  0                           0                      0
                        1-2                      1000                  46000
                        3-7                         0                      0
     to-internet(4090)  0-7                         0                      0
```

Configuring Routing Using SLPM

The following section gives an example of routing using SLPM on a core router in an enterprise environment, as shown in Figure 101. The switch has three principal network connections. The first connects to a local branch or campus network, the second connects to a remote branch or campus network, and the third connects to a firewall that is linked to the Internet. In addition to the Internet connection, the firewall also connects to a demilitarized zone (DMZ) where publicly-accessible web servers reside. A high-bandwidth forwarding path is desired between the branch networks and the DMZ. A high-bandwidth forwarding path is also desired between the branch networks, however, the remote branch network has an IP subnet containing a large number of low-bandwidth IP hosts.

Figure 101: SLPM Routing in an Enterprise



In this example, IP unicast traffic between the local and remote branches is forwarded using the BlackDiamond's switch fabric. However, IP subnet 10.4.0.0/16 does not require a high-bandwidth switching path. To conserve IP FDB entries, packets destined for this subnet are routed using LPM. IP unicast traffic between either branch network and the Internet is routed using LPM. However, IP packets destined for IP subnet 10.5.1.0/28 are forwarded using the BlackDiamond's switch fabric.

Configure the SLPM feature by following these steps:

1 Create VLANs for each attached IP network by using the following commands:

```
create vlan local_branch
configure local_branch ipaddress 10.2.0.1/16
configure local_branch add ports 7:1
```

```
create vlan remote_branch
configure remote_branch ipaddress 10.3.0.1/24
configure remote_branch add ports 7:2

create vlan to_internet
configure to_internet ipaddress 10.1.0.1/30
configure to_internet add ports 7:3

enable ipforwarding
```

2 Configure routing for the destination IP subnets by using the following commands:

```
configure iproute add 10.4.0.0/16 10.3.0.2
configure iproute add 10.5.1.0/28 10.1.0.2

configure bgp routerid 10.1.0.1
configure bgp AS-number 65001
create bgp neighbor 10.1.0.2 remote-AS-number 65002
enable bgp neighbor all
enable bgp
```

3 Enable LPM routing of IP packets for the `to_internet` VLAN by using the following commands. Though the LPM routing feature is disabled by default, the commands to disable it on the `local_branch` and `remote_branch` VLANs are included here.

```
enable ipforwarding lpm-routing to_internet
disable ipforwarding lpm-routing local_branch
disable ipforwarding lpm-routing remote_branch
```

4 Create access profiles for the DMZ and the remote branch's low-bandwidth IP subnet by using the following commands to create two different access profiles, `dmz` and `remote_hosts`. Each profile is defined to be type ipaddress. Each subnet is then assigned to one of the profiles.

```
create access-profile dmz type ipaddress
configure dmz add ipaddress 10.5.1.0/28

create access-profile remote_hosts type ipaddress
configure remote_hosts add ipaddress 10.4.0.0/16
```

5 Create a route map named `lpm_example,` and configure the LPM and IP host routing features for each of the subnets in the newly created route map by using the following commands:

```
create route-map lpm_example

configure lpm_example add 10 permit
configure lpm_example 10 add match nlri-list dmz
configure lpm_example 10 add set iphost-routing

configure lpm_example add 20 permit
configure lpm_example 20 add match nlri-list remote_hosts
configure lpm_example 20 add set lpm-routing
```

6 Apply the route map to static routes by using the following command:

```
configure iproute route-map static lpm_example
```

7 Enable the SLPM feature by using the following command:

```
enable lpm
```

The show vlan command has been enhanced to indicate which VLANs have the LPM routing feature enabled. The LPM routing feature is indicated by an “I” in the flags column of the show vlan command output.

Below is the output of the show vlan command for this example:

```
Name               VID  Protocol Addr        Flags        Proto  Super  Ports  STP
Default            1    0.0.0.0        /BP -----f------- ANY            0/0   0
MacVlanDiscover    4095 ------------------ -----         ANY            0/0   0
Mgmt               4094 ------------------ -----         ANY            1/1   0
local_branch       4093 10.2.0.1       /16 -----f------- ANY            1/1   0
remote_branch      4092 10.3.0.1       /24 -----f------- ANY            1/1   0
to_internet        4091 10.1.0.1       /30 -----f-I----- ANY            1/1   0

Flags: (C) Domain-masterVlan, (c) Domain-memberVlan, (d) DVMRP Enabled
       (E) ESRP Slave, (f) IP Forwarding Enabled, (G) GVRP Enabled
       (i) ISIS Enabled, (I) IP Forwarding lpm-routing Enabled
       (L) Loopback Enabled, (M) ESRP Master, (m) IPmc Forwarding Enabled
       (N) GNS Reply Enabled, (o) OSPF Enabled, (P) IPX SAP Enabled
       (p) PIM Enabled, (R) SubVLAN IP Range Configured, (r) RIP Enabled
       (S) SuperVlan, (s) SubVlan, (v) VRRP Enabled, (X) IPX RIP Enabled
       (2) IPX Type 20 Forwarding Enabled

Total number of Vlan(s) : 6
```

The show iproute command has been enhanced to indicate which routes have the LPM routing feature enabled. The LPM routing feature is indicated by a “P” in the flags column of the show iproute command output.

Below is the output of the show iproute command for this example:

```
Ori Destination        Gateway         Mtr Flags       VLAN        Duration
*d  10.1.0.0/30        10.1.0.1        1   U------u-P- to_inter    0d:0h:11m:34s
*s  10.5.1.0/28        10.1.0.2        1   UG---S-um-- to_inter    0d:0h:00m:21s
*d  10.3.0.0/24        10.3.0.1        1   U------u--- remote_b    0d:0h:11m:46s
*d  10.2.0.0/16        10.2.0.1        1   U------u--- local_br    0d:0h:11m:56s
*s  10.4.0.0/16        10.3.0.2        1   UG---S-umP- remote_b    0d:0h:00m:02s
*d  127.0.0.1/8        127.0.0.1       0   U-H----um-- Default     0d:0h:19m:34s

Origin(OR): (b) BlackHole, (be) EBGP, (bg) BGP, (bi) IBGP, (bo) BOOTP
            (ct) CBT, (d) Direct, (df) DownIF, (dv) DVMRP, (e1) ISISL1Ext
            (e2) ISISL2Ext, (h) Hardcoded, (i) ICMP, (i1) ISISL1
            (i2) ISISL2, (ma) MPLSIntra, (mr) MPLSInter, (mo) MOSPF
            (o) OSPF, (o1) OSPFExt1, (o2) OSPFExt2, (oa) OSPFIntra
            (oe) OSPFAsExt, (or) OSPFInter, (pd) PIM-DM, (ps) PIM-SM
            (r) RIP, (ra) RtAdvrt, (s) Static, (sv) SLB_VIP, (un) UnKnown
            (*) Preferred route

Flags: (B) BlackHole, (D) Dynamic, (G) Gateway, (H) Host Route
       (L) Direct LDP LSP, (l) Indirect LDP LSP, (m) Multicast
       (P) LPM-routing, (R) Modified, (S) Static, (T) Direct RSVP-TE LSP
       (t) Indirect RSVP-TE LSP, (u) Unicast, (U) Up

Mask distribution:
    1 routes at length  8           2 routes at length 16
    1 routes at length 24           1 routes at length 28
    1 routes at length 30

Route origin distribution:
    4 routes from Direct            2 routes from Static

Total number of routes = 6.
```

Retrieving Accounting Statistics

Accounting statistics are used to bill your customers. Destination Sensitive Accounting gives you the flexibility to bill your customers at predetermined and different rates. For a given set of counts, the source VLAN ID identifies the customer and the accounting bin number corresponds to a billing rate. You need to retrieve the destination sensitive accounting 64-bit counts of the number of packets and the number of bytes forwarded to the accounting bin. The following sections describe how to retrieve the accounting statistics using the Command Line Interface (CLI) or Simple Network Management Protocol (SNMP).

Using the CLI to Retrieve Accounting Statistics

You can display the accounting statistics for a single VLAN or all VLANs by issuing the `show accounting {vlan <vlan name>}` command. The `show accounting` command lists the packet and octet counts for each bin number per VLAN. Omitting the VLAN name displays the accounting statistics for all the VLANs.

In the following command example, traffic originates from VLANs six1, six2, six3, seven1, seven2, seven3, and seven4. All traffic received is sent to destinations mapped to accounting bin 0.

```
       VLAN Name(  ID) Bins                Packets                 Octets
---------------------- ---- ---------------------- ----------------------
         Default(   1) 0-7                       0                      0
 MacVlanDiscover(4095) 0-7                       0                      0
         vlan100(4093) 0-7                       0                      0
            six1(4085) 0                 840438040            38660149840
                       1-7                       0                      0
            six2(4084) 0                 838650339            38577915594
                       1-7                       0                      0
            six3(4083) 0                 839173438            38601978148
                       1-7                       0                      0
            six4(4082) 0-7                       0                      0
          seven1(4081) 0                 871702314            40098306444
                       1-7                       0                      0
          seven2(4080) 0                 871281308            40078940168
                       1-7                       0                      0
          seven3(4079) 0                 870416088            40039140048
                       1-7                       0                      0
          seven4(4078) 0                 870447512            40040585552
                       1-7                       0                      0
```

Using SNMP to Retrieve Accounting Statistics

Any network manager running SNMP can retrieve accounting statistics provided the Management Information Base (MIB) is installed correctly on the management station. Each network manager provides its own user interface to the management facilities. With support for the CISCO-BGP-POLICY-ACCOUNTING-MIB, you can retrieve accounting statistics using SNMP.

For information about the CISCO-BGP-POLICY-ACCOUNTING-MIB:

1. Go to http://www.cisco.com/public/mibs.
2. Select `SNMP v2 MIBs`.
3. Select `CISCO-BGP-POLICY-ACCOUNTING-MIB.my` for information about the MIB.

In this MIB, the accounting statistics are indexed using the following commands:

- interface index (`ifIndex`)
- traffic index (`cbpAcctTrafficIndex`)

To map a VLAN ID to an interface index, use the interface index of the router interface on the VLAN. The accounting bin number corresponds directly to the traffic index.

Refer to your SNMP Manager documentation for information on how to load MIBs for use within the network manager.

Diagnostics Commands

The `show diag slot <slot> iproute` command displays the ARM IP routing table. The ARM IP routing table is similar to the IP routing table maintained on the MSM module, but differs in the following ways:

- A maximum of four equal cost routes are stored.
- Directly attached hosts are inserted into the ARM IP routing table as host routes (OR=ho).

The following commands display the ARM IP routing table:

```
show diag slot <slot> iproute [origin | summary | <ipaddress>]

show diag slot <slot> iproute origin [bgp | blackhole | direct | e-bgp | best-route |
i-bgp | ospf-extern1 | ospf-extern2 | ospf-inter | ospf-intra | rip | static]
```

Below is an example of the `show diagnostics slot <slot number> iproute` command:

```
                                                     GWay                VLAN
 OR Destination        Gateway         Gateway MAC   Flags VLAN     Acct Flags
 d  192.168.20.0/30    192.168.20.1    000130032000  mf_L  to-internet    0 _____
 d  192.168.10.0/30    192.168.10.1    000130032000  mf_L  backbone    0 _____
 d  192.168.200.0/24   192.168.200.1   000130032000  mf_L  vlan1       0 _____
 d  192.168.201.0/24   192.168.201.1   000130032000  mf_L  vlan2       0 _____
 d  192.168.202.0/24   192.168.202.1   000130032000  mf_L  vlan3       0 _____
 ho 192.168.10.2/32    192.168.10.2    00a2f1000001  mf__  backbone    0 f_urt
 ho 192.168.20.2/32    192.168.20.2    00a2f2000001  mf__  to-internet    0 f_urt
 be 192.168.52.0/24    192.168.20.2    00a2f2000001  mf__  to-internet    1 f_urt
 be 192.168.53.0/24    192.168.20.2    00a2f2000001  mf__  to-internet    2 f_urt
 oa 192.168.100.0/24   192.168.10.2    00a2f1000001  mf__  backbone    3 f_urt
 oa 192.168.101.0/24   192.168.10.2    00a2f1000001  mf__  backbone    4 f_urt
 oa 192.168.102.0/24   192.168.10.2    00a2f1000001  mf__  backbone    5 f_urt

Origin(OR): b - BlackHole, bg - BGP, be - EBGP, bi - IBGP, bo - BOOTP, ct - CBT
            d - Direct, df - DownIF, dv - DVMRP, h - Hardcoded, ho - Host
            i - ICMP, mo - MOSPF, o - OSPF, oa - OSPFIntra, or - OSPFInter
            oe - OSPFAsExt, o1 - OSPFExt1, o2 - OSPFExt2, pd - PIM-DM
            ps - PIM-SM, r - RIP, ra - RtAdvrt, s - Static, sv - SLB_VIP
            mp - MPLS, un - UnKnown.

Flags: d - Discard, f - IP Forwarding, m - MAC Address Valid, L - Local Route

Vlan Flags: f - IP Forwarding, I - IP Forwarding lpm-routing, r - Redirect,
            t - Send Time Exceeded, u - Unreachable

Total number of routes = 12.

Mask distribution:
    8 routes at length 24           2 routes at length 30
    2 routes at length 32

Route origin distribution:
     5 routes from Direct            3 routes from OSPFIntra
     2 routes from EBGP              2 routes from Host
```

Layer 2 and Layer 3 Switching Attributes

NOTE

The ARM relies on the MSM switch fabric to support the layer 2 switching functions.

If Destination Sensitive Accounting is enabled, the switch fabric hardware does not perform layer 3 switching for any protocols. The ARM performs layer 3 forwarding for unicast IP packets.

All of the IP routing protocols are supported: RIP, OSPF, BGP, DVMRP, PIM.

IPX routing is not supported when Destination Sensitive Accounting is enabled.

Jumbo Ethernet frames are supported by the ARM.

Server Load Balancing (SLB) feature is not supported by the ARM.

Debug Trace Commands

System-level debug tracing is provided for the accounting subsystem. To enable this support, use the following command:

```
configure debug-trace accounting <debug level>
```

System-level debug tracing is provided for the Network Processor card (npcard) subsystem. To enable this support, use the following command:

```
configure debug-trace npcard <debug level>
```

NOTE

The debug commands should be used only under the guidance of Extreme Networks technical personnel.

In general, the “level” maps the severity of the log message. Table 67 displays the definitions for the npcard subsystem.

Table 67: NPCard Debug Log Messages

Debug Level	Debug Level Definition
0—Error	Indicates that a severe event has occurred that most likely will result in the termination or improper operation of the ARM.
1—Warning	Indicates that a major event has occurred. It may represent a negative operation. It should be reviewed to ensure proper continuation of ARM operation.
2—Informational	Indicates a minor event has occurred.
3—Debug	Provides additional information to support engineers for the purpose of diagnosing network problems.

23 Asynchronous Transfer Mode (ATM) Module

The Asynchronous Transfer Mode (ATM) module is an I/O module for the BlackDiamond 6800 series chassis-based system. The ATM module connects a BlackDiamond 6800 series switch to the ATM infrastructure used by service providers or enterprise customers.

This chapter includes information on the following topics:

- About the ATM Module on page 549
- Configuring the ATM Module on page 552

About the ATM Module

Key applications for the ATM module are: interconnecting metropolitan area networks across an ATM network infrastructure, interconnecting server co-location network sites directly using ATM links, and providing connectivity between a legacy Enterprise ATM network and an Ethernet backbone.

In the first application, the metropolitan area network service provider can build service network sites in various cities, then use ATM modules in a BlackDiamond 6800 series switch to connect those cities to a carrier's ATM infrastructure.

In the second application, operators of server co-location networks can use ATM modules in BlackDiamond 6800 series switches to create an ATM-based connection between server co-location sites. The result is that their network is simpler to manage, and problems can be isolated and resolved more expediently.

In the third application, a service provider can provide Ethernet-based services by using ATM modules in a BlackDiamond 6800 series switch to connect their Enterprise ATM network to an Ethernet backbone.

Extreme Networks offers the ATM module in the following configuration:

- A3cSi: four OC-3c/STM-1 single-mode, intermediate-reach optical interfaces
- A3cMi: four OC-3 multimode, short-reach optical interfaces

Feature Summary

The ATM module supports the following key networking functions:

- Synchronous Optical Network (SONET) and Synchronous Digital Hierarchy (SDH) modes of operation
- IP routing via the Logical Link Control (LLC) Encapsulation for Routed Protocols compatible with RFC 2684/RFC 1483
- Transparent LAN Services (TLS) over Asynchronous Transfer Mode (ATM) via the LLC Encapsulation Bridged Protocols compatible with RFC 2684/RFC 1483
- Permanent Virtual Circuits (PVCs) may be associated with one or more VLANs
- Routed and bridged encapsulations on the same PVC
- Jumbo frames
- Quality of Service (QoS) and Differentiated Services (DiffServ) features, including support for:
  - Eight ingress queues and eight egress queues per interface
  - Ingress and egress rate shaping and limiting
  - IEEE 802.1p VLAN priorities
  - Weighted RED (WRED) congestion avoidance algorithm
  - Assured Forwarding and Expedited Forwarding RFCs
- Service provider specific features, such as:
  - Flexible remapping of DiffServ codepoints
  - Flexible remapping of IEEE 802.1Q VLAN IDs
  - VLAN tunneling via nested 802.1Q tags

Function Summary

The following sections provide brief descriptions of the key functions provided by the ATM module. Each of these sections is expanded into greater detail in “Configuring the ATM Module” on page 552.

Asynchronous Transfer Mode (ATM)

ATM is a connection-oriented packet transmission technique that is widely used in existing telecommunications networks to transport voice, video, and data. ATM uses fixed size data packets called “cells” which are 53-bytes long and have a header that includes a connection identifier. The connection identifier makes it possible to support more than one point-to-point connection on a single physical ATM connection. The switches in an ATM network use the connection identifier in each cell to forward the cell to the next hop.

Synchronous Optical Network (SONET) and Synchronous Digital Hierarchy (SDH)

SONET and SDH are the two terms used to identify a time division multiplexing technology that is optimized for transporting voice traffic across a digital optical network, but that is also capable of providing high-speed capacity for transporting data.

The term SONET is used to identify the technology used within the North American digital network. Its standards are published by Bellcore and the American National Standards Institute (ANSI). The term SDH is used to identify the equivalent standard approved by the International Telecommunication

Union (ITU) for use in Europe and elsewhere in the global digital network. Because SDH evolved out of SONET, the two standards are closely related and have been widely accepted as a dominant choice for implementations requiring high transport capacity and resistance to failure. The term SONET is used through out this guide. In instances where there are differences between SONET and SDH, the differences are explicitly called out.

Jumbo Frames

The ATM module ports provide jumbo frame support that is similar to that provided by Ethernet ports on a BlackDiamond 6800 series switch.

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

Jumbo frames are used between endstations that support larger frame sizes for more efficient transfers of bulk data. Both endstations involved in the transfer must be capable of supporting jumbo frames.

QoS and Differentiated Services

The ATM module supports eight ingress queues and eight egress queues per port. The scheduling parameters for these queues (minimum bandwidth, maximum bandwidth, priority level, etc.) are controlled by QoS profiles that you can customize for individual ingress or egress queues on a specific ATM port.

You can assign frames to queues based on IEEE 802.1p priorities, Differentiated Services Code Points (DSCPs), or by configuring a QoS profile for the port or VLAN. You can tailor the DSCP-to-queue mapping on a per-port basis. Most of the existing ingress classification functions, along with the DiffServ replacement functions, are also supported for ATM ports.

The supported DiffServ functions maximize user flexibility while providing all of the features needed to support the standard per-hop behaviors (PHBs), including:

- Default
- Class Selector
- Assured Forwarding
- Expedited Forwarding

The ATM module also provides flexible support for the well-known Weighted RED (WRED) congestion avoidance algorithm.

Service Provider Features

The ATM module provides the following features for service provider environments:

- DSCP mapping
- VLAN ID (VID) tag mapping
- VLAN ID (VID) tag nesting
- VLAN to PVC mapping

DSCP Mapping. You can use the `diffserv dscp-mapping` command to configure a mapped relationship between an input DSCP and an associated output DSCP. Each ATM port supports three DSCP mapping tables: one of the tables is used in the ingress direction; two are used for egress flows (onto the ATM link). The two egress tables are for the congested and noncongested states, as determined by the RED algorithm. If RED is not enabled on the ATM port, the egress congested-state mapping table is not used.

In the ingress direction, the input DSCP of a packet received from the ATM link is replaced by an output DSCP before the packet is forwarded. In the egress direction, the operation is similar, except that the DSCP mapping occurs before the packet is transmitted onto the ATM link.

One potential use of the DSCP mapping capability is to reconcile varying DiffServ policies at the boundary between autonomous systems, such as at the boundary between two ISPs. The availability of different tables for the congested and noncongested states is useful in marking operations that increase the probability of packets being dropped during times of congestion, as discussed in the DiffServ Assured Forwarding RFC (RFC 2597).

VLAN ID (VID) Tag Mapping. An analogous feature has been added for the managing of 802.1Q tags. The `dot1q tagmapping` command provides support for VLAN ID (VID) mapping tables. Each ATM port supports two VID tables: one table is used in the ingress direction; the other is used in the egress direction. Each of the tables enables an input VID to be mapped to an output VID. This feature is useful in reconciling policy differences at the boundary between the customer and the service provider.

VLAN ID (VID) Tag Nesting. Another related enhancement provides support for nested 802.1Q tags by allowing a *tag push* or *tag pop* attribute to be associated with a VID. The *push* attribute indicates that a new tag is to be added to the frame, while the *pop* attribute indicates that the top-level tag is to be removed from the frame. This capability is augmented by an option that allows the 802.1p priority of the frame to be either preserved or set to a user-configurable value when a new tag is pushed. These functions make it possible for service providers to tunnel customer-specific VLANs across a common ATM backbone in a very simple manner.

VLAN to PVC Mapping. VLAN to PVC mapping can be used by service providers to isolate and provision a customer’s traffic using different VLANs and PVCs for each customer. Thus, a service provider can securely transport a customer’s Ethernet traffic across an ATM backbone or vice-versa.

Configuring the ATM Module

This section describes the ExtremeWare commands that support the ATM module. For hardware installation information on the BlackDiamond 6800 series switch, see the *Extreme Networks Consolidated “i” Series Hardware Installation Guide*.

NOTE

Documentation for Extreme Networks products is available on the World Wide Web at the Extreme Networks home page at http://www.extremenetworks.com/.

Basic ATM Module Configuration Information

This section uses several typical usage and configuration schemes to provide a brief overview of the ATM module configuration process as a general context for the detailed command description sections that follow.

ATM Module Characteristics

ATM is a packet transmission technique that uses fixed size data frames called “cells”. Each cell is 53-bytes long and includes a 5-byte ATM header and 48-byte payload. The ATM header includes a Virtual Path Identifier (VPI) and a Virtual Circuit Identifier (VCI). The VPI/VCI pair uniquely identifies a Virtual Circuit (VC) which is a logical connection configured on a physical ATM link. Each VC is a separate point-to-point connection and the ATM network uses the VPI/VCI in each ATM cell to determine how to forward the cell. Intermediate ATM switches in the network may change the VPI/VCI values for a VC so the same VC may be identified by a different VPI/VCI at the termination point. Multiple VCs can be configured on a single physical ATM link. The ATM module supports Permanent Virtual Circuits PVCs which are VCs that have been pre-provisioned by the ATM service provider. To connect to a service provider’s ATM network using a PVC, the VPI and VCI values must be obtained from the ATM service provider. The ATM module does not support Switched Virtual Connections (SVCs) which are VCs that are dynamically established using a signalling protocol.

The ATM module segments each outbound packet into ATM cells before transmitting and conversely re-assembles received cells into packets. Before segmenting a packet, the ATM module encapsulates the packet in an ATM Adaption Layer (AAL-5) format as defined in IETF RFC 2684/1483. The ATM module supports two types of encapsulations as defined in IETF RFC 2684/1483: LLC Encapsulation for Routed Protocols and LLC Encapsulation for Bridged Protocols. After the packets are segmented into ATM cells, the cells are transported inside a SONET payload.

The contents of ATM cells can be scrambled to randomize the pattern of 1s and 0s carried in the cells. Randomizing the bits can prevent long strings of all 1s and 0s. Transitions between 1s and 0s are used by the physical layer to maintain clocking and achieve signal synchronization which can improve the performance of delineating received ATM cells. The ATM module supports cell scrambling.

The ATM module responds to Operations, Administrations and Maintenance (OAM) F5 loopback cells but does not generate them. Loopback can be used to detect if the remote device is still active.

NOTE

The ATM module can support one PVC per VLAN for each port. The BlackDiamond 6800 series switch can support 3000 VLANs.

Default ATM Module Configurations

When the BlackDiamond 6800 series switch is powered on, the ExtremeWare software determines which slots are occupied by I/O modules, determines whether it has a configuration for each module, and generates a default configuration for each slot that is occupied by an I/O module that has not yet been configured. The default configuration is the minimal set of configuration parameter settings that will allow the I/O module and its ports to function.

By default, only ports 1 and 3 on the ATM module are assigned to the default VLAN, while ports 2 and 4 are not assigned to a VLAN. By default, ATM scrambling is enabled for all ATM ports. Before any data can be forwarded across an ATM port, PVCs must be configured on the port and mapped to a VLAN. Use the `configure atm add pvc` command to configure PVCs on the port and map PVCs to a VLAN. See “Configuring PVCs” on page 557 for more details.

Bridging and Routing Over ATM Ports

The ATM module supports bridging and routing across ATM PVCs. Frames can be forwarded across ATM PVCs using either bridged or routed protocol encapsulations as defined in IETF RFC 2648/1483. When using the bridged protocol encapsulation, the ATM module forwards the entire Ethernet frame (except the Frame Check Sequence) across an ATM PVC. The ATM PVC looks like an Ethernet segment to the rest of the switch. The Ethernet frame can carry any protocol including IP, IPX, and MPLS, and it can also include 802.1Q and 802.1p tags. The ATM module can also use the routed protocol encapsulation for sending IP packets across an ATM PVC. When using the routed protocol encapsulation, the ATM module strips the Ethernet header and only forwards the IP datagram across the ATM PVC, resulting in improved throughput for IP packets.

Before packets can be forwarded over ATM ports, at least one PVC must be configured on the port and mapped to a VLAN using the `configure atm add pvc` command. Each PVC must be mapped to one or more VLANs and each mapping must be designated to use the bridged protocol encapsulation (using the `encap l2` keywords in the `configure atm add pvc` command) or the routed protocol encapsulation (using the `encap ip` keywords in the `configure atm add pvc` command). Both encapsulations can be simultaneously used on a PVC as long as they are associated with different VLANs. ExtremeWare supports up to 500 routed VLANs and 4000 total VLANs in the BlackDiamond switch. When a routed VLAN is configured, the total number of VLANs supported in the BlackDiamond switch is 1500.

Each ATM port can support the previously described VLAN limits, and the following rules govern the association of PVCs with VLANs:

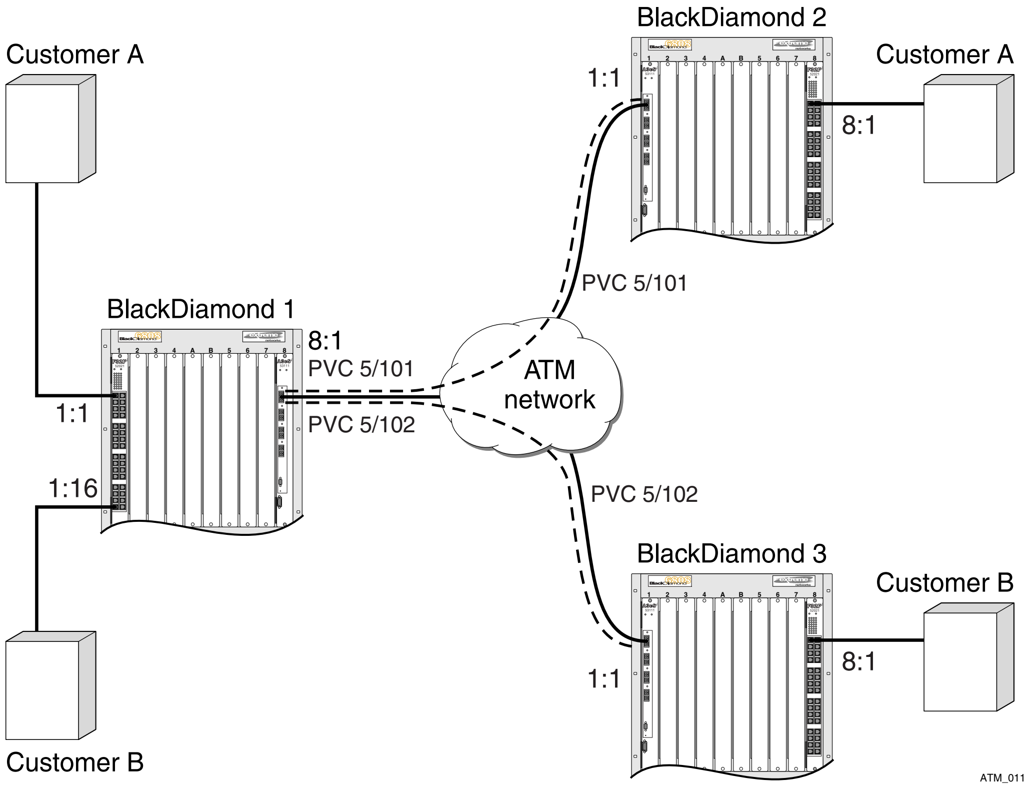
- Each PVC configured on a given ATM port must be associated with one or more VLANs.
- The same VLAN cannot be associated with multiple PVCs on the same ATM port.
- Ports 1 and 2 on the same ATM module may not be bridged together; similarly, ports 3 and 4 on the same ATM module may not be bridged together. Ports 1 and 2 or ports 3 and 4 may not be members of the same VLAN.
- Ports 1 and 2 on the same ATM module may not use the same VPI/VCI for a PVC; similarly, ports 3 and 4 on the same ATM module may not use the same VPI/VCI for a PVC.
- Both encapsulation types may be carried on the same PVC as long as they are associated with different VLANs.
- Multiple tagged VLANs may be configured to use the L2 encapsulation on the same PVC.
- Only one VLAN may be configured to use the IP encapsulation on a given PVC.
- Only one untagged VLAN may use the L2 encapsulation on a given PVC.
- When the IP encapsulation is configured, the ATM port must be the only member of the associated VLAN, and the IP address of the peer router must be configured using the `peer-ipaddress <ipaddress>` parameter in the `configure atm add pvc` command.

Frames received on an ATM port for VLANs that the ATM port is not a member of are discarded. Additionally, frames received from a PVC that contain a VLAN ID which does not match the VLAN ID associated with any of the VLANs configured for that PVC are discarded. Similarly, a frame received from the switch backplane is only forwarded on a PVC when the VLAN ID in the frame matches the VLAN ID associated with one of the VLANs configured for that PVC.

The ATM module supports all of the Spanning Tree Protocol (STP) commands. STP Bridge Protocol Data Units (BPDUs) are sent on a PVC when an L2 encapsulated VLAN associated with the PVC has been added to an STP domain. STP BPDUs are always transmitted as untagged frames on ATM PVCs. The `enable ignore-stp vlan` command can be used to indicate that the spanning tree forwarding state should be ignored for a particular VLAN.

Bridging Over ATM ports. Figure 102 displays multiple BlackDiamonds being used by an Ethernet Service Provider to provide point-to-point connectivity between their customer’s Ethernet networks using ATM PVCs. In this example, CustomerA has an Ethernet network in two different locations, one connected to BlackDiamond switch 1 via port 1:1 and the other connected to BlackDiamond switch 2 via port 8:1. Similarly, CustomerB is connected to BlackDiamond switch 1 via port 1:16 and BlackDiamond switch 3 via port 8:1. On BlackDiamond switch 1, the service provider has configured PVC 5/101 on ATM port 8:1 to connect to BlackDiamond switch 2 and PVC 5/102 on ATM port 8:1 to connect to BlackDiamond switch 3. The following configuration commands describe the basic steps necessary to configure the network displayed in Figure 102.

Figure 102: Bridging over ATM ports



Commands for configuring BlackDiamond switch 1:

```
create vlan customerA
configure vlan customerA tag 101
configure vlan customerA add ports 1:1, 8:1 tagged
configure atm add pvc 5/101 encap l2 vlan customerA port 8:1

create vlan customerB
configure vlan customerB tag 102
configure vlan customerB add ports 1:16, 8:1 tagged
configure atm add pvc 5/102 encap l2 vlan customerB port 8:1
```

Commands for configuring BlackDiamond switch 2:

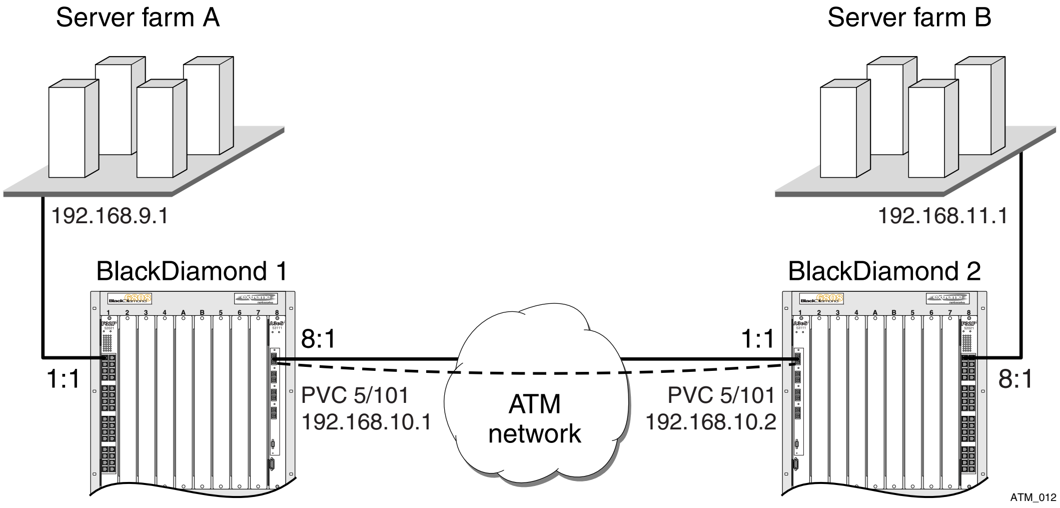
```
create vlan customerA
configure vlan customerA tag 101
configure vlan customerA add ports 1:1, 8:1 tagged
configure atm add pvc 5/101 encap l2 vlan customerA port 1:1
```

Commands for configuring BlackDiamond switch 3:

```
create vlan customerB
configure vlan customerB tag 102
configure vlan customerB add ports 1:1, 8:1 tagged
configure atm add pvc 5/102 encap l2 vlan customerB port 1:1
```

Routing Over ATM Ports. Figure 103 displays multiple BlackDiamonds being used to inter-connect server co-location sites using an ATM PVC. In this example, the customer has leased an ATM PVC between the different server co-location sites. The following configuration commands describe the basic steps necessary to configure the network displayed in Figure 103.

Figure 103: Routing over ATM ports



Commands for configuring BlackDiamond switch 1:

```
create vlan Serverfarma
configure vlan Serverfarma add ports 1:1
configure vlan Serverfarma ipaddress 192.168.9.1/24

create vlan wanLink
configure vlan wanLink add ports 8:1
configure vlan wanLink ipaddress 192.168.10.1/24
configure atm add pvc 5/101 encap ip peer-ipaddress 192.168.10.2 vlan wanLink port 8:1
enable ipforwarding
```

Commands for configuring BlackDiamond switch 2:

```
create vlan Serverfarmb
configure vlan Serverfarmb add ports 8:1
configure vlan Serverfarmb ipaddress 192.168.11.1/24

create vlan wanLink
configure vlan wanLink add ports 1:1
configure vlan wanLink ipaddress 192.168.10.2/24
configure atm add pvc 5/101 encap ip peer-ipaddress 192.168.10.1 vlan wanLink port 1:1
enable ipforwarding
```

Configuring and Monitoring ATM Ports

This section describes the commands used to configure ATM ports and provides information on the following topics:

- Configuring PVCs on page 557
- Deleting PVCs on page 557
- Displaying ATM Port Status Information on page 558
- Displaying PVC Status Information on page 559
- Configuring ATM Scrambling on page 559

Configuring PVCs

This section describes how to configure a PVC on an ATM port.

The following command is used to define a PVC on an ATM port:

```
configure atm add pvc <vpi/vci> encap [l2 | ip peer-ipaddress <ipaddress>] vlan <vlan
name> ports <portlist>
```

Where the following is true:

- The PVC is identified by the specified `vpi` and `vci` parameters. The `vpi` parameter is an integer in the range of 0 through 15. The `vci` parameter is an integer in the range of 17 through 4095.
- The `encap` parameter indicates the type of encapsulation that is to be used on the PVC for traffic from the associated VLAN. The `l2` keyword is an abbreviation for Layer-2 and indicates the LLC Encapsulation for Bridged Protocols (defined in RFC 2684). The `ip` keyword indicates that the VLAN will carry only routed IP traffic and that the LLC Encapsulation for Routed Protocols (defined in RFC 2684) should be used.

Deleting PVCs

The following command is used to delete a PVC configuration on an ATM port:

```
configure atm delete pvc [<vpi / vci> | all] {vlan <vlan name>} ports <portlist>
```

This command deletes the specified PVC configuration on the specified ATM port(s). The optional `vlan` parameter may be used to limit the scope of the command to the specified VLAN. The PVC may still exist following command execution if multiple VLANs have been configured to use the PVC. If the `vlan` parameter is omitted, the PVC configuration is deleted for all VLANs on the specified ATM port(s).

The command can be used to delete configuration information for the PVC identified via the `vpi` and `vci` parameters for all PVCs defined for the specified VLAN(s) or port(s). The all keyword may also be used as the portlist parameter to indicate that the command should be applied to all ATM ports. A PVC is completely deleted when there are no longer any VLANs configured for the PVC on a given ATM port.

NOTE

All associated PVCs must be deleted before an ATM port can be removed from a VLAN.

Displaying ATM Port Status Information

To display status information for the ATM ports, use the following command:

```
show atm {<portlist>}
```

You can use the optional `portlist` parameter to narrow the range of status information the command displays; otherwise, the command displays the status information for all ports.

By default, the command displays a summary of status information for the specified ports.

The summary of status information includes the following information for each port:

- Values of all port configuration parameters
- Port state
- ATM statistics

The detailed status information includes the summary information plus any ATM statistics. Table 68 describes the ATM receive statistics, and Table 69 describes the ATM transmit statistics.

Table 68: Summary of ATM Receive Statistics

Receive Statistics	Description
Cells Received	Number of cells received.
Cells OAM	Number of Operations, Administration, and Maintenance (OAM) cells received.
Cells Dropped (Congestion)	Number of cells dropped due to insufficient buffers.
Cells Dropped (Invalid VCC)	Number of cells dropped due to invalid VPI/VCI or AAL-5 header.
Cells Dropped (HEC)	Number of cells dropped with Header Error Control (HEC) errors. HEC is an 8 bit cyclic redundancy check (CRC) computed on all fields in an ATM header and capable of detecting bit errors. HEC is used for cell delineation.
PDUs Received	Number of PDUs received.
PDUs Dropped (CRC)	Number of PDUs discarded due to CRC-32 errors.
PDUs Dropped (Oversized)	Number of PDUs discarded because they were too large. See “Jumbo Frame Support” on page 581 for more details.
PDUs Dropped (Other)	PDUs dropped due to an invalid VLAN ID, Spanning Tree Protocol (STP) state, or invalid encapsulation.

Table 69 describes the ATM transmit statistics.

Table 69: Summary of ATM Transmit Statistics

Receive Statistics	Description
Cells Transmitted	Number of cells transmitted.
Cells Dropped (Congestion)	Number of cells dropped due to insufficient buffers.
PDUs Transmitted	Number of PDUs transmitted.

Displaying PVC Status Information

To display status information for a PVC, use the following command:

```
show atm [<vpi / vci> | all] {vlan <vlan name>} ports <portlist>
```

You can specify a particular PVC to display information for, or you can specify that information for all PVCs be displayed.

You can use the optional `vlan` parameter to narrow the range of status information the command displays; otherwise, the command displays status information for all VLANs.

You can use the optional `portlist` parameter to narrow the range of status information the command displays; otherwise, the command displays the status information for all PVCs associated with all ATM ports.

By default, the command displays a summary of status information for the specified PVC.

The summary of status information includes the following information for each PVC:

- Port number
- VPI/VCI
- VLAN IDs on this PVC
- Type of PVC (L2 or IP)
- Peer IP address (for IP PVCs)
- Received octets
- Received packets
- Transmitted octets
- Transmitted packets

The following command example displays all of the PVC status information for a PVC configured on an ATM port in a BlackDiamond switch:

```
show atm pvc 5/101 port 1:1
```

Configuring ATM Scrambling

To enable or disable payload data scrambling on the specified port, use the following command:

```
configure atm scrambling [on | off] ports <portlist>
```

Choose either `on` or `off`. Scrambling is enabled by default.

Scrambling is used to improve signal synchronization and the performance of the ATM cell delineation process.

The following command example turns off the scrambling function for port 1 of the ATM module installed in slot 8 of the BlackDiamond switch.

```
configure atm scrambling off ports 8:1
```

Configuring and Monitoring SONET

This section describes the commands used to configure and monitor SONET-specific attributes on ATM ports and provides information on the following topics:

- SONET Parameters and Values on page 560
- Configuring SONET Framing on page 561
- Configuring SONET Clocking on page 561
- Configuring the Signal Fail Threshold on page 561
- Configuring the Signal Degrade Threshold on page 562
- Configuring the Section Trace Identifier on page 562
- Configuring the Path Trace Identifier on page 563
- Configuring the Signal Label on page 563
- Resetting SONET Configuration Parameter Values on page 564
- Displaying SONET Status Information on ATM ports on page 564
- SONET Events on ATM Ports on page 565

SONET Parameters and Values

Table 70 describes the SONET parameters and values.

Table 70: SONET Parameters and Values

Parameter	Possible Values	Default Value
Framing	SONET or SDH	SONET
Clock source	internal or line	internal
Signal Failure threshold[1]	10^{-3} through 10^{-5}	10^{-5}
Signal Degrade threshold[2]	10^{-5} through 10^{-9}	10^{-6}
J0 Section Trace byte[3]	0 through 255	1
J0 Section Trace string[4]	Maximum of 15 characters	15 NULL characters
J1 Path Trace identifier string[5]	Maximum of 62 characters	NULL characters
C2 Signal Label[6]	0 through xFF	auto

[1] B2 bit error rate (BER) threshold; a Signal Failure (SF) event is generated if the BER exceeds the specified threshold.

[2] B2 bit error rate (BER) threshold; a Signal Degrade (SD) event is generated if the BER exceeds the specified threshold.

[3] The default value of 1 is per ANSI T1.105-1995. This parameter applies only when SONET framing is configured on the port.

[4] This parameter applies only when SDH framing is configured on the port.

[5] When SDH framing is configured on the port, only the first 15 characters of the string are applied.

[6] Set automatically based on synchronous payload envelope (SPE) payload type.

Configuring SONET Framing

You can configure each port for framing that complies with either the SONET standard or the SDH standard. SONET is primarily an American standard; SDH is the international version. The default is SONET.

To configure the framing for the specified SONET feature on an ATM port, use the following command:

```
configure sonet framing [sonet | sdh] ports <portlist>
```

The following command example selects SDH framing for port 1 of the ATM module installed in slot 8 of the BlackDiamond switch.

```
configure sonet framing sdh ports 8:1
```

Configuring SONET Clocking

You can configure each port on the ATM module to use either line clocking, where the clock source is recovered from the received bit stream, or internal clocking, where the clock source is based on an internal clock. The default is internal.

To configure the clocking source for the specified ATM port, use the following command:

```
configure sonet clocking [line | internal] ports <portlist>
```

The following command example selects line clocking for port 1 of the ATM module installed in slot 8 of the BlackDiamond switch.

```
configure sonet clocking line ports 8:1
```

Configuring the Signal Fail Threshold

A Signal Failure (SF) event is generated if the bit error rate (BER) for the SONET line exceeds the configured threshold. An SF event brings the port down.

To configure the Signal Fail threshold for the specified ATM port, use the following command:

```
configure sonet threshold signal fail <error_rate> ports <portlist>
```

The `error_rate` parameter is an integer in the range from 3 to 5, where the SF BER is 10^{-error_rate}. The default value of the `error_rate` parameter is 5, which equates to an SF bit error rate of 10^{-5}, or 1 per hundred thousand.

The following command example sets the Signal Fail threshold value to 3 for port 1 of the ATM module installed in slot 8 of the BlackDiamond switch.

```
configure sonet threshold signal fail 3 ports 8:1
```

NOTE

You can set the signal fail threshold to a value different than the default value of 5 if your particular application has a very low tolerance for errors. In general, you should not change the default setting unless you are an expert and have a specific reason for the change.

Configuring the Signal Degrade Threshold

A Signal Degrade (SD) event is generated if the BER for the SONET line exceeds the configured Signal Degrade threshold.

To configure the Signal Degrade threshold for the specified ATM port, use the following command:

```
configure sonet threshold signal degrade <error_rate> ports <portlist>
```

The `error_rate` parameter is an integer in the range from 5 to 9, where the SD bit error rate is 10^{-error_rate}. The default value of the `error_rate` parameter is 6, which equates to an SD bit error rate of 10^{-6}, or 1 per million.

The following command example sets the Signal Degrade threshold value to 8 for port 1 of the ATM module installed in slot 8 of the BlackDiamond switch.

```
configure sonet threshold signal degrade 8 ports 8:1
```

NOTE

You can set the signal degrade threshold to a different value than the default value of 6 depending on your particular application's tolerance for errors. In general, you should not change the default setting unless you are an expert and have a specific reason for the change.

Configuring the Section Trace Identifier

Section trace is a maintenance feature of SONET. One byte of the Section Overhead associated with each SONET frame is used to carry information identifying the transmitting equipment.

To configure the Section Trace identifier for the specified ATM port, use the following command:

```
configure sonet trace section [<id_byte> | string <id_string>] ports <portlist>
```

In this command, the Section Trace identifier can take one of two forms: an ID byte (`id_byte`) or an ID string (`id_string`).

The `id_byte` parameter is an integer in the range from 1 to 255, with a default value of 1. This parameter applies only when SONET framing is configured, in which case, the configured `id_byte` value is transmitted in each SONET frame.

The `id_string` parameter is a string of up to 15 characters. By default, the <id_string> parameter contains 15 NULL characters. This parameter applies only when SDH framing is configured, in which case the SDH framing cycles repetitively through a 15-character string, sending one character per frame. If the configured string contains fewer than 15 characters, it is padded to full length by NULL characters.

The following command example sets the Section Trace identifier to the string “1800wombat” for port 1 of the ATM module installed in slot 8 of the BlackDiamond switch:

```
configure sonet trace section string 1800wombat ports 8:1
```

Configuring the Path Trace Identifier

Path trace is a maintenance feature of SONET. One byte of the Path Overhead associated with each SONET frame is used to carry information identifying the originating Path Terminating Equipment (PTE).

To configure the Path Trace identifier for the specified ATM port, use the following command:

```
configure sonet trace path <id_string> ports <portlist>
```

The id_string parameter defaults to a string of 62 NULL characters.

When SONET framing is configured, a 62-character string is transmitted repetitively, one character per frame. If the configured string consists of fewer than 62 characters, it is padded to its full length with NULL characters.

When SDH framing is configured, the maximum length of the id_string parameter is 15 characters. If the configured string consists of more than 15 characters, it is truncated to 15 characters.

The following command example sets the Path Trace identifier to the string “parador” for port 1 of the ATM module installed in slot 8 of the BlackDiamond switch.

```
configure sonet trace path parador ports 8:1
```

Configuring the Signal Label

The Signal Label field occupies one byte (C2) of the Path Overhead associated with each SONET frame. It is used to indicate the type of contents carried in the Synchronous Payload Envelope (SPE). For example, 0x13 indicates that the SONET SPE contains ATM cells.

To configure the C2 Signal Label value for the specified ATM port, use the following command:

```
configure sonet signal label [auto | <hex_octet>] ports <portlist>
```

The hex_octet parameter is specified as a hexadecimal integer in the range from 00 to FF. It may be necessary to specify a particular Signal Label value in order to interoperate with implementations that do not follow the standard conventions for the Signal Label field.

To determine whether you need to specify a particular Signal Label value, perform the following tasks:

1. Use the show sonet command to display SONET status information on ATM ports.
2. Look for a Path Payload Label Mismatch (PLM-P) event indicating that the received payload type does not match the expected payload.
3. Compare the contents of the received C2 field (Signal Label value) with the contents of the transmitted C2 field.

If no Signal Label value is specified, the command defaults to auto, which causes the value of the Signal Label field to be set automatically based on standard conventions for the given payload type.

The following command example sets the Signal Label to the hexadecimal value CF for port 1 of the ATM module installed in slot 8 of the BlackDiamond switch:

```
configure sonet signal label CF ports 8:1
```

Resetting SONET Configuration Parameter Values

To reset the SONET configuration parameters for the specified ATM ports to their default values, use the following command:

```
unconfigure sonet ports <portlist>
```

Displaying SONET Status Information on ATM ports

To display SONET status information for the ATM ports, use the following command:

```
show sonet {<portlist>} {detail}
```

You can use the optional `portlist` parameter to narrow the range of status information the command displays; otherwise, the command displays the status information for all ports.

By default, the command displays a summary of status information for the specified ports. You can use the optional `detail` keyword to display detailed status information for the specified ports.

The summary of status information includes the following information for each port:

- Values of all port configuration parameters
- Port state
- Any active events

The detailed status information includes the summary information plus any SONET statistics (listed and described in Table 71).

Table 71: Summary of SONET Statistics

Statistic	Description
Section parity errors	Number of B1 parity errors detected
Line parity errors	Number of B2 parity errors detected
Path parity errors	Number of B3 parity errors detected
REI-L event counter	Number of B2 parity errors detected by peer LTE
REI-P event counter	Number of B3 parity errors detected by peer PTE
LOS event counter	Number of LOS events
LOF event counter	Number of LOF events
LOP event counter	Number of LOP events
AIS-L event counter	Number of AIS-L events
AIS-P event counter	Number of AIS-P events
RDI-L event counter	Number of RDI-L events
RDI-P event counter	Number of RDI-P events
PLM-P event counter	Number of PLM-P events
SF BER event counter	Number of SF BER events

Table 71: Summary of SONET Statistics (Continued)

Statistic	Description
SD BER event counter	Number of SD BER events

SONET Events on ATM Ports

The ATM module can detect and report a variety of error and alarm conditions, some of which also trigger actions on the SONET link. Table 72 describes these events and their associated actions. Syslog messages are output for these events. For more information about Syslog, see Chapter 11.

Table 72: SONET Events

Event	Description
Loss of Signal (LOS)	Loss of Signal is detected by the Section Terminating Equipment (STE) when an all-zeroes pattern on the incoming SONET signal lasts 100 microseconds or longer. This condition can be caused by loss of light on the fiber. SONET Action: Send RDI-L upon LOS detection.
Loss of Frame (LOF)	Loss of Frame is detected by the STE when a Severely Errored Framing (SEF) defect on the incoming signal persists for 3 milliseconds. Related SONET Overhead: A1, A2 (framing pattern). SONET Action: Send RDI-L upon LOF detection.
Loss of Pointer (LOP)	The Path Loss Of Pointer event is detected as a result of excess New Data Flags (NDFs) or invalid pointers in the H1/H2 fields of the received signal. Related SONET Overhead: H1,H2 contain NDF and pointer. SONET Action: Send RDI-P upon LOP detection.
Alarm Indication Signal—Line (AIS-L)	The Line Alarm Indication Signal is sent by the upstream STE to inform the LTE that a LOS or LOF defect has been detected. Extreme's SONET module never sends AIS-L. AIS-L was formerly known as Line Far End Receive Failure (FERF). Related SONET Overhead: K2 carries AIS-L. SONET Action: Send RDI-L upon reception of AIS-L.
Alarm Indication Signal—Path (AIS-P)	The Path Alarm Indication Signal is sent by the upstream LTE to inform the PTE that a LOS, LOF, AIS-L, or LOP defect has been detected. Extreme's SONET module never sends AIS-P. AIS-P was formerly known as Path Far End Receive Failure (FERF). Related SONET Overhead: H1,H2,H3 = 0 when indicating AIS-P. SONET Action: Send RDI-P upon receiving AIS-P.
Remote Defect Indicator—Line (RDI-L)	The Line Remote Defect Indication is sent by the downstream LTE when a LOS, LOF, or AIS-L defect is detected. Related SONET Overhead: K2 carries RDI-L.
Remote Defect Indicator—Path (RDI-P)	The Path Remote Defect Indication is sent by the downstream PTE when a LOP or AIS-P defect is detected. Related SONET Overhead: G1 carries RDI-P.
Remote Error Indicator—Line (REI-L)	The Line Remote Error Indicator conveys a count of detected B2 parity errors from the peer LTE. Related SONET Overhead: M1 carries REI-L.
Remote Error Indicator—Path (REI-P)	The Path Remote Error Indicator conveys a count of detected B3 parity errors from the peer PTE. Related SONET Overhead: G1 carries REI-P.

Table 72: SONET Events (Continued)

Event	Description
Path Payload Label Mismatch (PLM-P)	The Path Payload Label Mismatch event occurs when the received payload type does not match the expected payload. This event is commonly caused by a Signal Label or scrambling mode mismatch configuration error. Related SONET Overhead: C2 carries the Signal Label.
Signal Failure Bit Error Rate (SF BER)	The Signal Failure BER event occurs when the B2 bit error rate exceeds the configured SF threshold. Related SONET Overhead: B2 carries line parity. SONET Action: Send RDI-L upon detecting SF BER event.
Signal Degrade Bit Error Rate (SD BER)	The Signal Degrade BER event occurs when the B2 bit error rate exceeds the configured SD threshold. This event is used for APS switching. Related SONET Overhead: B2 carries line parity.

Configuring VLAN-Related Attributes

The ExtremeWare software and the Extreme Networks switch architecture provide a range of Virtual Local Area Network (VLAN) features. This section describes how these features are supported on the ATM module.

NOTE

This section assumes some familiarity with the Extreme Networks implementation of VLAN features. For more information about VLAN-related features supported by ExtremeWare, see Chapter 6, "Virtual LANs (VLANs)" on page 121.

This section provides information on the following topics:

- Configuring Tagged VLAN 802.1p and 802.1Q Functions on page 567
- Generic VLAN Registration Protocol Functions on page 569

ATM module ports do not support protocol-based VLANs or MAC address VLANs. Thus, there are restrictions on the use of the following commands:

- `configure vlan <vlan name> add ports <portlist> {tagged | untagged} {nobroadcast} {soft-rate-limit}`
- `configure vlan <vlan name> delete port <portlist>`
- `configure vlan <vlan name> protocol [<protocol_name> | any]`
- `enable mac-vlan mac-group [any | <group_number>] port <portlist>`

The restrictions are as follows:

- An ATM port cannot be added to a VLAN if the VLAN is a protocol-based VLAN.
- A VLAN cannot be configured to be a protocol-based VLAN if the VLAN contains an ATM port.
- A MAC address VLAN cannot be enabled on an ATM port.

The `configure vlan <vlan name> protocol [<protocol_name> | any]` command is supported, because it can be used to configure the default VLAN for ATM ports.

In the `configure vlan <vlan name> add ports <portlist> {tagged | untagged} {nobroadcast} {soft-rate-limit}` command, ATM ports support the optional `tagged` and `untagged` keywords when LLC encapsulation for bridged protocols is enabled, and ignore them when LLC encapsulation for routed protocols is enabled.

Configuring Tagged VLAN 802.1p and 802.1Q Functions

NOTE

The dot1q tag mapping and tag nesting commands are supported only by ATM ports and apply only when LLC encapsulation for bridged protocols is enabled on the ATM port.

The following ExtremeWare commands are supported for the ATM module:

- `configure dot1q ethertype <ethertype>`
- `configure dot1p type <dot1p_priority> qosprofile <qosprofile>`

NOTE

If an ATM port receives a frame with a priority value "n" that is not mapped to a profile in the range from qp1 through qp8, the frame is assigned to QoS profile qp_{n+1}.

The following commands provide ATM module support for managing 802.1Q tags:

- `configure dot1q tagmapping <input_vlanid/output_vlanid> ports <portlist> {egress {priority <priority>} | ingress {priority <priority>}}`
- `configure dot1q tagnesting {<vlanid> | <vlanid_range>} [off | pop | push <new_vlanid> {priority <priority>}] ports <portlist> {egress | ingress}`

Configuring VLAN Tag Mapping Tables

The `configure dot1q tagmapping ports` command provides support for VLAN ID (VID) mapping tables. Each ATM port supports two VID tables: one table is used in the ingress direction; the other is used in the egress direction. These tables make it possible to map an input VID to an output VID, which can be useful in reconciling policy differences at the boundary between the customer and the service provider. The tables also allow the option of preserving the 802.1p priority or overwriting the priority with a configured value.

To configure the VLAN tag mapping tables for an ATM port, use the following command:

```
configure dot1q tagmapping <input_vlanid/output_vlanid> ports <portlist> {egress
{priority <priority>} | ingress {priority <priority>}}
```

The input_vlanid and output_vlanid parameters are both integers in the range from 1 to 4095 and must be separated by a slash character.

The priority parameter is an integer in the range from 0 to 7.

Use the egress keyword to apply the mapping of the input VLAN ID to the output VLAN ID to frames received from the switch backplane prior to transmitting them onto the ATM link. Use the ingress keyword to apply the mapping to input frames received from the ATM link. The mappings are applied after they are classified to a QoS profile. Frames containing the VLAN ID specified in input_vlanid are changed so that the VLAN ID is set to the value specified in output_vlanid before the frame is forwarded.

If you omit both the egress and the ingress keywords, the command automatically applies the specified mapping to the egress direction, and also applies a symmetrical mapping (with the input_vlanid and output_vlanid values reversed) to the ingress direction.

These tables also give you the option of preserving the 802.1p priority or overwriting the priority with a user-configured value. Using the priority keyword in the command indicates that the 802.1p priority field is to be set to the value specified in priority. To preserve the 802.1p priority, do not enter the priority keyword and value when using this command.

The default behavior is that the tables are initialized such that VLAN IDs are not altered by the mapping operations, and frame priority is preserved. For example, an input VLAN ID of *n* is always mapped to an output VLAN ID of *n*, and the 802.1p priority field is not changed.

Configuring VLAN Tag Nesting Attributes

The configure dot1q tagnesting command provides support for 802.1Q tags by allowing a tag *push* or *pop* attribute to be associated with a VLAN ID. The push attribute indicates that a new tag is to be added to the frame, while the pop attribute indicates that the top-level tag is to be removed from the frame. The command also gives you the option to preserve the 802.1p priority of the frame or set it to a configured value when a new tag is added (pushed) to the frame. VLAN ID (VID) mapping occurs before a new tag is pushed, and after a nested tag is popped.

To configure the VLAN tag nesting attributes for an ATM port, use the following command:

```
configure dot1q tagnesting {<vlanid> | <vlanid_range>} [off | pop | push <new_vlanid>
{priority <priority>}] ports <portlist> {egress | ingress}
```

The vlanid parameter is an integer in the range from 1 to 4095. The vlanid_range parameter is specified in the form start_vlanid-end_vlanid, where the start and end values are both integers in the range from 1 to 4095 and must be separated by a hyphen.

The push keyword indicates that a new tag is to be added to frames containing the VID specified in vlanid or to one of the VIDs in the range specified in vlanid_range. The new tag added to frames contains the value specified in new_vlanid.

The pop keyword indicates that the top-level tag is to be removed from frames when that tag contains either the VID specified in vlanid or any one of the VIDs in the range specified in vlanid_range.

If you do not specify a VID or a range of VIDs, the command settings are applied to all VIDs.

Tag operations can be performed in either the egress direction (to the ATM link) or the ingress direction (from the ATM link). If you do not specify a direction, the default behavior is that tag operations are performed in the egress direction. If you do not use either the egress or ingress keyword and tag pushing is configured, a corresponding tag pop operation is automatically configured for the ingress direction. If you do not use either the egress or ingress keyword and tag nesting is disabled using the off keyword, tag nesting is disabled in both directions.

The optional priority keyword provides a way to overwrite the 802.1p priority with a user-configured value when a new tag is pushed. Using the priority keyword in the command indicates that the 802.1p priority field is to be set to the value specified in priority, which is an integer in the range from 0 to 7. To preserve the 802.1p priority, do not enter the priority keyword and value when using this command.

Default behavior is that tag nesting is disabled (off) for all VLAN IDs.

Tag push operations apply to egress frames only when the port is configured to transmit tagged frames for the associated VLAN. Tag nesting operations apply only to ingress frames that contain a VLAN tag. Tag nesting operations are applied after classification to a QoS profile.

NOTE

The DiffServ and RED functions are not performed by ATM ports when frames contain nested tags (more than one tag).

Generic VLAN Registration Protocol Functions

The Generic VLAN Registration Protocol (GVRP) is not supported on ATM module ports, so the following command will not work if you specify an ATM port:

```
configure gvrp {listen | send | both | none} port <portlist>
```

Configuring Forwarding Database Attributes

ATM ports support all of the existing ExtremeWare forwarding database (FDB) commands. For more information on these commands, see Chapter 7.

Configuring Spanning Tree Attributes

ATM ports support all of the existing ExtremeWare Spanning Tree (STP) commands except EMISTP and PVSTP. For more information on STP commands, see Chapter 14.

Configuring QoS Functions

The ExtremeWare software and the Extreme Networks switch architecture provide a number of Quality of Service (QoS) functions, which are described in detail in Chapter 8. This section describes how these QoS functions, such as Differentiated Services (DiffServ) and Random Early Detection (RED) are supported on the ATM module.

NOTE

This section assumes some familiarity with the Extreme Networks implementation of QoS and DiffServ features. For more information about QoS and DiffServ features supported by ExtremeWare, see Chapter 8.

This section contains information on the following topics:

- Configuring a QoS Profile on page 570
- Classification and Replacement Policies on page 571
- Configuring DiffServ on page 572
- Enhanced RED Support on page 574

Configuring a QoS Profile

The ATM module supports eight ingress queues and eight egress queues per port. The scheduling parameters (minimum bandwidth, maximum bandwidth and priority level) for these queues are controlled by QoS profiles qp1 through qp8, which are defined using the existing ExtremeWare `configure qosprofile` command.

This command has been enhanced to allow you to configure more module-specific parameters on a port-by-port basis, including the ability to customize the QoS profile parameters for individual ingress or egress queues on a specific ATM port.

The syntax and description of the enhanced `configure qosprofile` command are described below.

To configure the scheduling parameters for a specified QoS profile, use the following command:

```
configure qosprofile <qosprofile> minbw <min_percent> maxbw <max_percent> priority
<level> {[minbuf <percent> maxbuf <number> [K | M] | maxbuff <number> [K | M] |
<portlist>]}
```

The optional `egress` and `ingress` keywords apply only to ATM ports. As stated earlier, the ATM module supports eight egress queues and eight ingress queues per port, and the scheduling parameters for these queues are controlled by QoS profiles qp1-qp8, which means queue #0 is controlled by qp1, queue #1 is controlled by qp2, and so on.

The optional `portlist` parameter allows QoS profiles to be customized on a port-by-port basis for the ATM module. The `egress` and `ingress` keywords allow you to fine-tune the customization (down to a particular egress or ingress queue on a given port). If you do not enter either the `egress` or `ingress` keyword in the command, the configured parameters apply to the egress queue associated with the specified QoS profile by default.

The `minbw` parameter specifies the minimum percentage of the bandwidth guaranteed to be available to the specified queue for transmissions from the QoS profile. The value is an integer in the range from 0 through 100. The default value is 0. The sum of the minimum bandwidth parameters across all eight QoS profiles cannot exceed 90%.

The `maxbw` parameter specifies the maximum percentage of the bandwidth that the specified queue can use for transmissions from the QoS profile. The value is an integer in the range from 1 through 100. The default value is 100.

The optional `priority` keyword and `level` parameter specify the service priority for the specified queue. The service priority determines which traffic is scheduled when bandwidth is still available after the minimum requirements of all profiles have been satisfied. Settings for `level` include: low, lowHi, normal, normalHi, medium, mediumHi, high, or highHi. The default setting is low.

NOTE

The `minbuf` *and* `maxbuf` *keywords do not apply to ATM ports.*

Classification and Replacement Policies

This section deals primarily with classification operations performed by the ATM module.

Most of the existing ingress classification functions are supported for LLC Encapsulation for Routed Protocols or LLC Encapsulation for Bridged Protocols configured ATM ports. Functions such as access list and destination MAC address QoS policies are supported, as is the `enable diffserv replacement` command.

Egress frames are always assigned to a QoS profile based on their 802.1p priority. Thus, when an ATM port receives a frame from the switch fabric with a priority value *n*, that frame is assigned to egress QoS profile qp*n*+1.

The existing `enable diffserv examination ports` and `disable diffserv examination ports` commands are used on ATM ports to control whether the DiffServ code point (DSCP) is examined for ingress classification purposes.

When you enable the LLC Encapsulation for Bridged Protocols on an ATM port, non-IP frames that contain a VLAN tag are assigned to an ingress QoS profile based on their 802.1p priority value. You can configure this assignment using the `configure dot1p type` command, which is used to specify the mappings between 802.1p priority values and QoS profiles. However, if an ATM port receives a frame with a priority value *n*, for which there is no mapping to one of the eight profiles (qp1-qp8), that frame is assigned to ingress QoS profile qp*n*+1.

If `diffserv examination` is not enabled, then the preceding 802.1p priority classification rules are applied to tagged IP frames as well.

In both cases, untagged frames are assigned to a single ingress QoS profile (provided that the port is an untagged member of a VLAN; if that is not the case, then untagged frames are discarded). This QoS profile defaults to qp1, but you can assign it to another profile using the `configure ports <portlist> qosprofile <qosprofile>` command or the `configure vlan <vlan name> qosprofile <qosprofile>` command (where the port-based QoS configuration has higher precedence than VLAN-based QoS).

Additionally, if you enable the LLC Encapsulation for Routed Protocols on an ATM port and do not enable `diffserv examination` on the port, then all ingress frames (received from the SONET link) are assigned to a single ingress QoS profile. The profile defaults to qp1, but you can configure it to another profile using the `configure ports <portlist> qosprofile <qosprofile>` command or the `configure vlan <vlan name> qosprofile <qosprofile>` command.

If you enable `diffserv examination` on an ATM port, then ingress IP frames are assigned to a QoS profile based on the DiffServ code point (regardless of whether you enabled either LLC Encapsulation for Bridged Protocols or LLC Encapsulation for Routed Protocols on the port). The existing `configure diffserv examination code-point` command maps DiffServ code points to QoS profiles. This command has been enhanced for use with ATM ports. The syntax and description of the enhanced `configure diffserv examination code-point qosprofile ports` command are given below.

Also note that, in all cases, the 802.1p priority bits of ingress frames forwarded to the switch backplane are set based on the ingress QoS profile classification. More specifically, the 802.1p priority value is set to qp# – 1. For example, if the packet is classified to qp5, then the 802.1p priority value is set to 4.

Configuring DiffServ

All of the existing ExtremeWare DiffServ commands are supported by ATM ports with IP frames that are encapsulated for bridged or routed protocols. ATM ports also support a DiffServ code point (DSCP) mapping function that you configure using the `configure diffserv dscp-mapping` command, which is described below. The DSCP is a 6-bit value in the IP-TOS byte of the IP packet header. For more information on DSCPs, see Chapter 8.

DiffServ Classification

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

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

Changing DiffServ Code Point Assignments in the QoS Profile

Because the code point uses six bits, it has 64 possible values ($2^6 = 64$). By default, the values are grouped and assigned to the default QoS profiles listed in Table 73.

Table 73: Default Code Point-to-QoS Profile Mapping

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

To configure the mapping between a DiffServ code point and a specified QoS profile, use the following command:

```
configure diffserv examination code-point <code_point> qosprofile <qosprofile> ports
[<portlist> | all] {low-drop-probability | high-drop-probability}
```

The mapping is applied in the ingress direction—for IP packets received from the ATM link.

The optional `low-drop-probability` and `high-drop-probability` keywords apply only to ATM ports. If you do not enter either of these keywords in the command, the command uses `low-drop-probability` as the default.

The `low-drop-probability` and `high-drop-probability` keywords are useful in conjunction with the Weighted RED (WRED) implementation provided by ATM ports. This implementation supports two different drop probabilities: one for DiffServ code points designated as having low drop-probability; another for DiffServ code points designated as having high drop-probability. These keywords give you complete flexibility in assigning DiffServ code points to these two drop-probability levels.

Configuring DiffServ Code Point Mapping Tables

You can use the `diffserv dscp-mapping` command to configure a mapped relationship between an input DSCP and an associated output DSCP. Each ATM port supports three DSCP mapping tables: one of the tables is used in the ingress direction; two are used for egress flows (onto the ATM link). The two egress tables are for the congested and noncongested states, as determined by the RED algorithm. If RED is not enabled on the ATM port, the egress congested-state mapping table is not used.

In the ingress direction, the input DSCP of a packet received from the ATM link is replaced by an output DSCP before the packet is forwarded. In the egress direction, the operation is similar, except that the DSCP mapping occurs before the packet is transmitted onto the ATM link.

One potential use of the DSCP mapping capability is to reconcile varying DiffServ policies at the boundary between autonomous systems, such as at the boundary between two ISPs. The availability of different tables for the congested and noncongested states is useful in marking operations that increase the probability of packets being dropped during times of congestion, as discussed in the DiffServ Assured Forwarding RFC (RFC 2597).

NOTE

This command applies only to ATM ports with IP frames that are encapsulated for bridged or routed protocols. You should also be aware that DSCP mapping is performed even when the `diffserv examination` *function is disabled on the port.*

To configure the mapping between an input DSCP and an associated output DSCP, use the following command:

```
configure diffserv dscp-mapping <input_codepoint>/<output_codepoint> ports <portlist>
{egress {no-congestion | congestion} | ingress}
```

where:

`input_codepoint`	Specifies one of the 64 possible DiffServ code point values as the input code point.
`output_codepoint`	Specifies one of the 64 possible DiffServ code point values as the output code point.
`egress`	Applies the DSCP mapping to the egress direction.
`no-congestion`	Applies the DSCP mapping to the egress mapping table for the non-congested state.
`congestion`	Applies the DSCP mapping to the egress mapping table for the congested state.
`ingress`	Applies the DSCP mapping to the ingress direction.

If you omit the `no-congestion` and `congestion` keywords, the command applies the mapping to the tables for both states.

If you omit the `egress` and `ingress` keywords, the command applies the mapping to the egress direction, and automatically configures a symmetrical mapping (with the `input_codepoint` and `output_codepoint` values reversed) in the ingress direction.

By default, all the tables are initialized such that DSCPs are not altered by the mapping operations. For example, an input DSCP value of *n* is always mapped to an output DSCP value of *n*.

Resetting DiffServ Code Point Mapping Tables

To reset the DSCP mapping tables for a specified ATM port to their default values, use the following command:

```
unconfigure diffserv dscp-mapping ports <portlist>
```

Replacing DiffServ Code Points

To replace DiffServ code points, you must use the following command to enable DiffServ replacement:

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

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

```
configure diffserv replacement priority <value> code-point <code_point> ports
[<portlist> | all]
```

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

To verify the DiffServ configuration, use the command:

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

Enhanced RED Support

Random Early Detection (RED) is a congestion avoidance mechanism. The basic idea behind RED is that most data transports detect packet loss and will, therefore, restrain transmission—if only temporarily—when they detect dropped packets. Consequently, if the switch needs to signal another device to slow transmission due to congestion, RED provides a way of intelligently dropping packets.

This section describes the changes and additions to ExtremeWare to support RED in conjunction with ATM modules that have IP frames encapsulated in bridged or routed protocols. The Extreme implementation of RED combines the functions of the RED algorithm with IP precedence to provide support for preferential traffic handling for higher-priority packets. This implementation provides weighted RED (WRED) functionality through two packet-drop probabilities (described below), so that a device can selectively drop lower-priority traffic when an interface begins to show signs of congestion. This capability is combined with DiffServ attributes to allow you to tailor performance characteristics for different classes of service.

Configuring RED Drop Probability

To configure the RED drop probability for a specified ATM port, use the following command:

```
configure red [drop-probability | low-drop-probability | high-drop-probability]
<percent> {ports <portlist>}
```

The optional `low-drop-probability`, `high-drop-probability`, and `ports` keywords are supported only for ATM ports.

If you omit the `ports` keyword, the command applies the setting to all ports.

The drop probability is specified as a percentage, where the `percent` parameter is an integer in the range from 1 to 100.

Weighted RED (WRED) functionality is supported through two different drop probabilities: a low-drop-probability and a high-drop-probability. The DiffServ code points of IP packets indicate whether the packet should be dropped with low probability or high probability, and the appropriate percentage is then applied if WRED is active.

NOTE

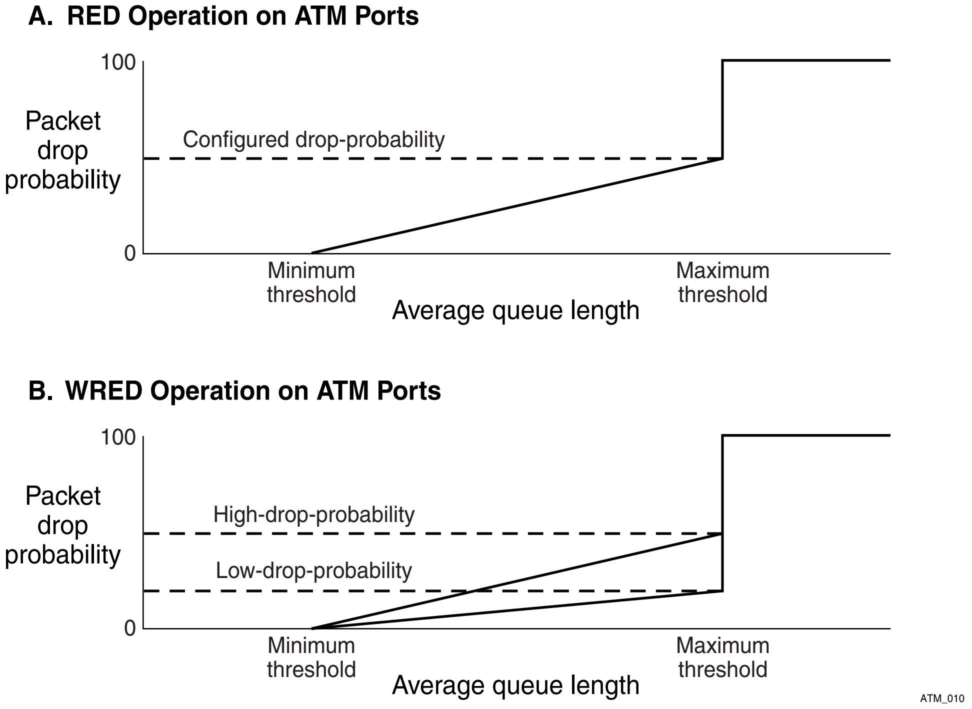
WRED is applied only to IP packets. The `configure diffserv examination code-point` *command gives you complete flexibility in assigning DSCPs to the two different drop-probability levels. This configured mapping of DSCPs to drop-probability levels is used by WRED even if* `diffserv examination` *is disabled on the port.*

The `drop-probability` keyword indicates that the specified percentage should be used for both the low and high drop-probabilities. This effectively disables WRED and reverts to standard RED operation. For ATM ports, both the low and high drop-probabilities default to 10%.

The role of the configured drop probability in RED operation on ATM ports is illustrated in Figure 104A. RED is active when the average queue length is between the minimum and maximum thresholds. In this region, the probability that a given packet is dropped increases in a straight line up to the configured drop probability at the maximum threshold. All packets are dropped when the average queue length exceeds the maximum threshold.

The operation of WRED on ATM ports is depicted in Figure 104B. In this case, the drop probability depends not only on the average queue length, but also upon whether the DSCP indicates that the packet should be dropped with a low or high probability, which is to say, the DSCP of the packet controls which curve is used.

Figure 104: Comparisons of RED and WRED operation



Enabling and Disabling RED on ATM Ports

The existing ExtremeWare commands to enable and disable RED ports have been enhanced to provide RED configuration attributes for the ATM module. Because the ATM module supports eight egress queues per port, the commands were enhanced to allow the user a way to enable RED selectively on an individual port and queue basis. By default, RED is disabled.

To enable RED on a specified ATM port, use the following command:

```
enable red ports <portlist>
```

To disable RED on a specified ATM port, use the following command:

```
disable red ports <portlist>
```

The optional `queue` keyword applies only to ATM ports. You can use this keyword to enable or disable the RED function on an individual queue basis.

The `queue#` parameter is an integer in the range from 0 to 7, and identifies one of the eight egress queues. If you omit the `queue` keyword, the command applies to all of the queues for the ATM port.

Configuring the RED Minimum Queue Length Threshold

The packet drop probability is based, in part, on the RED minimum queue length threshold. When the average queue length exceeds this threshold, the RED algorithm is activated and begins dropping packets. The packet drop rate increases in a linear fashion as the average queue length increases or until the average queue length hits the maximum threshold.

NOTE

This command applies only to PoS and ATM ports.

To configure the minimum queue length threshold for RED operation on a specified ATM port, use the following command:

```
configure red min-threshold <percent> ports <portlist>
```

The threshold value is specified as a percentage in the range from 1 to 100. For ATM ports, the minimum threshold is a percentage of 1000 packet buffers, and the maximum threshold is set to the value calculated by the formula:

*minimum ((3 * minimum threshold buffers), maximum available buffers)*

By default, the minimum threshold for ATM ports is 10%, or 100 buffers; thus, the default maximum threshold is 300 buffers.

You can use the `show ports info` command to display the settings of the minimum and maximum thresholds, displayed in terms of the number of buffers.

Use the `ports` keyword to configure the threshold parameter on specific ATM ports.

Support for Standard Per-Hop Behaviors

The per-hop behavior (PHB) describes the externally observable packet forwarding handling (or "behavior") to be applied by the receiving network element when there are competing requests for resources such as bandwidth and buffer space. In the packet forwarding path, differentiated services are identified by mapping the differentiated services code point (DSCP) contained in the IP packet header to a specific forwarding behavior at each network element along its path. The DSCP is 6 bits wide, and takes the form *xxxxxx*, where *x* can be either 0 or 1. The DSCP field is capable of identifying one of 64 distinct code points. For purposes of code point allocation and management, the code point space is divided into three pools: one pool of 32 code points (pool 1) constitutes the recommended code points to be allocated as standards; a second pool of 16 code points (pool 2) is set aside for experimental or local use; a third pool of 16 code points (pool 3) that are initially set aside for experimental or local use, but that might be used for standard assignments if pool 1 is ever exhausted. The mapping of DSCPs to PHBs is a user-configurable function, as described below.

The current standards call for two PHBs: Assured Forwarding (AF) and Expedited Forwarding (EF). The EF PHB describes the required behavior for voice-over-IP service. The AF PHB consists of four independently forwarded AF classes: AF1, AF2, AF3, and AF4. Within each of these classes, an IP packet can be assigned to different levels of drop precedence (used to determine drop probability) depending on how many levels of drop precedence the implementation supports. RFC 2597 describes two schemes for drop-precedence levels: a three-level scheme (see Table 74) and a two-level scheme (see Table 75). The three-level scheme supports low, medium, and high drop-precedence levels for the AF classes; the two-level scheme supports low and high drop-precedence levels (and groups the medium drop-precedence code-points with the high drop-precedence code-points). The Extreme implementation for the ATM module supports the two-level drop-precedence scheme.

Table 74: Assured Forwarding Classes and Three-Level Drop Precedence

Drop-Precedence Level	AF1	AF2	AF3	AF4
Low drop precedence	(AF11) 001010	(AF21) 010010	(AF31) 011010	(AF41) 100010
Medium drop precedence	(AF12) 001100	(AF22) 010100	(AF32) 011100	(AF42) 100100
High drop precedence	(AF13) 001110	(AF23) 010110	(AF33) 011110	(AF43) 100110

Table 75: Assured Forwarding Classes and Two-Level Drop Precedence

Drop-Precedence Level	AF1	AF2	AF3	AF4
Low drop precedence	(AF11) 001010	(AF21) 010010	(AF31) 011010	(AF41) 100010
High drop precedence	(AF12) 001100 (AF13) 001110	(AF22) 010100 (AF23) 010110	(AF32) 011100 (AF33) 011110	(AF42) 100100 (AF43) 100110

In addition, a network element that complies with the DiffServ standards must also provide a recommended *default* code point, which must be unique for code points in the standard space. The default PHB describes the common, best-effort forwarding behavior offered by existing network elements, as defined in RFC 1812.

As an additional differentiation, a set of code points has been allocated for use as the Class Selector code points, which describe the minimum forwarding handling requirements needed to preserve compatibility with existing practices while respecting flexibility for the future.

Table 76 and the command examples that follow show how the standard per-hop behaviors (PHBs) might be mapped onto ExtremeWare QoS profiles qp1 through qp8.

Table 76: Mapping PHBs to QoS Profiles

PHB	Default	Class Selector		AF1	AF2	AF3	AF4	EF
QoS Profile	qp1	qp2	qp3	qp4	qp5	qp6	qp7	qp8
DSCP	000000	001000 010000 011000 100000 101000	110000 111000	001010 001100 001110	010010 010100 010110	011010 011100 011110	100010 100100 100110	101110

The DSCPs associated with a PHB are assigned to the appropriate QoS profile using the `configure diffserv examination code-point` command. For example, the following command sets up the mapping for the EF PHB:

```
configure diffserv examination code-point 46 qosprofile qp8 ports 2:1-2:2
```

Additional configuration steps for ATM ports in this example are as follows:

- Enable RED for all PHBs except the EF PHB. For example:

  ```
  enable red ports 2:1-2:2
  disable red ports 2:1-2:2 queue 8
  ```

- Configure a high drop-probability of 20% on the ATM ports. For example:

  ```
  configure red high-drop-probability 20 ports 2:1-2:2
  ```

- Enable examination of DiffServ information. For example:

  ```
  enable diffserv examination ports 2:1-2:2
  ```

- Configure the default PHB. For example:

  ```
  configure diffserv examination code-point 0 qosprofile qp1 ports 2:1-2:2
  ```

- Configure the Class Selectors. For example:

  ```
  configure diffserv examination code-point 8 qosprofile qp2
     ports 2:1-2:2 high-drop-probability
  configure diffserv examination code-point 16 qosprofile qp2
     ports 2:1-2:2 high-drop-probability
  configure diffserv examination code-point 24 qosprofile qp2
     ports 2:1-2:2 high-drop-probability
  configure diffserv examination code-point 32 qosprofile qp2
     ports 2:1-2:2 low-drop-probability
  configure diffserv examination code-point 40 qosprofile qp2
     ports 2:1-2:2 low-drop-probability
  configure diffserv examination code-point 48 qosprofile qp3
     ports 2:1-2:2 high-drop-probability
  configure diffserv examination code-point 56 qosprofile qp3
     ports 2:1-2:2 low-drop-probability
  ```

- Configure the drop-probability for the DSCPs assigned to AF1 through AF4.

  For example, for AF1 (qp4):

  ```
  configure diffserv examination code-point 10 qosprofile qp4
     ports 2:1-2:2 low-drop-probability
  configure diffserv examination code-point 12 qosprofile qp4
     ports 2:1-2:2 high-drop-probability
  configure diffserv examination code-point 14 qosprofile qp4
     ports 2:1-2:2 high-drop-probability
  ```

  For example, for AF2 (qp5):

  ```
  configure diffserv examination code-point 18 qosprofile qp5
     ports 2:1-2:2 low-drop-probability
  configure diffserv examination code-point 20 qosprofile qp5
     ports 2:1-2:2 high-drop-probability
  configure diffserv examination code-point 22 qosprofile qp5
     ports 2:1-2:2 high-drop-probability
  ```

  For example, for AF3 (qp6):

  ```
  configure diffserv examination code-point 26 qosprofile qp6
     ports 2:1-2:2 low-drop-probability
  configure diffserv examination code-point 28 qosprofile qp6
     ports 2:1-2:2 high-drop-probability
  configure diffserv examination code-point 30 qosprofile qp6
     ports 2:1-2:2 high-drop-probability
  ```

For example, for AF4 (qp7):

```
configure diffserv examination code-point 34 qosprofile qp7
   ports 2:1-2:2 low-drop-probability
configure diffserv examination code-point 36 qosprofile qp7
   ports 2:1-2:2 high-drop-probability
configure diffserv examination code-point 38 qosprofile qp7
   ports 2:1-2:2 high-drop-probability
```

- Configure the congested-state mappings for DSCPs 10 (AF11), 18 (AF21), 26 (AF31), and 34 (AF41). For example:

```
configure diffserv dscp-mapping 10/12 egress congestion
configure diffserv dscp-mapping 18/20 egress congestion
configure diffserv dscp-mapping 26/28 egress congestion
configure diffserv dscp-mapping 34/36 egress congestion
```

- Use the EF PHB to configure bandwidth reservation and rate limiting. For example:

```
configure diffserv examination code-point 46 qosprofile qp8 ports 2:1-2:2
configure qosprofile qp8 minbw 10 maxbw 20 2:1-2:2 egress
configure qosprofile qp8 minbw 10 maxbw 20 2:1-2:2 ingress
```

Displaying RED Configuration Information for ATM Module Ports

While the syntax of the existing `show ports info` command has not changed, the output of the command now displays the RED and DiffServ configuration parameters associated with ATM module ports.

To display QoS, RED, and DiffServ information for a specified ATM port, use the following command:

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

NOTE

For ATM ports, the existing `show ports qosmonitor` command has also been enhanced to display the number of packet transmissions and discards from each queue (in both egress and ingress directions).

QoS Monitor

The QoS Monitor utility is supported for ATM module ports. The QoS Monitor and its associated ExtremeWare commands are described in Chapter 8.

Intra-Subnet QoS

Intra-Subnet QoS (ISQ) is not supported on switches that use the "*i*" chipset; the ATM module is supported only on switches that use the "*i*" chipset.

Limitations and Unsupported Features

This section describes additional command and configuration information related to the use of the ATM module. This section includes information on the following topics:

- Configuring Port Attributes on page 581
- Jumbo Frame Support on page 581
- Configuring IGMP Attributes on page 582
- Configuring Layer 2 and 3 Switching Attributes on page 582
- Configuring Access List Attributes on page 582
- Changing Image and Configuration Attributes on page 582

Configuring Port Attributes

The following ExtremeWare port commands are not supported for the ATM module:

- `show ports {mgmt | <portlist>} collisions`
- `configure ports [<portlist> | all | mgmt] auto off {speed [10 | 100 | 1000]} duplex [half | full]`
- `configure ports [<portlist> | mgmt | all] auto on`
- `disable smartredundancy [<portlist>]`
- `enable sharing <port> grouping <portlist> {dynamic | algorithm {port-based | address-based | round-robin}}`
- `enable mirroring to port [<port>] [tagged | untagged]`
- `disable learning ports <portlist>`
- `configure mirroring add [<mac_address> | vlan <vlan name> {ports <port number>} | ports <portnumber> {vlan <vlan name>}]]`

Jumbo Frame Support

The jumbo frame size affects the size of the payload that can be transmitted or received on an ATM port.

If jumbo frame support is enabled on an ATM port, the following can occur:

- No frames received from the switch backplane will be discarded due to being too large. Nor will any IP frames be fragmented.
- PDUs received from the ATM link with routed protocol encapsulation will be discarded if the size of the IP packet exceeds *(configured JUMBO_FRAME_MTU -22)* octets.
- PDUs received from the ATM link with bridged protocol encapsulation will be discarded if the size of the Ethernet frame (including a VLAN tag but excluding the LAN FCS) exceeds *(CONFIGURED JUMBO_FRAME_MTU - 4)* octets. If the Ethernet frame does not include a VLAN tag field, then the frame will be discarded if the size of the Ethernet frame (excluding the LAN FCS) exceeds *(CONFIGURED JUMBO_FRAME_MTU - 8)* octets.

If jumbo frame support is not enabled on an ATM port, the following can occur:

- Frames received from the switch backplane, whose size exceeds 1522 octets, will not be forwarded onto the ATM link. IP frames that meet this criteria will be sent to the MSM CPU for fragmentation/Path MTU Discovery processing. Non-IP frames that meet this criteria will be discarded.
- PDUs received from the ATM link with routed protocol encapsulation will be discarded if the size of the IP packet exceeds 1500 octets.
- PDUs received from the ATM link with bridged protocol encapsulation will be discarded if the size of Ethernet frame (including a VLAN tag but excluding the LAN FCS) exceeds 1518 octets. If the Ethernet frame does not include a VLAN tag field, then the frame will be discarded if the size of the Ethernet frame (excluding the LAN FCS) exceeds 1514 octets.

Consider these factors when configuring jumbo frame support on an ATM port:

- When the jumbo frame size is changed from a value of 6129 or less to a value greater than 6129, any ATM module that has ports with jumbo frame support enabled must be rebooted for the change to take effect.

For more information on the ExtremeWare jumbo frame commands, see Chapter 4.

Configuring IGMP Attributes

For more information on the ExtremeWare IGMP commands, see Chapter 20

Configuring Layer 2 and 3 Switching Attributes

All of the IP routing protocols are supported for either L2 encapsulation or IP encapsulation: RIP, OSPF, BGP, DVMRP, and PIM.

When L2 encapsulation is enabled on an ATM port, IPX RIP and SAP are supported.

Configuring Access List Attributes

For more information on the ExtremeWare access list commands, see Chapter 12.

NOTE

On the ATM module, the access list functions apply to port pairs, where ports 1 and 2 are a pair, and ports 3 and 4 are a pair. This pairing scheme means that the ports in a given pair share the same access lists: ports 1 and 2 share the same lists, while ports 3 and 4 share their access lists. For example, if an access list is configured for port 1, that access list also applies to port 2, and vice versa.

Changing Image and Configuration Attributes

For more information about these commands and operations, see Appendix A.

24 Packet Over SONET (PoS) Modules

The Packet over SONET (PoS) modules are I/O modules for the BlackDiamond 6800 series chassis-based system. These modules connect a BlackDiamond 6800 series switch to the SONET infrastructure used by metropolitan area service providers and operators of server co-location networks.

This chapter includes information on the following topics:

- About the PoS Modules on page 583
- Configuring the PoS Module on page 588

About the PoS Modules

Two key applications for the PoS modules are: interconnecting metropolitan area networks across the SONET network infrastructure, and interconnecting server co-location network sites directly using SONET links.

In the first application, the metropolitan area network service provider can build service network sites in various cities, then use PoS modules in a BlackDiamond 6800 series switch to connect those cities to a carrier's SONET infrastructure.

In the second application, operators of server co-location networks can use PoS modules in BlackDiamond 6800 series switches to create a SONET-based connection between server co-location sites. The result is that their network is simpler to manage, and problems can be isolated and resolved more expediently.

Extreme Networks offers the PoS module in the following configurations:

- P3cMi: four OC-3 multimode, short-reach optical interfaces
- P3cSi: four OC-3 single-mode, intermediate-reach optical interfaces
- P12cMi: two OC-12 multimode, short-reach optical interfaces
- P12cSi: two OC-12 single-mode, intermediate-reach optical interfaces

NOTE

The "c" in the names of the modules indicates that the optical interfaces on these modules operate in concatenated mode, which enables all the bandwidth to be devoted to a single payload stream.

The P3cMi (multimode version) operates in the 1310 nanometer (nm) wavelength window at a typical maximum cable distance of 2 kilometers (km) or 1.24 miles (mi). The P12cMi (multimode version) also operates in the 1310 nanometer (nm) wavelength, but at a typical maximum cable distance of 500 meters (m) or 0.31 (mi). The P3cSi and P12cSi (single-mode versions) also operate in the 1310 nanometer (nm) wavelength window, but at a typical maximum cable distance of 15 km or 9.32 (mi). All four versions of the PoS module use industry-standard duplex SC optical fiber connectors.

Summary of Features

The PoS modules provide the following key networking functions:

- Support for both Synchronous Optical Network (SONET) and Synchronous Digital Hierarchy (SDH) modes of operation
- Support for the Point-to-Point Protocol (PPP) suite, including:
  - — Link Control Protocol (LCP)
  - — Link Maintenance option for LCP
  - — Link Quality Report (LQR) Protocol
  - — Password Authentication Protocol (PAP)
  - — Challenge Handshake Authentication Protocol (CHAP)
  - — IP Control Protocol (IPCP)
  - — Bridging Control Protocol (BCP)
  - — Extreme Discovery Protocol Control Protocol (EDPCP)
  - — OSI Network Layer Control Protocol (OSINLCP)
  - — Support for MultiProtocol Label Switching Control Protocol (MPLSCP) via PPP
- Efficient support for IP routing over SONET via IPCP
- Support for Transparent LAN Services (TLS) over SONET via BCP
- Support for jumbo frames
- Extensive support for Quality of Service (QoS) and Differentiated Services (DiffServ), including:
  - — Eight ingress queues and eight egress queues per interface
  - — Ingress and egress rate shaping and limiting
  - — IEEE 802.1Q VLAN priorities
  - — Weighted RED (WRED) congestion avoidance algorithm
  - — Assured Forwarding and Expedited Forwarding RFCs
- Support for service provider specific features, such as:
  - — Flexible remapping of DiffServ codepoints
  - — Flexible remapping of IEEE 802.1Q VLAN IDs
  - — VLAN tunneling via nested 802.1Q tags
  - — Port tunneling of High-Level Data Link Control (HDLC) byte streams
- Support for NetFlow Version 1 per-flow statistics, including:
  - — Capacity for two million flow records per PoS module
  - — Scalability via distribution to groups of flow-record collector devices

  - — Filters enabling statistics to be maintained for selected flows
  - — Aggregation option for further reducing the volume of exported data
- Resiliency with fast recovery from SONET link failures via support for Automatic Protection Switching (APS) protocol in multiple configurations, including networks where the working and protection lines are:
  - — Terminated in the same SONET module
  - — Terminated in different SONET modules residing in the same BlackDiamond 6800 series system
  - — Terminated in different SONET modules residing in different BlackDiamond 6800 series systems

Function Summary

The following sections provide brief descriptions of the key functions provided by the PoS modules. Each of these sections is expanded into greater detail in "Configuring the PoS Module" on page 588.

SONET and SDH

SONET and SDH are the two terms used to identify a time division multiplexing technology that is optimized for transporting voice traffic across a digital optical network, but that is also capable of providing high-speed capacity for transporting data.

The term SONET is used to identify the technology used within the North American digital network. Its standards are published by Bellcore and the American National Standards Institute (ANSI). The term SDH is used to identify the equivalent standard approved by the International Telecommunication Union (ITU) for use in Europe and elsewhere in the global digital network. Because SDH evolved out of SONET, the two standards are closely joined and have been widely accepted as a dominant choice for implementations requiring high transport capacity and resistance to failure.

PPP

PPP encompasses a suite of protocols designed to provide standard methods for transporting datagrams over point-to-point links. The use of PPP over SONET links is commonly referred to as Packet over SONET, or PoS. The Extreme Networks implementation of PPP for the PoS module provides support for the following protocols in the PPP suite:

- Link Control Protocol (LCP)
- Link Quality Report (LQR) Protocol
- Challenge Handshake Authentication Protocol (CHAP)
- Password Authentication Protocol (PAP)
- IP Control Protocol (IPCP)
- Bridging Control Protocol (BCP)
- Extreme Discovery Protocol Control Protocol (EDPCP)
- MultiProtocol Label Switching Control Protocol (MPLSCP)
- OSI Network Layer Control Protocol (OSINLCP)

MPLS

The PoS module ports provide MPLS support via a PPP link. The MPLS Control Protocol (MPLSCP) allows MPLS labeled packets to be transported across a PPP link.

Jumbo Frames

The PoS module ports provide jumbo frame support that is similar to that provided by Ethernet ports on a BlackDiamond 6800 series switch.

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

Jumbo frames are used between endstations that support larger frame sizes for more efficient transfers of bulk data. Both endstations involved in the transfer must be capable of supporting jumbo frames.

QoS and Differentiated Services

The PoS modules support eight ingress queues and eight egress queues per port. The scheduling parameters for these queues (minimum bandwidth, maximum bandwidth, priority level, etc.) are controlled by QoS profiles that you can customize for individual ingress or egress queues on a specific PoS port.

You can assign frames to queues based on IEEE 802.1p priorities, MPLS EXP values, Differentiated Services Code Points (DSCPs), or by configuring a QoS profile for the port or VLAN. You can tailor the DSCP-to-queue mapping for ingress or egress directions on a per-port basis. Most of the existing ingress classification functions, along with the DiffServ replacement functions, are also supported for PoS ports.

The supported DiffServ functions maximize user flexibility while providing all of the features needed to support the standard per-hop behaviors (PHBs), including:

- Default
- Class Selector
- Assured Forwarding
- Expedited Forwarding

The PoS modules also provide flexible support for the well-known Weighted RED (WRED) congestion avoidance algorithm.

Service Provider Features

The PoS modules provide the following features for service provider environments:

- DSCP mapping
- VLAN ID (VID) tag mapping
- VLAN ID (VID) tag nesting
- Port tunneling

You can use the `diffserv dscp-mapping` command to configure a mapped relationship between an input DSCP and an associated output DSCP. Each PoS port supports three DSCP mapping tables: one of the tables is used in the ingress direction; two are used for egress flows (onto the SONET link). The two egress tables are for the congested and noncongested states, as determined by the RED algorithm. If RED is not enabled on the PoS port, the egress congested-state mapping table is not used.

In the ingress direction, the input DSCP of a packet received from the SONET link is replaced by an output DSCP before the packet is forwarded. In the egress direction, the operation is similar, except that the DSCP mapping occurs before the packet is transmitted onto the SONET link.

One potential use of the DSCP mapping capability is to reconcile varying DiffServ policies at the boundary between autonomous systems, such as at the boundary between two ISPs. The availability of different tables for the congested and noncongested states is useful in marking operations that increase the probability of packets being dropped during times of congestion, as discussed in the DiffServ Assured Forwarding RFC (RFC 2597).

An analogous feature has been added for managing 802.1Q tags. The `dot1q tagmapping` command provides support for VLAN ID (VID) mapping tables. Each PoS port supports two VID tables: one table is used in the ingress direction; the other is used in the egress direction. Each of the tables enables an input VID to be mapped to an output VID. This feature is useful in reconciling policy differences at the boundary between the customer and the service provider.

Another related enhancement provides support for nested 802.1Q tags by allowing a *tag push* or *tag pop* attribute to be associated with a VID. The *push* attribute indicates that a new tag is to be added to the frame, while the *pop* attribute indicates that the top-level tag is to be removed from the frame. This capability is augmented by an option that allows the 802.1p priority of the frame to be either preserved or set to a user-configurable value when a new tag is pushed. These functions make it possible for service providers to tunnel customer-specific VLANs across a common SONET backbone in a very simple manner.

The PoS module also supports port tunneling. Port tunneling can be used to encapsulate and transport the raw High-Level Data Link Control (HDLC) encapsulated byte stream from one PoS port to another PoS port across an MPLS network. This allows service providers to tunnel different types of SONET HDLC streams across a non-SONET backbone like Ethernet.

NetFlow Statistics

Each PoS port can maintain and export statistics for the flows that traverse the associated SONET link.

Per-flow statistics are useful for many management purposes, including:

- Accounting and billing
- Network capacity planning and trend analysis
- Network monitoring
- Workload characterization
- User profiling
- Data warehousing and mining

Each PoS module can maintain two million flow records. Per-flow statistics are reported in the NetFlow, Version 1 format, which groups flow records together into UDP datagrams for export to a flow-collector device.

The PoS module also provides a NetFlow distribution feature to provide a growth path to more scalable and robust collection architectures. This feature allows a single PoS port to distribute statistics across multiple groups of flow-collector devices in a load-balanced manner. The function also includes a health-check feature that significantly improves the reliability of the collection architecture. The health-checker ensures that only responsive flow-collector devices are included in the effective export distribution lists.

To further enhance scalability, the PoS module also offers filters and filter-based aggregation options that allow you to configure a PoS port to maintain statistics selectively for only those flows matching specified filters. The aggregation options can further reduce the volume of exported data by enabling a single set of statistics to be maintained for all the flows that match an aggregation filter.

Automatic Protection Switching

Automatic Protection Switching, or APS, is a physical-layer resiliency feature specified in the SONET standards. Multiplex Section Protection, or MSP, is the APS equivalent in the SDH standard, which is also supported by the PoS module. Throughout this guide, the terms *APS* and *Automatic Protection Switching* are used to refer to the protection switching features of both standards.

Of the various protection switching modes specified in the SONET/SDH standards, the BlackDiamond 6800 series switches use the linear 1+1 architecture to protect tributary SONET lines. In the linear 1+1 architecture, there is one protection line for each working line. If the working line fails, traffic is automatically switched to the protection line. You can also control whether traffic switched to the protection line is automatically switched back to the working line when it is restored to service.

The Extreme Networks implementation supports network configurations where:

- Working and protection lines are terminated in the same PoS module.
- Working and protection lines are terminated in different PoS modules residing in the same BlackDiamond 6800 series switch.
- Working and protection lines are terminated in different PoS modules residing in different BlackDiamond 6800 series switches.

Configuring the PoS Module

This section describes the ExtremeWare commands that support the PoS module. For hardware installation information on the BlackDiamond 6800 series switch, see the *Extreme Networks Consolidated "i" Series Hardware Installation Guide*.

NOTE

Documentation for Extreme Networks products is available on the World Wide Web at the Extreme Networks home page at http://www.extremenetworks.com/.

This section includes information on the following topics:

- Basic PoS Module Configuration Information on page 589
- Configuring and Monitoring SONET Ports on page 596
- Configuring and Monitoring PPP Functions on page 602
- Configuring VLAN-Related Attributes on page 614
- Configuring Forwarding Database Attributes on page 617
- Configuring Spanning Tree Attributes on page 617
- Configuring QoS Functions on page 617
- Configuring and Monitoring Flow Statistics on page 629
- Configuring and Monitoring APS Functions on page 639
- Configuring Port Tunneling on page 656
- Limitations and Unsupported Commands on page 658

Basic PoS Module Configuration Information

This section uses several typical usage and configuration schemes to provide a brief overview of the PoS module configuration process as a general context for the detailed command description sections that follow.

Default PoS Module Configurations

When the BlackDiamond 6800 series switch is powered on, the ExtremeWare software determines which slots are occupied by I/O modules, determines whether it has a configuration for each module, and generates a default configuration for each slot that is occupied by an I/O module that has not yet been configured. The default configuration is the minimal set of configuration parameter settings that will allow the I/O module and its ports to function.

For the PoS modules, the default configuration depends on whether the module is an OC-3 module (P3cSi or P3cMi) or an OC-12 module (P12cSi or P12cMi). The OC-3 modules have some port-pairing considerations that affect configuration (see "PoS Port Configuration and Default VLAN Assignments" on page 589). In either case, the default configuration on the PoS module is for bridging (see "Default Configuration: Bridging Over PoS Ports" on page 590), with the Bridging Control Protocol (BCP) enabled, so that the module's ports are brought up as members of the default VLAN and traffic is bridged between all ports in the VLAN. The default configuration includes values for the configurable SONET link parameters.

To perform routing over PoS ports using the IP Control Protocol (IPCP), or to take advantage of other features and capabilities, such as providing redundancy over the tributary links of the SONET network using Automatic Protection Switching (APS), you will need to perform additional configuration tasks. For examples of how to extend the configuration, see "Routing Over PoS Ports" on page 591 and "Automatic Protection Switching" on page 593.

PoS Port Configuration and Default VLAN Assignments

The ports on the PoS modules are identified by a port number that is a combination of the slot number where the module is installed and the port number on the module. The nomenclature for the port number is as follows:

```
slot:port
```

For example, you would refer to the four ports on an OC-3 PoS module installed in slot 4 of the BlackDiamond 6800 series chassis by the port numbers 4:1, 4:2, 4:3, and 4:4.

NOTE

For more information about port numbers and port configuration, see Chapter 4.

Because the default Point-to-Point Protocol (PPP) network control protocol is the Bridge Control Protocol (BCP), all PoS ports are initially enabled for bridging. By default, only ports 1 and 3 on the OC-3 PoS modules are assigned to the default VLAN, while ports 2 and 4 are not assigned to a VLAN.

Because the first port pair on the OC-3 PoS modules (ports 1 and 2) and the second port pair (ports 3 and 4) use a common link to the switch backplane, ports belonging to the same port pair cannot be assigned to the same VLAN. The only exception to this rule is when APS is defined and one of the two ports of a port pair is used as the working line port, while the second port is used as the protection line port.

NOTE

The port-pair restriction described above for the OC-3 PoS modules does not apply to the OC-12 PoS module.

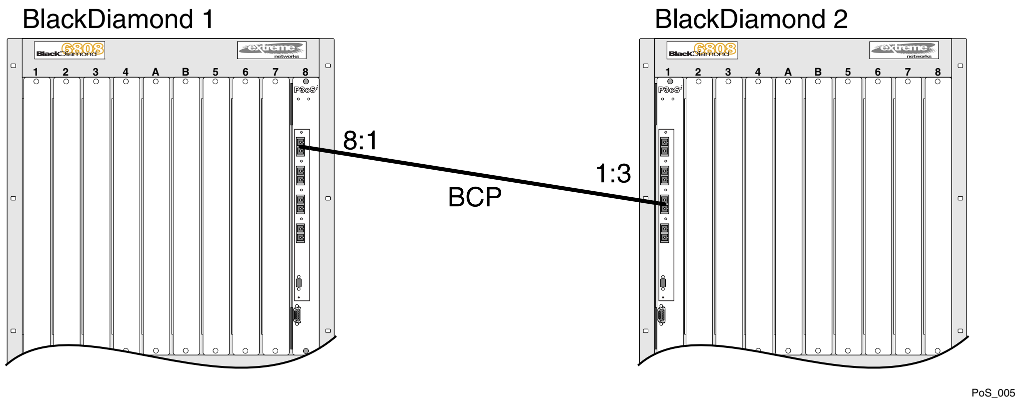
Default Configuration: Bridging Over PoS Ports

The default configuration of the OC-3 PoS module enables you to connect either port 1 or 3 of an OC-3 PoS module in a BlackDiamond 6800 series switch to either port 1 or 3 of an OC-3 PoS module in a second BlackDiamond switch. In this configuration, all ports reside in the default VLAN and traffic is bridged between all ports in the VLAN. If you enable the Spanning Tree protocol, you can connect more ports in parallel, but they will be blocked for traffic transmission. Loadsharing is not supported over PoS links.

Configuration Commands for BCP

The bridged network example shown in Figure 105 does not require additional configuration commands for BCP support, because the default SONET and PPP configuration values will bring up the ports as members of the default VLAN. However, the commands to enable BCP together with the default SONET values (see Table 77) are listed below for reference. The command `unconfigure ppp ports <portlist>` will also reset the configuration to these default values.

Figure 105: Default configuration for BCP



Configuring Default SONET and PPP Settings

The following configuration commands apply to the PoS module installed in slot 8 of BlackDiamond switch 1, as shown in Figure 105.

```
configure ppp echo off ports 8:1
configure ppp authentication off ports 8:1
configure ppp quality off ports 8:1
configure ppp user "extreme" encrypted "f7P*8aPO+86+'RL8E?MDZBJV`F)UC.-"
   ports 8:1
configure ppp bcp on ports 8:1
configure ppp ipcp off ports 8:1
configure ppp pos checksum 32 ports 8:1
configure ppp pos scrambling on ports 8:1
configure ppp delayed-down-time 1 ports 8:1
```

Table 77 lists the configurable SONET link parameters and their default values.

Table 77: SONET Parameters and Values

Parameter	Possible Values	Default Value
Framing	SONET or SDH	SONET
Clock source	internal or line	internal
Signal Failure threshold[1]	10^{-3} through 10^{-5}	10^{-5}
Signal Degrade threshold[2]	10^{-5} through 10^{-9}	10^{-6}
J0 Section Trace byte[3]	0 through 255	1
J0 Section Trace string[4]	Maximum of 15 characters	15 NULL characters
J1 Path Trace identifier string[5]	Maximum of 64 characters	IP address of port's VLAN (in dotted-decimal notation)
C2 Signal Label	0 through xFF	auto[6]

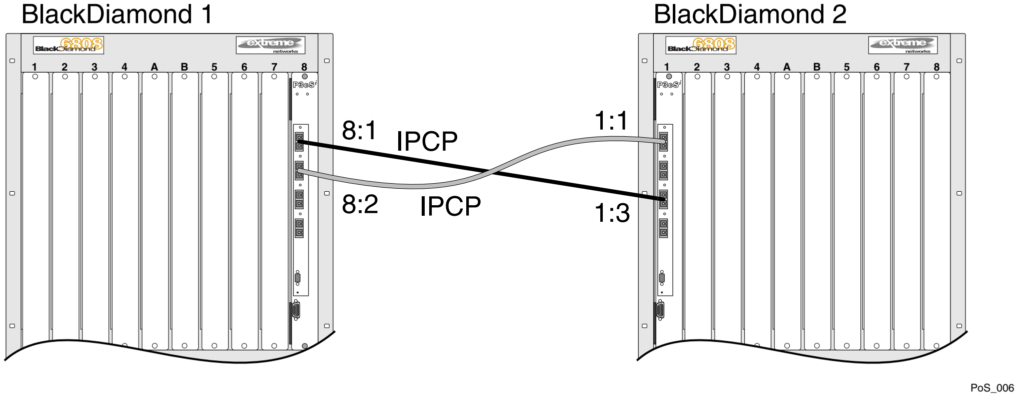
1. B2 bit error rate (BER) threshold; a Signal Failure (SF) event is generated if the BER exceeds the specified threshold.
2. B2 bit error rate (BER) threshold; a Signal Degrade (SD) event is generated if the BER exceeds the specified threshold.
3. The default value of 1 is per ANSI T1.105-1995. This parameter applies only when SONET framing is configured on the port.
4. This parameter applies only when SDH framing is configured on the port.
5. When SDH framing is configured on the port, only the first 15 characters of the string are applied.
6. Set automatically based on synchronous payload envelope (SPE) payload type.

Routing Over PoS Ports

While you can configure BCP to perform routing over PoS ports, IPCP might be a better choice than BCP in those cases where the link will carry only routed IP traffic, because it provides a more efficient encapsulation scheme than does BCP, and thereby increases the maximum link throughput.

To take best advantage of the wire-speed layer 3 routing capabilities of the BlackDiamond 6800 series switch using the PoS module, configure IPCP as the PPP network control protocol to route between the PoS ports and any other VLANs. If you do not configure APS, an IPCP port must be the only port in a VLAN.

Figure 106: IPCP configuration



Configuration Commands for IPCP

For the IPCP routing network configuration example shown in Figure 106, the default configuration parameter settings for PoS ports should be suitable for most installations. Thus, only minimal additional configuration is needed to get IPCP up and running on a PoS port. The necessary configuration steps are:

1. Create a VLAN for each SONET port using the `create vlan <vlan name>` command.
2. Add each SONET port to a VLAN using the `configure vlan <vlan name> add ports <portlist> {tagged | untagged} {nobroadcast} {soft-rate-limit}` command.
3. Define an IP router port on each VLAN by assigning an IP address to each VLAN using the `configure vlan <vlan name> ipaddress <ipaddress> {<netmask> | <mask length>}` command, and enable IP forwarding using the `enable ipforwarding` command.
4. Disable BCP on the SONET ports using the `configure ppp bcp off ports <portlist>` command, and then enable IPCP on the SONET ports using the `configure ppp ipcp on ports <portlist>` command.

The following configuration commands apply to the PoS module installed in slot 8 of BlackDiamond switch 1, as shown in Figure 106.

```
configure ppp bcp off ports 8:1, 8:2
configure ppp ipcp on ports 8:1, 8:2
create vlan vlanipcp1
create vlan vlanipcp2
configure vlanipcp1 ipaddress 192.168.100.1 /30
configure vlanipcp2 ipaddress 192.168.200.1 /30
enable ipforwarding vlanipcp1
enable ipforwarding vlanipcp2
configure vlanipcp1 add ports 8:1
configure vlanipcp2 add ports 8:2
```

The following configuration commands apply to the PoS module installed in slot 1 of BlackDiamond switch 2, as shown in Figure 106.

```
configure ppp bcp off ports 1:1, 1:3
configure ppp ipcp on ports 1:1, 1:3
create vlan vlanipcp1
create vlan vlanipcp2
configure vlanipcp1 ipaddress 192.168.100.2 /30
configure vlanipcp2 ipaddress 192.168.200.2 /30
enable ipforwarding vlanipcp1
enable ipforwarding vlanipcp2
configure vlanipcp1 add ports 1:3
configure vlanipcp2 add ports 1:1
```

Automatic Protection Switching

The ExtremeWare software APS implementation enables PoS links to provide redundancy over the tributary links of the SONET network. You can configure three levels of APS redundancy:

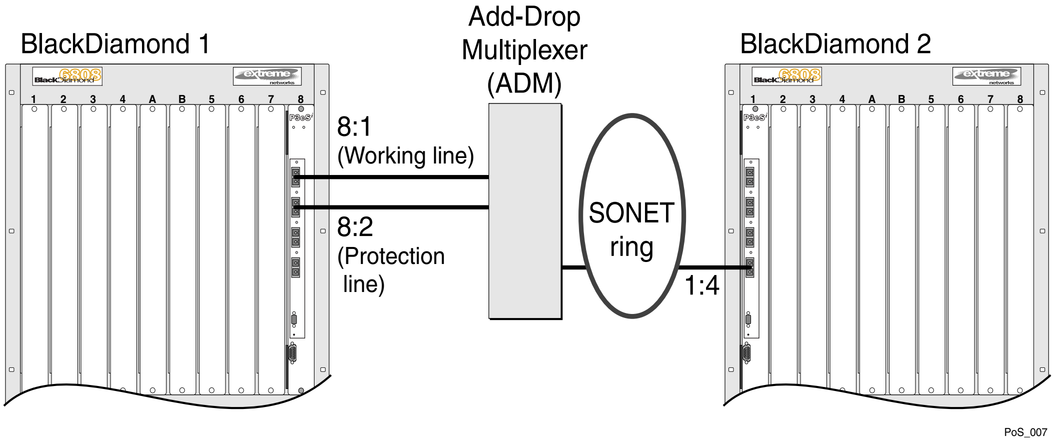
- Port redundancy (single PoS module configuration)
- Module redundancy (two PoS module configuration)
- Switch redundancy (two switch configuration)

These three APS redundancy options are described in the sections that follow. For more detailed information on the commands associated with APS, see “Configuring and Monitoring APS Functions” on page 639.

APS Port Redundancy

Figure 107 is an example of a single-module APS redundancy configuration, in which the working line and the protection line are terminated in the same PoS module in the BlackDiamond 6800 series switch. This configuration provides simple protection against line failures.

Figure 107: APS configuration, port redundancy



Configuration Commands for APS: Port Redundancy

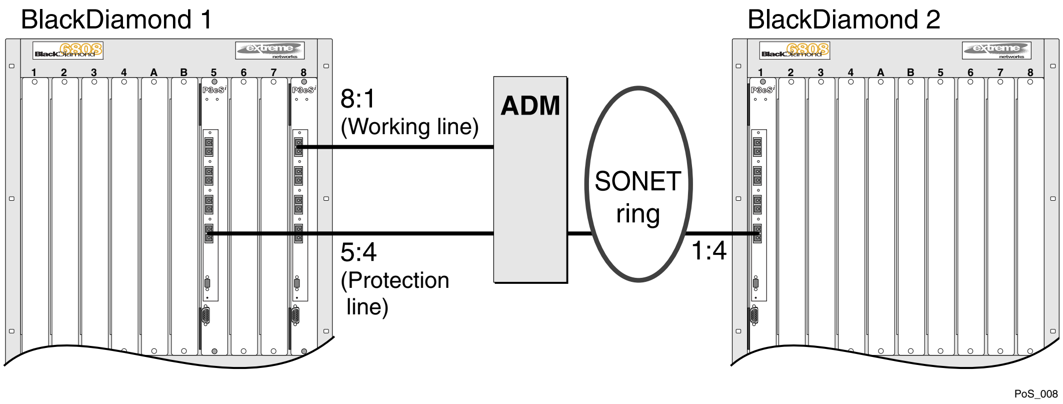
The following configuration commands apply to the PoS module installed in slot 8 of BlackDiamond switch 1, as shown in Figure 107.

```
create vlan apslbvlan
configure vlan apslbvlan ipaddress 192.168.1.1 /30
enable loopback-mode apslbvlan
create aps 1
configure aps 1 add 8:1 working
configure aps 1 add 8:2 protection 192.168.1.1
enable aps
```

APS Module Redundancy

Figure 108 is an example of a two-module APS redundancy configuration, in which the working line and the protection line are terminated in two different PoS modules in the same BlackDiamond 6800 series switch. This configuration provides simple protection against both line and module failures.

Figure 108: APS configuration, module redundancy



Configuration Commands for APS: Module Redundancy

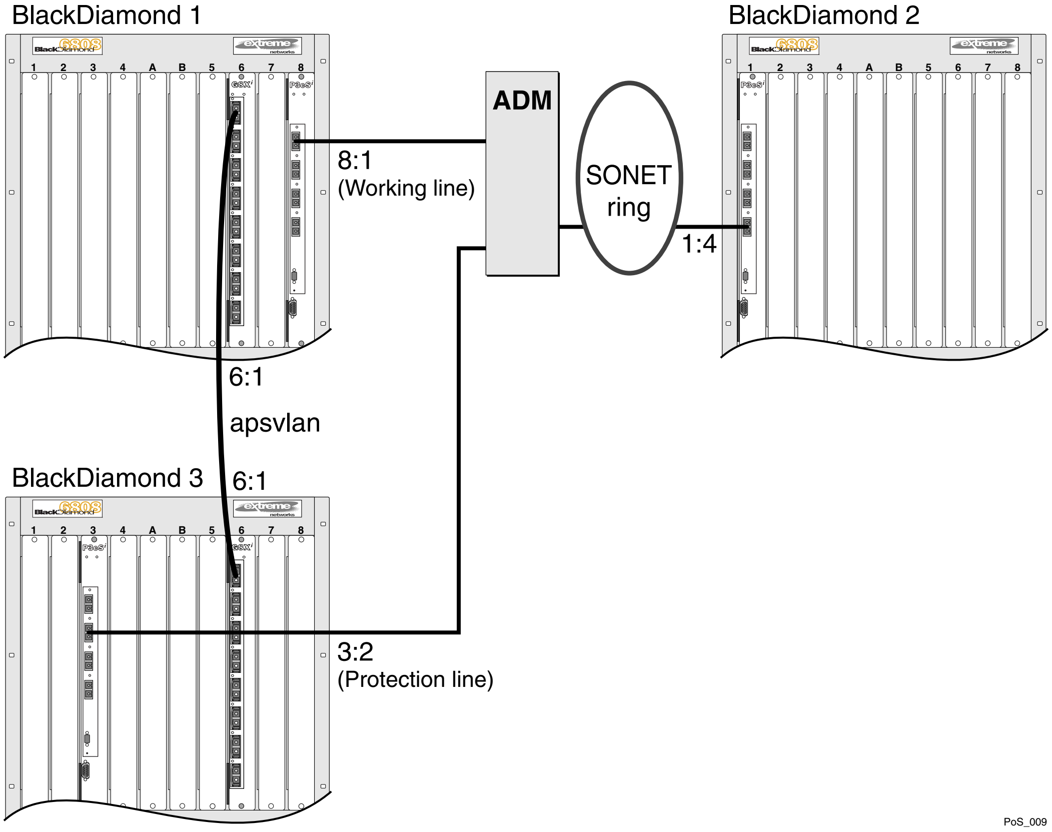
The following configuration commands apply to the two PoS modules installed in slots 5 and 8 of BlackDiamond switch 1, as shown in Figure 108.

```
create vlan apslbvlan
configure apslbvlan ipaddress 192.168.1.1 /30
enable loopback-mode apslbvlan
create aps 1
configure aps 1 add 8:1 working
configure aps 1 add 5:4 protection 192.168.1.1
enable aps
```

APS Switch Redundancy

Figure 109 is an example of a two-switch APS redundancy configuration, in which the working line is terminated in a PoS module in one BlackDiamond switch, while the protection line is terminated in a different PoS module in a different BlackDiamond switch. This configuration expands protection to include line, module, and switch failures.

Figure 109: APS configuration for switch redundancy



Configuration Commands for APS: Switch Redundancy

The following configuration commands apply to the PoS module installed in slot 8 of BlackDiamond switch 1, as shown in Figure 109.

```
create vlan apsvlan
configure apsvlan add port 6:1
configure apsvlan ipaddress 192.168.1.1 /30
enable loopback-mode apsvlan
enable ipforwarding
create aps 1
configure aps 1 add 8:1 working
enable aps
```

The following configuration commands apply to the PoS module installed in slot 3 of BlackDiamond switch 3, as shown in Figure 109.

```
create vlan apsvlan
configure apsvlan add port 6:1
configure apsvlan ipaddress 192.168.1.2 /30
enable ipforwarding

create aps 1
configure aps 1 add 3:2 protection 192.168.1.1
enable aps
```

Configuring and Monitoring SONET Ports

This section provides information on the following topics:

- Configuring SONET Framing on page 596
- Configuring SONET Loopback (OC12) on page 596
- Configuring the Signal Fail Threshold on page 597
- Configuring the Signal Degrade Threshold on page 597
- Configuring the Section Trace Identifier on page 598
- Configuring the Path Trace Identifier on page 598
- Configuring the Signal Label on page 599
- Resetting SONET Configuration Parameter Values on page 599
- Displaying SONET Port Status Information on page 599

Configuring SONET Framing

You can configure each port for framing that complies with either the SONET standard or the SDH standard. SONET is primarily an American standard; SDH is the international version. The default is SONET.

To configure the framing for the specified SONET port, use the following command:

```
configure sonet framing ports
```

The following command example selects SDH framing for port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
configure sonet framing sdh ports 8:1
```

Configuring SONET Loopback (OC12)

SONET loopback is only available on OC-12 ports. Configuring loopback on a SONET port may be useful for diagnostics or network troubleshooting. When internal loopback is configured, the transmitted signal is looped back onto the receive interface. When line loopback is configured, the received signal is looped back onto the transmit interface.

To configure SONET loopback, use the following command:

```
configure sonet loop
```

To configure loopback on SONET port 1 of the PoS module installed in slot 8 of the BlackDiamond switch:

```
configure sonet loop internal ports 8:1
```

Configuring SONET Clocking

You can configure each port on the PoS module to use either line clocking, where the clock source is recovered from the received bit stream, or internal clocking, where the clock source is based on an internal clock. The default is internal.

To configure the clocking source for the specified SONET port, use the following command:

```
configure sonet clocking [line | internal] ports <portlist>
```

The following command example selects line clocking for port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
configure sonet clocking line ports 8:1
```

Configuring the Signal Fail Threshold

A Signal Failure (SF) event is generated if the bit error rate (BER) for the SONET line exceeds the configured threshold. An SF event brings the port down. If Automatic Protection Switching (APS) is enabled on the port, an SF event initiates a line switch.

To configure the Signal Fail threshold for the specified SONET port, use the following command:

```
configure sonet threshold signal fail <error_rate> ports <portlist>
```

The `error_rate` parameter is an integer in the range from 3 to 5, where the SF BER is 10^{-error_rate}. The default value of the `error_rate` parameter is 5, which equates to an SF bit error rate of 10^{-5}, or 1 per hundred thousand.

The following command example sets the Signal Fail threshold value to 3 for port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
configure sonet threshold signal fail 3 ports 8:1
```

NOTE

You can set the signal degrade threshold to a different value than the default value of 6 depending on your particular application's tolerance for errors. In general, you should not change the default setting unless you are an expert and have a specific reason for the change.

Configuring the Signal Degrade Threshold

A Signal Degrade (SD) event is generated if the BER for the SONET line exceeds the configured Signal Degrade threshold. If APS is enabled on the port, an SD event initiates a line switch.

To configure the Signal Degrade threshold for the specified SONET port, use the following command:

```
configure sonet threshold signal degrade <error_rate> ports <portlist>
```

The `error_rate` parameter is an integer in the range from 5 to 9, where the SD bit error rate is $10^{\text{-error\_rate}}$. The default value of the `error_rate` parameter is 6, which equates to an SD bit error rate of 10^{-6}, or 1 per million.

The following command example sets the Signal Degrade threshold value to 8 for port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
configure sonet threshold signal degrade 8 ports 8:1
```

NOTE

You can set the signal degrade threshold to a different value than the default value of 6 depending on your particular application's tolerance for errors. In general, you should not change the default setting unless you are an expert and have a specific reason for the change.

Configuring the Section Trace Identifier

Section trace is a maintenance feature of SONET. One byte of the Section Overhead associated with each SONET frame is used to carry information identifying the transmitting equipment.

To configure the Section Trace identifier for the specified SONET port, use the following command:

```
configure sonet trace section [<id_byte> | string <id_string>] ports <portlist>
```

In this command, the Section Trace identifier can take one of two forms: an ID byte (`id_byte`) or an ID string (`id_string`).

The `id_byte` parameter is an integer in the range from 1 to 255, with a default value of 1. This parameter applies only when SONET framing is configured, in which case, the configured `id_byte` value is transmitted in each SONET frame.

The `id_string` parameter is a string of up to 15 characters. By default, the <id_string> parameter contains 15 NULL characters. This parameter applies only when SDH framing is configured, in which case the SDH framing cycles repetitively through a 15-character string, sending one character per frame. If the configured string contains fewer than 15 characters, it is padded to full length by NULL characters.

The following command example sets the Section Trace identifier to the string "1800wombat" for port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
configure sonet trace section string 1800wombat ports 8:1
```

Configuring the Path Trace Identifier

Path trace is a maintenance feature of SONET. One byte of the Path Overhead associated with each SONET frame is used to carry information identifying the originating Path Terminating Equipment (PTE).

To configure the Path Trace identifier for the specified SONET port, use the following command:

```
configure sonet trace path <id_string> ports <portlist>
```

The `id_string` parameter is a string of up to 64 characters. By default, the `id_string` parameter contains the IP address assigned to the VLAN to which the port belongs. This IP address is represented in dotted-decimal notation. If no IP address is assigned to the port's VLAN, the `id_string` parameter defaults to a string of 64 NULL characters.

When SONET framing is configured, a 64-character string is transmitted repetitively, one character per frame. If the configured string consists of fewer than 64 characters, it is padded to its full length with NULL characters.

When SDH framing is configured, the maximum length of the `id_string` parameter is 15 characters. If the configured string consists of more than 15 characters, it is truncated to 15 characters.

The following command example sets the Path Trace identifier to the string "parador" for port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
configure sonet trace path parador ports 8:1
```

Configuring the Signal Label

The Signal Label field occupies one byte (C2) of the Path Overhead associated with each SONET frame. It is used to indicate the type of contents carried in the Synchronous Payload Envelope (SPE). For example, 0x16 indicates scrambled PPP/HDLC, while 0xCF indicates unscrambled PPP/HDLC.

To configure the C2 Signal Label value for the specified SONET port, use the following command:

```
configure sonet signal label [auto | <hex_octet>] ports <portlist>
```

The `value` parameter is specified as a hexadecimal integer in the range from 00 to FF. It may be necessary to specify a particular Signal Label value in order to interoperate with implementations that do not follow the standard conventions for the Signal Label field.

To determine whether you need to specify a particular Signal Label value, perform the following tasks:

1. Use the `show sonet` command to display SONET port status information.
2. Look for a Path Payload Label Mismatch (PLM-P) event indicating that the received payload type does not match the expected payload.
3. Compare the contents of the received C2 field (Signal Label value) with the contents of the transmitted C2 field.

If no Signal Label value is specified, the command defaults to `auto`, which causes the value of the Signal Label field to be set automatically based on standard conventions for the given payload type.

The following command example sets the Signal Label to the hexadecimal value CF for port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
configure sonet signal label CF ports 8:1
```

Resetting SONET Configuration Parameter Values

To reset the SONET configuration parameters for the specified SONET ports to their default values, use the following command:

```
unconfigure sonet ports <portlist>
```

Displaying SONET Port Status Information

To display status information for the SONET ports, use the following command:

```
show sonet {<portlist>} {detail}
```

You can use the optional `portlist` parameter to narrow the range of status information the command displays; otherwise, the command displays the status information for all ports.

By default, the command displays a summary of status information for the specified ports. You can use the optional `detail` keyword to display detailed status information for the specified ports.

The summary of status information includes the following information for each port:

- Values of all port configuration parameters
- Port state
- Any active events

The detailed status information includes the summary information plus any SONET statistics (listed and described in Table 78).

Table 78: Summary of SONET Statistics

Statistic	Description
Section parity errors	Number of B1 parity errors detected
Line parity errors	Number of B2 parity errors detected
Path parity errors	Number of B3 parity errors detected
REI-L event counter	Number of B2 parity errors detected by peer LTE
REI-P event counter	Number of B3 parity errors detected by peer PTE
LOS event counter	Number of LOS events
LOF event counter	Number of LOF events
LOP event counter	Number of LOP events
AIS-L event counter	Number of AIS-L events
AIS-P event counter	Number of AIS-P events
RDI-L event counter	Number of RDI-L events
RDI-P event counter	Number of RDI-P events
PLM-P event counter	Number of PLM-P events
SF BER event counter	Number of SF BER events
SD BER event counter	Number of SD BER events

SONET Events

The PoS module can detect and report a variety of error and alarm conditions, some of which also trigger actions on the SONET link. Table 79 describes these events and their associated actions. Syslog messages are output for these events.

Table 79: SONET Events

Event	Description
Loss of Signal (LOS)	Loss of Signal is detected by the Section Terminating Equipment (STE) when an all-zeroes pattern on the incoming SONET signal lasts 100 microseconds or longer. This condition can be caused by loss of light. SONET Action: Send RDI-L upon LOS detection.
Loss of Frame (LOF)	Loss of Frame is detected by the STE when a Severely Errored Framing (SEF) defect on the incoming signal persists for 3 milliseconds. Related SONET Overhead: A1, A2 (framing pattern). SONET Action: Send RDI-L upon LOF detection.

Table 79: SONET Events (Continued)

Event	Description
Loss of Pointer (LOP)	The Path Loss Of Pointer event is detected as a result of excess New Data Flags (NDFs) or invalid pointers in the H1/H2 fields of the received signal. Related SONET Overhead: H1,H2 contain NDF and pointer. SONET Action: Send RDI-P upon LOP detection.
Alarm Indication Signal—Line (AIS-L)	The Line Alarm Indication Signal is sent by the upstream STE to inform the LTE that a LOS or LOF defect has been detected. Extreme's SONET module never sends AIS-L. AIS-L was formerly known as Line Far End Receive Failure (FERF). Related SONET Overhead: K2 carries AIS-L. SONET Action: Send RDI-L upon reception of AIS-L.
Alarm Indication Signal—Path (AIS-P)	The Path Alarm Indication Signal is sent by the upstream LTE to inform the PTE that a LOS, LOF, AIS-L, or LOP defect has been detected. Extreme's SONET module never sends AIS-P. AIS-P was formerly known as Path Far End Receive Failure (FERF). Related SONET Overhead: H1,H2,H3 = 0 when indicating AIS-P. SONET Action: Send RDI-P upon receiving AIS-P.
Remote Defect Indicator—Line (RDI-L)	The Line Remote Defect Indication is sent by the downstream LTE when a LOS, LOF, or AIS-L defect is detected. Related SONET Overhead: K2 carries RDI-L.
Remote Defect Indicator—Path (RDI-P)	The Path Remote Defect Indication is sent by the downstream PTE when a LOP or AIS-P defect is detected. Related SONET Overhead: G1 carries RDI-P.
Remote Error Indicator—Line (REI-L)	The Line Remote Error Indicator conveys a count of detected B2 parity errors from the peer LTE. Related SONET Overhead: M1 carries REI-L.
Remote Error Indicator—Path (REI-P)	The Path Remote Error Indicator conveys a count of detected B3 parity errors from the peer PTE. Related SONET Overhead: G1 carries REI-P.
Path Payload Label Mismatch (PLM-P)	The Path Payload Label Mismatch event occurs when the received payload type does not match the expected payload. This event is commonly caused by a Signal Label or scrambling mode mismatch configuration error. Related SONET Overhead: C2 carries the Signal Label.
Signal Failure Bit Error Rate (SF BER)	The Signal Failure BER event occurs when the B2 bit error rate exceeds the configured SF threshold. This event is used for APS switching. Related SONET Overhead: B2 carries line parity. SONET Action: Send RDI-L upon detecting SF BER event.
Signal Degrade Bit Error Rate (SD BER)	The Signal Degrade BER event occurs when the B2 bit error rate exceeds the configured SD threshold. This event is used for APS switching. Related SONET Overhead: B2 carries line parity.
Automatic Protection Switching (APS)	An APS event occurs when the value of K1 or K2 changes. This event is an input to the APS state machine, which is responsible for handling the event and outputting the appropriate syslog message. The LOS, LOF, AIS-L, SF BER, and SD BER events are also input to the APS state machine. Related SONET Overhead: K1,K2

Configuring and Monitoring PPP Functions

This section describes the commands you use to configure PPP attributes for PoS module ports.

This section provides information on the following topics:

- PPP Overview on page 602
- Configuring the PoS Checksum on page 606
- Configuring PoS Scrambling on page 606
- Configuring Link Maintenance on page 607
- Configuring PPP Link Quality Monitoring on page 607
- Configuring PPP Authentication on page 608
- Configuring the Name and Password for the Port on page 608
- Creating an Authentication Database Entry on page 609
- Configuring the Network Control Protocol on page 610
- Configuring the MPLS Control Protocol on page 611
- Configuring the Delayed-Down-Time Interval on page 612
- Displaying PPP Information on page 612
- Resetting PPP Configuration Parameter Values on page 614

PPP Overview

The Point-to-Point Protocol (PPP) encompasses a suite of protocols designed to provide standard methods for transporting datagrams over point-to-point links. The use of PPP over SONET links is commonly referred to as Packet over SONET, or PoS. The Extreme Networks implementation of PPP for the PoS module provides support for the following protocols in the PPP suite:

- Link Control Protocol (LCP)
- Link Quality Report (LQR) Protocol
- Challenge Handshake Authentication Protocol (CHAP)
- Password Authentication Protocol (PAP)
- IP Control Protocol (IPCP)
- Bridging Control Protocol (BCP)
- MultiProtocol Label Switching Control Protocol (MPLSCP)

- OSI Network Layer Control Protocol (OSINLCP)
- Extreme Discovery Protocol Control Protocol (EDPCP)

Link Control Protocol. The Link Control Protocol (LCP) establishes a logical connection with the peer LCP entity through an exchange of configuration packets. Data traffic cannot flow over the SONET link until LCP has successfully established this connection. LCP is also responsible for negotiating options that are independent of particular network layer protocols, such as the Quality Report, Authentication Protocol, and Maximum Receive Unit options.

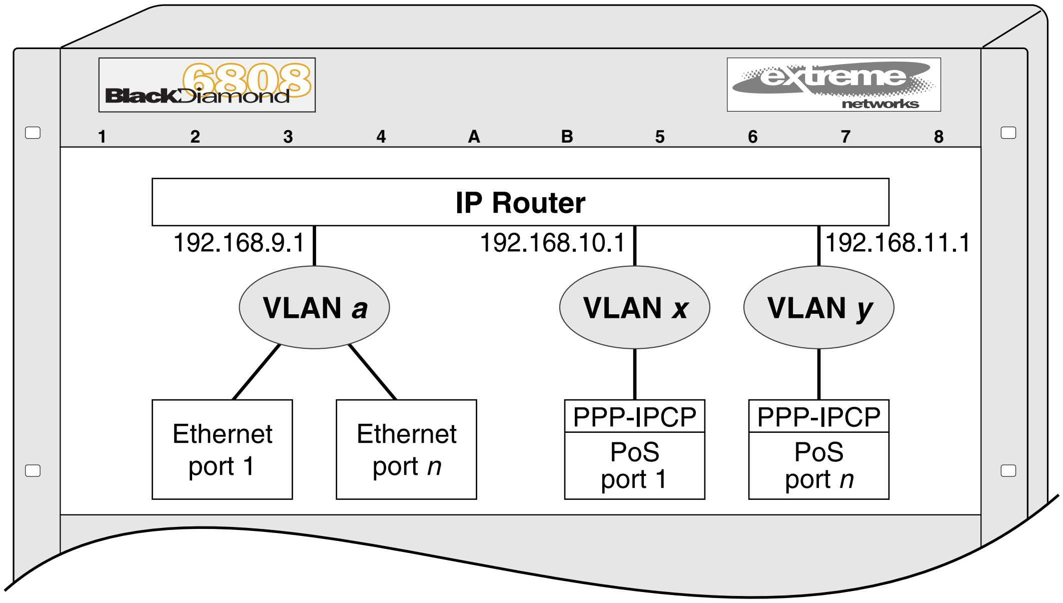
Quality Protocol Configuration Option. The LCP Quality Protocol configuration option can be used to specify the use of the Link Quality Report (LQR) Protocol to monitor the quality of the SONET link. If the LQR Protocol detects that the quality of the link is less than a configured threshold, all network layer protocols running over the link are brought down. This process of determining data loss and link viability is referred to as Link Quality Monitoring (LQM).

Link Maintenance Configuration Option. In addition to the LQR option, the Extreme Networks implementation of PPP also provides a Link Maintenance configuration option. When link maintenance is enabled on a port and that port is not receiving data packets, the link maintenance facility periodically transmits LCP echo-request packets. If an echo-reply is not received within a configured interval, LCP brings the link down.

Authentication Protocols. The Extreme Networks implementation of PPP uses the Challenge Handshake Authentication Protocol (CHAP) and the Password Authentication Protocol (PAP) to authenticate peer network elements. PAP is a simple protocol based on a clear-text user name and password pair, while CHAP is a stronger authentication protocol that uses the Message Digest, Version 5 (MD5) one-way hash algorithm. In the use of either protocol, if authentication fails, the connection with the peer is terminated.

IP Control Protocol. IPCP is a member of a family of Network Control Protocols (NCPs) defined for use with PPP. IPCP establishes and configures a connection to transport IP datagrams efficiently across a PPP link between two routers. When IPCP is enabled on a PoS port, all data forwarded over the SONET link must be routed by the BlackDiamond 6800 series switch, as illustrated in Figure 110.

Figure 110: View of logical connectivity to PoS ports with IPCP enabled

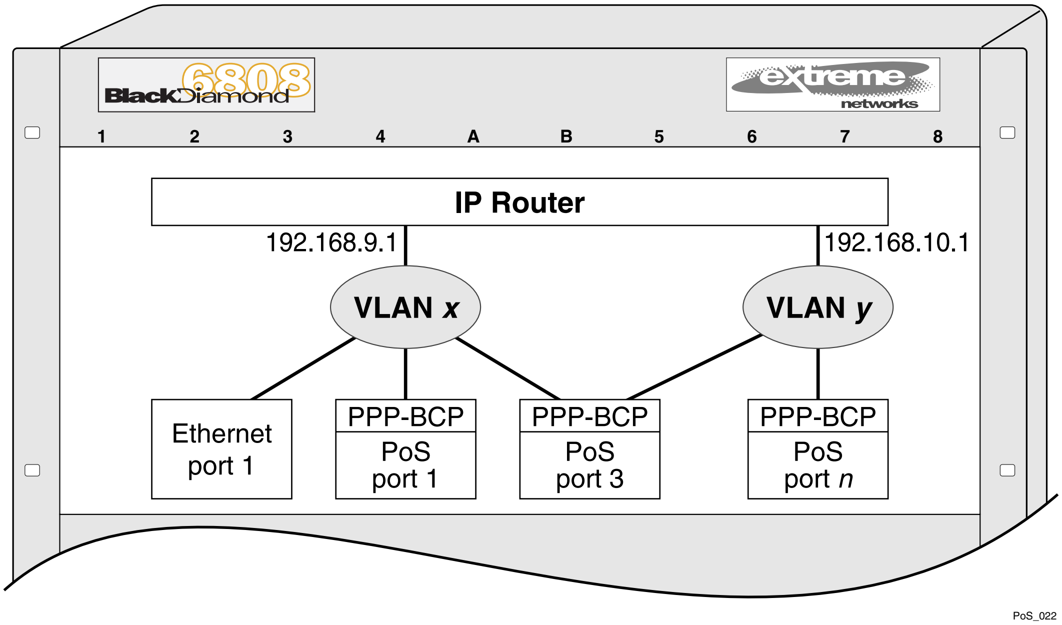


PoS_021

Generally, when IPCP is enabled on a port, the port must be a member of one and only one VLAN. Furthermore, no other ports may be members of this VLAN, and IP routing is the only protocol supported on the VLAN. The one exception to this rule occurs when APS is enabled. A single VLAN may contain two IPCP-enabled ports if they are members of the same APS group.

Bridging Control Protocol. BCP establishes and configures a connection for transporting Ethernet MAC frames across a PPP link. The BCP link must be established successfully before data traffic can flow over the link. Because BCP carries Ethernet MAC frames, any protocol can be transported across a BCP connection. In a simplified sense, BCP allows the PoS link to appear as an Ethernet LAN segment to the rest of the switch, so BCP makes it possible for LAN services to be extended transparently across SONET wide-area networks. Therefore, the port can be a member of multiple VLANs, and frames can be either bridged or routed onto the link, as illustrated in Figure 111.

Figure 111: View of logical connectivity to PoS ports with BCP enabled



As Figure 111 shows, PoS ports 1 and 3 are bridged together along with Ethernet port 1 to form VLAN *x*, PoS port 3 belongs to both VLAN *x* and VLAN *y*, and routed connectivity exists between VLAN *x* and VLAN *y*.

BCP is defined in RFC 2878, which was recently approved by the IETF as an update to RFC 1638. Two features of the updated version are: support for IEEE 802.1Q VLANs, and inline management. The VLAN support enables a BCP entity to advertise its ability to accept frames containing a VLAN tag. Inline management refers to the capability of transporting the Spanning Tree Protocol and other bridge management protocols inline using the Bridged Data PPP Protocol ID (previously, RFC 1638 specified that Spanning Tree Protocol messages be transported using a unique PPP Protocol ID). Extreme's implementation supports these features as specified in the new RFC.

MultiProtocol Label Switching Control Protocol. MPLSCP establishes and configures a connection for transporting MPLS labeled frames across a PPP link. The MPLSCP connection must be established successfully before data traffic can flow over the link. Only unicast MPLS labeled packets are supported. Multicast MPLS labeled packets are discarded by the PoS port.

MPLSCP is not explicitly configured on a PoS port. Rather, MPLSCP is automatically enabled on a PoS port when the port is configured for IPCP, and MPLS is enabled on the VLAN that the PoS port is a member of. When MPLSCP is enabled on a PoS port, the port will transport IP and MPLS labeled packets, and the port must be a member of one and only one VLAN. Furthermore, no other ports may be members of this VLAN, and IP routing is the only protocol supported on the VLAN. The one exception to this rule occurs when APS is enabled. A single VLAN may contain two IPCP-enabled ports if they are members of the same APS group.

OSI Network Layer Control ProtocolOSINLCP establishes and configures a connection for transporting OSI network layer packets (NPDUs) across a PPP link. OSI network layer packets may be transported across a PPP link in one of two ways: as bridged data using BCP or as NPDUs over the link negotiated with OSINLCP. When BCP is enabled on a PoS port, OSI NPDUs are sent as bridged data encapsulated in IEEE 802.3 framed packets containing an LLC header. When OSINLCP is enabled on a PoS port, OSI NPDUs are sent using the link negotiated with OSINLCP.

OSINLCP is not explicitly configured on a PoS port, it is automatically enabled on a PoS port when the port is configured for IPCP and IS-IS is enabled on the VLAN that the PoS port is a member of. When OSINLCP is enabled on a PoS port, the port will transport IP as well as OSI network layer packets. As with IPCP, the port must be a member of one and only one VLAN. Furthermore, no other ports may be members of this VLAN, and IP routing is the only protocol supported on the VLAN. The one exception to this rule occurs when APS is enabled. A single VLAN may contain two IPCP-enabled ports if they are members of the same APS group.

Extreme Discovery Protocol Control Protocol. EDPCP supports the exchange of EDP control packets across PoS links. EDP is used to gather information about neighboring Extreme switches, and to exchange topology information. EDPCP uses PPP protocol ID 0x820D; EDP packets use PPP protocol ID 0x020D. These PPP protocol IDs were assigned by the Internet Assigned Numbers Authority (IANA). When the PPP peer is from a vendor other than Extreme, EDPCP is disabled on the link.

Creating a PPP User Account

The following command is an enhanced application of the existing ExtremeWare `create account` command. The `pppuser` keyword is used to specify the name of a local database entry that is used to authenticate PPP peers.

```
create account pppuser <username> {encrypted} {<password>}
```

The PPP use of this command is described in “Creating an Authentication Database Entry” on page 609.

Configuring the PoS Checksum

To configure the size of the HDLC Frame Check Sequence (FCS) to be used on the specified SONET port, use the following command:

```
configure ppp pos checksum [32 | 16] ports <portlist>
```

Choose either the 32-bit FCS or the 16-bit FCS. A 32-bit FCS is the default. RFC 2615 recommends the use of the 32-bit FCS.

NOTE

For OC-3 applications, RFC 2615 allows the use of a 16-bit FCS, but recommends using a 32-bit FCS. You should limit your use of the 16-bit FCS to supporting interoperability with equipment that does not support the 32-bit FCS.

The following command example sets the FCS to 16 for port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
configure ppp pos checksum 16 ports 8:1
```

Configuring PoS Scrambling

To enable or disable payload data scrambling on the specified port, use the following command:

```
configure ppp pos scrambling [on | off] ports <portlist>
```

Choose either `on` or `off`. Scrambling is enabled by default.

RFC 2615 recommends that the SONET payload be scrambled. The option of disabling scrambling is provided for backward compatibility with an earlier PoS standard. Scrambling was introduced in RFC 2615 to alleviate potential security problems where malicious users might intentionally generate packets with bit patterns that create SONET synchronization problems.

The following command example turns off the scrambling function for port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
configure ppp pos scrambling off ports 8:1
```

Configuring Link Maintenance

The Extreme Networks implementation of PPP provides a link maintenance configuration option. When link maintenance is enabled on a port and that port is not receiving data packets, the link maintenance facility periodically transmits Link Control protocol (LCP) echo-request packets. If an echo-reply is not received within a configured interval, LCP brings the link down.

To enable the link maintenance protocol on a specified PPP port, use the following command:

```
configure ppp echo [<seconds> <consecutive_misses> | off] ports <portlist>
```

The `seconds` parameter is an integer in the range from 1 to 300 that specifies the period between transmissions of echo-request packets.

The `consecutive_misses` parameter is an integer in the range from 1 to 100 that determines how long PPP waits for a reply. If an echo-reply is not received within an interval of duration (*consecutive_misses * seconds*) seconds, the link is brought down.

When APS is enabled on a SONET port, link maintenance should also be enabled on that port.

The link maintenance protocol is off by default. If you enable link maintenance, the recommended `seconds` value is 3, and the recommended `consecutive_misses` value is 10.

The following example enables link maintenance on port 1 of a PoS module in slot 8 and sets `seconds` to 3 and `consecutive misses` to 10.

```
configure ppp echo 3 10 ports 8:1
```

Configuring PPP Link Quality Monitoring

The Link Control Protocol (LCP) establishes a logical connection with the peer LCP entity through an exchange of configuration packets. Data traffic cannot flow over the SONET link until LCP has successfully established this connection. LCP also allows the negotiation of a quality monitoring protocol to monitor the viability of the PPP link on a continuous basis. This process of determining data loss and link viability is referred to as Link Quality Monitoring (LQM).

The LQM protocol uses the Link Quality Report (LQR) packet as a mechanism in the test of the PPP link. The LQM protocol periodically transmits LQR packets containing counts of packets and octets that have been transmitted and successfully received. This information enables the LQM protocol to determine the percentage of data that is being dropped due to poor link quality. If the drop percentage is greater than a configured threshold, all network-layer protocols are brought down. Bringing a poor-quality link down may be desirable when an alternate network path exists, or when billing is based on the amount of data transmitted. By default, LQM is off.

To enable the LQM protocol on a specified PPP port, use the following command:

```
configure ppp quality [off | <required_percent> {<seconds>}] ports <portlist>
```

The `required_percent` parameter is an integer in the range from 1 to 99 that is used to determine the drop percentage threshold, where:

drop percentage threshold = (100–<required_percent>).

The optional `seconds` parameter is an integer in the range from 1 to 300. This parameter value determines how often quality reports should be received from the peer LQR entity. If you do not specify a value for the `seconds` parameter, the command uses the default value of 30 seconds.

It can take up to seven reporting intervals for LCP to bring a link down. If the link quality improves subsequent to being brought down, LCP automatically brings the link back up. This type of service restoration takes a minimum of seven reporting intervals.

The following example enables the LQM protocol on port 1 of a PoS module in slot 3 and sets `required_percent` to 95. Because no value is specified for the optional `seconds` parameter, the command uses the default of 30 seconds.

```
configure ppp quality 95 ports 3:1
```

Configuring PPP Authentication

The Extreme Networks implementation of PPP uses the Challenge Handshake Authentication Protocol (CHAP) and the Password Authentication Protocol (PAP) to authenticate peer network elements. PAP is a simple protocol based on a clear-text user name and password pair, while CHAP is a stronger authentication protocol that uses the Message Digest, Version 5 (MD5) one-way hash algorithm. In the use of either protocol, if authentication fails, the connection with the peer is terminated.

To configure authentication on a specified PPP port, use the following command:

```
configure ppp authentication [off | chap | pap | chap-pap] ports <portlist>
```

The default is authentication `off`, meaning the peer is not authenticated.

When you configure authentication using the `chap` keyword, the peer is authenticated using CHAP.

When you configure authentication using the `pap` keyword, the peer is authenticated using PAP.

When you configure authentication using the `chap-pap` keyword, a request is made to authenticate the peer using CHAP, but PAP may be used if the peer does not support CHAP.

The following command example turns on CHAP authentication for port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
configure ppp authentication chap ports 8:1
```

Configuring the Name and Password for the Port

In the event a PPP peer requests authentication, the Extreme Networks implementation of PPP responds to the peer’s CHAP or PAP authentication requests regardless of whether the port is configured to authenticate the peer.

To configure the name and password for a specified PPP port, use the following command:

```
configure ppp user <name> {encrypted} {<password>} ports <portlist>
```

The `name` and `password` parameters can contain a maximum of 32 alphanumeric characters each. As an option, you can use double quotation characters as delimiters to enclose the `name` and `password` parameters.

If you do not specify a `password` parameter in this command, the command prompts you to enter the new password two times: the first time to set the new password; the second time to confirm the password.

The factory default value for both the `name` and `password` parameters is the word *extreme*.

NOTE

You should not attempt to use the `encrypted` *keyword. It is used by the switch when generating an ASCII configuration.*

The following command example sets the name to “titus” and sets the password to “1Afortune” for port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
configure ppp user "titus" "1Afortune" ports 8:1
```

Creating an Authentication Database Entry

Responses to authentication requests include a username. When the requesting entity receives a response, it searches its local database for an entry with the specified username. When an entry is located, the associated password is used to validate the authentication response.

To create a local database entry that can be used to authenticate a PPP peer, use the following command:

```
create account pppuser <username> {encrypted} {<password>}
```

The `name` and `password` parameters are both character strings of up to 32 alphanumeric characters. Both strings must start with an alphabetic character, but can be any combination of alphanumerical characters thereafter. As an option, you can use double quotation characters as delimiters to enclose the `name` and `password` parameters.

If you do not specify a `password` string in this command, the command prompts you to enter the password two times: the first time to set the string; the second time to confirm it.

NOTE

You should not attempt to use the `encrypted` *keyword. It is used by the switch when generating an ASCII configuration.*

The following command example sets the authentication database name to “stretch” and sets the password to “baserunner” for port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
create account pppuser "stretch" "baserunner" ports 8:1
```

Configuring the Network Control Protocol

The Network Control Protocol is configured on a per-port basis, meaning that different ports on the same module can be running either the Bridging Control Protocol (BCP) or the IP Control Protocol (IPCP)—both protocols cannot be configured at the same time on any port.

Generally, when IPCP is configured on a port, that port must be a member of a single VLAN. Further, no other ports on this switch can be members of this VLAN, and IP routing is the only protocol supported on this VLAN. The one exception to this rule is when Automatic Protection Switching (APS) is enabled. In which case, a single VLAN may contain two ports configured for IPCP if they are both members of the same APS group.

NOTE

For more information about setting up VLANs, see Chapter 6.

BCP establishes and configures a connection for transporting Ethernet MAC frames across a PPP link. Because BCP carries Ethernet MAC frames, any protocol can be transported across a BCP connection. In a simplified sense, BCP allows the PoS link to appear as an Ethernet LAN segment to the rest of the switch, so BCP makes it possible for LAN services to be extended transparently across SONET wide-area networks. Therefore, the port can be a member of multiple VLANs, and frames can be either bridged or routed onto the link.

Generally, most of the switch capabilities provided for Ethernet ports are also available for PoS ports configured for BCP. One exception is that there are restrictions on which OC-3 PoS module ports can be bridged together (be configured as members of the same VLAN). Ports 1 and 2 on the same OC-3 PoS module cannot be bridged together, and ports 3 and 4 on the same OC-3 PoS module cannot be bridged together—unless they are members of the same APS group. There are no such restrictions on OC-12 PoS module ports.

To configure the Network Control Protocol for a specified PPP port, use the following command:

```
configure ppp [bcp [on | off] | ipcp [on {peer-ipaddress <ip address>} | off]] ports
<portlist>
```

By default, BCP is enabled on all PoS ports. BCP cannot be configured on a port unless IPCP is off; IPCP cannot be configured on a port unless BCP is off.

When used with IPCP, the optional `peer-ipaddress` keyword and parameter value provides a way to configure the IP address of the peer router. This capability is useful with peer routers that do not advertise their IP address through the IPCP IP-Address configuration option. If the peer router does advertise an IP address through IPCP, the configured value for `peer-ipaddress` is ignored.

The following command example turns IPCP off and BCP on for port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
configure ppp ipcp off port 8:1
configure ppp bcp on port 8:1
```

Configuring the MPLS Control Protocol

MPLSCP establishes and configures a connection for transporting MPLS labeled frames across a PPP link. The MPLSCP connection must be established successfully before MPLS labeled data traffic can flow over the link. Only unicast MPLS labeled packets are supported. Multicast MPLS labeled packets are discarded by the PoS port.

MPLSCP is not explicitly configured on a PoS port. However, MPLSCP is automatically enabled on a PoS port when the port is configured for IPCP and MPLS is enabled on the VLAN that the PoS port is a member of. When MPLSCP is enabled on a PoS port, the port will transport IP and MPLS labeled packets, and the port must be a member of one and only one VLAN. Furthermore, no other ports may be members of this VLAN, and IP routing is the only protocol supported on the VLAN. The one exception to this rule occurs when APS is enabled. A single VLAN may contain two IPCP-enabled ports if they are members of the same APS group.

NOTE

You must have a PoS module and an MPLS module installed in your BlackDiamond switch to use MPLS on a PoS port.

To configure MPLSCP on a PoS port, complete the following steps:

1 Create a VLAN for the PoS port using the `create vlan <vlan name>` command.

2 Add the PoS port to the VLAN using the `configure vlan <vlan name> add ports <portlist> {tagged | untagged} {nobroadcast} {soft-rate-limit}` command.

3 Define an IP router port on the VLAN by assigning an IP address to the VLAN using the `configure vlan <vlan name> ipaddress <ipaddress> {<netmask> | <mask length>}` command.

4 Disable BCP on the PoS port using the `configure ppp bcp off ports <portlist>` command and enable IPCP on the PoS port using the `configure ppp ipcp on ports <portlist>` command.

5 Configure MPLS on the VLAN using the `configure mpls add vlan [<vlan name> | all] {ldp | rsvp-te}` command.

The following command example creates a VLAN named *vlan1* and configures MPLSCP on PoS port 8:1 on VLAN *vlan1*:

```
create vlan vlan1
configure vlan vlan1 add ports 8:1
configure vlan vlan1 ipaddress 192.168.100.1
configure ppp bcp off ports 8:1
configure ppp ipcp on ports 8:1
configure mpls add vlan vlan1
```

For more information about MPLS and configuring MPLS, see Chapter 26.

Configuring the OSI Network Layer Control Protocol

OSINLCP implementation is based on RFC 1337. OSINLCP establishes and configures a connection for transporting OSI network layer packets (NPDUs) across a PPP link. OSI network layer packets may be transported across a PPP link in one of two ways: as bridged data using BCP or as NPDUs over the link negotiated with OSINLCP. When BCP is enabled on a PoS port, OSI NPDUs are sent as bridged data encapsulated in IEEE 802.3 framed packets containing an LLC header. When OSINLCP is enabled on a PoS port, OSI NPDUs are sent using the link negotiated with OSINLCP.

OSINLCP is not explicitly configured on a PoS port, it is automatically enabled on a PoS port when the port is configured for IPCP and IS-IS is enabled on the VLAN that the PoS port is a member of. When OSINLCP is enabled on a PoS port, the port will transport IP as well as OSI network layer packets. As with IPCP, the port must be a member of one and only one VLAN. Furthermore, no other ports may be members of this VLAN, and IP routing is the only protocol supported on the VLAN. The one exception to this rule occurs when APS is enabled. A single VLAN may contain two IPCP-enabled ports if they are members of the same APS group.

To configure OSINLCP on a PoS port, complete the following steps:

1. Create a VLAN for the PoS port using the `create vlan <vlan name>` command.
2. Add the PoS port to the VLAN using the `configure vlan <vlan name> add ports <portlist> {tagged | untagged} {nobroadcast} {soft-rate-limit}` command.
3. Define an IP router port on the VLAN by assigning an IP address using the `configure vlan <vlan name> ipaddress <ipaddress> {<netmask> | <mask length>}` command.
4. Disable BCP on the SONET port using the `configure ppp bcp off ports <portlist>` command, and then enable IPCP with `configure ppp ipcp on ports <portlist>`.
5. Enable IS-IS on the VLAN using the `configure isis add vlan [<vlan name> | all] [[level-1 | level-1-2] area <isis area identifier> | level-2-only]` command.

Configuring the Delayed-Down-Time Interval

The delayed-down-time interval is the amount of time that PPP waits before declaring a port down after a physical link failure has been detected. A non-zero value is useful when recovery from the link failure is fast, for example, when APS is enabled on a SONET port. In this case, APS may recover from the link failure before PPP responds, thereby minimizing network down time. Generally, you should set a non-zero value for the delayed-down-time interval any time APS is configured at either end of the link.

To configure the delayed-down-time interval for a specified PPP port, use the following command:

```
configure ppp delayed-down-time <seconds> ports <portlist>
```

The value of the `seconds` parameter is an integer number in the range from 0 to 20 seconds. The default is 1 second.

NOTE

A delayed-down-time interval of one second is usually sufficient to accommodate APS line switches.

The following command example sets the delayed-down-time interval to 2 seconds for port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
configure ppp delayed-down-time 2 ports 8:1
```

Displaying PPP Information

To display status information for PPP ports, use the following command:

```
show ppp {<portlist>} {detail}
```

If you enter the `show ppp` command without an argument or keyword, the command displays status information for all PPP ports. Use the optional `portlist` parameter to display status information for one or more specific ports.

By default, the command displays a summary of status information for the specified PPP port. Use the `detail` keyword to display detailed status information.

The summary display includes the following status information for each PPP port:

- Values of all PPP configuration parameters
- Physical link status
  - — operational
  - — down
  - — LCP state
  - — IPCP/BCP state
  - — EDPCP state
  - — MPLSCP state
  - — OSINLCP state
  - — link packet and octet counters

The detailed display includes the information reported in the summary display, and adds the following status and management counters:

- Detailed link status:
  - — PPP link phase
- Detailed LCP status:
  - — LCP options negotiated (local and remote)
  - — LCP packet counters
  - — Number of link-down events due to PPP maintenance
- Detailed authentication status:
  - — Remote username (if applicable)
  - — CHAP or PAP packet counters
- Detailed BCP or IPCP status:
  - — Options negotiated (local and remote)
  - — Packet counters
- Detailed LQM status:
  - — Statistics from the most recent Link Quality Report (LQR)
  - — Time since the most recent LQR
  - — LQR packet counters
  - — Number of link-down events due to LQM

Resetting PPP Configuration Parameter Values

To reset the PPP configuration parameters for the specified port to their default values, use the following command:

```
unconfigure ppp ports <portlist>
```

Configuring VLAN-Related Attributes

The ExtremeWare software and the Extreme Networks switch architecture provide a range of Virtual Local Area Network (VLAN) features, which are described in detail in Chapter 6. This section describes how these features are supported on the PoS module.

NOTE

This section assumes some familiarity with the Extreme Networks implementation of VLAN features as described in Chapter 6.

PoS module ports do not support protocol-based VLANs or MAC address VLANs. Thus, there are restrictions on the use of the following commands:

- `configure vlan <vlan name> add ports <portlist> {tagged | untagged} {nobroadcast} {soft-rate-limit}`
- `configure vlan <vlan name> delete port <portlist>`
- `configure vlan <vlan name> protocol [<protocol_name> | any]`
- `enable mac-vlan mac-group [any | <group_number>] port <portlist>`

The restrictions are as follows:

- A PoS port cannot be added to a VLAN if the VLAN is a protocol-based VLAN.
- A VLAN cannot be configured to be a protocol-based VLAN if the VLAN contains a PoS port.
- A MAC address VLAN cannot be enabled on a PoS port.

The `configure vlan <vlan name> protocol [<protocol_name> | any]` command is supported, because it can be used to configure the default VLAN for PoS ports.

In the `configure vlan <vlan name> add ports <portlist> {tagged | untagged} {nobroadcast} {soft-rate-limit}` command, PoS ports support the optional `tagged` and `untagged` keywords when BCP is enabled, and ignore them when IPCP is enabled.

IPCP and BCP are mutually exclusive configuration options for a given PoS port: they cannot both be enabled simultaneously on the same PoS port. Generally, when IPCP is enabled on a port, the port must be a member of one and only one VLAN. Furthermore, no other ports may be members of this VLAN, and IP routing is the only protocol supported on the VLAN. The one exception to this rule occurs when APS is enabled. A single VLAN may contain two IPCP-enabled ports if they are members of the same APS group.

Configuring Tagged VLAN 802.1p and 802.1Q Functions

NOTE

The dot1q tag mapping and tag nesting commands are supported only by PoS ports and apply only when BCP is enabled on the PoS port.

The following ExtremeWare commands are supported for the PoS module:

- `configure dot1q ethertype <ethertype>`
- `configure dot1p type <dot1p_priority> qosprofile <qosprofile>`

NOTE

If a PoS port receives a frame with a priority value "n" that is not mapped to a profile in the range from qp1 through qp8, the frame is assigned to QoS profile qp_{n+1}.

The following commands provide PoS module support for managing 802.1Q tags:

- `configure dot1q tagmapping <input_vlanid/output_vlanid> ports <portlist> {egress {priority <priority>} | ingress {priority <priority>}}`
- `configure dot1q tagnesting {<vlanid> | <vlanid_range>} [off | pop | push <new_vlanid> {priority <priority>}] ports <portlist> {egress | ingress}`

Configuring VLAN Tag Mapping Tables

The `configure dot1q tagmapping` command provides support for VLAN ID (VID) mapping tables. Each PoS port supports two VID tables: one table is used in the ingress direction; the other is used in the egress direction. These tables make it possible to map an input VID to an output VID, which can be useful in reconciling policy differences at the boundary between the customer and the service provider. The tables also allow the option of preserving the 802.1p priority or overwriting the priority with a configured value.

To configure the VLAN tag mapping tables for a PoS port, use the following command:

```
configure dot1q tagmapping <input_vlanid/output_vlanid> ports <portlist> {egress
{priority <priority>} | ingress {priority <priority>}}
```

The `input_vlanid` and `output_vlanid` parameters are both integers in the range from 1 to 4095 and must be separated by a slash character.

The `priority` parameter is an integer in the range from 0 to 7.

Use the `egress` keyword to apply the mapping of the input VLAN ID to the output VLAN ID to frames received from the switch backplane prior to transmitting them onto the PPP link. Use the `ingress` keyword to apply the mapping to input frames received from the PPP link. The mappings are applied after they are classified to a QoS profile. Frames containing the VLAN ID specified in `input_vlanid` are changed so that the VLAN ID is set to the value specified in `output_vlanid` before the frame is forwarded.

If you omit both the `egress` and the `ingress` keywords, the command automatically applies the specified mapping to the egress direction, and also applies a symmetrical mapping (with the `input_vlanid` and `output_vlanid` values reversed) to the ingress direction.

These tables also give you the option of preserving the 802.1p priority or overwriting the priority with a user-configured value. Using the priority keyword in the command indicates that the 802.1p priority field is to be set to the value specified in priority. To preserve the 802.1p priority, do not enter the priority keyword and value when using this command.

The default behavior is that the tables are initialized such that VLAN IDs are not altered by the mapping operations, and frame priority is preserved. For example, an input VLAN ID of *n* is always mapped to an output VLAN ID of *n*, and the 802.1p priority field is not changed.

Configuring VLAN Tag Nesting Attributes

The configure dot1q tagnesting command provides support for 802.1Q tags by allowing a tag *push* or *pop* attribute to be associated with a VLAN ID. The push attribute indicates that a new tag is to be added to the frame, while the pop attribute indicates that the top-level tag is to be removed from the frame. The command also gives you the option to preserve the 802.1p priority of the frame or set it to a configured value when a new tag is added (pushed) to the frame. VLAN ID (VID) mapping occurs before a new tag is pushed, and after a nested tag is popped.

To configure the VLAN tag nesting attributes for a PoS port, use the following command:

```
configure dot1q tagnesting {<vlanid> | <vlanid_range>} [off | pop | push <new_vlanid>
{priority <priority>}] ports <portlist> {egress | ingress}
```

The vlanid parameter is an integer in the range from 1 to 4095. The vlanid_range parameter is specified in the form start_vlanid-end_vlanid, where the start and end values are both integers in the range from 1 to 4095 and must be separated by a hyphen.

The push keyword indicates that a new tag is to be added to frames containing the VID specified in vlanid or to one of the VIDs in the range specified in vlanid_range. The new tag added to frames contains the value specified in new_vlanid.

The pop keyword indicates that the top-level tag is to be removed from frames when that tag contains either the VID specified in vlanid or any one of the VIDs in the range specified in vlanid_range.

If you do not specify a VID or a range of VIDs, the command settings are applied to all VIDs.

Tag operations can be performed in either the egress direction (to the SONET link) or the ingress direction (from the SONET link). If you do not specify a direction, the default behavior is that tag operations are performed in the egress direction. If you do not use either the egress or ingress keyword and tag pushing is configured, a corresponding tag pop operation is automatically configured for the ingress direction. If you do not use either the egress or ingress keyword and tag nesting is disabled using the off keyword, tag nesting is disabled in both directions.

The optional priority keyword provides a way to overwrite the 802.1p priority with a user-configured value when a new tag is pushed. Using the priority keyword in the command indicates that the 802.1p priority field is to be set to the value specified in priority, which is an integer in the range from 0 to 7. To preserve the 802.1p priority, do not enter the priority keyword and value when using this command.

Default behavior is that tag nesting is disabled (off) for all VLAN IDs.

Tag push operations apply to egress frames only when the port is configured to transmit tagged frames for the associated VLAN. Tag nesting operations apply only to ingress frames that contain a VLAN tag. Tag nesting operations are applied after classification to a QoS profile.

NOTE

The default PPP MRU is sufficient for a single level of tag nesting (where the frame contains two VLAN tags) between two Extreme Networks switches. If higher levels of VLAN tag nesting are needed, jumbo frame support must be enabled.

NOTE

The DiffServ and RED functions are not performed by PoS ports when frames contain nested tags (more than one tag).

Generic VLAN Registration Protocol Functions

The Generic VLAN Registration Protocol (GVRP) is not supported on PoS module ports, so the following command will not work if you specify a PoS port:

```
configure gvrp {listen | send | both | none} port <portlist>
```

Configuring Forwarding Database Attributes

PoS ports support all of the existing ExtremeWare forwarding database (FDB) commands. For more information on these commands, see Chapter 7.

Configuring Spanning Tree Attributes

PoS ports support all of the existing ExtremeWare Spanning Tree commands. For more information on these commands, see Chapter 14.

Configuring QoS Functions

The ExtremeWare software and the Extreme Networks switch architecture provide a number of Quality of Service (QoS) functions, which are described in detail in Chapter 8. This section describes how these QoS functions, such as Differentiated Services (DiffServ) and Random Early Detection (RED) are supported on the PoS module.

NOTE

This section assumes some familiarity with the Extreme Networks implementation of QoS and DiffServ features as described in Chapter 8.

This section contains information on the following topics:

- Configuring a QoS Profile on page 618
- Classification and Replacement Policies on page 618
- Configuring DiffServ on page 620

- Enhanced RED Support on page 622

Configuring a QoS Profile

The SONET modules support eight ingress queues and eight egress queues per port. The scheduling parameters (minimum bandwidth, maximum bandwidth and priority level) for these queues are controlled by QoS profiles qp1 through qp8, which are defined using the existing ExtremeWare `configure qosprofile` command.

This command has been enhanced to allow you to configure more module-specific parameters on a port-by-port basis, including the ability to customize the QoS profile parameters for individual ingress or egress queues on a specific SONET port.

The syntax and description of the enhanced `configure qosprofile` command are described below.

To configure the scheduling parameters for a specified QoS profile, use the following command:

```
configure qosprofile <qosprofile> minbw <min_percent> maxbw <max_percent> priority
<level> {[minbuf <percent> maxbuf <number> [K | M] | maxbuff <number> [K | M] |
<portlist>]}
```

The optional `egress` and `ingress` keywords apply only to PoS ports. As stated earlier, the PoS modules support eight egress queues and eight ingress queues per port, and the scheduling parameters for these queues are controlled by QoS profiles qp1-qp8, which means queue #0 is controlled by qp1, queue #1 is controlled by qp2, and so on.

The optional `portlist` parameter allows QoS profiles to be customized on a port-by-port basis for the PoS modules. The `egress` and `ingress` keywords allow you to fine-tune the customization (down to a particular egress or ingress queue on a given port). If you do not enter either the `egress` or `ingress` keyword in the command, the configured parameters apply to the egress queue associated with the specified QoS profile by default.

The `minbw` parameter specifies the minimum percentage of the bandwidth guaranteed to be available to the specified queue for transmissions from the QoS profile. The value is an integer in the range from 0 through 100. The default value is 0. The sum of the minimum bandwidth parameters across all eight QoS profiles cannot exceed 90%.

The `maxbw` parameter specifies the maximum percentage of the bandwidth that the specified queue can use for transmissions from the QoS profile. The value is an integer in the range from 1 through 100. The default value is 100.

The optional `priority` keyword and `level` parameter specify the service priority for the specified queue. The service priority determines which traffic is scheduled when bandwidth is still available after the minimum requirements of all profiles have been satisfied. Settings for `level` include: low, lowHi, normal, normalHi, medium, mediumHi, high, or highHi. The default setting is low.

NOTE

The `minbuf` *and* `maxbuf` *keywords do not apply to PoS ports.*

Classification and Replacement Policies

This section deals primarily with classification operations performed by IPCP or BCP configured PoS ports.

Most of the existing ingress classification functions are supported for IPCP or BCP configured PoS ports. Functions such as access list and destination MAC address QoS policies are supported, as is the `enable diffserv replacement` command.

Egress frames are always assigned to a QoS profile based on their 802.1p priority. Thus, when a PoS port receives a frame from the switch fabric with a priority value *n*, that frame is assigned to egress QoS profile qp*n*+1.

The existing `enable diffserv examination ports` and `disable diffserv examination ports` commands are used on PoS ports to control whether the DiffServ code point (DSCP) is examined for ingress classification purposes.

When you enable the PPP Bridging Control Protocol (BCP) on a PoS port, non-IP frames that contain a VLAN tag are assigned to an ingress QoS profile based on their 802.1p priority value. You can configure this assignment using the `configure dot1p type` command, which is used to specify the mappings between 802.1p priority values and QoS profiles. However, if a PoS port receives a frame with a priority value *n*, for which there is no mapping to one of the eight profiles (qp1-qp8), that frame is assigned to ingress QoS profile qp*n*+1.

If `diffserv examination` is not enabled, then the preceding 802.1p priority classification rules are applied to tagged IP frames as well.

In both cases, untagged frames are assigned to a single ingress QoS profile (provided that the port is an untagged member of a VLAN; if that is not the case, then untagged frames are discarded). This QoS profile defaults to qp1, but you can assign it to another profile using the `configure ports <portlist> qosprofile <qosprofile>` command or the `configure vlan <vlan name> qosprofile <qosprofile>` command (where the port-based QoS configuration has higher precedence than VLAN-based QoS).

Additionally, if you enable the PPP IP Control Protocol (IPCP) on a PoS port and do not enable `diffserv examination` on the port, then all ingress frames (received from the SONET link) are assigned to a single ingress QoS profile. The profile defaults to qp1, but you can configure it to another profile using the `configure ports <portlist> qosprofile <qosprofile>` command or the `configure vlan <vlan name> qosprofile <qosprofile>` command.

If you enable `diffserv examination` on a PoS port, then ingress IP frames are assigned to a QoS profile based on the DiffServ code point (regardless of whether you enabled either BCP or IPCP on the port). The existing `configure diffserv examination code-point` command maps DiffServ code points to QoS profiles. This command has been enhanced for use with PoS ports. The syntax and description of the enhanced `configure diffserv examination code-point` command are given below.

Also note that, in all cases, the 802.1p priority bits of ingress frames forwarded to the switch backplane are set based on the ingress QoS profile classification. More specifically, the 802.1p priority value is set to qp# – 1. For example, if the packet is classified to qp5, then the 802.1p priority value is set to 4.

When you enable MPLSCP on a PoS port, classification for MPLS labeled packets is done based only on the EXP bits in the label stack entry of the ingress frame. The EXP bits are used to map an ingress frame to an 802.1p priority and assigned to the corresponding ingress queue. Before the frame is forwarded to the switch backplane, the 802.1p bits in the frame are set based on the exp-to-dot1p mapping. You can use the `configure mpls qos-mapping exp-to-dot1p` command to configure the EXP to 802.1p mapping. You can use the `configure dot1p type dot1p_priority` command to configure the 802.1p to QoS mapping.

When you configure MPLSCP on a PoS port, other types of ingress commands such as `configure diffserv examination code-point`, `configure ports <portlist> qosprofile <qosprofile>`, and `configure vlan <vlan name> qosprofile <qosprofile>` are supported only for IPCP data frames and not MPLS labeled frames. Similarly, egress replacement commands such as `enable dot1p replacement` and `enable diffserv replacement` are supported only for IPCP data frame and not MPLS labeled frames.

Configuring DiffServ

All of the existing ExtremeWare DiffServ commands are supported by PoS ports with IP frames that are encapsulated in BCP or IPCP, not MPLSCP (including the enhancements to the `configure diffserv examination code-point` command, described earlier in this chapter). PoS ports also support a DiffServ code point (DSCP) mapping function that you configure using the `configure diffserv dscp-mapping` command, which is described below. The DSCP is a 6-bit value in the IP-TOS byte of the IP packet header. For more information on DSCPs, see "Configuring DiffServ" in Chapter 8.

DiffServ Classification

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

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

Changing DiffServ Code Point Assignments in the QoS Profile

Because the code point uses six bits, it has 64 possible values ($2^6 = 64$). By default, the values are grouped and assigned to the default QoS profiles listed in Table 80.

Table 80: Default Code Point-to-QoS Profile Mapping

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

To configure the mapping between a DiffServ code point and a specified QoS profile, use the following command:

```
configure diffserv examination code-point <code_point>
   qosprofile <qosprofile> ports <portlist>
   {low-drop-probability | high-drop-probability}
```

The mapping is applied in the ingress direction—for IP packets received from the SONET link.

The optional `low-drop-probability` and `high-drop-probability` keywords apply only to PoS ports. If you do not enter either of these keywords in the command, the command uses `low-drop-probability` as the default.

The `low-drop-probability` and `high-drop-probability` keywords are useful in conjunction with the Weighted RED (WRED) implementation provided by PoS ports. This implementation supports two different drop probabilities: one for DiffServ code points designated as having low drop-probability; another for DiffServ code points designated as having high drop-probability. These keywords give you complete flexibility in assigning DiffServ code points to these two drop-probability levels.

Configuring DiffServ Code Point Mapping Tables

You can use the `diffserv dscp-mapping` command to configure a mapped relationship between an input DSCP and an associated output DSCP. Each PoS port supports three DSCP mapping tables: one of the tables is used in the ingress direction; two are used for egress flows (onto the SONET link). The two egress tables are for the congested and noncongested states, as determined by the RED algorithm. If RED is not enabled on the PoS port, the egress congested-state mapping table is not used.

In the ingress direction, the input DSCP of a packet received from the SONET link is replaced by an output DSCP before the packet is forwarded. In the egress direction, the operation is similar, except that the DSCP mapping occurs before the packet is transmitted onto the SONET link.

One potential use of the DSCP mapping capability is to reconcile varying DiffServ policies at the boundary between autonomous systems, such as at the boundary between two ISPs. The availability of different tables for the congested and noncongested states is useful in marking operations that increase the probability of packets being dropped during times of congestion, as discussed in the DiffServ Assured Forwarding RFC (RFC 2597).

NOTE

This command applies only to PoS ports with IP frames that are encapsulated in BCP or IPCP, not MLSCP. You should also be aware that DSCP mapping is performed even when the `diffserv examination` *function is disabled on the port.*

To configure the mapping between an input DSCP and an associated output DSCP, use the following command:

```
configure diffserv dscp-mapping <input_codepoint>/<output_codepoint> ports <portlist>
{egress {no-congestion | congestion} | ingress}
```

where:

`input_codepoint`	Specifies one of the 64 possible DiffServ code point values as the input code point.
`output_codepoint`	Specifies one of the 64 possible DiffServ code point values as the output code point.
`egress`	Applies the DSCP mapping to the egress direction.
`no-congestion`	Applies the DSCP mapping to the egress mapping table for the non-congested state.
`congestion`	Applies the DSCP mapping to the egress mapping table for the congested state.
`ingress`	Applies the DSCP mapping to the ingress direction.

If you omit the no-congestion and congestion keywords, the command applies the mapping to the tables for both states.

If you omit the egress and ingress keywords, the command applies the mapping to the egress direction, and automatically configures a symmetrical mapping (with the input_codepoint and output_codepoint values reversed) in the ingress direction.

By default, all the tables are initialized such that DSCPs are not altered by the mapping operations. For example, an input DSCP value of *n* is always mapped to an output DSCP value of *n*.

Resetting DiffServ Code Point Mapping Tables

To reset the DSCP mapping tables for a specified PoS port to their default values, use the following command:

```
unconfigure diffserv dscp-mapping ports <portlist>
```

Replacing DiffServ Code Points

To replace DiffServ code points, you must use the following command to enable DiffServ replacement:

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

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

```
configure diffserv replacement priority <value> code-point <code_point> ports
[<portlist> | all]
```

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

To verify the DiffServ configuration, use the command:

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

Enhanced RED Support

Random Early Detection (RED) is a congestion avoidance mechanism. The basic idea behind RED is that most data transports detect packet loss and will, therefore, restrain transmission—if only temporarily—when they detect dropped packets. Consequently, if the switch needs to signal another device to slow transmission due to congestion, RED provides a way of intelligently dropping packets.

This section describes the changes and additions to ExtremeWare to support RED in conjunction with PoS modules that have IP frames encapsulated in BCP or IPCP, not MPLSCP. The Extreme implementation of RED combines the functions of the RED algorithm with IP precedence to provide support for preferential traffic handling for higher-priority packets. This implementation provides weighted RED (WRED) functionality through two packet-drop probabilities (described below), so that a device can selectively drop lower-priority traffic when an interface begins to show signs of congestion. This capability is combined with DiffServ attributes to allow you to tailor performance characteristics for different classes of service.

Configuring RED Drop Probability

To configure the RED drop probability for a specified PoS port, use the following command:

```
configure red [drop-probability | low-drop-probability | high-drop-probability]
<percent> {ports <portlist>}
```

The optional `low-drop-probability`, `high-drop-probability`, and `ports` keywords are supported only for SONET ports.

If you omit the `ports` keyword, the command applies the setting to all ports.

The drop probability is specified as a percentage, where the `percent` parameter is an integer in the range from 1 to 100.

Weighted RED (WRED) functionality is supported through two different drop probabilities: a low-drop-probability and a high-drop-probability. The DiffServ code points of IP packets indicate whether the packet should be dropped with low probability or high probability, and the appropriate percentage is then applied if WRED is active.

NOTE

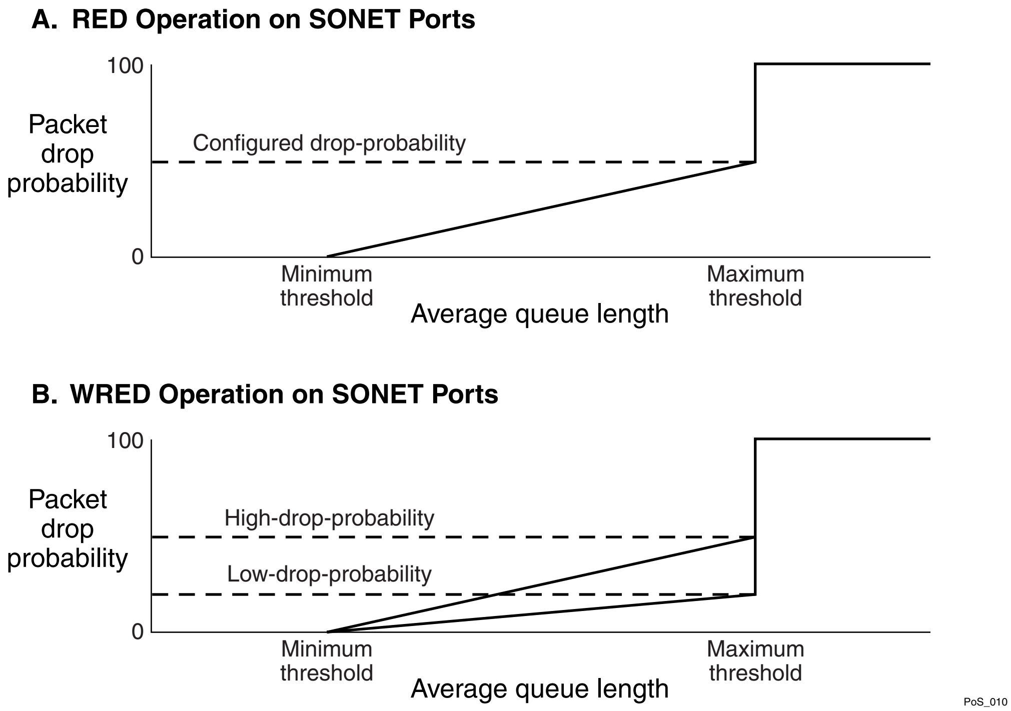
WRED is applied only to IP packets. The `configure diffserv examination code-point` *command gives you complete flexibility in assigning DSCPs to the two different drop-probability levels. This configured mapping of DSCPs to drop-probability levels is used by WRED even if* `diffserv examination` *is disabled on the port.*

The `drop-probability` keyword indicates that the specified percentage should be used for both the low and high drop-probabilities. This effectively disables WRED and reverts to standard RED operation. For SONET ports, both the low and high drop-probabilities default to 10%.

The role of the configured drop probability in RED operation on SONET ports is illustrated in Figure 112A. RED is active when the average queue length is between the minimum and maximum thresholds. In this region, the probability that a given packet is dropped increases in a straight line up to the configured drop probability at the maximum threshold. All packets are dropped when the average queue length exceeds the maximum threshold.

The operation of WRED on SONET ports is depicted in Figure 112B. In this case, the drop probability depends not only on the average queue length, but also upon whether the DSCP indicates that the packet should be dropped with a low or high probability, which is to say, the DSCP of the packet controls which curve is used.

Figure 112: Comparisons of RED and WRED operation



Enabling and Disabling RED Ports

The existing ExtremeWare commands to enable and disable RED ports have been enhanced to provide RED configuration attributes for the PoS modules. Because the PoS modules support eight egress queues per port, the commands were enhanced to allow the user a way to enable RED selectively on an individual port and queue basis. By default, RED is disabled.

To enable RED on a specified PoS port, use the following command:

```
enable red ports <portlist> queue <queue#>
```

To disable RED on a specified PoS port, use the following command:

```
disable red ports <portlist> queue <queue#>
```

The optional `queue` keyword applies only to SONET ports. You can use this keyword to enable or disable the RED function on an individual queue basis.

The `queue#` parameter is an integer in the range from 0 to 7, and identifies one of the eight egress queues. If you omit the `queue` keyword, the command applies to all of the queues for the PoS port.

Configuring the RED Minimum Queue Length Threshold

The packet drop probability is based, in part, on the RED minimum queue length threshold. When the average queue length exceeds this threshold, the RED algorithm is activated and begins dropping packets. The packet drop rate increases in a linear fashion as the average queue length increases or until the average queue length hits the maximum threshold.

NOTE

This command applies only to SONET ports.

To configure the minimum queue length threshold for RED operation on a specified PoS port, use the following command:

```
configure red min-threshold <percent> ports <portlist>
```

The threshold value is specified as a percentage in the range from 1 to 100. For SONET ports, the minimum threshold is a percentage of 1000 packet buffers, and the maximum threshold is set to the value calculated by the formula:

*minimum ((3 * minimum threshold buffers), maximum available buffers)*

By default, the minimum threshold for SONET ports is 10%, or 100 buffers; thus, the default maximum threshold is 300 buffers.

You can use the `show ports {mgmt | <portlist>} info {detail}` command to display the settings of the minimum and maximum thresholds, displayed in terms of the number of buffers.

Use the `ports` keyword to configure the threshold parameter on specific SONET ports.

Support for Standard Per-Hop Behaviors

The per-hop behavior (PHB) describes the externally observable packet forwarding handling (or “behavior”) to be applied by the receiving network element when there are competing requests for resources such as bandwidth and buffer space. In the packet forwarding path, differentiated services are identified by mapping the differentiated services code point (DSCP) contained in the IP packet header to a specific forwarding behavior at each network element along its path. The DSCP is 6 bits wide, and takes the form *xxxxxx*, where *x* can be either 0 or 1. The DSCP field is capable of identifying one of 64 distinct code points. For purposes of code point allocation and management, the code point space is divided into three pools: one pool of 32 code points (pool 1) constitutes the recommended code points to be allocated as standards; a second pool of 16 code points (pool 2) is set aside for experimental or local use; a third pool of 16 code points (pool 3) that are initially set aside for experimental or local use, but that might be used for standard assignments if pool 1 is ever exhausted. The mapping of DSCPs to PHBs is a user-configurable function, as described below.

The current standards call for two PHBs: Assured Forwarding (AF) and Expedited Forwarding (EF). The EF PHB describes the required behavior for voice-over-IP service. The AF PHB consists of four independently forwarded AF classes: AF1, AF2, AF3, and AF4. Within each of these classes, an IP packet can be assigned to different levels of drop precedence (used to determine drop probability) depending on how many levels of drop precedence the implementation supports. RFC 2597 describes two schemes for drop-precedence levels: a three-level scheme (see Table 81) and a two-level scheme (see Table 82). The three-level scheme supports low, medium, and high drop-precedence levels for the AF classes; the two-level scheme supports low and high drop-precedence levels (and groups the medium drop-precedence code-points with the high drop-precedence code-points). The Extreme implementation for the PoS module supports the two-level drop-precedence scheme.

Table 81: Assured Forwarding Classes and Three-Level Drop Precedence

Drop-Precedence Level	AF1	AF2	AF3	AF4
Low drop precedence	(AF11) 001010	(AF21) 010010	(AF31) 011010	(AF41) 100010
Medium drop precedence	(AF12) 001100	(AF22) 010100	(AF32) 011100	(AF42) 100100
High drop precedence	(AF13) 001110	(AF23) 010110	(AF33) 011110	(AF43) 100110

Table 82: Assured Forwarding Classes and Two-Level Drop Precedence

Drop-Precedence Level	AF1	AF2	AF3	AF4
Low drop precedence	(AF11) 001010	(AF21) 010010	(AF31) 011010	(AF41) 100010
High drop precedence	(AF12) 001100 (AF13) 001110	(AF22) 010100 (AF23) 010110	(AF32) 011100 (AF33) 011110	(AF42) 100100 (AF43) 100110

In addition, a network element that complies with the DiffServ standards must also provide a recommended *default* code point, which must be unique for code points in the standard space. The default PHB describes the common, best-effort forwarding behavior offered by existing network elements, as defined in RFC 1812.

As an additional differentiation, a set of code points has been allocated for use as the Class Selector code points, which describe the minimum forwarding handling requirements needed to preserve compatibility with existing practices while respecting flexibility for the future.

Table 83 and the command examples that follow show how the standard per-hop behaviors (PHBs) might be mapped onto ExtremeWare QoS profiles qp1 through qp8.

Table 83: Mapping PHBs to QoS Profiles

PHB	Default	Class Selector		AF1	AF2	AF3	AF4	EF
QoS Profile	qp1	qp2	qp3	qp4	qp5	qp6	qp7	qp8
DSCP	000000	001000 010000 011000 100000 101000	110000 111000	001010 001100 001110	010010 010100 010110	011010 011100 011110	100010 100100 100110	101110

The DSCPs associated with a PHB are assigned to the appropriate QoS profile using the `configure diffserv examination code-point` command. For example, the following command sets up the mapping for the EF PHB:

```
configure diffserv examination code-point 46 qosprofile qp8 ports 2:1-2:2
```

Additional configuration steps for SONET ports in this example are as follows:

- Enable RED for all PHBs except the EF PHB. For example:

  ```
  enable red ports 2:1-2:2
  disable red ports 2:1-2:2 queue 8
  ```

- Configure a high drop-probability of 20% on the SONET ports. For example:

```
configure red high-drop-probability 20 ports 2:1-2:2
```

- Enable examination of DiffServ information. For example:

```
enable diffserv examination ports 2:1-2:2
```

- Configure the default PHB. For example:

```
configure diffserv examination code-point 0 qosprofile qp1 ports 2:1-2:2
```

- Configure the Class Selectors. For example:

```
configure diffserv examination code-point 8 qosprofile qp2
   ports 2:1-2:2 high-drop-probability
configure diffserv examination code-point 16 qosprofile qp2
   ports 2:1-2:2 high-drop-probability
configure diffserv examination code-point 24 qosprofile qp2
   ports 2:1-2:2 high-drop-probability
configure diffserv examination code-point 32 qosprofile qp2
   ports 2:1-2:2 low-drop-probability
configure diffserv examination code-point 40 qosprofile qp2
   ports 2:1-2:2 low-drop-probability
configure diffserv examination code-point 48 qosprofile qp3
   ports 2:1-2:2 high-drop-probability
configure diffserv examination code-point 56 qosprofile qp3
   ports 2:1-2:2 low-drop-probability
```

- Configure the drop-probability for the DSCPs assigned to AF1 through AF4.

  For example, for AF1 (qp4):

  ```
  configure diffserv examination code-point 10 qosprofile qp4
     ports 2:1-2:2 low-drop-probability
  configure diffserv examination code-point 12 qosprofile qp4
     ports 2:1-2:2 high-drop-probability
  configure diffserv examination code-point 14 qosprofile qp4
     ports 2:1-2:2 high-drop-probability
  ```

  For example, for AF2 (qp5):

  ```
  configure diffserv examination code-point 18 qosprofile qp5
     ports 2:1-2:2 low-drop-probability
  configure diffserv examination code-point 20 qosprofile qp5
     ports 2:1-2:2 high-drop-probability
  configure diffserv examination code-point 22 qosprofile qp5
     ports 2:1-2:2 high-drop-probability
  ```

  For example, for AF3 (qp6):

  ```
  configure diffserv examination code-point 26 qosprofile qp6
     ports 2:1-2:2 low-drop-probability
  configure diffserv examination code-point 28 qosprofile qp6
     ports 2:1-2:2 high-drop-probability
  configure diffserv examination code-point 30 qosprofile qp6
     ports 2:1-2:2 high-drop-probability
  ```

  For example, for AF4 (qp7):

  ```
  configure diffserv examination code-point 34 qosprofile qp7
     ports 2:1-2:2 low-drop-probability
  configure diffserv examination code-point 36 qosprofile qp7
     ports 2:1-2:2 high-drop-probability
  configure diffserv examination code-point 38 qosprofile qp7
     ports 2:1-2:2 high-drop-probability
  ```

- Configure the congested-state mappings for DSCPs 10 (AF11), 18 (AF21), 26 (AF31), and 34 (AF41). For example:

  ```
  configure diffserv dscp-mapping 10/12 egress congestion
  configure diffserv dscp-mapping 18/20 egress congestion
  configure diffserv dscp-mapping 26/28 egress congestion
  configure diffserv dscp-mapping 34/36 egress congestion
  ```

- Use the EF PHB to configure bandwidth reservation and rate limiting. For example:

  ```
  configure diffserv examination code-point 46 qosprofile qp8 ports 2:1-2:2
  configure qosprofile qp8 minbw 10 maxbw 20 2:1-2:2 egress
  configure qosprofile qp8 minbw 10 maxbw 20 2:1-2:2 ingress
  ```

Displaying RED Configuration Information for PoS Module Ports

While the syntax of the existing `show ports info detail` command has not changed, the output of the command now displays the RED and DiffServ configuration parameters associated with PoS module ports.

To display QoS, RED, and DiffServ information for a specified PoS port, use the following command:

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

NOTE

For PoS ports, the existing `show ports qosmonitor` *command has also been enhanced to display the number of packet transmissions and discards from each queue (in both egress and ingress directions).*

QoS Monitor

The QoS Monitor utility is supported for PoS module ports. The QoS Monitor and its associated ExtremeWare commands are described in Chapter 8.

Intra-Subnet QoS

Intra-Subnet QoS (ISQ) is not supported on switches that use the "*i*" chipset; the PoS module is supported only on switches that use the "*i*" chipset.

Configuring and Monitoring Flow Statistics

Each PoS port can maintain and export traffic statistics for the flows that traverse the associated SONET link. A flow is defined as a unidirectional sequence of packets between a particular source device and destination device that share the same protocol and transport-layer information. Flows are defined by the following fields: source IP address, destination IP address, source port, destination port, protocol type, and SONET interface. Per-flow statistics are useful for many management purposes, including:

- Accounting and billing
- Network capacity planning and trend analysis
- Network monitoring
- Workload characterization
- User profiling
- Data warehousing and mining

Flow Statistics Background Information

Each PoS module can maintain two million flow records. Per-flow statistics are exported in the NetFlow Version 1 record format described in Table 84. NetFlow records are unidirectional in nature, which implies that two flow records are maintained for a typical TCP connection: one record for flow in the ingress direction; a second for the flow in the egress direction. Also, records are maintained only for TCP and UDP flows.

Table 84: NetFlow Version 1 Record Format

Field Name	Octets	Field Description
srcaddr	4	Source IP address
dstaddr	4	Destination IP address
nexthop	4	IP address of next-hop router; set to zero for per-flow statistics; set to xFFFF for filter-based aggregated statistics
input	2	Input interface index; set to index of PoS interface for ingress flows received from the SONET link; set to zero for egress flows that are being transmitted over the SONET link
output	2	Output interface index; set to index of PoS interface for egress flows that are being transmitted over the SONET link; set to zero for ingress flows received from the SONET link
dPkts	4	Number of packets sent in this flow
dOctets	4	Number of octets sent in this flow
First	4	SysUptime when flow record was created
Last	4	SysUptime at most-recent, or last packet of flow
srcport	2	Source port number, valid only for TCP and UDP flows
dstport	2	Destination port number, valid only for TCP and UDP flows
pad	2	Unused field
prot	1	Number identifying the IP protocol; for example, 6=TCP and 17=UDP
tos	1	IP Type-of-Service (TOS) field value from initial packet that caused this flow record to be created
tcp_flags	1	Cumulative OR of TCP flags field, valid only when *prot*=6
pad	11	Unused field

Flow records are grouped together into UDP datagrams for export to a flow-collector device. A NetFlow Version 1 export datagram can contain up to 25 flow records. Figure 113 shows the format of the export datagram; Table 85 describes the export datagram header.

Figure 113: Format of NetFlow export datagram

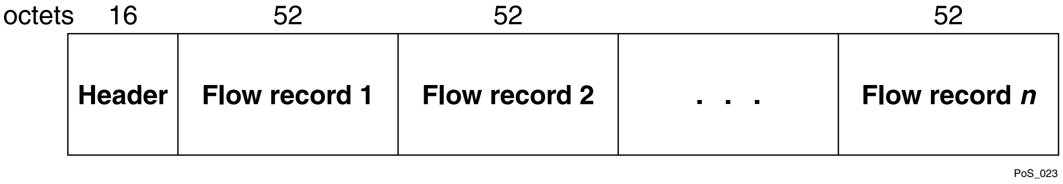


Table 85: Format of NetFlow Version 1 Export Datagram Header

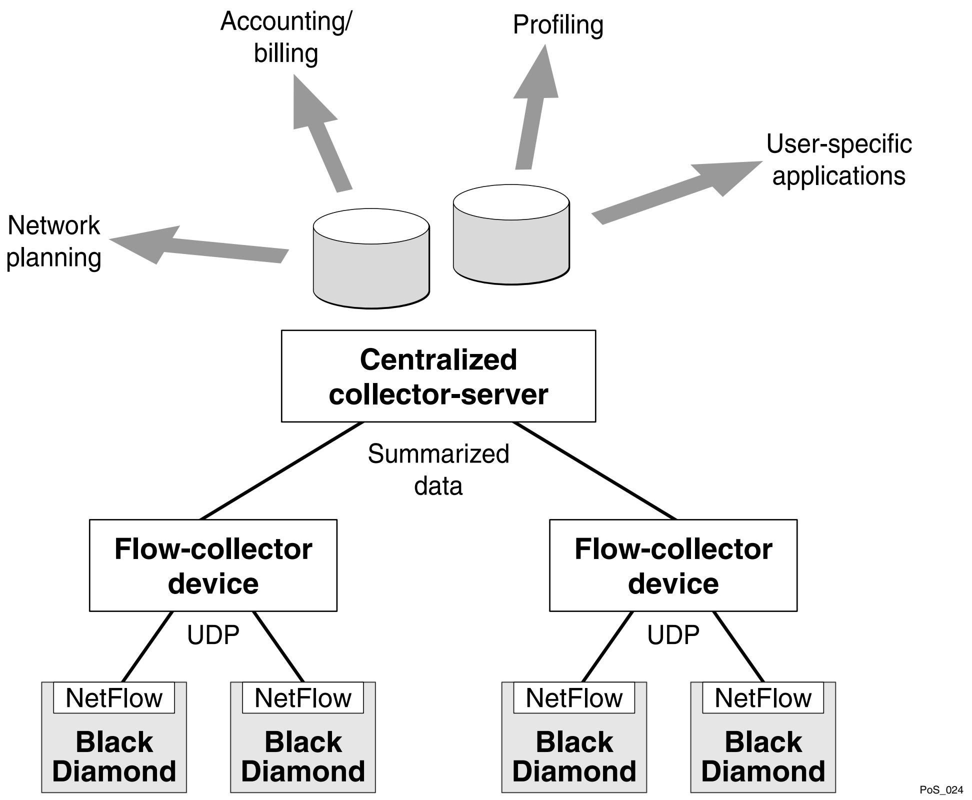
Field Name	Octets	Field Description
version	2	Header version=1.
count	2	Number of flow records in datagram.
SysUptime	4	Current time in milliseconds since the switch booted.
unix_secs	4	Current count of seconds since 0000 UTC 1970.
unix_nsecs	4	Current count of residual nanoseconds since 0000 UTV 1970.

The IP addresses (or hostnames) and UDP port numbers of the available flow collectors can be configured on a per-switch basis. The flow collection architecture example in Figure 114 illustrates how multiple BlackDiamond switches might export flow records to flow-collector devices that, in turn, feed records into a central collector-server. Other flow-collector architectures are also possible. For example, each SONET port might export statistics to a dedicated flow-collector device.

The ExtremeWare NetFlow implementation for the PoS module also enables a single SONET port to distribute statistics across multiple groups of flow-collector devices. This NetFlow distribution feature enables a scalable collection architecture that is able to accommodate high volumes of exported data. The NetFlow distribution feature is enabled by configuring *export distribution groups* that contain the addresses of multiple flow-collector devices. The feature uses a distribution algorithm that ensures all of the records for a given flow are exported to the same collector. The algorithm also ensures that the flow records for both the ingress and egress directions of a TCP or UDP connection are exported to the same collector when both flows traverse the SONET link and both filters are configured to export to the same group. For example, a potentially different group can be associated with a filter. The flow records that match the filter are then sent to one of the flow collector devices in that group. You could also establish redundancy by allowing multiple flow collector devices per group so that data is still collected as long as there is one working flow collector device in that group.

To implement flow-collector devices, you can choose from commercial software products and public-domain software packages.

Figure 114: NetFlow Collection Architecture Example



Collection Port and Filtering Options

By default, each PoS port maintains statistics for all the flows traversing the SONET link in both the ingress and egress directions. However, generalized filtering options exist that enable a port to maintain statistics only for ingress flows, only for egress flows, or only for selected ingress and/or egress flows.

You can use these filtering options to configure a PoS port to maintain statistics selectively for only those flows that match a specified filter. Up to 16 filters are supported for each PoS port: eight filters for ingress flows; eight filters for egress flows. The filters consist of a {*value,mask*} pair for each of the following flow components: destination IP address, source IP address, destination port, source port, and protocol. Conceptually, the filters work by logically ANDing the contents of each of these five components of a forwarded flow with the associated *masks* from the first filter. Statistics are maintained if the results of the AND operations match the configured filter values for all fields of the five flow components. If there is not a match on all fields of the five components, then the operation is repeated for the second filter, and so on. If there is no match for any of the filters, then statistics are not maintained for the flow.

Collection Architecture Scalability and Reliability

By supporting statistics distribution across groups of flow-collector devices, the NetFlow distribution function enables a scalable collection architecture that is able to accommodate high volumes of exported data. The function also includes a health-check feature that significantly improves the reliability of the collection architecture. The health-checker ensures that only responsive flow-collector devices are included in the effective export distribution lists.

Up to 32 export distribution groups can be configured on a Black Diamond 6800 series switch. Each of these groups can contain the addresses of up to eight flow-collector devices. A particular export group can then be specified for each filter, which provides a high-degree of flexibility.

A filter-based aggregation capability is also offered to further enhance scalability. Each filter can be configured to be either a *per-flow filter* or an *aggregation* filter. When a flow matches a filter that is configured as an aggregation, normal per-flow statistics are not maintained for the flow. Instead, a single set of statistics is maintained for all the flows that match the aggregation filter, which can substantially reduce the volume of exported data.

Aggregated flow statistics are also exported in the NetFlow Version 1 format. The *nexthop* field of the flow record (see Table 84) is set to xFFFF to indicate that the record is associated with a filter-based aggregation. The *srcaddr*, *dstaddr*, *srcport*, *dstport*, and *prot* fields of an aggregated flow record are set to the corresponding value components of the associated filter specification.

Export Criteria

TCP flow records are exported when the associated connection is terminated. Flow records are also exported on an age basis. All flow records, including aggregation records, are examined at least once every 30 minutes. If the age of the flow is greater than a configurable time, the record is exported. If the flow is still active, a new flow record will be created when the next packet arrives.

The PoS module transmits a NetFlow Export Datagram when 25 flow records are ready for export, or when at least one flow has been awaiting export for one second.

Enabling and Disabling Flow Statistics

To enable the flow statistics function on the specified SONET port, use the following command:

```
enable flowstats ports <portlist>
```

The flow statistics function is disabled by default.

NOTE

Flow statistics are collected only on SONET ports that are configured to use the IP Control Protocol (IPCP). No flow statistics are collected on ports that are configured to use the Bridging Control Protocol (BCP). You will not be prevented from enabling the flow statistics function on ports not configured for IPCP, but statistics will not be collected on those ports.

To disable the flow statistics function on the specified SONET port, use the following command:

```
disable flowstats ports <portlist>
```

The flow statistics function is disabled by default.

Configuring the Export Destination

A single SONET port can distribute statistics across multiple groups of flow-collector devices. This NetFlow distribution capability makes it possible to create a collection architecture that scales to accommodate high volumes of exported data. It also offers a health-checking function that improves the reliability of the collection architecture by ensuring that only responsive flow-collector devices are included in active export distribution lists.

The distribution algorithm ensures that all the records for a given flow are exported to the same collector. The algorithm also ensures that flow records for both the ingress and egress directions of a

TCP or UDP connection are exported to the same collector (when both flows traverse the same SONET link and both filters are configured to export to the same group).

NetFlow distribution is enabled by configuring export distribution groups that identify the addresses of multiple flow-collector devices. You can configure up to 32 export distribution groups on a BlackDiamond 6800 series switch, and each group can contain as many as eight flow-collector devices.

To configure the export groups and flow-collector devices to which NetFlow datagrams are exported, use the following command:

```
configure flowstats export <group#> delete [<ipaddress> | <hostname>] <udp_port>
```

The optional `group#` parameter is an integer in the range from 1 through 32 that identifies the specific group for which the destination is being configured. If you do not specify a value for the `group#` parameter, the parameter value defaults to 1.

You can use the `add` and `delete` keywords to add or delete flow-collector destinations.

To export NetFlow datagrams to a group, you must configure at least one flow-collector destination. By default, no flow-collector destinations are configured. To configure a flow-collector destination, use either an IP address and UDP port number pair or a hostname and UDP port number pair to identify the flow-collector device to which NetFlow export datagrams are to be transmitted. You can configure up to eight flow-collector destinations for each group. When multiple flow-collectors are configured as members of the same group, the exported NetFlow datagrams are distributed across the available destinations.

Configuring the Source IP Address

To configure the IP address that is to be used as the source IP address for NetFlow datagrams to be exported, use the following command:

```
configure flowstats source ipaddress <ipaddress>
```

No NetFlow datagrams are exported until the source IP address is configured. Depending on how it is configured, a flow-collector device can use the source IP address of received NetFlow datagrams to identify the switch that sent the information.

NOTE

The configured IP address should be associated with a VLAN that has loopback-mode enabled.

The following command example specifies that the IP address 192.168.100.1 is to be used as the source IP address for exported NetFlow datagrams.

```
configure flowstats source ipaddress 192.168.100.1
```

Configuring Flow Record Timeout

Flow records are exported on an age basis: All flow records are examined at least once every 30 minutes. If the age of the flow record is greater than the configured timeout, the record is exported. If the flow is still active, a new flow record will be created when the next packet arrives.

To configure the timeout value for flow records on the specified SONET port, use the following command:

```
configure flowstats timeout <minutes> ports [<portlist> | all]
```

The timeout value is the number of minutes to use in deciding when to export flow records. The number is an integer in the range from 1 to 1440. The default timeout is 5 minutes.

The following command example specifies a 10-minute timeout for exported NetFlow datagrams on port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
configure flowstats timeout 10 ports 8:1
```

Configuring a Flow Record Filter

You can configure a SONET port to maintain statistics selectively for only those flows that match a specified filter. Each port on an PoS module supports 16 filters: eight filters for ingress flows; eight filters for egress flows.

To configure a flow record filter for the specified SONET port, use the following command:

```
configure flowstats filter <filter#> {aggregation} {export <group#>} ports <portlist>
[ingress | egress] <filterspec>
```

where:

`filter#`	The `filter#` parameter is an integer in the range from 1 to 8 that operates with either the `ingress` or `egress` keyword to identify the filter that is being defined.
`aggregation`	To reduce the volume of exported data, use this optional keyword to maintain a single set of statistics for all the flows that match the specified filter.
`export <group#>`	To specify a particular export distribution group on a per-filter basis, use the optional `export` keyword with a group number value to identify the set of flow collector devices to which records for flows matching the filter are to be exported. If you do not specify a value for `group#`, the value defaults to 1.
`ingress`	Use this keyword to specify that the filter being defined in the command is one of the eight filters to be applied to ingress flows.
`egress`	Use this keyword to specify that the filter being defined in the command is one of the eight filters to be applied to egress flows.

`filterspec`

Each filter is defined using a *value/filtermask* pair for each of the five components in the following sequence:

{destination IP address, source IP address,
destination port number, source port number, protocol}

in the form:

```
[{dest-ip <ipaddress_value/ipaddress_filtermask>}
{source-ip <ipaddress_value/ipaddress_filtermask>}
{dest-port <port_value/port_filtermask>}
{source-port <port_value/port_filtermask>}
{protocol <protocol_value/protocol_filtermask>} |
match-all-flows | match-no-flows]
```

The `ipaddress_filtermask`, `port_filtermask`, and `protocol_filtermask` parameters are configured using hexadecimal notation.

You can also use either the `match-all-flows` keyword or the `match-no-flows` keyword in place of settings for the five components. The `match-all-flows` keyword adjusts the *value/filtermask* settings for all the components to 0/0 such that the filter matches any flow. The `match-no-flows` keyword adjusts the *value/filtermask* settings for all the components such that the filter does not match any flow.

By default, filter #1 is configured to `match-all-flows`, and the remaining filters are configured to `match-no-flows`.

Conceptually, the filters work by ANDing the contents of each of the five components of a forwarded flow with the associated masks from the first defined filter (filter #1). Statistics are maintained if the results of the AND operations match the configured filter values for all fields of the sequence. If there is no match, then the operation is repeated for filter #2, and so on. If there is no match for any of the filters, then statistics are not maintained for the flow. Filters for any or all of the sequence components can be configured with a single command.

The following command example configures a filter to collect statistics on ingress flows destined for 192.168.1.1 from the 192.169.0.0/16 subnet with a destination port of 80 using protocol 6.

```
configure flowstats filter 1 export 1 ports all ingress
   dest-ip 192.168.1.1/FFFFFFFF source-ip 192.169.0.0/FFFF0000
   dest-port 80/FFFF source-port 0/0 protocol 6/FF
```

Likewise, the following command example configures a filter to collect statistics on egress traffic from the 192.168.0.0/16 subnet to 192.169.1.1 with a destination port of 80 using protocol 6.

```
configure flowstats filter 1 export 1 ports all egress
   dest-ip 192.169.1.1/FFFFFFFF source-ip 192.168.0.0/FFFF0000
   dest-port 80/FFFF source-port 0/0 protocol 6/FF
```

The following command example configures a filter to collect aggregate statistics for all egress traffic flowing from the 192.170.0.0/16 subnet to the 192.171.255.255 subnet.

```
configure flowstats filter 2 aggregation export 1 ports all egress
   dest-ip 192.171.0.0/FFFF0000 source-ip 192.170.0.0/FFFF0000
   dest-port 0/0 source-port 0/0 protocol 0/0
```

Likewise, the following command example configures a filter to collect aggregate statistics for all ingress traffic flowing from the 192.171.0.0/16 subnet to the 192.170.0.0/16 subnet.

```
configure flowstats filter 2 aggregation export 1 ports all ingress
   dest-ip 192.170.0.0/FFFF0000 source-ip 192.171.0.0/FFFF0000
   dest-port 0/0 source-port 0/0 protocol 0/0
```

Finally, the following command examples configure two filters—an egress filter and an ingress filter—to collect statistics on any remaining flows that did not match the ingress and egress filters defined in the four previous command examples.

```
configure flowstats filter 3 export 1 ports all egress match-all-flows
configure flowstats filter 3 export 1 ports all ingress match-all-flows
```

Enabling and Disabling a Flow Record Filter

To enable a specified flow record filter for the specified SONET port, use the following command:

```
enable flowstats filter <filter#> ports <portlist> {ingress | egress}
```

By default, filter #1 is enabled on all SONET ports for both ingress and egress flows, and all remaining filters are disabled.

To disable a specified flow record filter for the specified SONET port, use the following command:

```
disable flowstats filter <filter#> ports <portlist> {ingress | egress}
```

where:

`filter#`	The `filter#` parameter is an integer in the range from 1 to 8 that operates with either the `ingress` or `egress` keyword to identify the filter that is being enabled or disabled.
`ingress`	Use this keyword to specify that the filter being enabled or disabled is one of the eight filters to be applied to *ingress* flows.
`egress`	Use this keyword to specify that the filter being enabled or disabled is one of the eight filters to be applied to *egress* flows.

The following command example enables ingress filter #2 on port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
enable flowstats filter 2 ports 8:1 ingress
```

The following command example disables ingress filter #2 on port 1 of the PoS module installed in slot 8 of the BlackDiamond switch.

```
disable flowstats filter 2 ports 8:1 ingress
```

Enabling and Disabling Flow Statistics Ping-Check

To enable the flow statistics ping-check function for a specified group of collector devices, use the following command:

```
enable flowstats ping-check {<group#>}
```

If you do not specify a value for the `group#` parameter, the ping-check function is enabled for all collector groups.

The ping-check function is enabled by default.

When the ping-check function is enabled, each of the flow collector devices is pinged periodically to check its network connectivity. If a flow collector device is repetitively unresponsive, it is temporarily removed from the export distribution list for that group. The flow collector device will be returned to the export distribution list automatically when subsequent ping checks are consistently successful.

The following command example enables the ping-check function for export group 2.

```
enable flowstats ping-check 2
```

To disable the flow statistics ping-check function for a specified group of collector devices, use the following command:

```
disable flowstats ping-check {<group#> | all}
```

If you do not specify a value for the group# parameter, the ping-check function is disabled for all collector groups.

The following command example disables the ping-check function for export group 2.

```
disable flowstats ping-check 2
```

Unconfiguring Flow Statistics

To reset the flow statistics configuration parameters for a specified SONET port to their default values, use the following command:

```
unconfigure flowstats ports [<portlist> | all]
```

NOTE

This command does not affect the enabled or disabled status of flow statistics collection, nor does it affect the configured export destinations.

The following command example resets the flow statistics configuration parameters for port 1 of the PoS module installed in slot 8 of the BlackDiamond switch to their default values.

```
unconfigure flowstats ports 8:1
```

Displaying Flow Statistics Status Information

To display status information for the flow statistics function, use the following command:

```
show flowstats {<portlist> | export {<group#>}}
```

where:

portlist	Use this optional parameter to specify the SONET port for which status information is to be displayed.
export	Use this optional keyword to display status information for export groups, which are configured on a switch-wide basis.
group#	Use this optional parameter with the export keyword to display status information for a specific export group. If you do not specify a value for the group# parameter, the export keyword by itself displays status information for all export groups.
detail	Use this optional keyword to display detailed export group status information.

If you enter the show flowstats command with none of the optional keywords or parameters, the command displays a summary of status information for all ports.

The summary status display for a port includes the following information:

- Values for all flow statistics configuration parameters
- Count of flow records that have been exported
- Counts of the number of packets/bytes for which flow statistics were not maintained because of insufficient resources

The summary status display for an export group includes the following information:

- Values for all configuration parameters
- Status of each export destination device

The detailed status display for an export group includes the summary information, plus the following management information:

- Counts of the flow records that have been exported to each flow collector destination
- Counts of the number of times each flow collector destination has been taken out of service due to health-check (ping check) failures

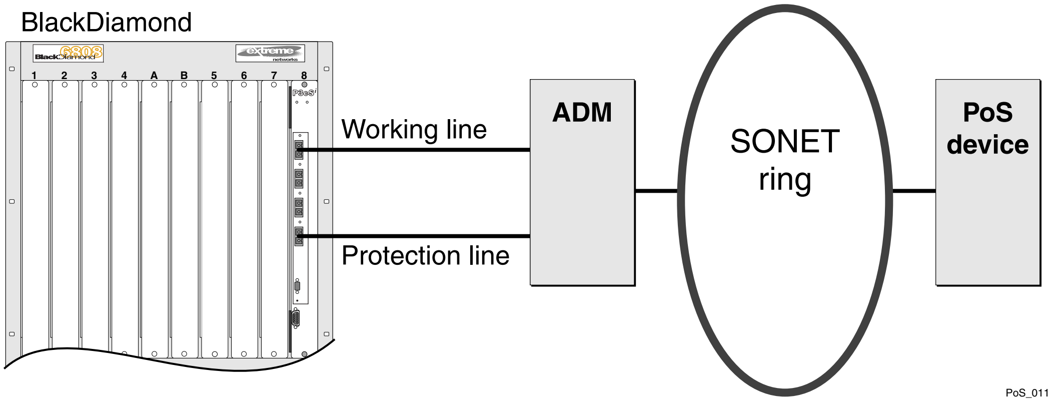
MIB Support for Flow Statistics

Because there are no standard MIBs defined for managing the NetFlow function, Extreme Networks has defined and implemented an enterprise MIB that provides read-only support (GET operations but not SET operations) for NetFlow configuration parameters and status information. Any of the parameters that can be set with the `configure flowstats` commands can be accessed using the MIB, and any of the status information displayed by the `show flowstats` command can also be read using the MIB. For more information on the MIB, see Appendix B, “Supported MIBs and Standards.”

Configuring and Monitoring APS Functions

Automatic Protection Switching, or APS, is a resiliency feature specified in the SONET standards. Of the different modes of operation defined in the APS specifications, the BlackDiamond 6800 series switch supports the Linear 1+1 APS architecture to protect tributary SONET lines connecting switches to Add-Drop Multiplexers (ADMs). Linear APS can be contrasted with the Ring APS architectures, which protect the lines between the equipment comprising a SONET ring. Figure 115 is an example of the Linear 1+1 architecture, where there is one protection line for each working line, and the ADM transmits the same data to both the working line and the protection line.

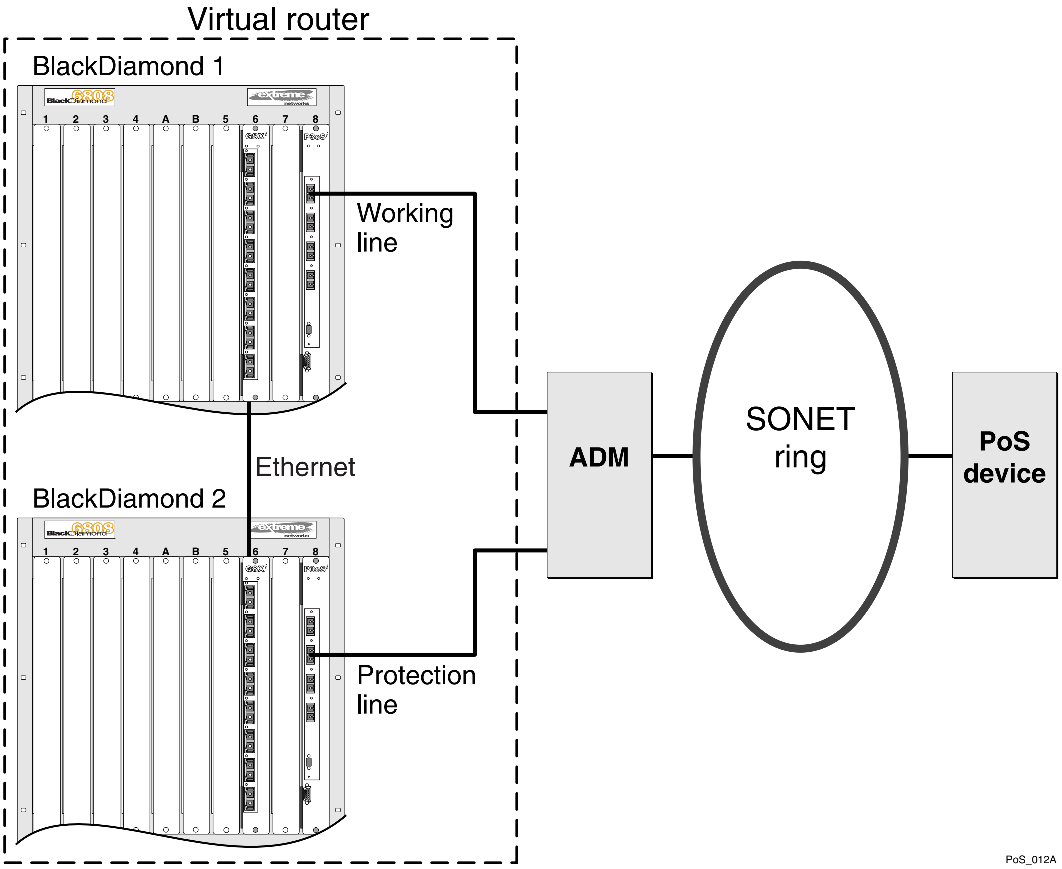
Figure 115: Linear 1+1 APS architecture



The APS standards specify both unidirectional and bidirectional-switching modes. In the bidirectional mode, both ends must select, or receive data from, the same line. Thus, switching from one line to another must be coordinated. This synchronization is achieved using APS protocols that are carried in the K1 and K2 bytes of the SONET line overhead. The K1 and K2 bytes must be transmitted on the protection line, and may also be transmitted on the working line; however, receivers cannot assume that the K1 and K2 bytes will be transmitted on the working line.

Bidirectional switching is advantageous for data communication applications where the working line and the protection line are terminated in different switches, as depicted in Figure 116. Because the working and protection lines form a single SONET interface with respect to the rest of the network, it is clearly more straightforward and efficient for one switch to handle all the payload transmission and reception responsibilities for the interface. Consequently, the BlackDiamond 6800 series switch supports bidirectional switching, but not unidirectional switching.

Figure 116: Linear 1+1 APS architecture with two switches



The 1+1 architecture can also operate in *revertive* or *nonrevertive* mode, which allows you to determine what action should be taken when traffic is active on the protection line and the working line becomes operational. The BlackDiamond 6800 series switch supports both revertive and non-revertive modes of operation.

In revertive mode, when traffic is active on the protection line and the working line becomes operational, traffic will be switched automatically from the protection line to the working line.

Conversely, in nonrevertive mode, when traffic is active on the protection line and the working line becomes operational, traffic will remain on the protection line (until either manual intervention or a failure on the protection line forces a switch back to the working line).

APS Network Configuration Options

Three basic APS configurations are supported:

- Two-switch configuration, where the working line is terminated in one BlackDiamond switch and the protection line is terminated in another.
- Two-module configuration, where the working line and the protection line are terminated in two different SONET modules that reside in the same BlackDiamond chassis.
- Single-module configuration, where the working line and the protection line are terminated in the same BlackDiamond SONET module.

Because the two-switch configuration is the most advanced, it is discussed first, followed by the two simpler configurations.

In the two-switch configuration (see Figure 117), the two BlackDiamond switches form a virtual APS switch. The PoS interface in BlackDiamond switch #1 is configured to be the working line, while the PoS interface in BlackDiamond switch #2 is configured to be the protection line. The same IP address is configured for both PoS interfaces. In this example, the common IP address is 192.168.10.1. The use of a common IP address enables the neighboring PPP router to view the virtual APS switch as a single router entity; the neighboring router is unaware that its partner is actually two cooperating switches. Figure 118 illustrates the logical PPP connectivity between the virtual APS router and the neighboring PPP router.

NOTE

Note: The two-switch configuration is supported only if PPP is configured on the PoS ports. The two-switch configuration is not supported if HDLC tunneling is configured on the PoS ports.

Figure 117: Virtual APS router configuration

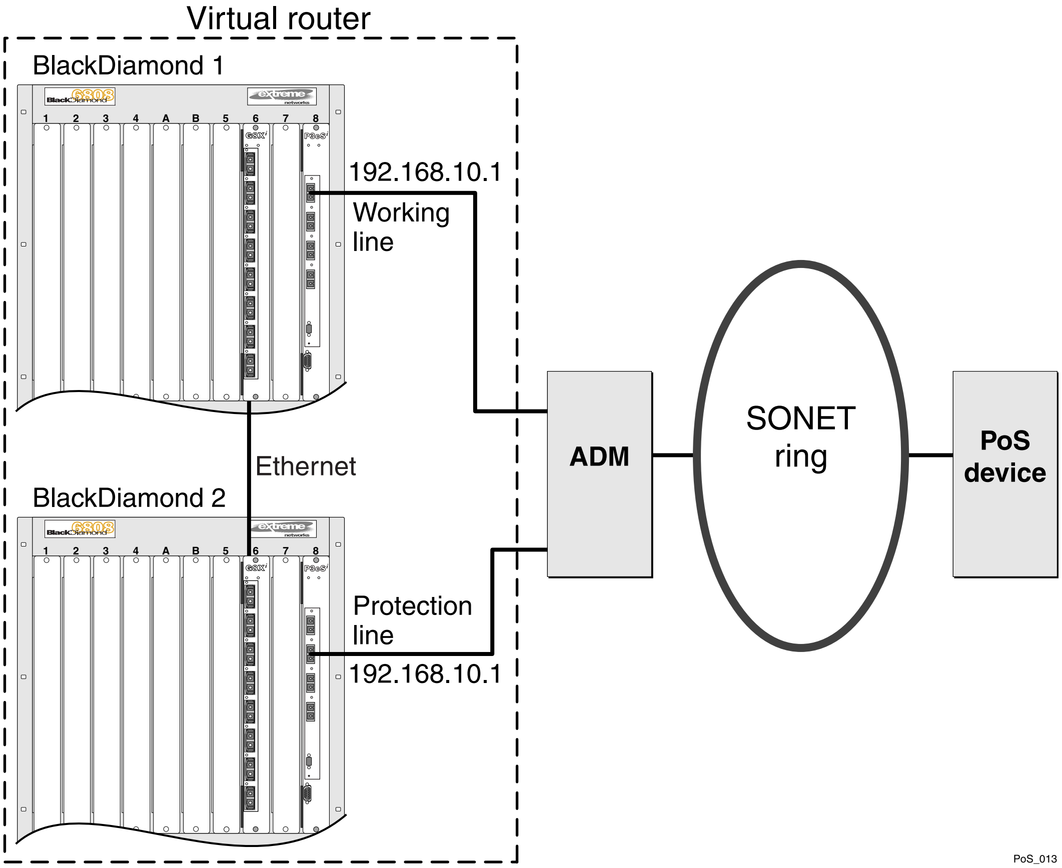
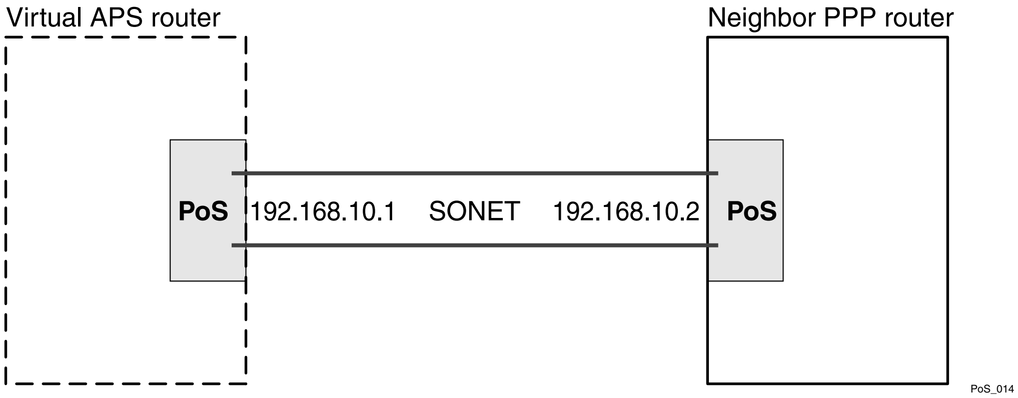


Figure 118: Logical PPP connectivity to virtual APS router



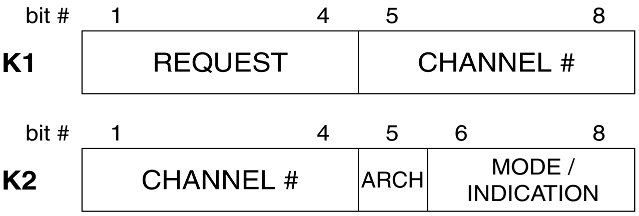
Another important characteristic of the virtual APS router configuration shown in Figure 117 is the Ethernet link between BlackDiamond #1 and BlackDiamond #2. This Ethernet link provides an out-of-band communications channel that provides a way for the two switches to synchronize their use of the SONET interfaces. For example, if BlackDiamond #1 detects poor signal quality on the working line, it sends a message over the Ethernet link to BlackDiamond #2, which initiates a switch to the protection line. The Ethernet link is also used to carry heartbeat messages that enable the protection switch to take over if the working switch fails.

The two-module and single-module configurations are similar to the two-switch configuration, except that there is no out-of-band Ethernet communications link. These configurations are simpler, because a single switch manages both the working line and the protection line. One advantage of the simpler single-switch configurations is faster network-recovery times following a line or module failure. The single-module configuration protects against line failures, while the two-module configuration protects against both line and module failures. The two-switch configuration further expands the protection scope to include line, module, and switch failures.

Sample Line-Switching Scenario

In the following sample line-switching scenario, the working router initiates the APS switch to the protection line. In this sample scenario, assume that the working line is active, and that the working router initiates a switch to the protection line upon detecting a signal fail or signal degrade condition on the working line. The working router initiates the line switch by sending a message to the protection router over the out-of-band Ethernet connection. All APS-related Ethernet communications between the working router and the protection router are via UDP. Upon receiving the message, the protection router invokes the APS protocol to request that the ADM switch to the protection line. The APS protocol is carried in the K1 and K2 bytes of the SONET overhead. The format of the K1 and K2 bytes is illustrated in Figure 119.

Figure 119: Format of SONET K1 and K2 Bytes



Legend

REQUEST

0000	No Request
0001	Do Not revert (nonrevertive only)
0010	Reverse Request (bidirectional only)
0100	Excercise
0110	Wait-To-Restore (revertive only)
1000	Manual Switch
1010	Signal Degrade
1100	Signal Fail
1110	Forced Switch
1111	Lockout of Protection

CHANNEL #

K1 - number of channel issuing request (1=>working, 0=>protection)
K2 - 0 if channel # in received K1=0, else channel # bridged to protection line

ARCHITECTURE

0 => provisioned for 1+1 architecture

MODE / INDICATION

100	Provisioned for Unidirectional Switching Mode
101	Provisioned for Bidirectional Switching Mode
110	Line Remote Defect Indication (RDI-L)
111	Line Alarm Indication Signal (AIS-L)

PoS_019

Based on the K1 and K2 definitions, Table 86 shows the detailed APS protocol exchanges for switching from the working line to the protection line. The example assumes the switch occurs because a Signal Degrade condition is detected on the working line. All APS protocol exchanges occur on the protection line, between the protection router and the ADM.

Table 86: APS Protocol for Switch from Working Line to Protection Line

Protect Router → ADM		ADM → Protect Router		Comments
K1 Byte	K2 Byte	K1 Byte	K2 Byte	
0000 0000	0000 0 101	0000 0000	0000 0 101	No failures; working line active. Example is provisioned for 1+1 architecture and bidirectional switching mode.
1010 0001	0000 0 101	0000 0000	0000 0 101	Protection router receives Signal Degrade message from working router over Ethernet link, and sends Signal Degrade request for channel 1 (the working line) to the ADM.

Table 86: APS Protocol for Switch from Working Line to Protection Line (Continued)

Protect Router → ADM		**ADM → Protect Router**		**Comments**
K1 Byte	**K2 Byte**	**K1 Byte**	**K2 Byte**	
1010 0001	0000 0 101	0010 0001	0001 0 101	ADM acknowledges the Signal Degrade request by sending Reverse Request for channel 1 in K1; K2 indicates that the ADM has bridged channel 1 to the protection line.
1010 0001	0001 0 101	0010 0001	0001 0 101	Protection router selects (receives) channel 1 data from the protection line based on received K2, and uses K2 to indicate that channel 1 is bridged to the protection line.
1010 0001	0001 0 101	0010 0001	0001 0 101	ADM selects (receives) channel 1 data from the protection line based on received K2.

After the APS line switch has completed, the protection router sends a message to the working router over the Ethernet link. The message indicates that the line switch has been performed. The working router responds by taking down the SONET interface and initiating a routing topology update. Similarly, the protection router brings the SONET interface up and advertises availability of routes accessible via the SONET interface. The neighboring PPP router will think that its partner (which is now the protection router) has renegotiated the link. On the LAN side, packets with destinations accessible via the SONET interface will be forwarded to the protection router. These packets may be forwarded to the protection router as a result of the routing topology updates or the Extreme Standby Router Protocol (ESRP).

APS Benefits

In this section, we examine the benefits provided by APS. A typical redundant switch configuration is illustrated in Figure 120. In this scheme, both BlackDiamond switches have two SONET interfaces that are connected to different ADMs. In this configuration, no switch, PoS interface, SONET line, or ADM represents a single point-of-failure. Compare this with the APS configuration depicted in Figure 121.

Figure 120: Typical redundant switch configuration without APS

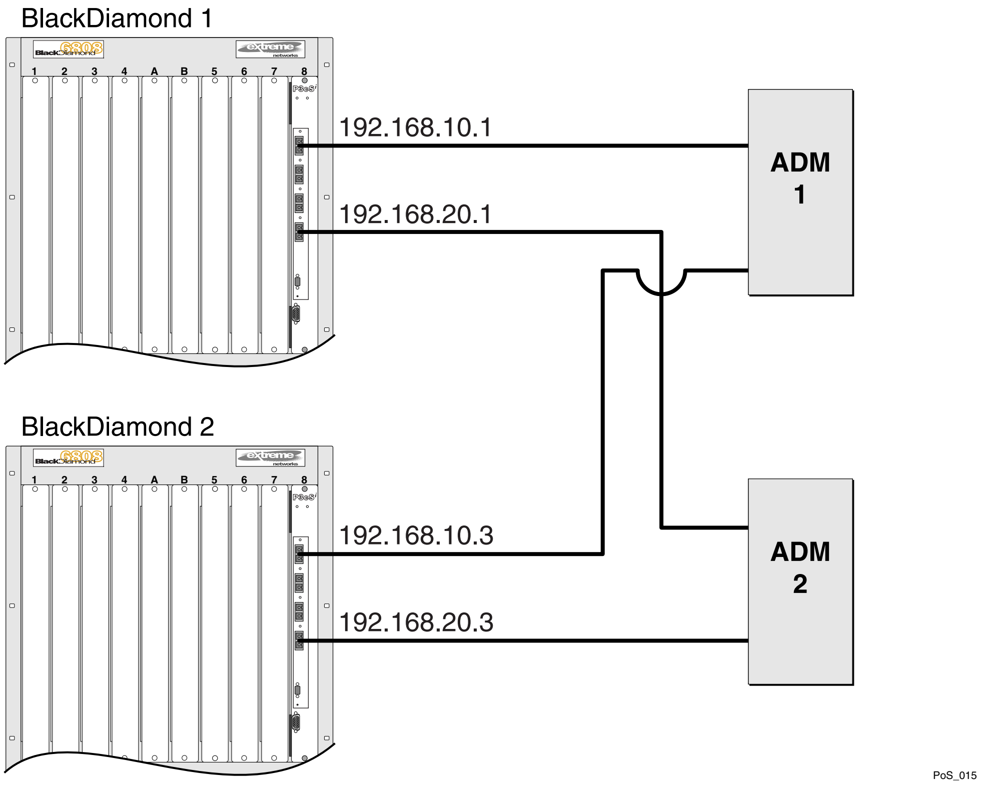
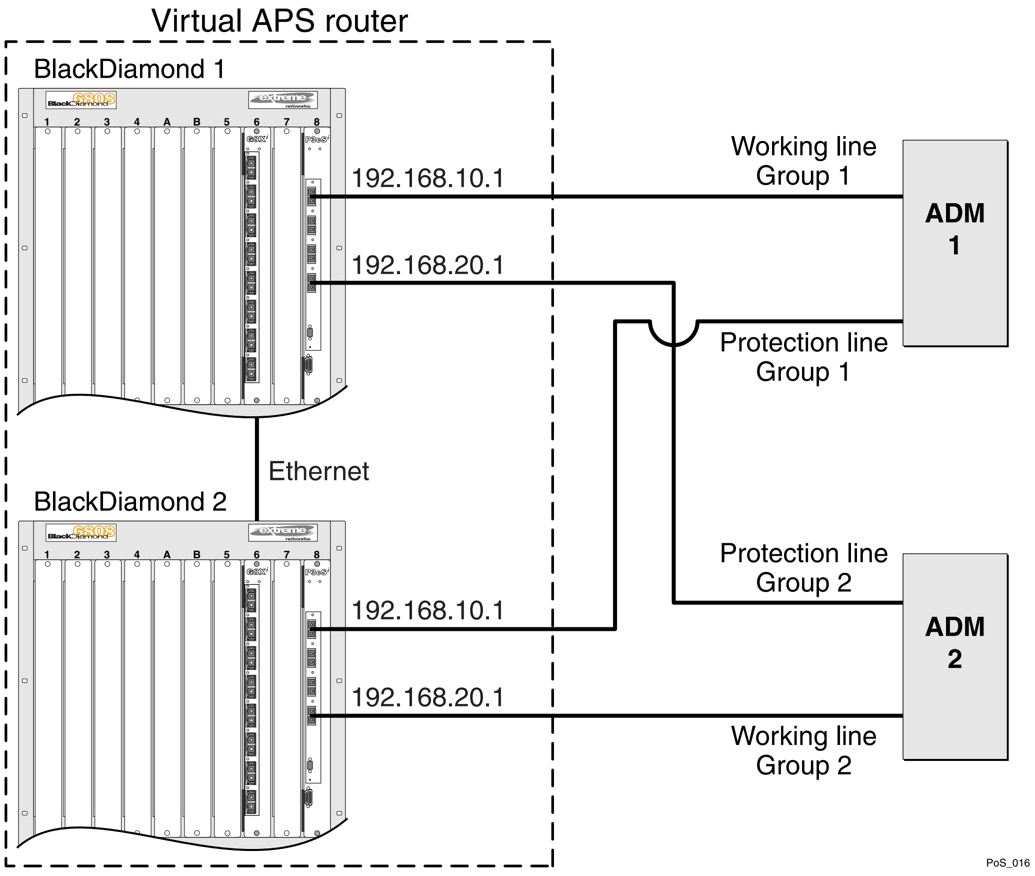


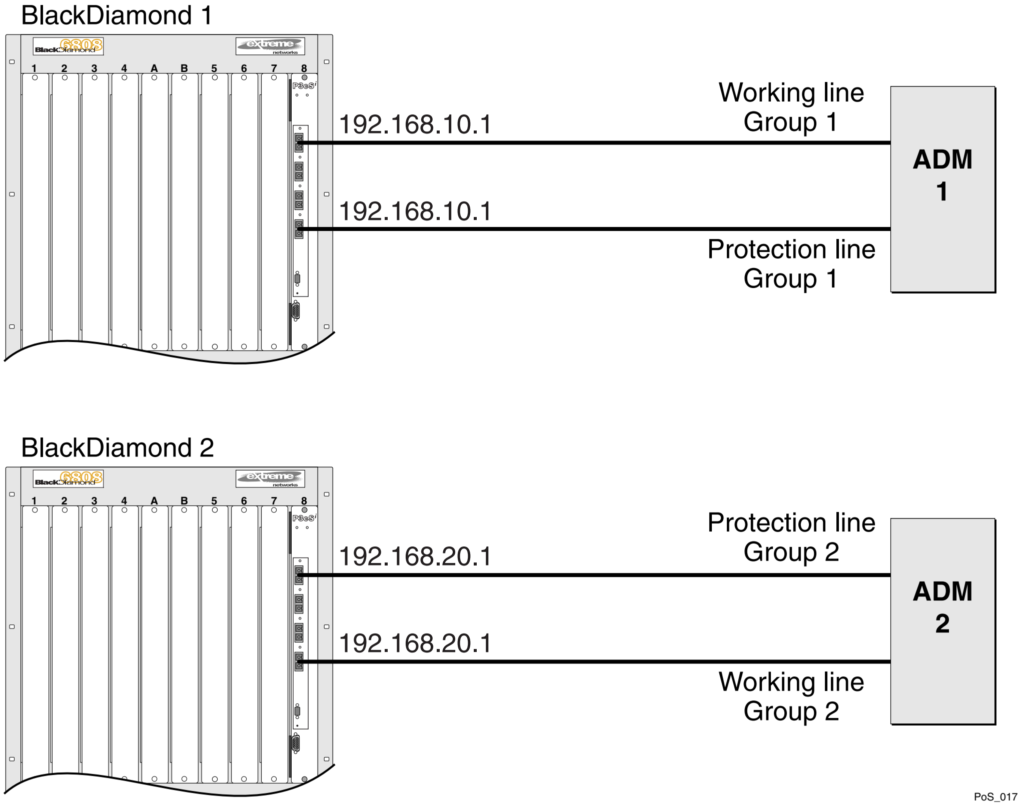
Figure 121: Redundant switch configuration with APS



While these two configurations appear similar, the significant difference between them is that the BlackDiamond switches in Figure 121 appear to the rest of the network as two PoS interfaces (IP addresses 192.168.10.1 and 192.168.20.1), as opposed to the four PoS interfaces shown in Figure 120 (IP addresses 192.168.10.1, 192.168.20.1, 192.168.10.3, and 192.168.20.3). The configuration in Figure 121 enables customers to purchase half the SONET bandwidth without sacrificing resiliency. In fact, the APS configuration offers increased resiliency by virtue of not reducing maximum throughput as a result of a single line or switch failure. Furthermore, if the extra bandwidth is needed, two larger bandwidth interfaces are more efficient than four smaller bandwidth interfaces, due to suboptimal load-balancing.

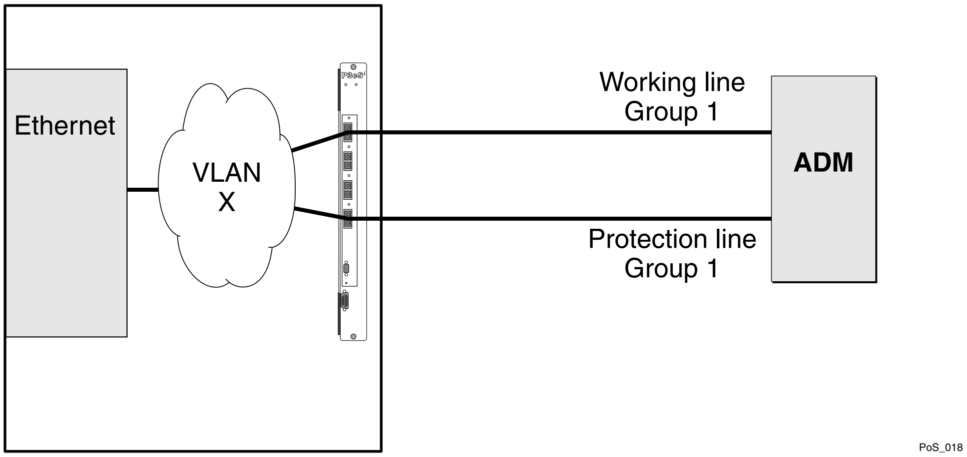
Figure 122 shows an APS configuration that provides faster network recovery from SONET line failures or degradations. Recovery is faster in this case because no routing topology updates are needed. Recovery is isolated to the switch and ADM pair connected to the failed line, and consists of performing an APS line switch operation. The downside of the configuration shown in Figure 122, relative to Figure 121, is that failure of a BlackDiamond switch will reduce the maximum SONET bandwidth by half. Note that failure of an ADM will also halve the maximum available bandwidth in either configuration.

Figure 122: APS configuration providing faster recovery from line failure



As mentioned earlier, APS can also be applied to the interconnection of bridges. Figure 123 illustrates a configuration where two PoS ports are members of the same VLAN. Assume that, in this example, both PoS ports are configured to run BCP on the common VLAN and bridge traffic for the VLAN across the SONET link. Assigning the two PoS ports to the same APS group improves the resiliency of the bridged network by enabling faster recovery from SONET line failures relative to that achieved by the Spanning Tree Protocol (STP). This recovery is accomplished by simply performing a local APS line switch. Because APS recovers at layer 1, the Spanning Tree Protocol does not need to be informed of the line failure, and therefore, no time-consuming STP reconvergence is necessary.

Figure 123: APS in bridging configuration



Enabling and Disabling APS

To enable the APS function for the entire switch, use the following command:

```
enable aps
```

To disable the APS function for the entire switch, use the following command:

```
disable aps
```

Creating and Deleting an APS Group

An APS group includes one working line and one protection line. The working line and protection line can reside on the same BlackDiamond switch or on two different BlackDiamond switches. The group is identified by a unique number.

To create an APS group, use the following command:

```
create aps <group#>
```

The `group#` parameter is an integer in the range from 1 through 65535 that identifies the APS group to be created. The APS group numbers must be unique across all BlackDiamond switches that are cooperating to provide the APS function. The group numbers must also be used in a consistent manner across BlackDiamond switches. For example, if the working line is assigned to group #1 on BlackDiamond #1, and the associated protection line resides on BlackDiamond #2, the protection line must also be assigned to group #1 on BlackDiamond #2. The `group#` is used to identify the partner line, which can be either the working line or the protection line, in Ethernet messages exchanged by BlackDiamond switches that are cooperating to provide the APS function.

The following command example creates APS group 1001 on the BlackDiamond switch:

```
create aps 1001
```

To delete an APS group, use the following command:

```
delete aps <group#>
```

The `group#` parameter is an integer in the range from 1 to 65535 that identifies the APS group to be deleted.

The following command example deletes APS group 1001:

```
delete aps 1001
```

Adding a Port to an APS Group

To add a SONET port to an APS group, use the following command:

```
configure aps <group#> add <port> [working | protection <ip address>]
```

The `group#` parameter is an integer in the range from 1 to 65535 that identifies the APS group to which the specified port is to be added.

The `port` parameter identifies the SONET port that is to be added to the APS group.

You must also specify whether the port is the APS working or protection line. You can add only one working line and one protection line to an APS group. If you designate the port the protection line, then you must also specify the IP address (`ipaddress` parameter) of the BlackDiamond switch where the working line resides. This IP address is used to send APS control messages to the BlackDiamond switch containing the working line.

NOTE

The configured IP address should be associated with an Ethernet VLAN that has loopback mode enabled to minimize the impact of network outages on APS functionality. Also, when using APS to protect links on different BlackDiamond 6800 series switches, the network connecting the working and protection switches must always have sufficient bandwidth to support APS control transfers.

In routing configurations, the working line and the protection line should represent the same IP address from the perspective of the neighboring PPP switch. When the working line and protection line reside in the same BlackDiamond switch, both ports should be members of the same VLAN. The case where both the working line and the protection line for an APS group reside in the same BlackDiamond switch is the only situation where IPCP can be enabled on multiple SONET ports that are members of the same VLAN. In general, if IPCP is enabled on a PoS module port, that port can be a member of only one VLAN and no other ports on that switch can be members of that VLAN.

The following command example adds port 1 of the module installed in slot 8 of the BlackDiamond switch to APS group 1001 as the working line.

```
configure aps 1001 add 8:1 working
```

Deleting a Port from an APS Group

To delete a SONET port from an APS group, use the following command:

```
configure aps <group#> delete <port>
```

The `group#` parameter is an integer in the range from 1 to 65535 that identifies the APS group from which the specified port is to be deleted.

The `port` parameter identifies the SONET port that is to be deleted from the APS group.

NOTE

Deleting the working line from an APS group initiates a switch to the protection line, but deleting the active protection line from an APS group does not initiate a switch to the working line.

The following command example deletes port 1 of the module installed in slot 8 of the BlackDiamond switch from APS group 1001.

```
configure aps 1001 delete 8:1
```

Configuring APS Authentication

The authentication string is used to validate APS control frames received over an Ethernet link. If authentication fails, the associated APS control frame is discarded.

To configure authentication of APS control messages, use the following command:

```
configure aps <group#> authenticate [off | on <string>]
```

The group# parameter is an integer in the range from 1 to 65535 that identifies the APS group to which the authentication command applies.

You must also specify whether authentication is to be turned off or turned on. The default setting is off.

If you are enabling authentication, you must also specify a text authentication string of no more than eight alphanumeric characters as part of the command. If the working line and the protection line for an APS group reside in different BlackDiamond switches, the same authentication string must be configured at both BlackDiamond switches; otherwise, authentication will not work.

The following command example enables APS authentication for group 1001, with "seer5dog" as the authentication string.

```
configure aps 1001 authenticate on seer5dog
```

Configuring Nonrevertive or Revertive Mode

You can configure the APS action that should be taken when traffic is active on the protection line and the working line becomes operational.

The default switching mode is nonrevertive switching, which means traffic remains on the protection line until either manual intervention or a failure on the protection line forces a switch back to the working line.

If you configure revertive switching mode on an APS group, traffic is switched automatically from the protection line to the working line after the user-defined Wait-To-Restore (WTR) period. The WTR period minimizes frequent switching due to intermittent errors on the working line by restoring service only when no errors are detected on the working line during the WTR period.

NOTE

A longer WTR period provides more protection against frequent switching by waiting to assure that the working line is fully operational, but prolongs the time it takes to restore traffic to the working line after it is fully operational.

To configure APS operation in either nonrevertive or revertive switching mode, use the following command:

```
configure aps <group#> [nonrevert | revert <minutes>]
```

The group# parameter is an integer in the range from 1 to 65535 that identifies the APS group to which the configuration command applies.

The minutes parameter is an integer in the range from 0 to 12. If you select revertive switching mode, you must enter a value for minutes.

NOTE

This command applies only to SONET ports performing the protection line function.

The following command example configures APS group 1001 to operate in revertive switching mode, with a WTR of 5 minutes.

```
configure aps 1001 revert 5
```

Configuring APS Timers

To set the values of the timers used in the APS hello protocol that is exchanged between the working and protection switches for an APS group, use the following command:

```
configure aps <group#> timers <seconds> <consecutive_misses>
```

The `group#` parameter is an integer in the range from 1 to 65535 that identifies the APS group to which this configuration command applies.

The `seconds` parameter is an integer in the range from 1 to 300 that specifies the amount of time the protection switch waits between transmissions of hello packets to the working switch. The default value is 1.

The `consecutive_misses` parameter is an integer in the range from 1 to 100 that controls the time interval the protection switch waits before assuming that the working switch has failed. If the working switch does not respond within `consecutive_misses` hello intervals, or (`consecutive_misses` * `seconds`) seconds, the protection switch assumes that the working switch has failed and initiates a line switch. The default value is 5.

NOTE

In some cases, even if the working switch and working line are both operational, congestion might temporarily slow the response time of the working switch to the point that the protection switch assumes the working switch has failed, causing premature or unnecessary line switches. While setting larger values for `seconds` *and* `consecutive_misses` *will protect against premature or unnecessary line switches, they can also delay a line switch when an actual switch failure occurs.*

NOTE

This command applies only to SONET ports performing the protection line function.

The following command example configures the timers for APS group 1001 to 1 second and 3 consecutive misses.

```
configure aps 1001 timers 1 3
```

Configuring APS Lockout

You can specify that an APS group operates in lockout mode, which means switches from the working line to the protection line are prohibited until you turn off lockout mode for that APS group. You should use this command when you want to prevent a switchover to the protection line, such as when the protection line is being reprovisioned, repaired, or debugged.

To control whether a switch to the protection line is locked out, use the following command:

```
configure aps <group#> lockout [off | on]
```

The group# parameter is an integer in the range from 1 to 65535 that identifies the APS group to which the lockout command applies.

By default, lockout mode is off.

NOTE

This command applies only to SONET ports performing the protection line function. Also, the settings from this command are not preserved when the switch reboots.

The following command example turns on lockout mode for APS group 1001.

```
configure aps 1001 lockout on
```

Configuring Forced Switch Mode

You can request that an APS group be forced to use the working line as the active line, or be forced to use the protection line as the active line. Use this command when you plan to perform service on the other link and don't want a switchover to occur.

To request that an APS group be forced to use a specified line as the active line, use the following command:

```
configure aps <group#> force [off | working | protection]
```

The group# parameter is an integer in the range from 1 to 65535 that identifies the APS group to which the force command applies.

The off keyword turns off forced switch mode. By default, force switch mode is off.

The working keyword forces the specified APS group to use the working line as the active line. The protection keyword forces the specified APS group to use the protection line as the active line.

A forced switch is a high priority request. Only three events can override a forced switch request:

- A configure aps force off command
- A configure aps lockout on command (that was either in effect before the force command or issued after the force command)
- A Signal Fail condition detected on the protection line

NOTE

This command applies only to SONET ports performing the protection line function. Also, the settings from this command are not preserved when the switch reboots.

The following command example forces APS group 1001 to use the protection line as the active line:

```
configure aps 1001 force protection
```

Configuring Manual Switch Mode

You can manually determine whether an APS group uses its working line as the active line, or uses its protection line as the active line. One potential use of this capability is to perform a manual switch back to the working line after an error condition has cleared without waiting for the full Wait-To-Restore period to elapse.

To manually determine whether an APS group uses its working line or its protection line as the active line, use the following command:

```
configure aps <group#> manual [off | working | protection]
```

The `group#` parameter is an integer in the range from 1 to 65535 that identifies the APS group to which the command applies.

The `off` keyword turns off manual switch mode. By default, manual switch mode is off.

The `working` keyword causes the specified APS group to use the working line as the active line. The `protection` keyword causes the specified APS group to use the protection line as the active line.

A manual switch is a lower priority request than a forced switch. The following events can override a manual switch:

- A `configure aps manual off` command
- A `configure aps force working` or a `configure aps force protection` command
- A `configure aps lockout on` command
- A detected Signal Fail or Signal Degrade line condition

NOTE

This command applies only to SONET ports performing the protection line function. Also, the settings from this command are not preserved when the switch reboots.

The following command example configures APS group 1001 to use its working line as the active line:

```
configure aps 1001 manual working
```

Resetting APS Group Configuration Parameters

To reset the APS group configuration parameters to their default values, use the following command:

```
unconfigure aps <group#>
```

The `group#` parameter is an integer in the range from 1 to 65535 that identifies a particular APS group.

NOTE

This command does not affect the ports that have been added to the APS group, but does cancel any outstanding `lockout`, `force`, *or* `switch` *requests.*

The following command example resets the configuration parameters of APS group 1001 to their default values:

```
unconfigure aps 1001
```

Displaying APS Group Status Information

To display APS group status information, use the following command:

```
show aps {<group#>} {detail}
```

The optional `group#` parameter is an integer in the range from 1 to 65535 that identifies a particular APS group for which status is to be shown.

If you enter the `show aps` command without an argument or keyword, the command displays a summary of status information for all configured APS groups. You can use the `detail` keyword to display more detailed status information.

Summary status includes the following information for each APS group:

- Provisioned values of all APS configuration parameters, including SONET port numbers and whether the ports are performing the working or protection line function.
- An indication of whether the line associated with each configured port is active or inactive from an APS perspective, along with a timestamp indicating when the last APS state change occurred.
- An indication of whether an error condition currently exists on the line associated with each configured port, along with a timestamp indicating when the last error occurred (errors include Signal Fail and Signal Degrade Events).
- An indication of whether a Signal Fail (SF) or Signal Degrade (SD) Event due to an excessive Bit Error Rate (BER) currently exists on the line associated with each configured port. The BER thresholds that cause SF and SD Events can be specified as part of configuring a SONET port.
- Counts of the number of SF and SD Events initiated by each configured port due to an excessive BER.
- A count of the number of APS Authentication Failures, which is a count of the number of received APS control packets that have been discarded due to authentication failures.

Detailed status includes the information reported in the summary status along with additional status and management counters. Detailed status only applies to ports performing the protection line function.

Detailed management counters reported for each protection-line port include:

- Automatic line switches initiated by the working-line switch, by the protection-line switch, and by the ADM
- Line switches initiated due to external commands, such as through either the `configure aps <group#> force` command or the `configure aps <group#> manual` command)
- Line switches completed successfully
- Hello Protocol failures (this count is included as a component of the counter for automatic line switches initiated by the protection-line switch)
- APS mode mismatch failures, which occur when the ADM indicates that it is provisioned for the 1:n APS architecture, or when the ADM indicates that it is provisioned for unidirectional-switching mode
- Protection switching byte failures, which occur when the received K1 byte is either inconsistent or contains an invalid request code

- Channel mismatch failures, which occur when the channel number in the transmitted K1 byte does not match the channel number in the received K2 byte
- Far-end protection line failures, which occur when a Signal Fail request code is received on the protection line

Additional detailed status information reported for each protection-line port includes:

- Current contents of received K1 and K2 bytes
- Contents of K1 and K2 bytes that are currently being transmitted
- Indication of whether an APS Mode Mismatch Failure is currently active
- Indication of whether a Protection Switching Byte Failure is currently active
- Indication of whether a Channel Mismatch Failure is currently active
- Indication of whether a Far-End Protection Line Failure is currently active

MIB Support for APS

Because no standard MIBs are defined for managing the APS function, Extreme Networks has defined and implemented an enterprise MIB that provides read-only support (GET operations but not SET operations) for APS configuration parameters and status information. Any of the parameters that can be set with the `configure aps` commands can be accessed using the MIB, and any of the status information displayed by the `show aps` command can also be read using the MIB. For more information on the MIB, see Appendix B.

Configuring Port Tunneling

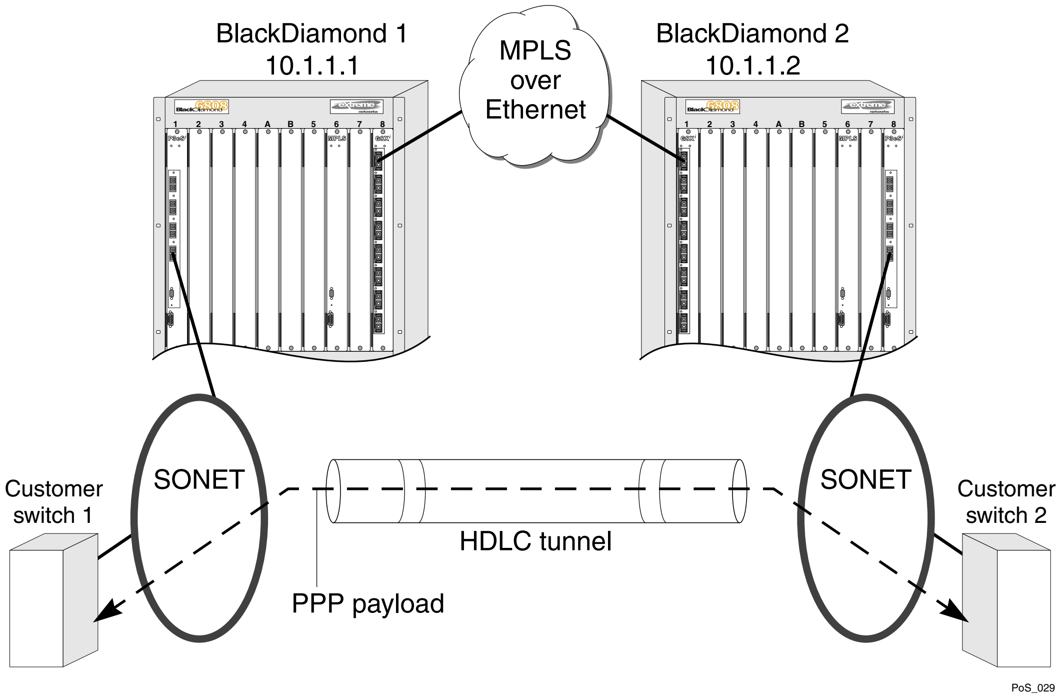
Port tunneling can be used to encapsulate and transport the raw High-Level Data Link Control (HDLC) encapsulated byte stream from one PoS port to another PoS port across an MPLS network. This allows service providers to tunnel different types of SONET HDLC streams across a non-SONET backbone like Ethernet. The initial implementation of port tunneling requires an MPLS backbone network.

The following ExtremeWare port command has been added to support HDLC tunneling on a PoS module:

```
configure ports <portlist> tunnel hdlc [off | mpls]
```

After you configure the PoS port, you can tunnel HDLC encapsulated frames from a PoS port across a SONET or Ethernet based MPLS network. The ingress PoS port encapsulates the entire HDLC frame, including the HDLC header and FCS, inside an Ethernet/MPLS header. HDLC control bytes are de-stuffed on the ingress PoS port. The egress PoS port strips the Ethernet/MPLS header and forwards the HDLC frame. HDLC control bytes are stuffed on the egress PoS ports. HDLC idle bytes, x7E, are not tunneled, but runts and aborted frames are tunneled. Figure 124 displays port tunneling between PoS port 1:4 on BlackDiamond switch 1 and PoS port 8:4 on BlackDiamond switch 2 with a PPP link between Customer switch 1 and Customer switch 2. PPP is not terminated on either BlackDiamond switch 1 or BlackDiamond switch 2.

Figure 124: Port tunneling via a PPP link



When you configure a PoS port for HDLC tunneling, make sure PPP is not configured and BCP and IPCP are off. Furthermore, the PoS port should be the only port in the VLAN, and an MPLS tls-tunnel should be configured for this VLAN. For more information about MPLS and MPLS commands, see Chapter 26. The payload inside the HDLC can be PPP or another HDLC encapsulated protocol. SONET Automatic Protection Switching (APS) is supported between tunneled PoS ports on the same module or different modules in the same switch. APS is not supported for tunneled PoS ports on different switches. By default, HDLC tunneling is turned off on PoS ports.

The following sections describe how to configure a port tunnel.

Configuring the PoS Port Tunnel

The following configuration commands apply to the PoS module installed in slot 1 of BlackDiamond switch 1, as shown in Figure 124.

```
configure ppp ipcp off port 1:4
configure ppp bcp off port 1:4
create vlan customerx
configure vlan customerx add port 1:4
configure ports 1:4 tunnel hdlc mpls
```

The following configuration commands apply to the PoS module installed in slot 8 of BlackDiamond switch 2, as shown in Figure 124.

```
configure ppp ipcp off port 8:4
configure ppp bcp off port 8:4
create vlan customerx
configure vlan customerx add port 8:4
configure ports 8:4 tunnel hdlc mpls
```

NOTE

The PoS port should be the only port in the VLAN.

Configuring the Ethernet Module

The following configuration commands apply to the Ethernet module installed in slot 8 of BlackDiamond switch 1, as shown in Figure 124.

```
create vlan mplsCloud
configure vlan mplsCloud add port 8:1
configure vlan mplsCloud ipaddress 10.1.1.1/24
enable ipforwarding mplsCloud
configure ospf routerid automatic
configure ospf add vlan mplsCloud area 0.0.0.0
enable ospf
```

The following configuration commands apply to the Ethernet/MPLS module installed in slot 1 of BlackDiamond switch 2, as shown in Figure 124.

```
create vlan mplsCloud
configure vlan mplsCloud add port 1:1
configure vlan mplsCloud ipaddress 10.1.1.2/24
enable ipforwarding mplsCloud
configure ospf routerid automatic
configure ospf add vlan mplsCloud area 0.0.0.0
enable ospf
```

Configuring the MPLS tls-Tunnel

The following configuration commands create an MPLS tls-tunnel between BlackDiamond switch 1 and BlackDiamond switch 2, as shown in Figure 124.

```
configure mpls add vlan mplsCloud
configure mpls add tls-tunnel BD2 10.1.1.2 customerX tls-labels 8F100 8F200
enable mpls
```

The following configuration commands create an MPLS tls-tunnel between BlackDiamond switch 2 and BlackDiamond switch 1, as shown in Figure 124.

```
configure mpls add vlan mplsCloud
configure mpls add tls-tunnel BD1 10.1.1.1 customerX tls-labels 8F200 8F100
enable mpls
```

Limitations and Unsupported Commands

This section describes additional command and configuration information related to the use of the PoS modules. This section includes information on the following topics:

- Configuring General Switch Attributes on page 659
- PoS Module Limitations on page 659
- Configuring Port Attributes on page 659

- Configuring Access List Attributes on page 661
- Configuring Access List Attributes on page 661
- Configuring Access List Attributes on page 661
- Changing Image and Configuration Attributes on page 661

Configuring General Switch Attributes

The PoS module supports all of the general ExtremeWare switch commands.

PoS Module Limitations

The following limitations apply to PoS modules:

- EAPS, ESRP, VRRP, and GVRP are not supported on SONET interfaces
- Protocol and MAC-based VLANs are not supported on SONET interfaces
- EMISTP and PVSTP are not supported over SONET interfaces
- No ISIS support over ATM IP PVCs

Configuring Port Attributes

The following ExtremeWare port commands are not supported for the PoS module:

- `show ports {mgmt | <portlist>} collisions`
- `configure ports [<portlist> | all | mgmt] auto off {speed [10 | 100 | 1000]} duplex [half | full]`
- `configure ports [<portlist> | mgmt | all] auto on`
- `enable smartredundancy <portlist>`
- `enable sharing <port> grouping <portlist> {dynamic | algorithm {port-based | address-based | round-robin}}`
- `enable mirroring to port [<port>] [tagged | untagged]`
- `disable learning ports <portlist>`
- `configure mirroring add [<mac_address> | vlan <vlan name> {ports <port number>} | ports <portnumber> {vlan <vlan name>}]`

Jumbo Frame Support

The Extreme Networks implementation of PPP supports the Link Control Protocol (LCP) maximum receive unit (MRU) option, which specifies the maximum number of octets that a PPP information field can contain and still be received successfully. In the Extreme Networks implementation, the advertised MRU size depends mainly on two factors:

- Whether IPCP or BCP is enabled on the PoS port
- Whether jumbo frame support is enabled on the PoS port

If IPCP is configured on the port and jumbo frame support is not enabled, the Extreme Networks implementation of PPP advertises an MRU of 1500 octets and requires that the peer have an MRU of at least 1500 octets.

If BCP is configured on the port and jumbo frame support is not enabled, the advertised MRU is 24 octets larger than in the corresponding IPCP case. The additional octets are needed to accommodate the larger frame size associated with the bridged format, which includes the MAC header. If VLAN tags are to be transmitted, the peer's MRU must be at least 1520 octets; otherwise, the peer's MRU must be a minimum of 1516 octets.

If IPCP is configured on the port and jumbo frame support is enabled on the port, the advertised MRU size in octets is calculated using the following formula:

(configured jumbo frame MTU – 22)

and the peer is also required to have an MRU at least this large.

If BCP is configured on the port and jumbo frame support is enabled on the port, the peer's MRU must be (configured jumbo frame MTU – 6) octets at a minimum, and at least (configured jumbo frame MTU – 2) octets if VLAN tags are to be transmitted.

Consider these factors when configuring jumbo frame support on a PoS port:

- Because the jumbo frame MTU setting affects the PPP MRU setting of the PoS port and the peer, changing the jumbo frame MTU setting can have the following results:
  - Temporary disruption of the logical connection because the Link Control Protocol might need to terminate the logical connection and then re-establish it with larger MRU sizes.
  - Longer term disruption of the logical connection because of the requirement that the logical connection can only be established when (a) jumbo frame support is enabled on the peer PoS port, and (b) the same jumbo frame MTU size must be configured on both ends of the logical connection when the peer is also a BlackDiamond switch.
- When the jumbo frame size is changed from a value of 8191 or less to a value greater than 8192, any PoS modules that have ports with jumbo frame support enabled must be rebooted for the change to take effect.
- The peer MRU is always allowed to be greater than or equal to the MRU size of the local port.
- Fragmentation and path MTU discovery is performed, but is based on checking the peer's MRU in conjunction with the IP MTU configured for the egress VLAN (which can be set using the `configure ip-mtu <number> vlan <vlan name>` command), rather than the jumbo frame MTU setting.

For more information on the ExtremeWare jumbo frame commands, see Chapter 4.

Configuring Access List Attributes

For more information on the ExtremeWare access list commands, see Chapter 12.

NOTE

On the OC-3 PoS module, the access list functions apply to port pairs, where ports 1 and 2 are a pair, and ports 3 and 4 are a pair. This pairing scheme means that the ports in a given pair share the same access lists: ports 1 and 2 share the same lists, while ports 3 and 4 share their access lists. For example, if an access list is configured for port 1, that access list also applies to port 2, and vice versa. This restriction does not apply to the OC-12 PoS module.

Changing Image and Configuration Attributes

The PoS module supports all of the ExtremeWare commands associated with managing image and configuration attributes. For more information about these commands and operations, see Appendix A.

25 T1, E1, and T3 WAN Modules

This chapter describes the T1, E1, and T3 features that can be configured in the ExtremeWare. It covers the following topics:

- Overview on page 663
- Configuring WAN Physical Links on page 664
- Monitoring WAN Physical Links on page 668
- Configuring PPP and MLPPP on page 671
- WAN Multilink Configuration Examples on page 675
- VLAN Tunneling (VMANs) on page 676

Overview

In this document, WAN refers to either T1, E1, or T3 technologies. T1 is a mature technology originally developed for voice telephone transmission. It was used to aggregate a number of voice lines into a single connection to the telephone network. Today, T1 is also used to transmit digital data using widely available equipment and established wiring commonly available in diverse locations.

A similar technology standard is in use in Europe, namely E1. T1 and E1 are similar, but not identical.

Higher bandwidth characterizes T3 connections. Essentially, a T3 connection is equivalent to a bundle of 28 T1 connections. Extreme Networks support unchannelized T3 only.

The T1 and E1 modules maintain a subset of the switch's FDB entries. The SMMi and WAN module FDBs are synchronized via occasional SMMi flooding of dynamic entries. Static entries are synchronized as you enter them. This allows you to configure multiple T1 and E1 ports on the same module in the same VLAN when using BCP.

Layer 2 multicast traffic is treated as broadcast traffic by the T1 and E1 modules.

The following features are not supported on T1 or E1 modules:

- T1 port mirroring
- Static Load sharing
- Software-Controlled Redundant Ports
- ACLs on a per port basis

- Per port egress QoS
- Traffic Grouping for source ports
- BiDirectional Rate Shaping
- DLCS
- MAC address and protocol-based VLANs that include T1 ports
- VLAN aggregation

Red, Blue, and Yellow Alarms

WAN links have error detection built into the link hardware. The hardware can detect different types of errors, labeled red, blue and yellow alarms.

A red alarm occurs when the signal is lost or an out of frame error occurs. An out of frame error can be caused when the framing type configured for the local interface does not match the framing type of the incoming signal or when the incoming signal does not contain a framing pattern.

A yellow alarm is also called a Remote Alarm Indication (RAI). When the remote end of a link does not receive a signal, it will transmit a yellow alarm signal back to the local end.

A blue alarm is also called an Alarm Indication Signal (AIS). A blue alarm indicates that a device somewhere upstream has experienced a loss of signal.

Alarms affecting a link can be viewed by using one of the show commands, for example, `show ports t1 alarms`.

Configuring WAN Physical Links

There are a number of parameters that can be configured for a WAN link. If you have control of both sides of the link, then the default configuration is probably the best choice. If you must connect to a line controlled by another organization, you will need to configure the line to correspond with the settings at the other end. Some parameters are only configurable, or only apply to some of the WAN link types. The following list of parameters also displays which types of WAN links allow you to configure that parameter:

- Cable Length (T1, T3)
- Clock Source (T1, E1, T3)
- Facility Data Link (T1)
- Framing (T1, E1, T3)
- Inband Loopback Detection (T1)
- Linecoding (T1)
- Receiver Gain (E1)
- SNMP Alerts (T1, E1, T3)
- Timeslots (E1)
- Yellow Alarms (T1)

Cable Length

Longer cable lengths cause greater losses for signals, so transmitter hardware must transmit at a higher level to transmit data successfully. However, too high a signal level can cause crosstalk from one cable to another. The cablelength parameter allows you to control the transmitter signal level for your conditions. Typically, your service provider will suggest the correct level.

The parameter values available differ for T1 and T3 links. For E1, the parameter value is not changeable, but is always set to 120 Ohms. However, for E1 links you can configure the receiver gain to meet your conditions. See "Receiver Gain" on page 667.

For short haul connections (less than 1000 feet) the typical equipment uses less sensitive receivers. The transmitter level for T1 is set by selecting a cable length in feet, from the following values: 133, 266, 399, 533 or 655. For T3, select from the following values: 249 or 900. Choose the next higher value if the cable length provided by your service provider does not match one of these values. For example, choose 133 for a 50 foot cable and 533 for a 450 foot cable. The default value is 133, which corresponds to cables in the range of 0-133 feet.

For longer distances (up to 6000 feet) T1 equipment uses more sensitive receivers, and crosstalk is more likely to occur. Under these conditions, the transmitter level is set by selecting a transmitter attenuation level in dB from the following values: -22.5, -15, -7.5, or 0.

From lowest to highest transmitter level, use the following values for the `configure ports t1 cablelength` command: -22.5 db, -15 db, -7.5 db, 0 db, 133 feet, 266 feet, 399 feet, 533 feet, and 655 feet.

To configure the cable length, use one of the following commands:

```
configure ports <portlist> t1 cablelength [[0 | -7.5 | -15 | -22.5] db | [133 | 266 |
399 | 533 | 655] feet]
configure ports <portlist> t3 cablelength [349 | 900] feet
```

Clock Source

A clock is used to synchronize data transmission on the line. Generally, one end of the link provides the master clock, and the other end of the link recovers the clock from the signal on the line. By default the clock source is derived from the line. If needed, an internal clock is available. To configure the clock source, use the following command:

```
configure ports <portlist> [t1 | e1 | t3] clock source [internal | line]
```

NOTE

If the clock source is configured as "line", but the clock cannot be recovered from the signal on the line, the hardware will use the internal clock instead.

Facility Data Link

Facility data link (FDL) for T1 links uses twelve bits in the ESF frame to signal information about line and connection status. Since FDL is only meaningful for ESF framing, FDL settings are ignored when a port is configured for SF framing. See "Inband Loopback Detection" for information on configuring framing.

The two T1 standards supported for FDL are ATT, described by the ATT 54016 specification, and ANSI, described by the T1.403 standard. The default value is off. To configure FDL, use the following command:

```
configure ports <portlist> t1 fdl [off | att | ansi]
```

Framing

Framing is used to synchronize data transmission on the line. Framing allows the hardware to determine when each packet starts and ends. The two choices for T1 framing are Super Frame (SF), also known as D4, and Extended Super Frame (ESF). The ESF scheme is a newer standard and is enabled by default. To choose the T1 framing scheme, use the following command:

```
configure ports <portlist> t1 framing [esf | sf]
```

If you choose to use SF framing, you should disable yellow alarm detection for the T1 line. SF framing may generate false yellow alarms. See “Yellow Alarms” on page 667 for more details.

The framing choices for E1 are CRC4 or no-CRC4. To choose the E1 framing scheme, use the following command:

```
configure ports <portlist> e1 framing [crc4 | no-crc4]
```

The framing choices for T3 are C-bit and M13. To choose the T3 framing scheme, use the following command:

```
configure ports <portlist> t3 framing [c-bit | m13]
```

Inband Loopback Detection

When inband loopback detection is enabled, a specific sequence of data in the signal payload from the remote end of the T1 link will cause the local end to enter network line loopback mode and send any received signal back to the remote end. Inband loopback detection is only possible if the FDL standard is configured as ATT. See “Facility Data Link” on page 665 for more details. By default, inband loopback detection is off. See “Loopback” on page 668 for more information about loopback modes. To configure inband loopback detection, use the following command:

```
configure ports <portlist> t1 lbdetect [off | inband]
```

Linecoding

Linecoding is the convention used to encode signals for transmission over the line.

For T1 connections you can choose from two linecoding standards, bipolar eight zero suppression (B8ZS) or alternate mark inversion (AMI). The default value is B8ZS. To configure linecoding, use the following command:

```
configure ports <portlist> t1 linecoding [b8zs | ami]
```

Receiver Gain

The receiver gain for E1 links can be configured to improve performance of the link. Changing the receiver gain can help to receive the E1 signal or to reduce crosstalk. Receiver gain is only configurable for E1 links. To configure receiver gain, use the following command:

```
configure ports <portlist> e1 receivergain [-12 | -43] db
```

SNMP Alerts

If the WAN module hardware detects a red, yellow, or blue alarm, the alarms are displayed by using a show command. Additionally, the module can be configured to send an SNMP alert to the SMMi in the switch when red, yellow, or blue alarms are detected. If the module is configured to send SNMP alerts, and the switch is configured to send SNMP trap messages, then the switch will send a message to any SNMP trap receivers that have been configured. To configure SNMP trap receivers, and for more information about configuring SNMP in ExtremeWare, see Chapter 3.

The module can also be configured not to send an SNMP alert to the SMMi. Any red, yellow, or blue alarms will not be reported to the SNMP trap receivers. The default value for SNMP alerts is enabled. To configure whether SNMP alerts are generated from WAN alarms, use the following command:

```
configure ports <portlist> [t1 | e1 | t3] snmp alert [enable | disable]
```

Timeslots

The E1 signal is divided into thirty-two timeslots, numbered 0 through 31. The first timeslot (0) is reserved and cannot be used to transmit data. The timeslot numbered 16 is often used for voice phone calls in installations that combine voice and data. For installations that use the full E1 bandwith for data communications, you will not need to configure which timeslots are used. For installations that do not use the total E1 bandwith, your E1 provider will tell you which timeslots to use.

To configure which timeslots to use for your E1 link, use the following command:

```
configure ports <portlist> e1 timeslots <timeslots>
```

A timeslot list uses a dash to represent a range of numbers and a comma to separate single numbers or ranges. Valid timeslots range from 1 to 31. For example, to specify timeslots 1 through 15 and 17 through 31 for the E1 port 1 on slot 4, use the following command:

```
configure ports 4:1 e1 timeslots 1-15,17-31
```

Yellow Alarms

A yellow alarm occurs on a device when its signal is not received at the remote end. It is also called a Remote Alarm Indication (RAI). You can disable detection and generation of yellow alarms for a T1 port. When SF framing is used, yellow alarm detection and generation should be set to off, because detection of yellow alarms is not reliable when data traffic is transmitted with SF framing (data traffic often contains bit combinations that do not occur for encoded voice traffic). The default value for yellow alarm generation and detection is both. To configure yellow alarms, use the following command:

```
configure ports <portlist> t1 yellow [detection | generation | both | off]
```

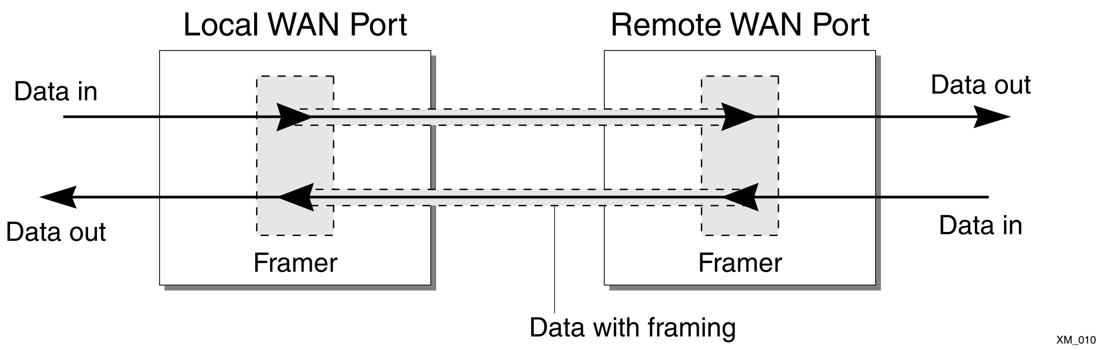
Monitoring WAN Physical Links

T1, E1, and T3 devices have a built-in facility designed for troubleshooting the physical link, called loopback. The link can also be monitored using show commands to display the current configuration of the link, any alarms on the link, link statistics, and link errors.

Loopback

The WAN device can be set up to loopback, that is, return a transmitted signal back to the sender so it can be compared with the original. There are several different types of loopback available to test different parts of the device and the line, as specified in the T1, E1, and T3 standards.

Figure 125: Normal operation of WAN link



During normal operation of a link, as the local data stream enters the framer, the appropriate framing bits are inserted into the data, and the framed signal is transmitted to the remote end. At the remote end, the process is reversed as the framing bits are discarded and the data stream is passed to the remote system.

Loopback can be enabled on the near-end of a WAN link, but only the T1 and T3 modules can enable loopback on the far-end of a link. The near-end loopback modes are controlled directly by the hardware on the near-end. Far-end loopback modes require the cooperation of the far-end hardware. A message is sent to the far-end to cause it to enter a far-end loopback mode. When loopback is enabled on a WAN port, the green port LED will blink.

Near-end Loopback Modes

The near-end of T1 links can be enabled for the following three loopback modes:

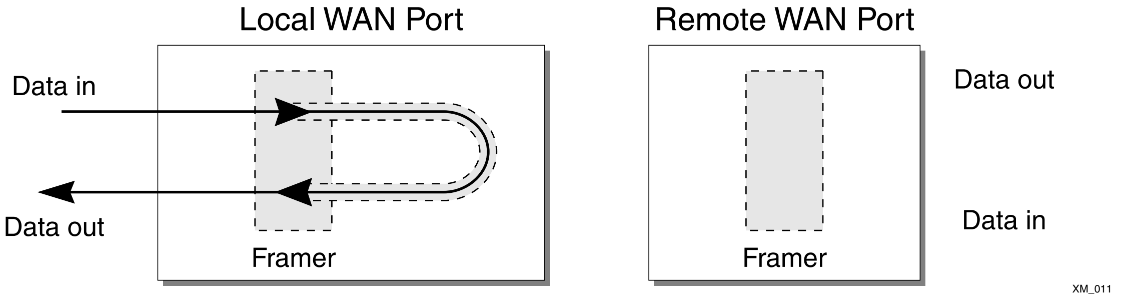
- Local
- Network Line
- Network Payload

The near-end of E1 and T3 links can be enabled for the following two loopback modes:

- Local
- Network Line

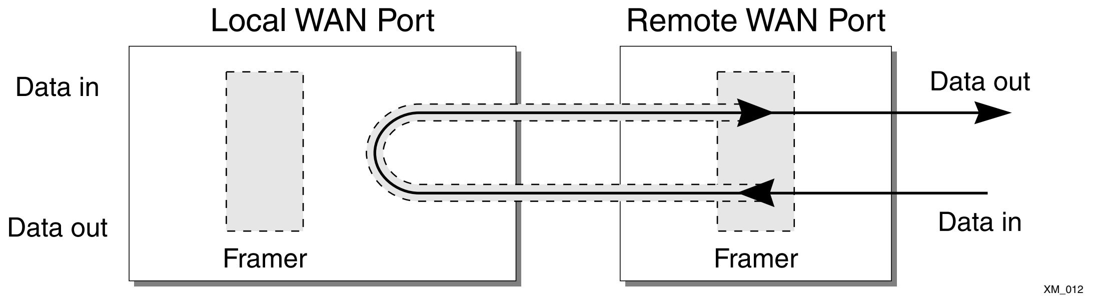
The local loopback mode reflects the data stream internally to the near-end. The network line loopback mode reflects the signal to the far-end. The network payload mode reflects the data carried in the signal and regenerates framing information back to the far-end.

Figure 126: Local loopback mode



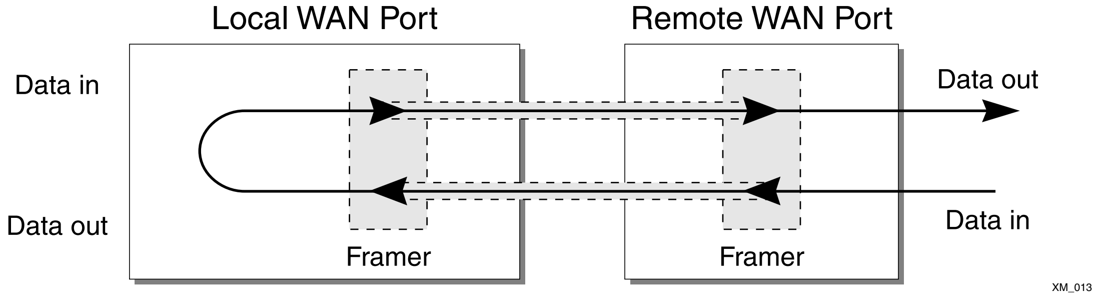
Local Loopback Mode. When the local port is enabled for local loopback, the local data stream goes into the framer and the framing bits are inserted into the data, but the data is not transmitted to the remote end. Instead, it is sent back through the local framer, the framing bits are discarded, and the original data is returned. This mode tests the local end.

Figure 127: Network line loopback mode



Network Line Loopback Mode. When the local port is enabled for network line loopback mode, the received signal is sent back to the remote end without reframing the data. This mode primarily tests the integrity of the line from the remote side.

Figure 128: Network payload loopback mode



Network Payload Loopback Mode. When the local port is enabled for network payload mode, the framer removes the framing bits from the received signal and recovers the transmitted data. This same data is then reframed and transmitted back to the remote end. This mode tests the line and the local circuitry from the remote side.

Far-End Loopback Modes

The far-end of T1 links can be enabled for the following two loopback modes:

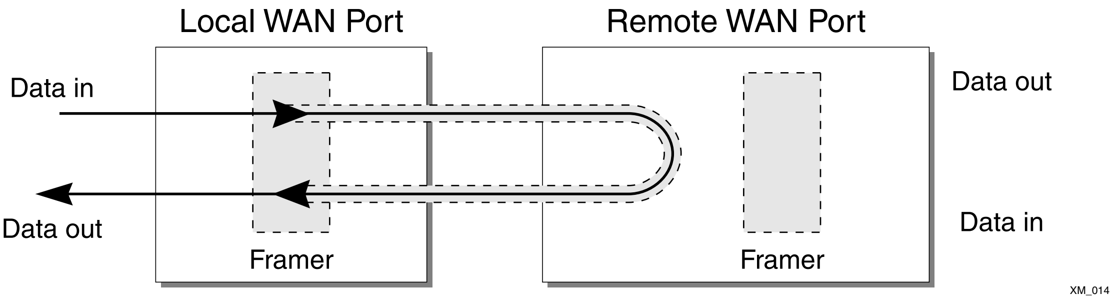
- Remote Line
- Remote Payload

The far-end of T3 links can be enabled for the following loopback mode:

- Remote Line

The remote line mode reflects the received signal back to the near-end. The remote payload mode reflects the data and regenerates the framing information back to the near-end.

Figure 129: Remote line loopback mode

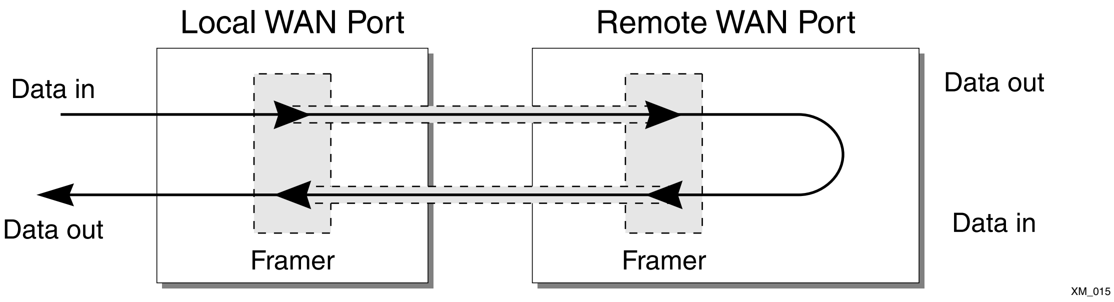


Remote Line Loopback Mode. When the local port is enabled for remote line loopback mode, it sends a request to the remote end to enter the equivalent of network line loopback mode. The signal transmitted to the remote end will be retransmitted as received back to the local end.

NOTE

If the T1 line is configured to use the ATT FDL standard, the remote end must be configured to detect inband loopback requests for the remote end to enter remote line loopback mode.

Figure 130: Remote payload loopback mode



Remote Payload Loopback Mode. When the local port is enabled for remote payload loopback mode, it sends a request to the remote end to enter the equivalent of network payload loopback mode. When the remote end enters loopback mode, the framer at the remote end removes the framing bits from the received signal and recovers the transmitted data. This same data is then reframed and transmitted back to the local end.

Enabling Loopback Mode

To enable a local loopback mode, use one of the following commands:

```
enable ports <portlist> [t1 | e1 | t3] loopback [local | network line]
enable ports <portlist> t1 loopback network payload
```

To enable a remote loopback mode, use the following command:

```
enable ports <portlist> [t1 | t3] loopback remote [line | payload | loopdown]
```

Disabling Loopback Mode

Use the following command to return the near and remote side of a T1, E1 or T3 link from loopback mode to normal mode:

```
disable ports <portlist> [t1 | e1 | t3] loopback
```

You can also use the following command to return the remote T1 or T3 port to normal function from loopback mode:

```
enable ports <portlist> [t1 | t3] loopback remote [line | payload | loopdown]
```

If you add a 10/100 port as a loopback port and delete it, autonegotiation is set to *off*.

Configuring PPP and MLPPP

Point-to-Point Protocol (PPP) is used across the entire range of communication speeds and devices found on the internet. Typically, PPP uses Layer 3 to connect two broadcast networks, say two Ethernet LANs, into a single WAN by transporting IP packets over a link. PPP can also use Layer 2 to bridge VLAN traffic.

Multilink PPP (MLPPP) is a protocol for combining a number of PPP links into one bundle that transports traffic over the links in the bundle. Multilink PPP is supported for T1 and E1 technologies in ExtremeWare, but not for T3. Instead, a T3 link is configured as a single PPP link.

A multilink group is a bundle of individual PPP links that are configured to work together as a single link. With a multilink group configured, it is easy to add or remove PPP links in order to provide appropriate bandwidth. The multilink group balances traffic among the individual PPP links and properly sequences packets across the multilink group.

Typically, you would create a multilink group, configure the multilink group by adding T1 or E1 ports and configuring PPP/MLPPP parameters, add the multilink group to a VLAN, and finally, enable the multilink group.

For a T3 port, you would configure its PPP parameters and add it to a VLAN.

This section covers the following topics:

- Multilink PPP and Multilink Groups on page 672
- Configuring a PPP/MLPPP Link on page 672

Multilink PPP and Multilink Groups

Each multilink PPP group is given a name, up to 16 characters in length. All named components of the switch configuration must have unique names, so multilink groups and VLANs cannot have identical names. See Chapter 2 for more information on allowable names for named components. Components are named using the `create` command. Once a component is named, you do not need to use the keyword for the component (see the shortcut below).

Create the multilink group using the following command:

```
create multilink <groupname>
```

Once the multilink group is created, assign ports to it. All T1/E1 ports must be added as tagged ports. If the ports are configured as IPCP ports, then the tags will be stripped as traffic passes over the link. BCP-configured ports will pass the tag across the link. See the section "Encapsulation" for more information. Add ports by using the following command:

```
configure multilink <groupname> add ports <portlist>
```

or you can use the following shortcut:

```
configure <groupname> add ports <portlist> tag
```

If the first port added to a multilink group is already configured for PPP, the multilink group will inherit the configuration of the first port. Any other ports added to the link will be configured to match the multilink configuration. The next section lists the configuration commands for multilink groups and single PPP links.

Once the multilink group has been configured, it is added to a VLAN so that it can pass traffic from the VLAN across the link. To add a multilink group to a VLAN, use the following command:

```
configure vlan <vlan name> add multilink <groupname>
```

Typically the last step in configuring a multilink group is to use the following command to enable it:

```
enable multilink <groupname>
```

Any changes to an enabled multilink group will not take effect until the multilink group is restarted. To restart a multilink group, use the following command:

```
restart multilink <groupname>
```

Configuring a PPP/MLPPP Link

All of the PPP configuration commands can be used to configure a single port or to configure a multilink group, so the following sections for PPP links also apply to MLPPP links. To configure a PPP/MLPPP link you will need to choose the authentication and encapsulation for the link.

If you change the configuration of an enabled PPP or MLPPP link, the changes will not take effect until the link is restarted. To restart a PPP link, use the following command:

```
restart ports [<portlist>
```

To restart an MLPPP link, use the following command:

```
restart multilink <groupname>
```

Authentication

By default, no authentication is configured on PPP links since the WM-4T1i module will typically be used with leased lines—where both sides of the link are controlled and authentication is not required. If authentication is needed, the WM-4T1i module supports either PAP or CHAP. Password authentication protocol (PAP) authenticates a user as the connection is established by sending a username and password. Challenge Handshake Authentication Protocol (CHAP) authenticates a user by sending a challenge across the link. The remote end calculates a response based on the user password and sends the response back across the link. CHAP is a more secure authentication protocol than PAP. The link can also be configured to attempt to use CHAP first, followed by PAP, if CHAP fails.

To configure authentication on a PPP link, use the following command:

```
configure ppp authentication [off | chap | pap | chap-pap] [ports <portlist> |
multilink <groupname>]
```

PPP Link Username. When the local end of a link initiates a PPP connection, the local end must send the appropriate authentication information. For PAP it sends the username and password, for CHAP it sends the username and must respond correctly to the challenge, and for no authentication it sends nothing. To configure the username and password used to initiate the link, use the following command:

```
configure ppp user <name> {encrypted} {<password>} [ports <portlist> | multilink
<groupname>]
```

The encrypted keyword is used to hide the password when the switch configuration is displayed; it does not control whether the password is encrypted across the link during authentication.

PPP User Accounts. When the remote end initiates the link, the local end must verify the authentication information. The local end maintains a list of authorized user accounts and passwords. To add a user to the list, use the following command:

```
create account pppuser <username> {encrypted} {<password>}
```

Encapsulation

The packets passed over the PPP/MLPPP link can use either bridged or routed encapsulation. You would use bridged packets if you plan to have VLANs span the link. You would use routed packets if the link connects two different routed networks or separate VLANs.

Using bridged packets allows the VLAN tags to be carried across the PPP/MLPPP link. Bridged packets are transported using the PPP Bridging Control Protocol (BCP), described in RFC 2878, except in the case of Legacy BCP, described below. When the encapsulation is set to BCP, 802.1Q and 802.1p information is preserved and transported across the link.

Routed packets are transported across a PPP/MLPPP link using IP Control Protocol (IPCP), described in RFC 1332. This is the encapsulation that is familiar to most users of PPP. The routed packets do not contain Ethernet headers so cannot preserve VLAN tags. However, the WAN ports still must be added as tagged ports to the VLAN that contains them. The module uses the tags internally and strips them off before the packets are transmitted. The IP addresses used for the PPP/MLPPP link are taken from the IP address assigned to the VLAN at each end of the link. The VLAN that contains the IPCP encapsulated PPP/MLPPP ports cannot contain other ports. In other words, the only ports allowed in the VLAN are those that make up the IPCP encapsulated link. There can only be one VLAN spanning an IPCP-encapsulated link.

You must have one and only one encapsulation type configured on a PPP/MLPPP link. Setting BCP encapsulation off implies that IPCP encapsulation is on. The default setting is BCP encapsulation on and IPCP encapsulation off. To configure encapsulation, use the following command:

```
configure ppp [bcp [on | off] | ipcp [on | off]] [ports <portlist> | multilink
<groupname>]
```

Legacy BCP. Some routers supported by other vendors implemented BCP using an older standard, RFC 1638. For interoperability, the Extreme Networks implementation supports both standards. The limitation with RFC 1638-based BCP is that 802.1Q tags are not supported. So Legacy BCP cannot support multiple VLANs or preserve 802.1p priority across the PPP link. Both types of BCP can operate over single and multilink PPP.

When BCP is negotiated over a link, RFC 2878 BCP is initially proposed. If the peer only supports Legacy BCP (RFC 1638), then the link is made using Legacy BCP. Since the WAN module ports are always configured as tagged ports, the VLAN tag is removed in the egress direction and inserted in the egress direction when BCP is operating in Legacy mode.

There is no Legacy BCP specific configuration, and the display for the command `show ppp info` is identical for BCP and Legacy BCP. To determine if the link is using Legacy BCP, use the following command:

```
show log warning
```

and look for the message:

```
BCP: Legacy BCP UP;Only a single VLAN over BCP is supported
```

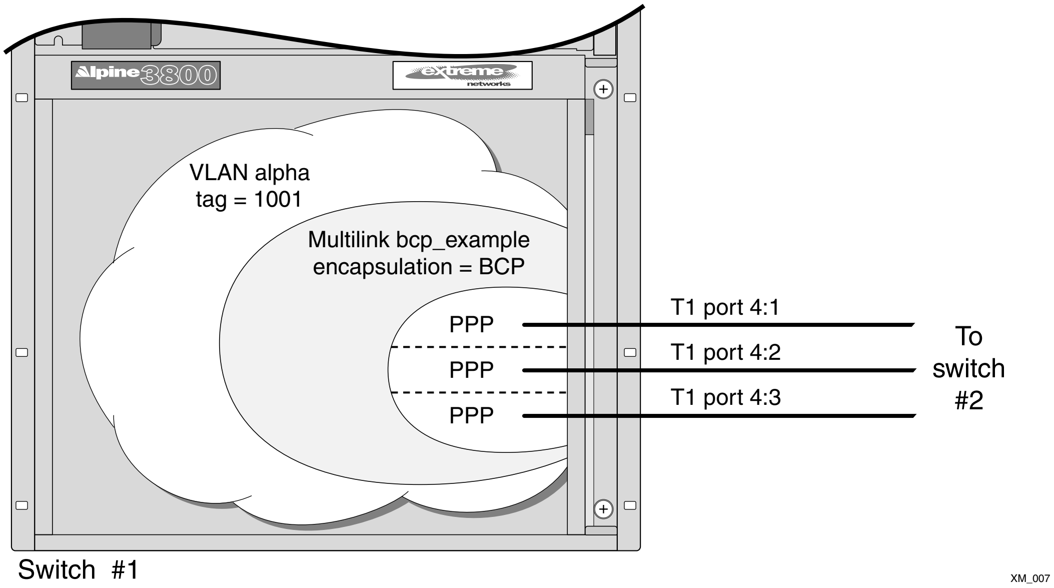
WAN Multilink Configuration Examples

The following examples show how to configure WAN links with multilink groups.

Configuring a Bridged PPP/MLPPP Link Example

The following example shows how to configure a BCP-encapsulated multilink group. BCP is the default encapsulation, so it is not explicitly included in this example. While only one VLAN is shown in this example, you may configure multiple VLANs across the link. The `configure ports t1 clocksource` command is included to show where you might need to configure the T1 parameters for your link. Each T1 port in the multilink group will have the same T1 and PPP configurations. If you change the configuration for a single port, the change will affect the entire group.

Figure 131: BCP multilink example

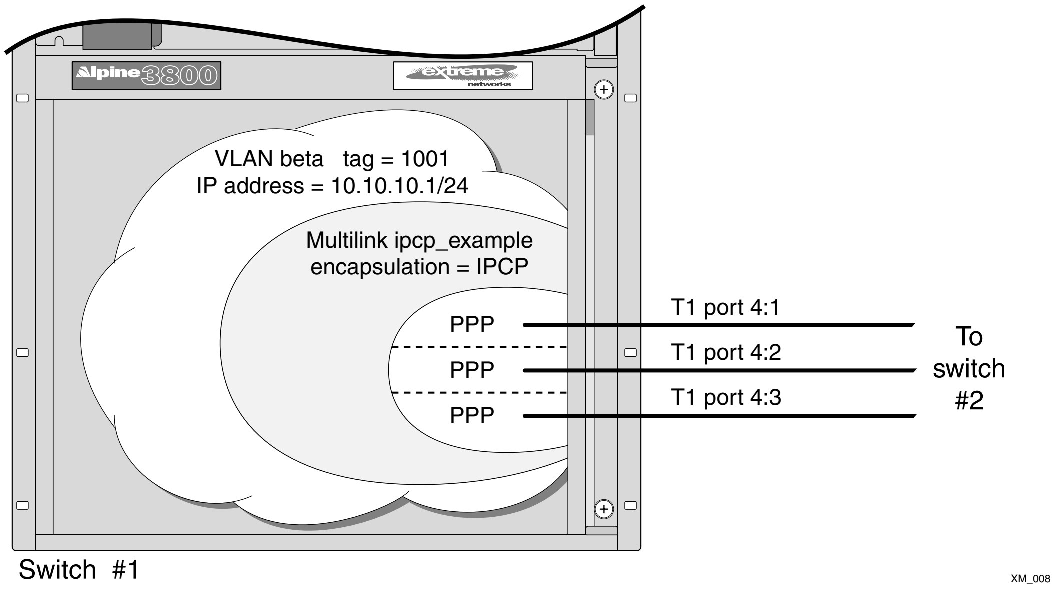


```
create vlan alpha
configure alpha tag 1001
create multilink bcp_example
configure ports 4:1-4:3 t1 clocksource internal
configure bcp_example add ports 4:1-4:3 tag
configure alpha add multilink bcp_example
enable bcp_example
```

Configuring a Routed PPP/MLPPP Link Example

The following example shows how to configure a IPCP-encapsulated multilink group. The VLAN that contains the IPCP-encapsulated multilink group cannot contain any other ports, and only one VLAN is allowed across the link. Notice that the T1 ports must be added as tagged ports even though the tag will be removed before the packet is transmitted over this link.

Figure 132: IPCP multilink example



```
create vlan beta
configure beta tag 1001
configure beta ipaddress 10.10.10.1/24
create multilink ipcp_example
configure ipcp_example add ports 4:1-4:3 tag
configure ppp ipcp on ports 4:1-4:3
configure beta add multilink ipcp_example
enable ipcp_example
```

VLAN Tunneling (VMANs)

The procedure for creating VMANs over Ethernet links is described in Chapter 6, “Virtual LANs (VLANs)”. Here is the procedure from Chapter 6:

To configure a VMAN tunnel, follow these steps:

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

However, some of the commands needed for the steps are different for the WAN ports. For WAN links, PPP is used to transport the packets, so an additional command, `configure ppp mru`, is used for step 2 to allow the larger frame sizes to be transported. For step 3, the command, `enable vman termination`, is used for the ingress/egress ports to allow untagged packets to enter and leave the ports. In general, WAN ports are tagged ports, but for this special VMAN termination usage, the ports deliver unencapsulated packets (the WAN ports are still added as tagged ports in the CLI).

The PPP type must be set to BCP, not IPCP, but this is not shown in the examples since BCP is the default. PPP also adds some overhead to the packets, therefore the PPP MRU size is set to a higher value than the Ethernet jumbo frame size. For multilink groups, the overhead is six bytes. For single PPP links, the overhead is two bytes.

There are two cases to consider: VMAN tunnels transported switch-to-switch across a WAN link and WAN ports as ingress/egress ports of a tunnel.

NOTE

When you modify the 802.1Q Ethertype, you must reboot the switch for the change to take effect.

VMAN Transport by WAN Links

VMAN transport refers to a port that transports one or more VMAN tunnels across a link. Typically, you would configure a group of T1 or E1 ports as a multilink group for VMAN transport. A T3 link cannot be configured as a multilink group, so the second example below must be used for a T3 link.

In the two following examples, the WAN ports act as a trunk to transport the tunnels, while the Ethernet ports act as ingress/egress ports to the VMAN tunnel.

Multilink VMAN Transport Example

In this first example, the WAN ports 1:1 and 1:2 are configured as the multilink group *link1*, used to transport the two VMAN tunnel VLANS *tunnel1* and *tunnel2* across the VMAN cloud, while the Ethernet ports 2:1-2:2 deliver untagged *tunnel1* VLAN packets and Ethernet ports 2:3-2:4 deliver untagged *tunnel2* VLAN packets.

```
configure dot1q ethertype 88a8
enable jumbo-frame ports 1:1-1:2
configure jumbo-frame size 1530
create multilink link1
configure multilink link1 ports 1:1-1:2
configure ppp mru 1536 multilink link1
create vlan tunnel1
configure vlan tunnel1 tag 50
configure vlan tunnel1 add multilink link1 tagged
create vlan tunnel2
configure vlan tunnel2 tag 60
configure vlan tunnel2 add multilink link1 tagged

configure vlan tunnel1 add port 2:1-2:2 untag
configure vlan tunnel2 add port 2:3-2:4 untag
```

Single PPP Link VMAN Transport

In this second example, the WAN port 1:1 is used like the multilink group in the first example to transport the two VMAN tunnel VLANs *tunnel1* and *tunnel2* across the VMAN cloud, while the Ethernet ports 2:1-2:2 deliver untagged *tunnel1* VLAN packets and Ethernet ports 2:3-2:4 deliver untagged *tunnel2* VLAN packets.

```
configure dot1q ethertype 88a8
enable jumbo-frame ports 1:1
configure jumbo-frame size 1530
configure ppp mru 1532 1:1
create vlan tunnel1
configure vlan tunnel1 tag 50
configure vlan tunnel1 add port 1:1 tagged
create vlan tunnel2
configure vlan tunnel2 tag 60
configure vlan tunnel2 add port 1:1 tagged

configure vlan tunnel1 add port 2:1-2:2 untag
configure vlan tunnel2 add port 2:3-2:4 untag
```

VMAN Termination at WAN ports

VMAN termination is the VMAN tunnel ingress/egress port that delivers the VLAN packets. You can configure a group of T1 or E1 ports as a multilink group for VMAN termination, or a single port can act as the ingress/egress port for the tunnel. A T3 link cannot be configured as a multilink group, so the second example below must be used for a T3 link.

Opposite to the previous two examples, for the next two examples, the Ethernet ports act as a trunk to transport the tunnels, while the WAN ports act as ingress/egress ports to the VMAN tunnel.

Multilink VMAN Termination

In this first example, the WAN ports 1:1 and 1:2 are configured as the multilink group *link1*, used to terminate the VMAN tunnel VLAN *tunnel1.* Ports 1:3 and 1:4 are configured as the multilink group *link2* to terminate the VMAN tunnel VLAN *tunnel2*. The Ethernet ports 2:1-2:2 provide the tunnel transport across the VMAN cloud.

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

create multilink link1
configure multilink link1 add ports 1:1-1:2
enable vman termination multilink link1
configure dot1q ethertype 8100 link1
configure vlan tunnel1 add multilink link1
create multilink link2
configure multilink link1 add ports 1:3-1:4
```

```
enable vman termination multilink link2
configure dot1q ethertype 8100 link1
configure vlan tunnel2 add multilink link2
```

Single PPP Link VMAN Termination

In this second example, the WAN port 1:1 is configured as a single PPP link, used to terminate the VMAN tunnel VLAN *tunnel1.* Port 1:3 is configured to terminate the VMAN tunnel VLAN *tunnel2*. The Ethernet ports 2:1-2:2 provide the tunnel transport across the VMAN cloud.

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

enable vman termination ports 1:1,1:3
configure dot1q ethertype 8100 port 1:1,1:3
configure vlan tunnel1 add port 1:1 tag
configure vlan tunnel2 add port 1:3 tag
```

26 MultiProtocol Label Switching (MPLS) Module

The MPLS module is a self-contained module for the BlackDiamond 6800 series chassis-based system. Unlike other BlackDiamond modules, there are no external network interfaces on the MPLS module. Instead, the MPLS module provides advanced IP services for the other input/output (I/O) modules installed in the chassis. The MPLS module contains a powerful set of packet processing resources that operate in a one-armed fashion: receiving frames from the switch fabric, processing the frames, and transmitting the frames back into the switch fabric.

This chapter covers the following topics:

- About MPLS on page 681
- About the MPLS Module on page 691
- Configuring the MPLS Module on page 692
- Configuring the Label Distribution Protocol (LDP) on page 697
- MPLS and IP Routing on page 702
- Configuration Example on page 706

About MPLS

MPLS is a technology that allows routers to make protocol-independent forwarding decisions based on fixed-length labels. The use of MPLS labels enables routers to avoid the processing overhead of delving deeply into each packet and performing complex route lookup operations based upon destination IP addresses.

In an MPLS environment, incoming packets are initially assigned “labels” by a Label Edge Router (LER). The labels allow the packets to be more efficiently handled by MPLS-capable routers at each point along the forwarding path.

An MPLS label essentially consists of a short fixed-length value carried within each packet header and that identifies a Forwarding Equivalence Class (FEC). The FEC tells the router how to handle the packet. An FEC is defined to be a group of packets that are forwarded in the same manner. Examples of FECs include an IP prefix, a host address, or a VLAN ID. The label concept in MPLS is analogous to other connection identifiers, such as an ATM VPI/VCI or a Frame Relay DLCI.

By mapping to a specific FEC, the MPLS label efficiently provides the router with all of the local link information needed for immediate forwarding to the next hop. MPLS creates a Label Switched Path (LSP) along which each Label Switch Router (LSR) can make forwarding decisions based solely upon the content of the labels. At each hop, the LSR simply strips off the existing label and applies a new one that tells the next LSR how to forward the packet.

Overview of MPLS

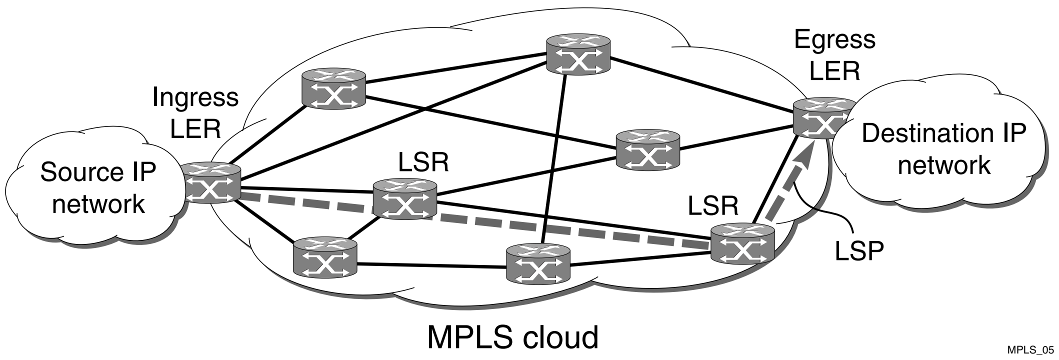
MPLS encompasses a growing set of protocols defined by the IETF. True to its name, MPLS is based on a label-switching forwarding algorithm. ATM and Frame Relay are examples of other protocols that use label-switching forwarding algorithms.

Conceptually, label switching is straightforward. A label is a relatively short, fixed-length identifier that is used to forward packets received from a given link. The label value is locally significant to a particular link and is assigned by the receiving entity.

Because labels are relatively short (for example, 20 bits in a MPLS shim header), the label of a received packet can be used as an index into a linear array containing the forwarding database. Forwarding database entries indicate the outgoing port and any label(s) to be applied to forwarded frames. Thus, forwarding may consist of a simple lookup and replacement of the incoming label with the appropriate outgoing label (otherwise known as *label swapping*).

Figure 133 illustrates an MPLS network.

Figure 133: MPLS network



MPLS Module Limitations

The following limitations apply to the MPLS module:

- The only applicable QoS commands are `dot1p-to-exp` and `exp-to-dot1p`
- SLB and Flow Redirection are mutually exclusive functions with MPLS
- Port state changes on TLS VLANs as a result of EAPS, VRRP, and STP state changes are not supported
- MPLS does not advertise a label mapping for a default route
- There is no support for indirect LSPs across ISIS networks
- No native MPLS RIP support is provided (labels can be advertised for RIP routes exported into OSPF)
- MPLS does not advertise label mappings for BGP routes exported into OSPF

- IP multicast MPLS is not supported
- IPX MPLS is not supported
- GVRP is not supported over MPLS LSPs
- PoS/ATM bridging is not compatible with MPLS when two MSMs installed
- ARM and MPLS modules cannot be installed in the same switch
- Commands with port parameters are not directly applicable to the MPLS module

MPLS Terms and Acronyms

Table 87 defines common MPLS terms and acronyms.

Table 87: MPLS Terms and Acronyms

Term or Acronym	Description
CSPF	Constrained Shortest Path First. Route selection determined by an algorithm based on available link bandwidth and path cost.
DoD	Downstream-on-Demand. Distribution of labels as a result of explicit upstream label requests.
DU	Downstream Unsolicited. Distribution of labels downstream without an explicit label request.
FEC	Forward Equivalence Class. A group of packets that are forwarded in the same manner (for example, over the same Label Switched Path).
Label	A short, fixed-length identifier used to forward packets from a given link.
Label stack	A set of one or more MPLS labels used by MPLS to forward packets to the appropriate destination.
Label swapping	Lookup and replacement of an incoming label with the appropriate outgoing label.
LDP	Label Distribution Protocol. A protocol defined by the IETF used to establish an MPLS Label Switched Path (LSP).
LER	Label Edge Router. A Label Switch Router that is at the beginning (ingress) or end (egress) of a Label Switched Path.
LSP	Label Switched Path. The unidirectional MPLS connection between two routers over which packets are sent.
LSR	Label Switch Router. A router that receives and transmits packets on an MPLS network.
MPLS	MultiProtocol Label Switching. A set of protocols defined by the IETF used to transmit information based on a label-switching forwarding algorithm.
NHLFE	Next Hop Label Forwarding Entry. The NHLFE represents the MPLS router next hop along the LSP.
PHP	Penultimate Hop Popping. A label stack optimization used for conserving the number of allocated labels.
RSVP	Resource ReSerVation Protocol. A resource setup protocol designed for an integrated services network.
RSVP-TE	The combination of RSVP and MPLS label signaling to provide traffic engineered LSPs as specified in draft-ietf-mpls-rsvp-lsp-tunnel-09.txt.
Shim header	MPLS-specific header information that is inserted between layer-2 and layer-3 information in the data packet.
SP	Service Provider. An entity that provides network services for individuals or organizations.
TE	Traffic Engineering. The provisioning of an autonomous flow along a specified network path.

Table 87: MPLS Terms and Acronyms (Continued)

Term or Acronym	Description
TLS	Transparent LAN Services. A method for providing layer-2 virtual private networks (VPNs).
TLS Tunnel	A specific type of VC tunnel that carries only VLAN tagged Ethernet traffic.
Tunnel LSP	Any active RSVP-TE LSP used to forward IP traffic through an MPLS network.
VC	Virtual Circuit. A logical point-to-point connection.
VC Tunnel	A two label stack LSP used to tunnel a specific type of traffic. The type of traffic carried over the VC tunnel is negotiated when VC tunnel is established.
VPLS	Virtual Private LAN Services. A multipoint Layer-2 VPN service that has the property that all VC tunnels within a VPN are signaled with the same vcid, where the vcid represents the VPN identifier.
VPN	Virtual Private Network. A logical private network domain that spans a public or service provider network infrastructure.

Label Switched Paths

Protocols that use label switching are connection-oriented. In MPLS, the connections are called *Label Switched Paths* (LSPs) and are unidirectional in nature.

LSPs are established using LDP or RSVP-TE. Once established, an LSP can be used to carry IP traffic or to tunnel other types of traffic, such as bridged MAC frames. The tunnel aspects of LSPs, which are important in supporting virtual private networks (VPNs), result from the fact that forwarding is based solely on labels and not on any other information carried within the packet.

Label Advertisement Modes. MPLS provides two modes for advertising labels:

- Downstream-on-demand (DoD)
- Downstream unsolicited (DU)

Using DoD mode, label bindings are only distributed in response to explicit requests. A typical LSP establishment flow begins when the ingress LER originates a label request message to request a label binding for a particular FEC (for a particular IP address prefix or IP host address). The label request message follows the normal routed path to the FEC. The egress LER responds with a label mapping message that includes a label binding for the FEC. The label mapping message then follows the routed path back to the ingress LSR, and an unsolicited label binding is provided by each LSR along the path. LSP establishment is complete when the ingress LER receives the label mapping message.

Conversely, using DU mode, an LSR may distribute label bindings to LSRs that have not specifically requested them. These bindings are distributed using the label mapping message, as in downstream-on-demand mode. From an LDP message perspective, the primary difference using DU mode is the lack of a preceding label request message.

Architecturally, the difference is more significant, because the DU mode is often associated with a topology-driven strategy, where labels are routinely assigned to entries as they are inserted into the routing database. In either case, an LSR only uses a label binding to switch traffic if the binding was received from the current next hop for the associated FEC.

Both label advertisement modes can be concurrently deployed in the same network. However, for a given adjacency, the two LSRs must agree on the discipline. Negotiation procedures specify that DU mode be used when a conflict exists. Label request messages can still be used when MPLS is operating in unsolicited mode.

The Extreme LDP implementation supports DU mode only. RSVP-TE, by definition, is DoD.

Label Retention Modes. MPLS provides two modes for label retention:

- Conservative
- Liberal

Using conservative label retention mode, an LSR retains only the label-to-FEC mappings that it currently needs (mappings received from the current next hop for the FEC). Using liberal retention mode, LSRs keep all the mappings that have been advertised to them. The trade-off is memory resources saved by conservative mode versus the potential of quicker response to routing changes made possible by liberal retention (for example, when the label binding for a new next hop is already resident in memory).

The Extreme MPLS implementation supports liberal label retention, only.

LSP Control Modes. MPLS provides two LSP control modes:

- Independent
- Ordered

Using independent LSP control, each LSR makes independent decisions to bind labels to FECs. By contrast, using ordered LSP control, the initial label for an LSP is always assigned by the egress LSR for the associated FEC (either in response to a label request message or by virtue of sending an unsolicited label mapping message).

More specifically, using ordered LSP control, an LSR only binds a label to a particular FEC if it is the egress LSR for the FEC, or if it has already received a label binding for the FEC from its next hop for the FEC. True to its name, the mode provides a more controlled environment that yields benefits such as preventing loops and ensuring use of consistent FECs throughout the network.

The Extreme MPLS implementation supports ordered LSP control, only.

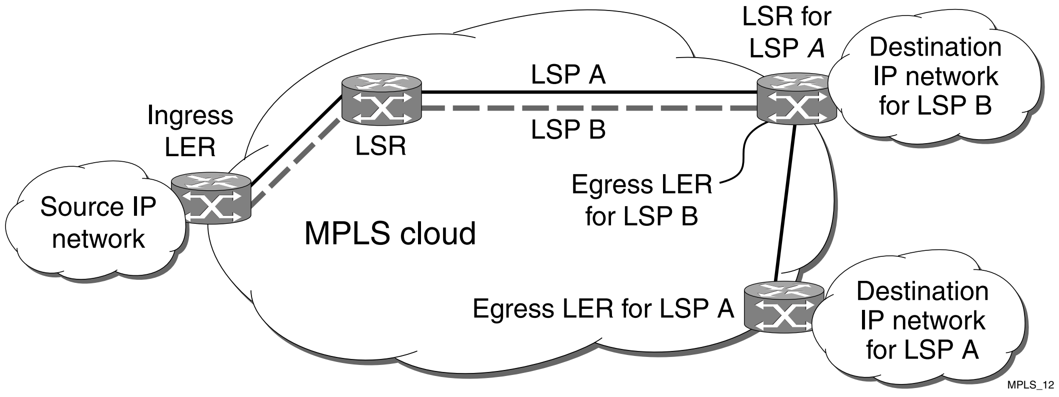
Label Switch Routers

MPLS protocols are designed primarily for routed IP networks and are implemented by *Label Switch Routers* (LSRs). The router where an LSP originates is called the *ingress* LSR, while the router where an LSP terminates is called the *egress* LSR.

Ingress and egress LSRs are also referred to as *Label Edge Routers* (LERs). For any particular LSP, a router is either an ingress LER, an intermediate LSR, or an egress LER. However, a router may function as an LER for one LSP, while simultaneously function as an intermediate LSR for another LSP.

Figure 134 illustrates the three types of LSRs.

Figure 134: LSR types



The functions of the LSR types are described in Table 88.

Table 88: LSR Functions

LSR	Function
Ingress LER	Inserts one or more labels into packets transmitted onto an LSP.
Intermediate LSR	Forwards packets via label swapping.
Egress LER	Removes the last label(s) before forwarding packets received from an LSP.

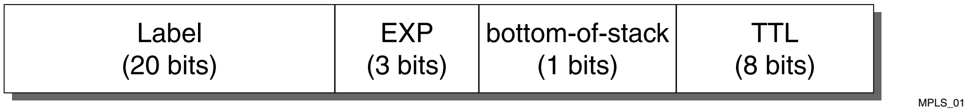
Supporting Quality of Service Features

Quality of Service (QoS) LSP support is an important attribute of MPLS. MPLS supports the Differentiated Services (DiffServ) model of QoS. The DiffServ QoS model is supported by mapping different traffic classes to different LSPs, or by using the EXP bits in the MPLS shim header to identify traffic classes with particular forwarding requirements.

MPLS Layer

MPLS can be thought of as a *shim-layer* between layer 2 and layer 3 of the protocol stack. MPLS provides connection services to layer-3 functions while making use of link-layer services from layer-2. To achieve this, MPLS defines a *shim header* that is inserted between the link layer header and the network layer header of transmitted frames. The format of a 32-bit MPLS shim header is illustrated in Figure 135.

Figure 135: MPLS shim header



Label (20 bits)	EXP (3 bits)	bottom-of-stack (1 bits)	TTL (8 bits)

MPLS Label Stack

The MPLS shim header is also referred to as a *label stack*, because it can contain multiple entries. Each entry contains the following fields:

- 20-bit label
- 3-bit experimental (EXP) field

  The EXP field can be used to identify different traffic classes to support the DiffServ QoS model.
- 1-bit bottom-of-stack flag

  The bottom-of-stack bit is set to 1 to indicate the last stack entry.
- 8-bit Time-To-Live (TTL) field.

  The TTL field is used for loop mitigation, similar to the TTL field carried in IP headers.

The format of an MPLS label stack containing two entries is shown in Figure 136.

Figure 136: MPLS label stack

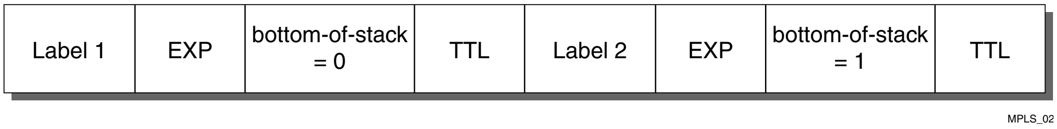


Figure 137 illustrates the format of a unicast MPLS frame on an Ethernet link. The MAC addresses are those of the adjacent MPLS router interfaces. The x8847 Ethertype value indicates that the frame contains a MPLS unicast packet. A different Ethertype value (x8848) is used to identify MPLS multicast packets.

Figure 137: MPLS unicast frame on Ethernet

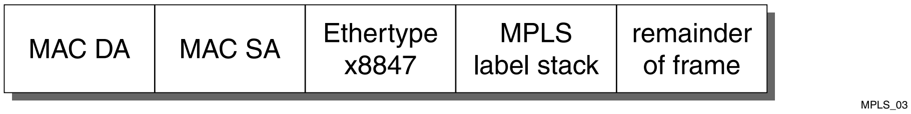
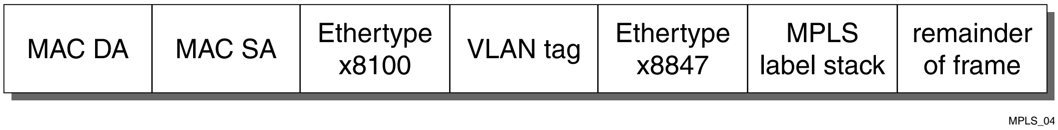


Figure 138 shows the format of a unicast MPLS frame that contains an 802.1Q VLAN tag. In both cases, the Ethertype values no longer identify the network layer protocol type. This implies that, generally, the protocol type must be inferable from the MPLS label value(s). For example, when only one type of protocol is carried on a given LSP.

Figure 138: MPLS unicast frame on tagged Ethernet VLAN



The approach of the shim header encapsulation is similar for Packet over SONET (PoS) interfaces running PPP. For PoS interfaces running PPP, the MPLS shim header follows the PPP Protocol ID (PID) field. A PID of x0281 is used to indicate MPLS unicast, while a PID of x0283 identifies MPLS multicast.

MPLS can also take advantage of technologies that can carry labels in the link layer header. For example, MPLS labels can be carried in the VPI/VCI fields of ATM cell headers. Frame Relay provides another example; an MPLS label can be carried in the DLCI field.

NOTE

For more detailed information on MPLS encapsulations, see RFC 3032, MPLS Label Stack Encoding.

Penultimate Hop Popping

Penultimate hop popping (PHP) is an LSR label stack processing optimization feature. When enabled, the LSR can "pop" (or discard) the remaining label stack and forward the packet to the last router along the LSP as a normal Ethernet packet.

By popping the label stack one hop prior to the LSP egress router, the egress router is spared having to do two lookups. After the label stack has been popped by the penultimate hop LSR, the LSP egress router must only perform an address lookup to forward the packet to the destination.

PHP label advertisements using implicit NULL labels can be optionally enabled. Support for receiving implicit NULL label advertisements by neighbor LSRs is always enabled. For example, if an LSR advertises implicit NULL labels for IP prefixes, the neighbor LSRs must support PHP.

Label Binding

Label binding is the process of, and the rules used to, associate labels with FECs. LSRs construct label mappings and forwarding tables that comprise two types of labels: labels that are locally assigned and labels that are remotely assigned.

Locally assigned labels are labels that are chosen and assigned locally by the LSR. For example, when the LSR assigns a label for an advertised direct interface. This binding information is communicated to neighboring LSRs. Neighbor LSRs view this binding information as remotely assigned.

Remotely assigned labels are labels that are assigned based on binding information received from another LSR.

Label Space Partitioning

The Extreme MPLS implementation supports approximately 64 K locally-assigned labels. The label space is partitioned as described in Table 89.

Table 89: MPLS Label Space Partitions

Label Range	Label Partition Description
x00000-x0000F	Defined/reserved by MPLS standards specified in RFC 3032.
x00010-x0BBFF (48,112)	**LSR Partition**—Used to identify intermediate LSR LSPs.
x8C000-x8FFFF (16,384)	**TLS LER Partition**—Used to identify the VLAN for which TLS traffic is destined when performing the egress LER function.
xCBC00-xCBFFF (1024)	**IP LER Partition**—Used for mappings to IP FECs when performing the egress LER function.

The partitioning described in Table 89 maximizes forwarding performance, and supports efficient load sharing of MPLS traffic across the Gigabit Ethernet backplane links of high-speed input/output modules.

The data path uses the least significant 16 bits of the label (bits 0-15) as an index when a label lookup is required. The next 2 bits of the label (bits 16-17) are currently not used by the data path. The most significant 2 bits of the label (bits 18-19) are used to identify the partition. The data path uses the label partition bits in conjunction with the bottom-of-stack flag to efficiently determine how a label should be processed, as described in Table 90.

Table 90: Label Processing by the NP Data Path

Partition	Bottom-of-stack	Label Processing
LSR	Don't Care	Perform label lookup.
IP	Yes	Remove MPLS header and perform normal IP forwarding.
TLS	Yes	Remove MPLS header and parse encapsulated Ethernet frame as if it were received.
IP or TLS	No	Pop the label and repeat processing on the next label.

The MPLS module does not limit the number of labels that can be popped by the egress LSR function, as indicated in Table 90.

When the switch performs label swapping as a transit or intermediate LSR, no hard limits are imposed on the maximum size of the label stack, other than the constraint of not exceeding the maximum frame size supported by the physical links comprising the LSP. You should enable jumbo frame support on the ports that are members of an MPLS VLAN. The jumbo frame size should be set to accommodate the addition of a maximally-sized label stack. For example, a jumbo frame size of at least 1530 bytes is needed to support a two-level label stack on a tagged Ethernet port and a jumbo frame size of at least 1548 bytes is needed to support a TLS encapsulated MPLS frame.

About MPLS Layer-2 VPNs

As networks grow and become more pervasive, the need to separate the physical network infrastructure from the logical network or VLAN organization has become increasingly important. By logically separating the network topology from the service provided by the physical network, services are more easily managed, reliability through increased redundancy is improved, and you gain more efficient use of the physical network infrastructure.

By mapping a VLAN to a specific set of MPLS tunnels, you can create virtual private networks (VPNs). Within a VPN, all traffic is opaquely transported across the service provider network. Each VPN can be managed and provisioned independently.

VPNs may have two or more customer points of presence (PoP). All PoPs are interconnected using point-to-point tunnels. If there are two PoPs in the VPN, the VPN is considered to be point-to-point. If there are more than two PoPs in the VPN, the VPN is considered to be multipoint. Multipoint VPNs can be fully-meshed or hub-and-spoke.

Layer-2 VPNs are constructed from a set of interconnected point-to-point MPLS tunnels. Tunnel endpoint nodes operate as virtual VPN switches, bridging traffic between tunnels and the local egress VLAN. MAC caching is integrated into the MPLS module. Source MAC addresses within each VPN are associated with the tunnel from which the packet is received. Up to 256K MAC addresses can be cached. Within a VPN, once a MAC address has been learned, unicast traffic destined to the cached MAC address is transmitted over a single tunnel. Integrated VPN MAC caching enhancement increases network performance and improves VPN scalability.

For information about configuring MPLS Layer-2 VPNs, see Chapter 28.

About IP Unicast Forwarding

IP unicast forwarding is performed on the MPLS module to facilitate implementation of MPLS and accounting. When MPLS or accounting functions are enabled, the MPLS module, rather than the switch fabric hardware, performs layer-3 IP unicast forwarding. Layer-2 switching and Layer-3 IP multicast forwarding are unaffected.

The MSM distributes its IP unicast routing table, ARP table, MPLS incoming label mappings (ILMs), FEC-to-NHFLE database, and interface IP addresses to each MPLS module so that every MPLS module contains the same IP routing database.

Each MPLS module has sufficient capacity to support 256K IP longest prefix match lookup route entries. Each route entry also supports up to four equal-cost paths. IP forwarding is configurable per VLAN.

Each MPLS module IP routing database provides an aggregate IP forwarding throughput of up to 4 Gbps. The total forwarding throughput for a single BlackDiamond chassis can be scaled up to 16 Gbps by adding up to four MPLS modules. MPLS modules interface to the BlackDiamond switch fabric via four 1 Gbps internal links. IP unicast traffic is internally forwarded from the BlackDiamond I/O modules using one of three backplane load-sharing policies: port-based, address-based, or round-robin. See Chapter 17 for more information.

About Destination-Sensitive Accounting

Destination-sensitive accounting allows you to bill your customers at different rates depending upon the destination of the IP unicast packets they send.

Destination-sensitive accounting categorizes IP unicast packets according to two parameters:

- The ID of the VLAN from which the packet was received
- The accounting bin number associated with the route used to forward the packet

For each category, 64-bit counts of both the number of packets and number of bytes forwarded, including those locally delivered to the MSM CPU, are collected. Eight accounting bin numbers, with values from 0-7, are available for each of the possible 4096 VLAN IDs. This yields a maximum of 32768 sets of accounting statistics.

You use accounting statistics to bill your customers. For a given set of statistics, the source VLAN ID identifies the customer and the accounting bin number corresponds to a billing rate.

Use the ExtremeWare `route-map` function to configure policies that assign accounting bin numbers to IP routes. Bin 0 is the default bin. Any route that does not have an explicit bin assignment via the `route-map` function defaults to bin 0.

You retrieve accounting statistics via the command-line interface (CLI) and Simple Network Management Protocol (SNMP).

About the MPLS Module

The MPLS module contains a powerful set of network processors specifically programmed to implement the MPLS function. The card has no external ports, but contains four full-duplex gigabit Ethernet internal ports to the BlackDiamond backplane switch fabric. Each internal processor provides media speed packet processing for two internal full-duplex gigabit Ethernet ports. The MPLS module operates in a one-armed fashion: receiving frames from the switch fabric, processing the frames, and transmitting the frames back into the switch fabric to the appropriate I/O module output port.

NOTE

MPLS modules are only compatible with "i" series MSM modules.

Summary of Features

The MPLS module includes the following features:

- **MultiProtocol label switching (MPLS)**—MultiProtocol Label Switching (MPLS) is a forwarding algorithm that uses short, fixed-length labels to make next-hop forwarding decisions for each packet in a stream.
- **Selective Longest Prefix Match—**IP unicast packets are routed in the ARM hardware using a longest prefix match (LPM) algorithm. This differs from the BlackDiamond switch fabric, which uses an exact match algorithm. The BlackDiamond switch fabric has great forwarding capacity, but the ARM module has better handling of large numbers (hundreds of thousands) of destination IP addresses to match each packet's destination IP address. To take advantage of the BlackDiamond switch fabric forwarding capacity and the ARM module's scalability, the ARM module can be configured to use the BlackDiamond switch fabric for some routes and the ARM's LPM for others. This feature is called Selective Longest Prefix Match (Selective-LPM).
- **Destination-sensitive accounting**—Counts of IP packets and bytes are maintained based on the IP routes used to forward packets. Destination-sensitive accounting gives you the flexibility to bill your customers at predetermined and different rates. The rates are based on the customers' IP unicast packet destinations.

  The accounting feature categorizes IP unicast packets using two parameters, input VLAN ID and accounting bin number. The VLAN ID is used to identify from which customer the packet is received. The accounting bin number is associated with the route used to forward the packet. External billing application servers can correlate the accounting bin number to a specific billing rate.

Configuring the MPLS Module

This section describes how to configure the MPLS module. For hardware installation information for the BlackDiamond 6800 series switch, see the *Extreme Networks Consolidated "i" Series Hardware Installation Guide*.

NOTE

Documentation for Extreme Networks products is available at the Extreme Networks home page at http://www.extremenetworks.com/.

This section describes how to configure:

- MPLS interfaces
- LDP
- OSPF support
- QoS support
- Filter support

Configuring MPLS Interfaces

To configure MPLS interfaces, first enable MPLS on the router by using the following command:

```
enable mpls
```

Next, enable MPLS on a specific VLAN or on all VLANs, using the following command:

```
configure mpls add vlan [<vlan name> | all] {ldp | rsvp-te}
```

MPLS must be enabled on all VLANs that transmit or receive MPLS-encapsulated frames. Using the `configure mpls add vlan` command causes the LDP neighbor discovery process to begin on the specified VLAN.

NOTE

The specified VLAN must be configured with an IP address, and have IP forwarding enabled. IGMP snooping must also be enabled on the switch.

If `all` VLANs are selected, MPLS is enabled on all VLANs that have an IP address and IP forwarding enabled. This command optionally enables LDP or RSVP-TE for the specified VLAN. If not specified, both LDP and RSVP-TE are enabled on the specified VLAN.

If you have enabled MPLS on an OSPF interface that is used to reach a particular destination, make sure that you enable MPLS on all additional OSPF interfaces that can reach that same destination (for example, enable MPLS on all VLANs that are connected to the backbone network).

Configuring the Maximum Transmission Unit Size

After you have enabled MPLS, you can configure the maximum transmission unit (MTU) size using the following command:

```
configure mpls vlan [<vlan name> | all] ip-mtu <number>
```

This command configures the IP MTU for frames transmitted onto MPLS LSPs via the specified egress VLAN. The default settings is 1496 bytes. If `all` is selected, the configuring MTU applies to all MPLS-enabled VLANs.

This command applies to the ingress LSR only when a received IP packet is destined for an MPLS LSP. In this case, if the length of the IP packet exceeds the configured MTU size for the egress VLAN and the Don't Fragment (DF) bit is *not* set in the IP header of the packet, the packet is fragmented before it is forwarded onto an MPLS LSP. If the DF bit is set in the packet header, Path MTU Discovery starts.

Fragmentation is based on either the minimum value of the configured MPLS IP MTU size or the configured IP MTU size for the egress VLAN. (The IP MTU size is configured using the `configure ip-mtu <number> vlan <vlan name>` command.)

You should configure the MPLS IP MTU so that the addition of the MPLS label stack the link layer header does not cause the packet to be too large to be transmitted on the egress ports. To avoid potential problems, you should enable jumbo frame support on all ports that are members of an MPLS VLAN.

Configuring the Propagation of IP TTL

To enable or disable the propagation of the IP time-to-live (TTL) function, use the following command:

```
configure mpls propagate-ip-ttl [enabled | disabled]
```

This command enables and disables the propagation of the IP TTL value for routed IP packets. The default setting is enabled.

NOTE

You must maintain identical `propagate-ip-ttl` *settings on all LERs in the MPLS domain. Not doing so may cause packets to loop endlessly and not be purged from the network if a routing loop is inadvertently introduced.*

When `propagate-ip-ttl` is disabled, the LSP is viewed as a point-to-point link between the ingress LSR and the egress LSR. Intermediate LSRs in the MPLS network are not viewed as router hops (from an IP TTL perspective). In this case, the IP TTL is decremented once by the ingress LSR and once by the egress LSR. When disabled, the MPLS TTL is set to 255 by the ingress LSR and is independent of the IP TTL.

When `propagate-ip-ttl` is enabled, each LSR is viewed as a router hop (from an IP TTL perspective). When a packet traverses an LSP, it emerges with the same TTL value that it would have had if it had traversed the same sequence of routers without being label-switched. When enabled, the MPLS TTL field is initially set by the IP TTL field at the ingress LSR, and the IP TTL field is set to the MPLS TTL by the egress LSR.

Configuring Penultimate Hop Popping

To enable or disable PHP, use the following command:

```
configure mpls php [enabled | disabled]
```

This command enables or disables whether PHP is requested by the egress LER.

When PHP is enabled, PHP is requested on all LSPs for which the switch is the egress LER.

PHP is requested by assigning the Implicit Null Label in an advertised mapping. PHP is always performed when requested by an egress LSR (for example, when the switch is acting as an intermediate LSR). The Implicit Null Label is always used in conjunction with routes exported by OSPF, regardless of the PHP configuration.

This command can only be executed when MPLS is disabled. The default setting is disabled.

Configuring QoS Mappings

To configure QoS mappings, use the following command:

```
configure mpls qos-mapping [dot1p-to-exp | exp-to-dot1p] [all |
<input_value>]/<output_value>
```

This command configures MPLS QoS mappings. If `all` is specified, all input values are mapped to the specified `<output_value>`. The valid range of integers for the `<input_value>` and the `<output_value>` is 0 to 7. By default, the mapping tables are initialized such than an `<input_value>` of *n* is mapped to an `<output_value>` of *n*.

Two mappings are supported:

- dot1p-to-exp
- exp-to-dot1p

Dot1p-to-exp Mappings

The dot1p-to-exp mappings are used by the ingress LSR. When a non-MPLS ingress frame arrives at the MPLS module, the frame always contains an IEEE 802.1p priority field.

The value of the priority field is set based on the QoS classification performed by the ingress I/O module. The ingress I/O modules assign each packet to a hardware queue, based on the configured ExtremeWare QoS policies. There is a one-to-one mapping between the hardware queue and the 802.1p priority values that are inserted into frames forwarded to the MPLS module. For example, the 802.1p priority value is set to 0 for frames forwarded from hardware queue 0, set to 1 for frames forwarded from hardware queue 1, and so on.

The dot1p-to-exp table maps 802.1 priority values to MPLS EXP values. The table is completely flexible, such that any 802.1p priority `<input_value>` can be mapped to any EXP `<output_value>`. The EXP output_value is set in the MPLS header of the packet as it is forwarded to the MPLS network.

Exp-to-dot1p Mappings

The exp-to-dot1p mappings are used when the switch performs label swapping as an intermediate LSR and when the switch is the egress LSR. In both of these cases, the MPLS module receives an MPLS-encapsulated frame.

The EXP field in the frame is used as an `<input_value>` to the exp-to-dot1p table. The corresponding `<output_value>` is an 802.1p priority value. The 802.1p priority value is inserted into the frame before the frame is forwarded by the MPLS module.

The exp-to-dot1p table is completely flexible, such that any EXP `<input_value>` can be mapped to any 802.1p priority `<output_value>`.

The exp-to-dot1p table is also used by Packet over SONET (PoS) ports when classifying MPLS-encapsulated packets received from the SONET link. When a PoS port receives an MPLS-encapsulated packet from the SONET link, the packet is classified based on the EXP value in the MPLS shim header. The EXP value from the received frame is used as an index into the exp-to-dot1p mapping table to retrieve and 802.1p priority value. The frame is then assigned to a QoS profile, based on the retrieved 802.1p priority value. The mappings between 802.1p priority values and QoS profiles are configured using the following command:

```
configure dot1p type
```

NOTE

For more information on QoS, see Chapter 8. For more information on the PoS module, see Chapter 24.

Resetting MPLS Configuration Parameter Values

To reset MPLS configuration parameters to their default values, use the following command:

```
unconfigure mpls
```

This command resets the following configuration parameters:

- IP-MTU
- LDP propagation filter settings on all VLANs
- LDP advertisement filter settings
- LDP session timers
- RSVP-TE interface parameters
- RSVP-TE profile parameters
- Settings for propagate-ip-ttl
- QoS mapping tables

To restore the default values for the QoS mapping tables, use the following command:

```
unconfigure mpls qos-mapping [dotp-to-exp | exp-to-dot1p | lsp <lsp_name>]
```

The default contents of either QoS mapping table maps an input value of *n* to an output value of *n*.

Displaying MPLS Configuration Information

You can display MPLS information about the following topics:

- MPLS configuration information for the entire switch or for a specific VLAN
- MPLS forwarding entry information
- MPLS LDP peer information
- MPLS RSVP-TE peer information
- MPLS label mapping information
- MPLS QoS mapping information

Displaying MPLS Configuration Information

To display MPLS configuration information, use the following command:

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

When the `vlan` parameter is omitted, this command displays the values of all MPLS configuration parameters that apply to the entire switch, the current status of peer LSRs, and a list of the VLANs for which MPLS is enabled.

When the `vlan` parameter is specified, this command displays the current values of the MPLS configuration parameters that are specific to the VLAN.

If the optional `detail` keyword is specified, additional detailed VLAN information is displayed.

Displaying MPLS Interface Information

To display MPLS interface information, use the following command:

```
show mpls interface {ldp | targeted-ldp | rsvp-te}
```

When the optional parameters are omitted, this command displays information for all of the configured MPLS VLAN interfaces. When the `ldp`, `rsvp-te`, or `targeted-ldp` parameters are supplied, this command will display only those interfaces of that type.

When the `vlan` parameter is specified, this command displays the current values of the MPLS interface parameters that are specific to the VLAN.

Displaying MPLS Forwarding Entry Information

To display MPLS forwarding entry information, use the following command:

```
show mpls forwarding {summary | detail | inactive | host <ipaddress> {detail |
inactive} | prefix <ipaddress/masklength> {detail | inactive} | rsvp-te <ipaddress>
{detail}}
```

This command displays information from the Forwarding Equivalence Class (FEC)-to-Next Hop Label Forwarding Entry (NHLFE) database. This command also displays information for RSVP-TE LSPs.

If the `host` or `prefix` keywords are specified, summary information is displayed for a single FEC. Use the `summary` keyword to display summary route information associated with labeled paths.

By default, the information displayed includes:

- Next hop IP address
- Outgoing label
- Interface number of the outgoing VLAN

If the `detail` keyword is specified, the following additional information is displayed:

- Outgoing port number
- Counts of packets and bytes that have been transmitted using the database entry

By default, information is displayed for active mappings. To display information for liberally-retained inactive mappings, use the inactive keyword. An inactive mapping is a mapping that was received from an LDP peer, but is not being used to reach the associated FEC. Using the `inactive` keyword causes inactive mappings to be displayed. The inactive keyword does not apply to RSVP-TE LSPs, because RSVP-TE operates in downstream-on-demand mode.

Displaying MPLS Label Mapping Information

To display MPLS label mapping information, use the following command:

```
show mpls label {summary {detail} | <label_number> {detail} | host <ipaddress>
{detail} | prefix <ipaddress/masklength> {detail} | rsvp-te <ipaddress> {detail}}
```

This command displays information from the Incoming Label Map (ILM), which is used when forwarding packets that arrive labeled as MPLS packets.

When the `label_number` parameter is omitted, summary information is displayed for all incoming label assignments that have been made by the switch. When the `label_number` is specified, summary information is displayed for the label.

Use the `fec` keyword to display the label associated with an FEC. You can specify both host and prefix FEC types. The `summary` keyword displays the number of labels allocated from each label range partition.

By default, the information displayed includes:

- Next hop IP address
- Outgoing and incoming labels
- Interface number of the outgoing VLAN
- FEC associated with the incoming label

If the detail keyword is specified, the following additional information is displayed:

- Outgoing port number
- Counts of packets and bytes that have been received with the incoming label
- Counts of packets and bytes that have been transmitted with the outgoing label
- LSP type

This command also displays information from the Incoming Label Map (ILM) for RSVP-TE LSPs.

Displaying MPLS QoS Mapping Information

To display MPLS QoS mapping information, use the following command:

```
show mpls qos-mappings
```

Configured mappings for both dot1p-to-exp and exp-to-dot1p are displayed.

Configuring the Label Distribution Protocol (LDP)

This section describes the Label Distribution Protocol (LDP), part of MPLS, and covers the following topics:

- Overview of MPLS on page 682
- Configuring LDP on page 698

- Configuration Example on page 706

Overview of LDP

The Label Distribution Protocol (LDP) is a protocol defined by the IETF for the purpose of establishing an MPLS LSP. Using LDP, peer LSRs exchange label binding information to create the LSP.

LDP Neighbor Discovery

LDP includes a neighbor discovery protocol that runs over UDP. Using the basic discovery mechanism, each LSR periodically multicasts a hello message to a well-known UDP port to which all LSRs listen. These hello messages are transmitted to the *all routers on this subnet* multicast group. When a neighbor is discovered, a hello-adjacency is formed and the LSR with the numerically greater IP address is denoted as the active LSR.

Hello messages must continue to be received periodically for the hello-adjacency to be maintained. The hold time that specifies the duration for which a hello message remains valid defaults to 15 seconds in the basic discovery mechanism and can be negotiated by the peer LSRs as part of the HELLO exchange. During the HELLO exchange, each LSR proposes a value and the lower of the two is used as the hold time.

Targeted LDP Sessions between nondirectly connected LSRs are supported using an extended discovery mechanism. In this case, targeted hello messages are periodically sent to a specific IP address. The default HELLO time for targeted LDP sessions is 45 seconds.

After the hello-adjacency is formed, the active LSR initiates establishment of a TCP connection to the peer LSR.   At this point, an LDP session is initiated over the TCP connection. The LDP session consists of an exchange of LDP messages that are used to setup, maintain, and release the session.

Advertising Labels

You can control whether labels are advertised for:

- Direct routes
- RIP routes exported by OSPF
- Static routes exported by OSPF

To conserve label space, the Implicit NULL Label is advertised for RIP and static routes exported by OSPF. The Implicit NULL Label is advertised for direct routes when PHP is enabled.

Propagating Labels

LDP propagates labels for FECs that exactly match a routing table entry, with the exception of mappings for 32-bit prefixes corresponding to OSPF router IDs (where the router ID IP addresses are dynamically learned from the advertising router field of received OSPF router and AS external LSAs).

Configuring LDP

This section describes the following tasks:

- Configuring LDP on a VLAN on page 699

- Configuring LDP Filters on page 699
- Configuring LDP Session Timers on page 700
- Restoring LDP Session Timers on page 701
- Displaying LDP Peer Information on page 701

Configuring LDP on a VLAN

To configure LDP on a VLAN, use the following command:

```
configure mpls add vlan [<vlan name> | all] {ldp | rsvp-te}
```

This command enables LDP on one of all VLAN. If not specified, both LDP and RSVP-TE are enabled on the specified VLAN.

To disable LDP on a VLAN, use the following command:

```
configure mpls delete vlan [<vlan name> | all] {ldp | rsvp-te}
```

This command disables LDP on one or all VLANs. This command terminates all LDP sessions and all established LDP LSPs.

Configuring LDP Filters

You can configure two types of LDP filters:

- Label propagation filters
- Label advertisement filters

Configuring an LDP Label Propagation Filter. To configure an LDP label propagation filter, use the following command:

```
configure mpls vlan [<vlan name> | all] ldp propagate [all | none | route-map
<route_map>]
```

This command configures a filter to be used by LDP when propagating unsolicited label mappings to all LDP neighbors on the specified VLAN. If all VLANs are selected, the settings of this command apply to all MPLS-enabled VLANs.

You can configure the propagation filter, as follows:

- `all`—Unsolicited label mappings are propagated to the VLAN. This is the default setting.
- `none`—No unsolicited label mappings are propagated to the VLAN.
- `route-map <route_map>`—The specified route map is used to permit or deny the propagation of unsolicited label mappings to the VLAN.

  The only supported route map match operation keyword is `nlri-list`. If selected, the access_profile parameter of the `nlri-list` keyword is compared to the FEC that is associated with each label mapping.

NOTE

For more information on route maps, see Chapter 12.

Configuring an LDP Label Advertisement Filter. To configure an LDP label advertisement filter, use the following command:

```
configure mpls ldp advertise [direct | rip | static] [all | none | route-map
<route_map>]
```

This command configures a filter to be used by LDP when originating unsolicited label mapping advertisements to LDP neighbors.

You can configure how the advertisement filter is applied, as follows:

- `direct`—The advertisement filter is applied to the FECs associated with direct routes exported by OSPF.
- `rip`—The advertisement filter is applied to the FECs associated with RIP routes exported by OSPF.
- `static`—The advertisement filter is applied to the FECs associated with static routes exported by OSPF.

You can configure the advertisement filter, as follows:

- `all`—All unsolicited label mappings are originated for all routes of the specified type (direct, RIP, or static). This is the default setting for direct routes.
- `none`—No unsolicited label mappings are originated for all routes of the specified type. This is the default setting for RIP and static routes.
- `route-map <route_map>`—The specified route map is used to permit or deny the origination of unsolicited label mappings for all routes of the specified type.

  The only supported route map match operation keyword is `nlri-list`. If selected, the access_profile parameter of the `nlri-list` keyword is compared to the FEC that is associated with each route.

RIP and static routes are advertised with the Implicit NULL label and direct routes are advertised with an MPLS label, unless PHP is enabled.

You can control the number of labels advertised using the `configure mpls ldp advertise` command. Advertising labels for a large number of routes may increase the required number of labels that must be allocated by LSRs. Take care to insure that the number of labels advertised by LERs does not overwhelm the label capacity of the LSRs.

Configuring LDP Session Timers

To configure LDP session timers, use the following command:

```
configure mpls [ldp | targeted-ldp] [hello | keep-alive] <hold_time> <interval_time>
```

LDP session timers are separately configurable for LDP and targeted LDP sessions. The `hello <hold_time> <interval_time>` parameter specifies the amount of time (in seconds) that a hello message received from a neighboring LSR remains valid. If a hello message is not received from a particular neighboring LSR within the specified `hello <hold_time>`, the hello-adjacency is not maintained with that neighboring LSR.

The session `keep-alive <hold_time> <interval_time>` parameter specifies the time (in seconds) during which an LDP message must be received for the LDP session with a particular peer LSR to be maintained. If an LDP PDU is not received within the specified session `keep-alive <interval_time>`, the corresponding LDP session is torn down.

The minimum and maximum values for both the `hello <hold_time> <interval_time>` and `keep-alive <hold_time> <interval_time>` are 6 and 65,534, respectively.

The default values are as follows:

- ldp hello <hold_time> – 15
- targeted-ldp hello <hold_time> – 45
- ldp hello <interval_time> – 5
- targeted-ldp hello <interval_time> – 15
- ldp keep-alive <hold_time> – 40
- targeted-ldp keep-alive <hold_time> – 60
- ldp keep-alive <interval_time> – 13
- targeted-ldp keep-alive <interval_time> – 20

This command can only be executed when MPLS is disabled.

Restoring LDP Session Timers

To restore the default values for LDP session timers, use the following command:

```
unconfigure mpls
```

This command can only be executed when MPLS is disabled.

Displaying LDP Peer Information

To display MPLS LDP peer information, use the following command:

```
show mpls ldp {<ipaddress>} {detail}
```

This command displays information about the status of LDP peers. Summary information is displayed for all known LDP peers and LDP peer sessions. If you specify the `<ipaddress>` of the LDP peer, information for a single LDP peer is displayed. To display additional information in the comprehensive detailed format, use the `detail` keyword.

By default the information displayed includes:

- Peer type (targeted or not targeted)
- Peer sessions
- Peer state
- Uptime

If you specify the `detail` keyword, the following additional information is displayed:

- Discontinuity time
- Negotiated label distribution
- Next hop address

MPLS and IP Routing

This section describes how MPLS and IP routing work together to forward information on your network.

This section covers the following topics:

- Routing Using LSPs on page 702
- LSPs and IBGP Next Hops on page 705
- Optimized Forwarding of Non-MPLS IP Traffic on page 705

MPLS provides a great deal of flexibility for routing packets. Received IP unicast frames can be transmitted over LSPs or routed normally. If a matching FEC exists for the received packet, the packet is transmitted over an LSP that is associated with the FEC. The packet is encapsulated using an MPLS shim header before being transmitted.

Received MPLS packets can be label switched or routed normally toward the destination. Packets that are in the middle of an LSP are label switched. The incoming label is swapped for a new outgoing label and the packet is transmitted to the next LSR. For packets that have arrived at the end of an LSP (the egress end of the LSP), the label is popped. If this label is the bottom of the stack, the shim header is stripped and the packets are routed to the destination as normal IP packets.

NOTE

Multicast routing is not supported.

An MPLS domain is generally defined to be an OSPF or IS-IS autonomous system (AS). You can use MPLS to reach destinations inside one of these AS types. You can also use MPLS to reach destinations outside of an OSPF AS.

Routing Using LSPs

This section describes the following topics:

- Routing Using Direct and Indirect LSPs on page 702
- LSP Precedence and Interaction on page 704
- Equal Cost LSPs on page 704
- Overriding IBGP Metrics for RSVP-TE LSPs on page 705

Routing Using Direct and Indirect LSPs

Using MPLS, two types of LSPs can be used to route a packet to its destination:

- Direct LSP

  An LSP is considered direct with respect to an FEC if it has been associated with the FEC via LDP or RSVP-TE. Direct LSPs are supported for both OSPF and IS-IS IGP networks.

- Indirect LSP

  An LSP is considered indirect with respect to an FEC if it has been associated with the FEC via a routing protocol. Indirect LSPs are supported for both OSPF and IS-IS IGP networks only.

Figure 139 illustrates the concept of direct and indirect LSPs.

Figure 139: Direct and indirect LSPs

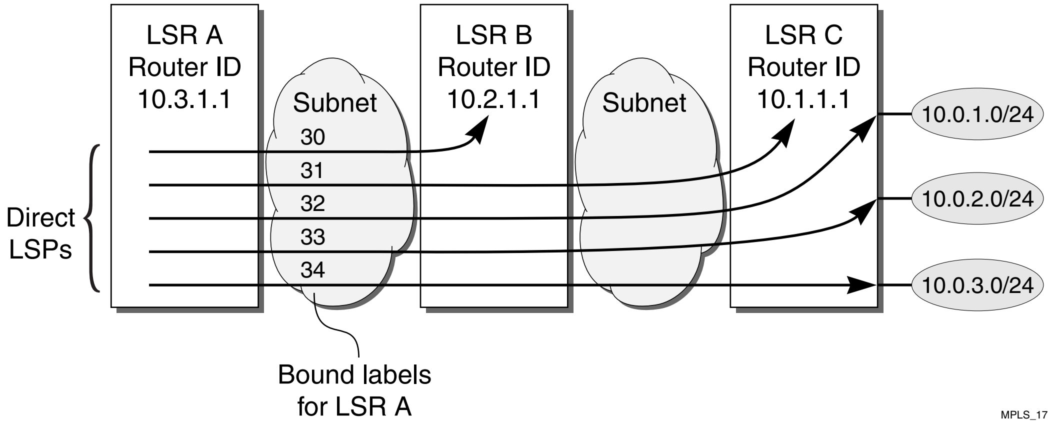


Table 91 describes the label bindings in the MPLS forwarding table for LSR A that are maintained for FECs reachable via LSR A to LSR C, shown in Figure 139.

Table 91: Label Bindings for LSR A

Destination	Next Hop	Direct LSP Label	Indirect LSP Label
10.1.1.1/32	10.2.1.1	31	30
10.0.1.0/24	10.2.1.1	32	31
10.0.2.0/24	10.2.1.1	33	31
10.0.3.0/24	10.2.1.1	34	31

A direct LSP is always preferred over an indirect LSP. When a route table entry is added or updated, MPLS first checks for the existence of a direct LSP. If a direct LSP exists, the information is simply added to the route table entry at that time.

Managing indirect LSP entries is more involved. The OSPF Shortest Path First (SPF) algorithm determines the availability of indirect LSPs through an egress router. The intra-area SPF algorithm begins with the calculating router as the root of a graph. The graph is expanded by examining the networks connected to the root and then the routers connected to those networks. Continuing in this manner, the graph is built as a series of parent and child nodes. A check is made for a direct LSP as each entry is added. A check is also made for an indirect LSP that can be inherited from the parent node. Thus, for each route table entry, the modified SPF algorithm determines whether a direct LSP is available and whether an indirect LSP is available for use whenever a direct LSP is not present.

This design allows label mapping changes for direct LSPs to be managed without requiring an SPF recalculation. An SPF recalculation is performed when advertisements and withdrawals of label mappings for /32 FECs are received, which is analogous to the situation where an OSPF link changes state.

The modification to the SPF algorithm described above is important, because it enables the capabilities provided by LDP or RVSP-TE LSPs to be fully utilized, while minimizing the resources devoted to label management.

For example, in a network where all the LSRs implement this feature (such as an all-Extreme MPLS network), labels only need to be advertised for the router IDs of the LSRs. Yet, LSPs can still be used to route traffic destined for any OSPF route.

More specifically, LSPs can be used for all routes advertised by OSPF, with the possible exception of LDP LSPs to routes summarized by OSPF area border routers (ABRs). The problem with using routes summarized by OSPF ABRs is that route summarization can prevent label mappings from being propagated for the links internal to the area being summarized, since a LSR will typically only propagate labels for FECs that exactly match a routing table entry.

LSP Precedence and Interaction

LSPs can be LDP or RSVP-TE based, and can be either direct or indirect with respect to a given set. RSVP-TE based LSPs are preferred over LDP LSPs and direct LSPs are preferred over indirect LSPs. Routed IP traffic always flows over an LSP, if one is available. Therefore, if an LSP is established or torn down, routed IP traffic may flow over a more preferred or next best LSP, respectively. These changes take place whenever there is an OSPF routing topology change, LDP label advertisement event, or RSVP-TE signaling action.

Traffic is never load-shared across LSPs of different types. For example, if multiple LSPs exist for an FEC that has one RSVP-TE LSP and four equal-cost LDP LSPs, all IP routed traffic for the FEC flows across the single RSVP-TE LSP (not load-shared among the five active LSPs). If the RSVP-TE LSP is torn down, the IP routed traffic is then load-shared across the four remaining equal-cost LDP LSPs.

Equal Cost LSPs

Traditional IP routers provide session-level IP traffic load distribution across equal cost routed paths. When MPLS is enabled, multiple equal cost routed paths may result in multiple active LSPs for a given FEC. If a label binding for the FEC exists, only the multipath route entries for the FEC that have a label binding are included in the load distribution forwarding table for the FEC. Thus, load distribution of IP traffic is performed over MPLS LSPs or over traditional IP routed paths, but not both simultaneously. MPLS LSPs are always preferred over IP routed paths.

The MPLS module supports distributing IP traffic to an FEC across a maximum of four LSPs. If more than four LSPs are available for an FEC, only four LSP are used. Ingress IP traffic is load-balanced across multiple LSPs using a hashing algorithm based on the IP addresses of the packet. The IP hash algorithm is based on a hash of the source and destination IP addresses. LSR traffic is load balanced across multiple LSPs using a hash algorithm based only on the label stack and MAC addresses of the packet. The label stack and MAC address hash algorithm is based on a hash of the source and destination MAC addresses and the label stack.

TLS tunnels use a two-label stack to tunnel Layer 2 traffic across an IP MPLS domain. If multiple equal-cost LSPs exist to the egress tunnel LSR, TLS tunnel traffic is distributed across the LSPs using multiple two-label stack MPLS headers. Each two-label stack MPLS header has a different outer label, each outer label representing a different NHLFE, with the same inner label representing the TLS VLAN. TLS tunnels can be logically bound to multiple equal-cost LSPs.

As stated earlier, up to four equal-cost LSPs are supported per FEC. Non-IP ingress tunnel traffic is distributed across TLS tunnel LSPs based on the MAC addresses of the packet. Ingress IP tunnel traffic is distributed based on the IP addresses of the packet. The distribution hash algorithms are similar to those previously discussed.

Overriding IBGP Metrics for RSVP-TE LSPs

By default, RSVP-TE LSPs inherit the underlying IGP path cost. You can override the path cost by configuring the LSP IGP metric. The IGP metric can only be specified for RSVP-TE LSPs. RSVP-TE LSPs can be assigned a fixed cost metric, independent of the actual topological IGP cost metric. By controlling the path cost for RSVP-TE LSPs, you can manipulate how different traffic flows are tunneled across an MPLS domain. For example, if the RSVP-TE IGP path cost is set higher than its actual IGP metric, the LSP is not used to transport IP routed traffic, but can still be used to transport TLS VLAN traffic.

LSPs and IBGP Next Hops

You can also use indirect LSPs to reach BGP next hops. For example, an IBGP session is established across the OSPF/MPLS backbone, and the communicating routers run both OSPF and IBGP. When an IBGP route is installed, MPLS determines whether a direct LSP exists to the destination and whether an indirect LSP exists to the BGP next hop. If an indirect LSP exists to the BGP next hop, the LSP is included in the indirect LSP field of the route table entry. If an LSP to an EBGP next hop is not available, a check is made for an LSP to the ASBR used to reach the BGP next hop.

The recalculation requirements for BGP are similar to those for OSPF; when an indirect LSP to an ASBR (corresponding to a BGP next hop router) changes state; the BGP routing table entries must be checked to ensure their LSP information is still valid.

Multivendor Support for Indirect LSPs

To support the use of indirect LSPs, Extreme LSRs automatically advertise a label mapping for a /32 LSP to its OSPF router ID (configured using the `configure ospf routerid` command).

Unfortunately, some MPLS implementations do not support indirect LSPs, and they require that a label mapping be advertised for each FEC. If your MPLS network includes equipment that does not support indirect LSPs, you must use configuration commands to explicitly control the advertising of labels.

Optimized Forwarding of Non-MPLS IP Traffic

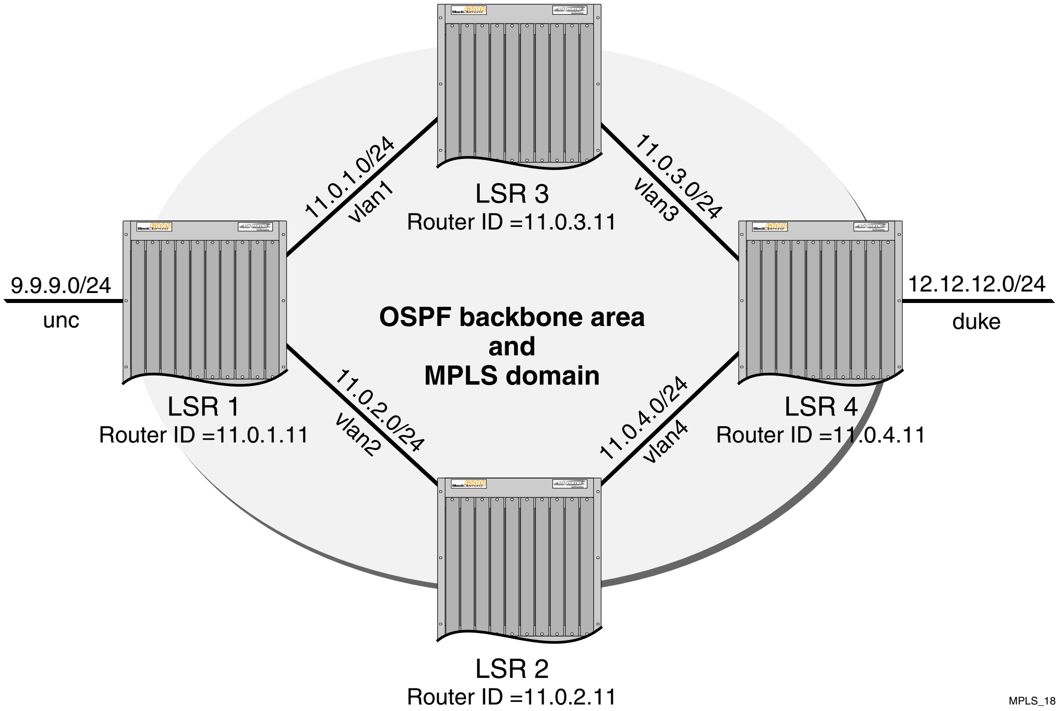
By default, IP packets received by the switch are passed to the MPLS module for IP forwarding. This allows IP packets to be forwarded into LSPs. However, not all IP routes necessarily have LSPs as their next hops. When the MPLS module finds that the route for an IP packet has a normal IP next hop (no LSP to the destination IP address), it sends the destination IP address of the packet to the MSM. The MSM then installs an IP FDB entry for that IP address. From that point, until a routing change causes the IP FDB entry to be deleted or the destination IP address becomes reachable via a newly established LSP, IP packets for that IP address are forwarded by the switch without going through the MPLS module.

This installation of IP FDB entries is disabled when Destination-Sensitive Accounting is enabled.

Configuration Example

The network configuration, shown in Figure 140, illustrates how to configure a BlackDiamond switch to support a routed MPLS network.

Figure 140: MPLS configuration example



The four switches, labeled LSR 1, LSR 2, LSR 3, and LSR 4, have the same physical hardware configuration. Each switch contains an F48ti module, a G8xi module, an MPLS module, and an MSMi module. The switches are all interconnected via Gigabit Ethernet to form the OSPF backbone area and the MPLS domain. In this example, two directly connected OSPF-disabled VLANs are shown: *unc* and *duke*. Traffic between *unc* and *duke* follows routed paths over indirect LSPs established between LSR 1 and LSR 4.

The commands used to configure LSR 1 are described below. The remaining LSRs are configured similarly.

The following commands configure the module types for the specific BlackDiamond slots:

```
configure slot 2 module f48t
configure slot 3 module g8x
configure slot 7 module mpls
```

The following command sets the maximum jumbo frame size for the switch chassis to 1600:

```
configure jumbo-frame size 1600
```

The following commands create the VLANs:

```
create vlan vlan1
create vlan vlan2
create vlan unc
```

The following commands configure the VLAN IP address and assign ports participating in each VLAN:

```
configure vlan vlan1 ipaddress 11.0.1.1/24
configure vlan vlan1 add port 3:2 untagged
configure vlan vlan2 ipaddress 11.0.2.1/24
configure vlan vlan2 add port 3:3 untagged
configure vlan unc ipaddress 9.9.9.0/24
configure vlan unc add port 2:24 untagged
```

The following commands enable IP packet forwarding for the specified VLANs:

```
enable ipforwarding vlan1
enable ipforwarding vlan2
enable ipforwarding unc
```

The following commands enable IP forwarding on the configured VLANs. The MTU size is increased on the MPLS VLANs to accommodate the MPLS shim header:

```
enable ipforwarding vlan vlan1
configure ip-mtu 1550 vlan vlan1
enable ipforwarding vlan vlan2
configure ip-mtu 1550 vlan vlan2
enable ipforwarding vlan unc
```

The following command enables MPLS on VLANs vlan1 and vlan2:

```
configure mpls add vlan vlan1
configure mpls add vlan vlan2
```

The following command globally enables MPLS on the switch:

```
enable mpls
```

The following commands add vlan1 and vlan2 to the backbone area, each with a cost of 10. The 0.0.0.0 (backbone) area does not need to be created because it exists by default:

```
configure ospf add vlan vlan2 area 0.0.0.0
configure ospf vlan vlan2 cost 10
configure ospf add vlan vlan1 area 0.0.0.0
configure ospf vlan vlan1 cost 10
```

The following command enables distribution of local (direct) interfaces into the OSPF area:

```
enable ospf export direct cost 10 ase-type-1
```

The following commands configure the OSPF router ID on the switch and enable the distribution of a route for the OSPF router ID in the router LSA. Originating the router ID as a host route allows other routers in the same OSPF area to establish indirect LSPs for external routes to this router:

```
configure ospf routerid 11.0.1.11
enable ospf originate-router-id
```

The following command enables OSPF:

```
enable ospf
```

MPLS Configuration Constraints

MPLS has the following configuration constraints:

- **GVRP—**GVRP is not supported over MPLS LSPs.
- **Server Load Balancing (SLB)**—SLB and MPLS are mutually exclusive functions. Both functions cannot be simultaneously enabled.
- **IP flow redirection—**IP flow redirection commands and MPLS are mutually exclusive functions. Both functions cannot be enabled simultaneously.
- **IGMP snooping—**OSPF and LDP session establishment require the MSM to receive and process IP multicast frames. Therefore, IGMP snooping must be enabled to support MPLS.

27 Configuring RSVP-TE

This chapter describes the Resource Reservation Protocol (RSVP), traffic engineering (TE) extensions to RSVP, and how you configure RSVP-TE using ExtremeWare.

This chapter covers the following topics:

- RSVP Elements on page 710
- Traffic Engineering on page 714
- RSVP Features on page 715
- Configuring RSVP-TE on page 718
- Configuration Example on page 724

RSVP is a protocol that defines procedures for signaling QoS requirements and reserving the necessary resources for a router to provide a requested service to all nodes along a data path.

RSVP is not a routing protocol. It works in conjunction with unicast and multicast routing protocols. An RSVP process consults a local routing database to obtain routing information. Routing protocols determine where packets get forwarded; RSVP is concerned with the QoS of those packets that are forwarded in accordance with the routing protocol.

Reservation requests for a flow follow the same path through the network as the data comprising the flow. RSVP reservations are unidirectional in nature, and the source initiates the reservation procedure by transmitting a path message containing a traffic specification (Tspec) object. The Tspec describes the source traffic characteristics in terms of peak data rate, average data rate, burst size, and minimum/maximum packet sizes.

RSVP-TE is a set of traffic engineering extensions to RSVP. RSVP-TE extensions enable RSVP to be used for traffic engineering in MPLS environments. The primary extensions add support for assigning MPLS labels and specifying explicit paths as a sequence of loose and strict routes. These extensions are supported by including label request and explicit route objects in the path message. A destination responds to a label request by including a label object in its reserve message. Labels are then subsequently assigned at each node the reserve message traverses. Thus, RSVP-TE operates in downstream-on-demand label advertisement mode with ordered LSP control.

NOTE

ExtremeWare does not support native RSVP. RSVP is supported only on TE LSPs.

RSVP Elements

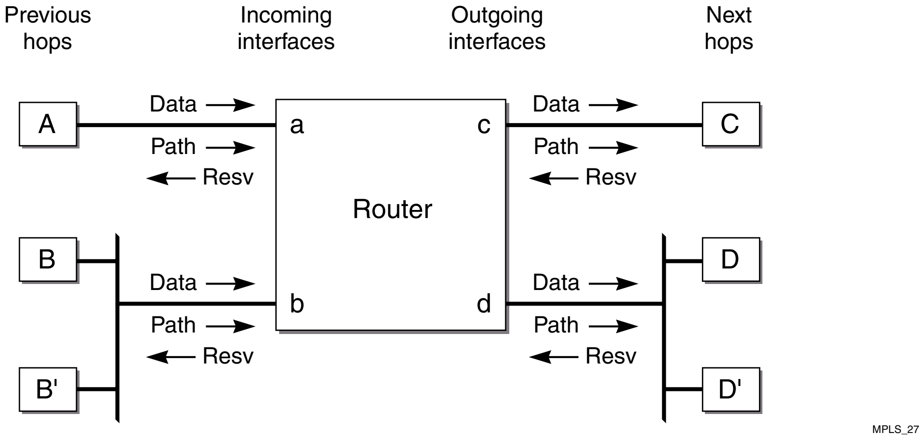
This section describes the following elements of the RSVP protocol:

- Message Types on page 710
- Reservation Styles on page 712
- Bandwidth Reservation on page 712

Message Types

RSVP has two basic message types, path message and reserve message, as shown in Figure 141.

Figure 141: RSVP Messages



In addition to the path and reserve messages, RSVP has the following additional message types:

- Path error message
- Reservation error message
- Path tear message
- Reserve tear message
- Reservation confirm message

Path Message

The RSVP path message is used to store state information about each node in the path. Each RSVP sender periodically transmits a path message downstream along the route for each data path. The path state includes, at minimum, the IP address of the previous hop node. This IP address is used to route the reserve message on a hop-by-hop basis, in the reverse direction.

In addition to the previous hop address, the path message contains the sender Tspec and Adspec. The reservation message carries the flowspec.

Reservation Message

Each receiver host transmits an RSVP reservation request to its upstream neighbor. Reservation messages follow the reverse path that the data packets use. The reservation message creates and maintains a reservation state in each node on the path.

Reservation messages are eventually delivered to the sender, so that the sender can configure appropriate traffic control parameters for the first hop node.

Path Error Message

The path error message is used to report errors that are encountered when processing path or reservation messages. Path error messages travel upstream towards the sender. Path error messages do not modify the state of any node; they are only reported to the sender.

Reservation Error Message

The reservation error message is used to report errors that are encountered when processing reserve messages. In addition, reservation error messages are used to report the spontaneous disruption of a reservation. Reservation error messages travel downstream to the receiver.

Path Tear Message

The path tear message is used to delete a matching path state. When used for a multicast session, path tear messages can only match the path state for the incoming interface on which the path tear message arrived. If there is no matching path state, the path tear message is discarded.

Path tear messages are initiated by senders or by the expiration of the path state timeout. Path tear messages travel downstream towards all receivers. The routing of a path tear message is identical to the corresponding path message.

When a path state is deleted as the result of the path tear message, the related reservation state must also be adjusted to maintain consistency in the node. The adjustment depends on the reservation style.

Reservation Tear Message

The reservation tear message deletes the matching reservation state. If there is no matching reservation state, the message is discarded. The reservation tear message can delete any subset of the filter specification in FF-style or SE-style reservation state. Reservation styles are described in Table 92.

Reservation tear messages are initiated explicitly by receivers or by a node in which the reservation state has timed out. Reservation tear messages travel upstream towards all matching senders.

Reservation Confirm Message

The reservation confirmation message is used to acknowledge a reservation request. Reservation confirmation messages are sent to the receiver host.

Reservation Styles

A reservation style is a set of options that is included in the reservation request.

One reservation style concerns how reservations requested by different senders within the same session are handled. This type of reservation style is handled in one of two ways: either create a *distinct* reservation for each sender in the session, or use a single reservation that is *shared* among all packets of the selected senders.

Another reservation style concerns how senders are selected. Again, there are two choices: an *explicit* list of all selected senders or a *wildcard* that implies all senders in the session.

Table 92 describes the relationship between reservation attributes and styles

Table 92: Reservation Attributes and Styles

Sender Selection	Distinct Reservation Style	Shared Reservation Style
Explicit	Fixed filter (FF)	Shared explicit (SE)
Wildcard	Not defined	Wildcard filter (WF)

The following sections describe the three reservation styles:

- Fixed filter
- Shared explicit
- Wildcard

Fixed Filter

The fixed filter (FF) reservation style uses a distinct reservation and an explicit sender selection. A fixed filter reservation creates a distinct reservation for data packets for a particular sender.

Shared Explicit

The shared explicit (SE) reservation style uses a shared reservation and an explicit sender selection. A shared explicit reservation creates a single reservation that is shared by selected upstream senders. This style permits a receiver to specify the set of senders to be included.

The Extreme MPLS implementation does not support SE reservation style.

Wildcard

The wildcard (WF) reservation style uses the shared reservation and wildcard sender options. A wildcard reservation creates a single reservation that is shared by data flows from all upstream senders.

The Extreme MPLS implementation does not support WF reservation style.

Bandwidth Reservation

As mentioned previously, RSVP reservations are unidirectional in nature. The source initiates the reservation procedure by transmitting a path message containing a Sender Tspec object. The Tspec describes the source traffic characteristics in terms of peak data rate, average data rate, burst size, and minimum/maximum packet sizes. The path message can also contain an optional AdSpec object that is updated by network elements along the path to indicate information such as the availability of particular QoS services, the maximum bandwidth available along the path, the minimum path latency, and the path maximum transmission unit (MTU).

LSRs make a bandwidth reservation on a per-LSP basis. Only Controlled-Load[1] service requests are supported. When bandwidth is requested, it is possible for the the LSP to be established, even when the requested bandwidth is not reserved. You must verify that the requested bandwidth was actually reserved. In cases when the bandwidth reserved is less than the amount requested, you can manually tear down the LSP and resignal it using a different path. CSPF is not supported. To specify a best effort LSP, configure the reserved bandwidth as zero.

Bandwidth Accounting

ExtremeWare RSVP-TE supports the accounting of bandwidth reserved. The available bandwidth specified in the Adspec object is not modified when the path message is forwarded to the LSP endpoint. As reserve messages are processed, the reserved bandwidth specified in the Flowspec is added to the total reserved bandwidth for the appropriate VLANs. LSP path message setup and hold priorities are not used to preempt previously established LSPs established through an Extreme LSR.

ExtremeWare does not support SE style labels. Therefore, increasing the reserved bandwidth parameter for an LSP will force the LSP to be torn down. If the LSP is torn down, the LSP is resignaled with the new reserved bandwidth value. There are no guarantees that the LSRs along the path will be able to accommodate the increased bandwidth reservation request.

RSVP State

State is installed at each device traversed by the path message, but no resources are reserved. Among other things, the state identifies the adjacent RSVP nodes, which describes the path for the reservation. Resources are not actually reserved until the receiver responds to the path message with a reserve message.

Upon receiving a path message, a destination may examine the Tspec and the AdSpec from the sender, in conjunction with local status/policy information, to determine the actual QoS specification that is to be included in the reserve message. The reserve message follows the reverse of the path established by the path message and the appropriate resources are reserved at each node.

The state maintained by RSVP is temporary, or *soft*. Consequently, path and reserve messages must be periodically retransmitted to maintain an active reservation. Soft state is advantageous because it naturally adapts to changing network conditions, such as topology changes that alter the routed path for a flow. However, the increased control traffic load can be a scalability concern. For this reason, considerable work has been done towards reducing RSVP refresh overhead through the implementation of RFC 2961, *RSVP Overhead Refresh Reduction Extensions*. One aspect of RSVP refresh reduction enables a very long refresh timer by adding support for reliable delivery of RSVP control messages. Prior to refresh reduction, the refresh timer had to be relatively short to ensure timely reservation establishment in the event of a dropped packet. Further reductions are achieved through a mechanism called *summary refresh*, which involves transmitting only the message identifiers associated with the RSVP messages to be refreshed, instead of transmitting the entire unchanged contents of the RSVP messages, and bundling the message identifiers for multiple refresh operations into a single packet.

[1] Controlled Load service is defined in RFC 2211.

Traffic Engineering

This section describes RSVP traffic engineering and the following topics:

- RSVP Tunneling on page 714
- RSVP Objects on page 714

RSVP Tunneling

An RSVP tunnel sends traffic from an ingress node through an LSP. The traffic that flows through the LSP is opaque (or tunneled) to the intermediate nodes along the path. Traffic flowing through the tunnel to an intermediate node along the path is identified by the previous hop and is forwarded, based on the label value(s), to the downstream node.

RSVP tunnels can:

- Establish tunnels with or without QoS requirements.
- Dynamically reroute an established tunnel.
- Observe the actual route traversed by a tunnel.
- Identify and diagnose tunnels.
- Use administrative policy control to preempt an established tunnel.
- Perform downstream-on-demand label allocation, distribution, and binding.

RSVP Objects

This section describes the RSVP objects that are used to establish RSVP-TE LSPs:

- Label
- Label request
- Explicit route
- Record route
- Session attribute

Label

The label object is carried in the reservation message and is used to communicate a next hop label for the requested tunnel endpoint IP address upstream to towards the sender.

Label Request

A label request object specifies that a label binding for the tunneled path is requested. It also provides information about the network layer protocol that is carried by the tunnel. The network layer protocol sent through a tunnel is not assumed to be IP and cannot be deduced from the layer-2 protocol header, which simply identifies the higher layer protocol as MPLS. Therefore, the layer-3 Protocol ID (PID) value must be set in the Label Request Object, so that the egress node can properly handle the tunneled data. Extreme switches only support the IP PID value (0x0800).

To create an RSVP-TE LSP, the sender on the MPLS path creates an RSVP path message and inserts the label request object into the path message.

Explicit Route

The explicit route object specifies the route of the traffic as a sequence of nodes. Nodes may be loosely or strictly specified.

The explicit route object is used by the MPLS sender if the sender knows about a route that:

- Has a high likelihood of meeting the QoS requirements of the tunnel
- Uses the network resources efficiently
- Satisfies policy criteria

If any of the above criteria are met, the sender can decide to use the explicit route for some or all of its sessions. To do this, the sender node adds an explicit route object to the path message.

After the session has been established, the sender node can dynamically reroute the session (if, for example, if discovers a better route) by changing the explicit route object.

Record Route

The record route object is used by the sender to receive information about the actual route traversed by the RSVP-TE LSP. It is also used by the sender to request notification if there are changes to the routing path. Intermediate or transit nodes can optionally use the RRO to provide loop detection.

To use the object, the sender adds the record route object to the path message.

Session Attribute

The session attribute object can also be added to the path message. It is used for identifying and diagnosing the session. The session attribute includes the following information:

- Setup and hold priorities
- Resource affinities
- Local protection

RSVP Features

This section covers the following features of RSVP:

- Route recording
- Explicit route path LSPs
- Redundant LSPs
- Improving LSP scaling

Route Recording

The route a path takes can be recorded. Recording the path allows the ingress LER to know, on a hop-by-hop basis, which LSRs the path traverses. Knowing the actual path of an LSP can be especially useful for diagnosing various network issues.

Network path recording is configurable per LSP. If enabled, the record route object (RRO) is inserted into the path message using a single RRO subobject, representing the ingress LER. When a path message is received by an Extreme LSR that contains an RRO, an RRO IPv4 subobject representing the /32 address of the outgoing interface of the path message is pushed onto the top[1] of the first RRO. If the setup of an LSP originates from an Extreme LER for which route recording is enabled, the path message is originated with an RRO containing a single RRO subobject specifying the outgoing interface address of the path message. A similar RRO is constructed as the RESV message goes from egress node to ingress node.

The label recording flag is not supported by Extreme LSRs. This flag instructs all LSRs along the LSP to include the advertised downstream label in a label object as part of the RRO. If an Extreme LSR receives a path message with the label recording flag set in the RRO, the LSR does not push a label subobject onto the RRO.

If a path message is received that contains an RRO, the Extreme LSR uses the RRO to perform loop detection. The RRO is scanned to verify that the path message has not already traversed this LSR. If the RRO contains an IPv4 subobject that represents a local LSR interface, the path message is dropped and a “Routing Problem” error message is sent to the originating LER with an error value of “Loop detected.”

Explicit Route Path LSPs

An explicit route is a specified path through a routed network topology. The path may be strictly or loosely specified. If strictly specified, each node or group of nodes along the path must be configured. Thus, no deviation from the specified path is allowed.

Loosely specified paths allow for local flexibility in fulfilling the requested path to the destination. This feature allows for significant leeway by the LSR in choosing the next hop when incomplete information about the details of the path is generated by the LER. Each node along the path may use other metrics to pick the next hop along the path, such as bandwidth available, class of service, or link cost.

An explicit routed path is encoded using the explicit route object (ERO) and is transmitted in the path message. The ERO consists of a list of subobjects, each of which describes an abstract node. By definition, an abstract node can be an IPv4 Prefix, IPv6 Prefix, or an autonomous system (AS) number. ExtremeWare RSVP-TE supports IPv4 abstract nodes, only. They can be an IP prefix interface address or an OSPF router-id. The /32 IP address may represent the OSPF router ID, direct interface, or loopback address.

Received path messages with EROs that contain any other subobject type result in the transmittal of an “Unknown object class” error message. All LSRs along the specified path must support the inclusion of the ERO in the path message for an explicitly routed path to be successfully set up.

All ERO subobjects describing the path must be defined by the ingress LER.

Redundant LSPs

Two methods are available for provisioning redundant RSVP-TE LSPs at the ingress LER. The first uses the concept of secondary or backup LSPs and the second relies on equal-cost LSP route metrics.

Redundant RSVP-TE LSPs can be configured to provide alternate paths in the event that the primary path fails. Secondary paths are fully provisioned preestablished RSVP-TE LSPs that are maintained as inactive TE /32 routes to the path endpoint. If the primary path is torn down, the primary path TE /32 route is removed from the routing table, and a TE /32 route representing one of the active secondary

[1] RRO is organized as a LIFO stack.

paths is installed as the preferred path for the LSP. If multiple secondary are paths available, the secondary path is randomly selected. If the primary path is reestablished, the primary path TE /32 route is reinstalled as the preferred path.

Stateful failovers can be managed by configuring only secondary paths for an LSP. When no primary paths are configured for an LSP, a TE /32 route representing one of the secondary paths is installed in the route table. If the secondary path fails, for which a TE /32 route has been installed in the route table, another secondary TE /32 route representing separate path is installed in the route table (provided one is configured and active). Secondary path TE /32 routes remain the preferred route unless a primary path is configured for the LSP, the active secondary path fails, or the active secondary path is deleted. Thus, no switch-back to the original secondary path is performed if the original secondary path fails and is later reestablished.

Parallel RSVP-TE LSPs can exist to the same endpoint. Parallel LSPs exist when multiple paths are configured to the same egress LSR, with each LSP having a configured metric that is less than, or equal to, the interior gateway protocol (IGP) metric. In both cases, a TE /32 route to the egress LER is installed in the route table of the ingress LER for all of the best equal-cost RSVP-TE paths. Traffic is distributed across up to four TE /32 routes based on a MAC and IP address hash algorithms. If one of the LSPs fail, the traffic is redistributed across the remaining active LSPs. In this example, no LSP secondary paths are required.

Ping Health Checking

After an LSP has been established, the egress LSR may be optionally pinged to determine end-to-end path connectivity. If a ping response is not received within [2 * *ping-interval* – 1] seconds, the LSP is considered unavailable. You can specify how frequently an ICMP echo request is transmitted to the egress LER IP address on the established LSP.

Improving LSP Scaling

You can improve LSP scaling by configuring the following RSVP-TE parameters:

- `refresh-time`—The refresh-time specifies the interval for sending refresh path messages. RSVP refresh messages provide soft state link-level keep-alive information for previously established paths and enable the switch to detect when an LSP is no longer active. RSVP sessions are torn down if an RSVP refresh message is not received from a neighbor within [(*keep-multiplier* + 0.5) * 1.5 * *refresh-time*] seconds. The valid refresh-time may be set to any value between one and 36000 seconds. The default setting is 30 seconds. Configuring a longer refresh time reduces both switch and network overhead.
- `summary-refresh-time`—The summary-refresh-time, specified in tenths of a second, indicates the time interval for sending summary refresh RSVP messages. The summary-refresh-time must be less than the configured refresh-time. The default summary-refresh-time is zero, indicating that no summary refresh RSVP messages are sent. The summary-refresh-time value may be set to any value between zero to 100 (or 10 seconds). If configured, the bundled and summary refresh RSVP messages are only sent to RSVP-TE peers supporting RSVP refresh reduction.
- `bundle-time`—The bundle-time, specified in tenths of a second, indicates the maximum amount of time a transmit buffer is held so that multiple RSVP messages can be bundled into a single PDU. The default bundle-time is zero, indicating that RSVP message bundling is not enabled. The bundle-time value can be set to any value between zero and 30 (or 3 seconds).

Configuring RSVP-TE

This section describes the following tasks:

- Configuring RSVP-TE on a VLAN on page 718
- Configuring RSVP-TE Protocol Parameters on page 718
- Configuring an RSVP-TE Path on page 719
- Configuring an Explicit Route on page 720
- Configuring an RSVP-TE Profile on page 721
- Configuring an Existing RSVP-TE Profile on page 722
- Configuring an RSVP-TE LSP on page 722
- Adding a Path to an RSVP-TE LSP on page 723
- Displaying RSVP-TE LSP Configuration Information on page 723
- Displaying the RSVP-TE Routed Path on page 724
- Displaying the RSVP-TE Path Profile on page 724
- Displaying the RSVP-TE LSP on page 724

Configuring RSVP-TE on a VLAN

To configure RSVP-TE on one or all VLANs, use the following command:

```
configure mpls add vlan [<vlan name> | all] {ldp | rsvp-te}
```

To disable RSVP-TE on a VLAN, use the following command:

```
configure mpls delete vlan [<vlan name> | all] {ldp | rsvp-te}
```

This command disables RSVP-TE on one or all VLANs. Deleting RSVP-TE causes all TE LSPs to be released, and prevents TE LSPs from being established or accepted on the specified VLAN.

Configuring RSVP-TE Protocol Parameters

To configure RSVP-TE protocol parameters, use the following command:

```
configure mpls rsvp-te vlan [<vlan name> | all] {hello-interval <seconds>}
{refresh-time <seconds>} {summary-refresh-time <tenth-seconds>} {bundle-time
<tenth-seconds>} {keep-multiplier <number>}
```

This command configures the RSVP-TE protocol parameters for the specified VLAN. The RSVP-TE keyword `all` indicates that the configuration changes apply to all RSVP-TE enabled VLANs.

The `hello-interval` time specifies the RSVP hello packet transmission interval. The RSVP hello packet is used by the switch to detect when a RSVP-TE peer is no longer reachable. If an RSVP hello packet is not received from a peer with [hello-interval * `keep-multiplier`] seconds, the peer is declared down and all RSVP sessions to and from that peer are torn down. The default `hello-interval` time is zero, indicating that RSVP hellos are not enabled. The hello-interval may be set to any value between zero and 60 seconds.

The `refresh-time` parameter specifies the interval for sending refresh path messages. RSVP refresh messages provide “soft state” link-level keep-alive information for previously established paths and enables the switch to detect when an LSP is no longer active. RSVP sessions are torn down if an RSVP refresh message is not received from a neighbor within [(keep-multiplier + 0.5) * 1.5 * refresh-time] seconds. The default refresh-time is 30 seconds and the default keep-multiplier value is three. The minimum and maximum refresh-time values are one and 36,000 seconds (or ten hours) respectively. The minimum and maximum keep-multiplier values are one and 255 respectively.

The bundle-time, specified in tenths of a second, indicates the maximum amount of time a transmit buffer is held so that multiple RSVP messages can be bundled into a single PDU. The default bundle-time is zero, indicating that RSVP message bundling is not enabled. The bundle-time value may be set to any value between zero and 30 (or 3 seconds).

The summary-refresh-time, specified in tenths of a second, indicates the time interval for sending summary refresh RSVP messages. The summary-refresh-time must be less than the configured refresh-time. The default summary-refresh-time is zero, indicating that no summary refresh RSVP messages are sent. The summary-refresh-time value may be set to any value between zero to 100 (or 10 seconds).

If configured, the bundled and summary refresh RSVP messages are only sent to RSVP-TE peers supporting RSVP refresh reduction.

Configuring an RSVP-TE Path

To add an RSVP-TE routed path, use the following command:

```
configure mpls rsvp-te add path <path_name> [<ipaddress> | <host_name>] {from
<local_endpoint_vlan>}
```

The <path_name> and <ipaddress> or <host_name> must be specified for the path. The <path_name> parameter is a character string that is to used to identify the path within the switch. The <path_name> string must begin with an alphabetic character, and may contain up to 31 additional alphanumeric characters. Each <path_name> represents a routed path to a single IP destination.

If the <host_name> is specified, the DNS client on the switch must be configured so that the <host_name> can first be resolved to an IP address. Alternate routed paths to the same IP destination may be configured by adding additional <path_names> and specifying the same <ipaddress> or <host_name> as the path endpoint.

The RSVP-TE path is not signaled until an LSP is added with the specified <path_name>. If no explicit route objects are configured, the path will follow the best-routed path to the configured <ipaddress> (or IP address obtained from DNS name resolution). Optionally, the from keyword can be used to specify the <local_endpoint_vlan> from which the path is signaled. The maximum number of configurable paths is 255.

To delete an RSVP-TE path, use the following command:

```
configure mpls rsvp-te delete path [<path_name> | all]
```

This command deletes a configured MPLS RSVP-TE routed path with the specified <path_name>. All associated configuration information for <path_name> is deleted. A path cannot be deleted as long as the <path_name> is associated with an LSP. If the all keyword is specified, all paths not associated with an LSP are deleted.

Configuring an Explicit Route

To add an RSVP-TE explicit route, use the following command:

```
configure mpls rsvp-te path <path_name> add ero [ipaddress <ipaddress/masklength> |
<host_name>] {strict | loose} {order <number>}
```

This command adds an IP address to the explicit route object (ERO) for the specified path name. The RSVP-TE routed path may be described by a configured sequence of the LSRs and/or subnets traversed by the path. Each defined LSR or subnet represents an ERO subobject. Up to 64 subobjects can be added to each path name.

When specifying an LSR using the `<host_name>` parameter, the DNS client on the switch must be configured so that the `<host_name>` can first be resolved to an IP address. The `ipaddress` keyword identifies an LSR using either a /32 address, which may represent an LSR router ID, loopback address, or direct router interface, or an IP prefix, which represents a directly connected subnet. Each IP address or prefix is included in the ERO as an IPv4 subobject.

If the IP address is specified as `strict`, the strict subobject must be topologically[1] adjacent to the previous subobject as listed in the ERO. If the IP address is specified as `loose`, the loose subobject is not required to be topologically adjacent to the previous subobject as listed in the ERO. If omitted, the default subobject attribute is `loose`. Each IP address or prefix is included in the ERO as an IPv4 subobject.

If the subobject matches a direct router interface or a directly attached subnet, the switch verifies that the path message is received on the matching router interface. If the LSR specified matches the OSPF router ID or a configured loopback IP address, the router interface which the packet is received is ignored.

The LSR path order is optionally specified using the `order` keyword. The `order number` parameter is an integer value from 1 to 65535. IP prefixes with a lower number are sequenced before IP prefixes with a higher number. You can specify multiple paths and assign them an order number. The order number determines the path that the LSP follows. Thus, the LSP path follows the configured path of the IP prefix with the order value from low to high. If the `order` keyword is not specified, the number value for the LSR defaults to a value 100 higher than the current highest number value.

If the list of IP prefixes, added to the path, does not reflect an actual path through the network topology, the path message is returned with an error from a downstream LSR and the LSP is not established.

The order of a configured subobject can not be changed. The ERO subobject must be deleted and re-added using a different order. If a subobject is added to or deleted from the ERO while the associated LSP is established, the path is torn down and is resignaled using the new ERO.

Duplicate ERO subobjects are not allowed. Defining an ERO for the path is optional. If you do not configure an ERO, the path is signaled along the best-routed path and the ERO is not included in the path message. When the last subobject in the ERO of the path message is reached and the egress IP node of the path has not been reached, the remaining path to the egress node is signaled along the best-routed path. Specification of an ERO could lead to undesirable routed paths, so you should be careful when terminating the ERO routed-path definition prior to the configured path egress node.

[1] The LSP next hop matches either the interface IP address or the OSPF router-id of the immediate neighbor LSR.

To delete an RSVP-TE explicit route, use the following command:

```
configure mpls rsvp-te path <path_name> delete ero [all | ipaddress
<ipaddress/masklength> | <host_name> | order <number>]
```

This command deletes an LSR or subnet from the ERO for the specified path name. The LSR is specified using the `ipaddress`, `<host_name>`, or `order` parameter. If an LSR is deleted from an ERO while the associated LSP is established, the path is torn down and is resignaled using a new ERO. Use the `all` keyword to delete the entire ERO from the path name. When there is no configured ERO, the path is no longer required to take an explicit routed path. The path is then signaled along the best-routed path and no ERO is included in the path message.

Configuring an RSVP-TE Profile

To add an RSVP-TE profile, use the following command:

```
cconfig mpls rsvp-te profile <profile_name> {bandwidth <bps>} {setup-priority
<priority>} {hold-priority <priority>} {retry-timeout <seconds>} {hop-count <number>}
{ping-interval <seconds>} {metric [<metric> | igp-tracking} {record [enabled |
disabled]} {mtu <number>}
```

A profile is a set of attributes that are applied to the LSP when the LSP is configured using the `configure mpls rsvp-te add lsp` command. A default profile is provided which cannot be deleted, but can be applied to any configured LSP. The profile name for the default profile is *default*. The default profile parameter values are initially set to their respective default values. The maximum number of configurable profiles is 255 (one of which is reserved for the default profile).

The `bandwidth` parameter specifies the desired reserved bandwidth for the LSP. Any positive integer bps value is valid. Optionally, you can append the characters, k for kilobits, m for megabits, or g for gigabits, to the bps value to specify the unit of measure. If the k, m, or g, character is omitted, the unit of measure is assumed to be kilobits. The default bandwidth bps value is zero, which indicates that the QoS for the LSP is best effort. ExtremeWare does not support bandwidth reservation.

The `setup-priority` and `hold-priority` are optional parameters indicating the LSP priority. During path set up, if the requested bandwidth cannot be reserved through the LSR, the `setup-priority` parameter is compared to the `hold-priority` of existing LSPs to determine if any of the existing LSPs need to be preempted to allow a higher priority LSP to be established. Lower numerical values represent higher priorities. The `setup-priority` range is 0 to 7 and the default value is 7. The `hold-priority` range is also 0 to 7 and is set equal to the `setup-priority` by default. ExtremeWare does not support LSP preemption.

The `retry-timeout` keyword specifies the maximum number of seconds the switch allows for LSP setup. If the LSP cannot be established within `retry-timeout` seconds, the LSP is resignaled. The default value for `retry-timeout` is 30 seconds with a configurable range of 5 to 600 seconds. The `hop-count` parameter limits the number of LSRs the path can traverse, including the ingress and egress router. The default `hop-count` value is 255 with a configurable range of two to 255.

After an LSP has established, the egress LSR may be optionally pinged to determine end-to-end path connectivity. If a ping response is not received within [2 * `ping-interval` – 1] seconds, the LSP is considered unavailable. The `ping-interval` keyword specifies how frequently an ICMP echo request is transmitted to the egress LSR IP address on the established LSP. The default `ping-interval` is zero, which indicates no end-to-end LSP health checking is performed. You can set the `ping-interval` value to any interval between 0 and 60 seconds.

The route `metric` is used to determine if an established RSVP-TE LSP will actually be used to send data. Whenever the configured metric is less than, or equal, to the calculated IGP metric, the LSP is used for sending routed IP traffic. In this case, the LSP is also used to send TLS data when the TLS tunnel is configured by specifying the tunnel LSP endpoint IP address. Traffic is distributed across up to four equal-cost LSPs. The valid metric values range from 1 to 65535. Specifying the `igp-tracking` keyword forces the route metric to track the underlying IGP metrics. If no IGP metric exists for the LSP (for example, the LSP traverses a RIP network), the metric is ignored. Tracking IGP metrics is the default behavior.

The `record` keyword is used to enable hop-by-hop path recording. The enabled keyword causes the record route object (RRO) to be inserted into the path message. The RRO is returned in the reserve message and contains a list of IPv4 subobjects that describe the RSVP-TE path. Path recording by default is disabled. When disabled, no RRO is inserted into the path message.

To delete an RSVP-TE path profile, use the following command:

```
configure mpls rsvp-te delete profile [<profile_name> | all]
```

This command deletes a configured RSVP-TE profile with the specified profile name. The default profile cannot be deleted. If a profile is associated with a configured LSP, the profile cannot be deleted. If you specify the `all` keyword, all profiles not associated with an LSP are deleted (except for the default profile).

Configuring an Existing RSVP-TE Profile

To configure an existing RSVP-TE profile, use the following command:

```
configure mpls rsvp-te profile <profile_name> {bandwidth <bps>} {setup-priority
<priority>} {hold-priority <priority>} {retry-timeout <seconds>} {hop-count <number>}
{ping-interval <seconds>} {metric [<metric> | igp-tracking} {record [enabled |
disabled]} {mtu <number>}
```

This command configures RSVP-TE attributes for the specified profile. The `<profile_name>` must have been previously added. All of the LSP profile values are updated dynamically. For LSPs configured with this profile, the LSP parameters are updated automatically with the sending of the next refresh path message. If the metric is changed, all LSPs using this profile are rechecked against the calculated IGP metric. In some cases, the LSP may be torn down because of a profile configuration change. For example, if the bandwidth value is increased, the LSRs along the existing path may not be able to accommodate the additional reserved bandwidth. In this scenario, the LSP is torn down and resignaled.

Configuring an RSVP-TE LSP

To add an RSVP-TE LSP, use the following command:

```
configure mpls rsvp-te add lsp <lsp_name> path <path_name> {<profile_name>} {primary |
secondary}
```

Both the `<lsp_name>` and `<path_name>` must be specified. The `<lsp_name>` parameter is a character string that is to be used to identify the LSP within the switch. The `<lsp_name>` string must begin with an alphabetic character and can contain up to 31 additional alphanumeric characters. The `<profile_name>` is optional. If omitted, the default profile is applied to the LSP. The LSP is immediately signaled as soon as it is configured. The maximum number of configurable LSPs is 1024.

To delete an RSVP-TE LSP, use the following command:

```
configure mpls rsvp-te delete lsp [<lsp_name> | all]
```

Deleting an LSP name disassociates all configured paths with this LSP and all configuration information for the LSP name is deleted. LSPs cannot be deleted if the specified <lsp_name> has been configured as the LSP for a TLS tunnel. If you specify the all keyword, all LSPs not associated with a TLS tunnel are deleted.

Adding a Path to an RSVP-TE LSP

To add a path to an RSVP-TE LSP, use the following command:

```
configure mpls rsvp-te lsp <lsp_name> add path <path_name> {<profile_name>} {secondary
| primary}
```

The <lsp_name> must represent a configured LSP. Only one primary path and up to two secondary paths can be added per <lsp_name>. The <path_name> specified defaults to primary when no primary path has been configured for <lsp_name> and defaults to secondary if the primary path has been previously configured for <lsp_name>.

You do not need to configure the primary path for an LSP. Each <path_name> added to an <lsp_name> must be unique, but a <path_name> can be associated with multiple LSP names.

All configured primary and secondary paths for the <lsp_name> must have the same endpoint IP address. For example, three paths can be configured for the <lsp_name>, but all paths should represent different topological paths through the network to the same LSP endpoint.

Adding a secondary <path_name> designates a path as a hot-standby redundant path, used in the event that the primary or secondary path cannot be established or fails. Provided the <path_name> has not already been established, all path names are signaled as soon as they are associated with an <lsp_name>. If the primary <path_name> fails, is not configured, or cannot be established after the specified LSP retry-timeout, one of the configured secondary paths may become the active path for <lsp_name>. All of the secondary paths have equal preference; the first one available is chosen. If at any time the primary path is established, <lsp_name> immediately switches to using the primary path. If a secondary path fails while in use, the remaining configured secondary paths can become the active path for <lsp_name>.

To delete a path from an RSVP-TE LSP, use the following command:

```
configure mpls rsvp-te delete lsp [<lsp_name> | all]
```

When you issue this command, the LSP associated with the path is immediately torn down. If the deleted path represents the in-use LSP for <lsp_name> and another secondary path is configured, the LSP immediately fails over to an alternate LSP. Because at least one path must be defined for each LSP, the last configured path cannot be deleted from the LSP.

Displaying RSVP-TE LSP Configuration Information

To display RSVP-TE LSP configuration information, use the following command:

```
show mpls rsvp-te {<ipaddress>} {detail}
```

This command displays information about the status of RSVP-TE enabled interfaces. Summary information is displayed for all known RSVP-TE peers including the peer IP address and peer status. If you specify the ipaddress of the RSVP-TE interface, the information for a single RSVP-TE interface is displayed. Additional information is displayed in the detailed format if you specify the optional detail keyword. The more detailed RSVP-TE information includes the number and type of RSVP messages transmitted through the local RSVP-TE interface.

Displaying the RSVP-TE Routed Path

To display the RSVP-TE routed path, use the following command:

```
show mpls rsvp-te path {<path_name>} {detail}
```

This command displays the configuration and status information for MPLS RSVP-TE routed paths. Information is listed in tabular format and includes the path name, path endpoint LSR IP address, and local VLAN (if configured). If the path endpoint is specified as a host name, the host name and the DNS resolved IP address are both displayed. If a specific path name is specified, only information for the specified path is displayed. If you specify the optional `detail` keyword, the list of subobjects specified for the explicit route object and any LSPs that are configured to use the path are displayed.

Displaying the RSVP-TE Path Profile

To display the RSVP-TE path profile, use the following command:

```
show mpls rsvp-te profile {<profile_name>}
```

By default, this command displays all configured profile parameters for the specified profile. If the profile name is omitted, the profile parameter values for all configured LSP profiles are displayed.

Displaying the RSVP-TE LSP

To displays the RSVP-TE LSP, use the following command:

```
show mpls rsvp-te lsp {<lsp_name>} {detail}
```

This command displays the configuration and status information for RSVP-TE LSPs. Information is listed in tabular format and includes the LSP name, LSP state, active path name, bandwidth requested, bandwidth actually reserved, ERO flag, egress LSR, LSP up-time, and RSVP error codes (if LSP setup failed). If you specify a specific LSP name, only information for the specified LSP is displayed. If you specify the optional `detail` keyword, additional information is displayed for each LSP. The detailed information includes a list of all configured paths, including the path state, error codes for the LSP associated with each path, up-time for each LSP, the RRO (if enabled) for each LSP, the bound profile name, and a list of TLS tunnels configured to use the LSP.

Configuration Example

RSVP-TE LSPs comprise profiles, paths, and the actual LSP. This section describes how to configure an RSVP-TE LSP.

Configuring RSVP LSPs is a multi-step process with some optional steps, depending on the specific requirements of the LSP. Conceptually, a number of mandatory elements must be configured to create an RSVP-TE LSP. In addition, you can also configure optional elements. In certain configurations, there are also order dependencies.

The profile contains constraints that you wish to apply to the LSP. These constraints may affect the path selected across the MPLS domain in order to meet. Examples of profile parameters include bandwidth, setup, and hold priority relative to other configured LSPs.

The path can be used to specify the local and remote endpoints for the LSP and, optionally, the explicit path across the MPLS domain that the LSP should follow.

The ERO is an object, sent as part of the LSP setup request (path message), explicitly specifies the path across the MPLS domain the setup request should follow. You can configure a loose or strict path.

Certain elements of configuration are order dependent. For example if you specify a profile or path when creating an LSP, those path or profile definitions must already exist. Similarly a path must exist before an ERO is created, as the ERO is added explicitly to the path.

The typical steps used to configure and verify an RSVP-TE LSP are as follows:

1 Configure a path (mandatory).

2 Configure a profile (optional).

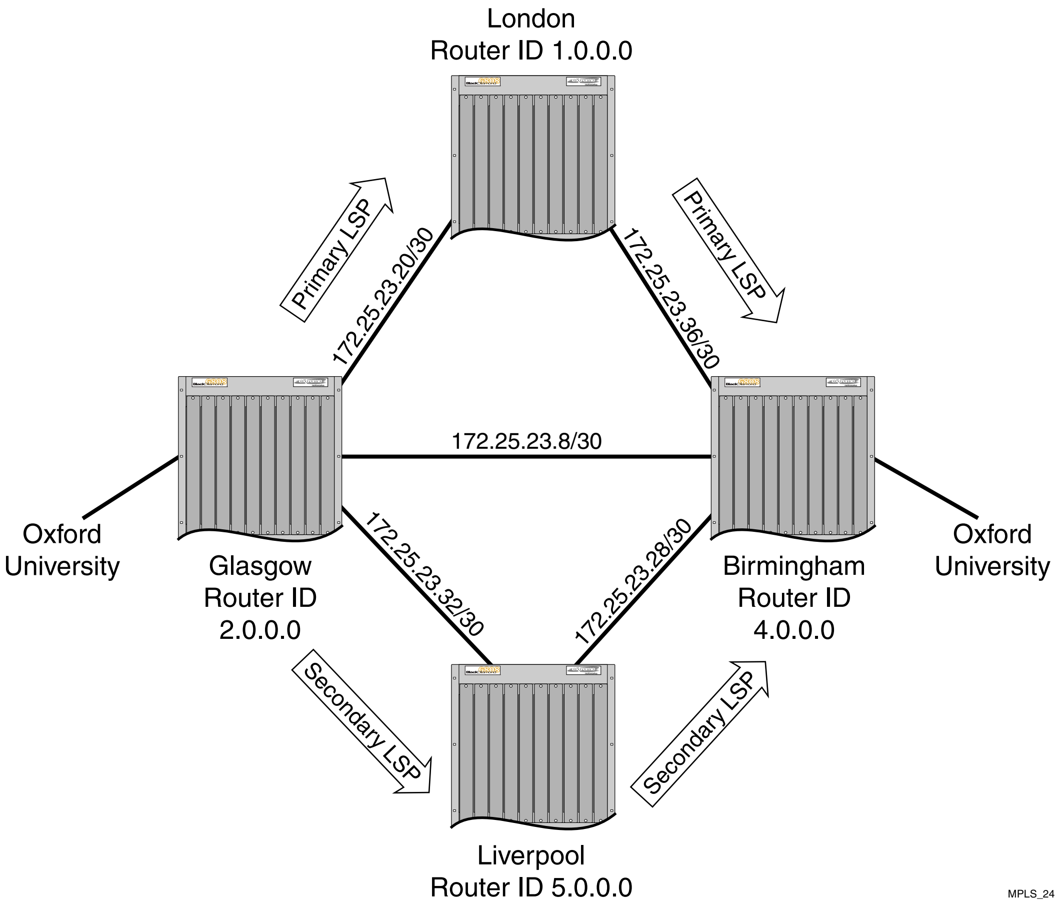
3 Configure an ERO for a path (optional).

4 Configure a primary/secondary LSP (mandatory).

5 Add a secondary LSP (optional).

6 Verify LSP status (recommended).

Figure 142: RSVP-TE Configuration Example



The configuration example, shown in Figure 142, creates primary and secondary LSP between the node Glasgow and and the node Birmingham. The steps specifically create an LSP between Glasgow and Birmingham based on an explicitly routed path via London with bandwidth, and setup and hold priority profile requirements. A secondary path is also created which, in the event of failure of a link or node on the primary path, activates the secondary path for the LSP. This path is Glasgow, Birmingham via Liverpool.

NOTE

An initial step of adding RSVP-TE to a VLAN must be carried out for all VLANs over which the user wishes RSVP-TE LSPs to be signaled. This is a one-time operation.

The following commands add RSVP signaling capabilities to the specified VLANs:

```
configure mpls add vlan gla-lon rsvp-te
configure mpls add vlan gla-liv rsvp-te
```

The following commands create an LSP profile named Glasgow-Birmingham-pro. LSPs that use the Glasgow-Birmingham-pro profile are signaled with a reserved bandwidth of 10 Mbps and an LSP setup and hold priority of 5.

```
configure mpls rsvp-te add profile Glasgow-Birmingham-pro bandwidth 10m setup-priority
5 hold-priority 5
```

The following commands define the primary and secondary paths between Glasgow and Birmingham. The paths are defined such that they originate from a loopback VLAN called *loop* and terminate at the endpoint 4.0.0.0.

```
configure mpls rsvp-te add path Glasgow-Birmingham-pri-path 4.0.0.0 from loop
configure mpls rsvp-te add path Glasgow-Birmingham-sec-path 4.0.0.0 from loop
```

The following commands strictly pin each path to an LSR, such that each path takes a different route to the endpoint 4.0.0.0. Path Glasgow-Birmingham-pri-path is routed through LSR 1.0.0.0 and path Glasgow-Birmingham-sec-path is routed through LSR 5.0.0.0.

```
configure mpls rsvp-te path Glasgow-Birmingham-pri-path add ero ipaddress 1.0.0.0
strict
configure mpls rsvp-te path Glasgow-Birmingham-sec-path add ero ipaddress 5.0.0.0
strict
```

The following commands configure two RSVP-TE LSPs; one is the primary and the other is a secondary or backup LSP. Each LSP uses the same profile but different paths.

```
configure mpls rsvp add lsp Glasgow-Birmingham-lsp path Glasgow-Birmingham-pri-path
Glasgow-Birmingham-pro primary

configure mpls rsvp lsp Glasgow-Birmingham-lsp add path Glasgow-Birmingham-sec-path
Glasgow-Birmingham-pro secondary
```

NOTE

The secondary LSP is signaled, however it remains in a standby state unless the primary path becomes unavailable.

By default, a TLS tunnel flows over any available LSP. However, a TLS tunnel can be specifically directed to use a configured RSVP-TE based LSP. Configuration is no different from configuring an LDP-based TLS tunnel, except that the RSVP-TE LSP is explicitly specified. The following command specifically directs the TLS tunnel to use a previously configured RSVP-TE:

```
configure mpls add tls-tunnel Glasgow-Birmingham-cust1 lsp Glasgow-Birmingham-lsp
oxford-university vcid 50 from 2.0.0.0
```

28 Configuring MPLS Layer-2 VPNs

This chapter describes Layer-2 VPN services and the following topics:

- Overview of MPLS Layer-2 VPNs on page 729
- TLS VPN Characteristics on page 732
- Configuring MPLS Layer-2 VPNs on page 732
- TLS VPN Configuration Examples on page 736
- Using ESRP with MPLS TLS on page 740

Overview of MPLS Layer-2 VPNs

The idea behind transparent LAN services (TLS) over MPLS is to enable Layer-2 virtual private networking (VPN) service offerings in a simple manner that is easy to deploy and operate. Layer-2 VPN services, based on a combination of Ethernet and MPLS/IP technologies, are designed to enable service providers to offer Ethernet business private line services. These services are also referred to as Transparent LAN Services (TLS) or Virtual Private LAN Services (VPLS). Layer-2 VPN services use a simple Layer-2 interface at the customer edge combined with the resilience and scalability of an MPLS/IP core to provide VPN connectivity.

Layer-2 VPN Services

There are two basic types of Layer-2 VPN services. The first is a *VLAN* service. This service transparently interconnects two or more VLAN segments together over an MPLS network. The configured VLAN IDs for the customer switch interfaces are not required to match, as long as the TLS egress LSR overwrites the VLAN tag with the locally defined VLAN ID, or if the local VLAN is untagged, strips the 802.1Q tag completely. The second service is a *port* service. This service transparently interconnects two or more ports together over an MPLS network. Traffic is transported unmodified between ports.

Extremeware supports both services, but only the VLAN service is interoperable with other vendor implementations. Port-based TLS service requires that the dot1q tag ethertype be configured to 9100. By changing the configured dot1q ethertype value, the Ethernet switch ports treat 8100 tagged traffic as untagged and insert a new dot1q tag with the configured ethertype value. By inserting a new dot1q tag, all traffic received on a single port can be aggregated into a single VLAN and transported across an MPLS domain as a VLAN service. All TLS edge switches must be configured to use the same dot1q ethertype value.

MPLS VC Tunnels

MPLS virtual circuit (VC) tunnels are logical connections between two LERs over an LSP. Like ATM VCs, these connections can be signaled (dynamic) or statically configured. Dynamic TLS tunnel connections are commonly referred to as VC tunnels, because the TLS tunnel label is signaled based on the configured VC identifier (vcid). The signaled VC label is used to create a two-label stack LSP. The outer label is the LSP label obtained from LDP or RSVP-TE and the inner label is the signaled VC label. LERs also signal the VC type when attempting to establish a VC tunnel. Extremeware only supports the VLAN VC type and reject all other VC types, including the Ethernet VC type used to signal Ethernet port service.

VLAN type VC tunnels are also referred to as TLS tunnels. Static TLS tunnels are not signaled. The ingress and egress VC label for each TLS tunnel must be configured at each end of the tunnel. Both static and dynamic TLS tunnels can be configured simultaneously, but both share the same 16K TLS LER label space partition.

Transporting 802.1Q Tagged Frames

When an 802.1Q Ethernet frame is encapsulated for transport over a VC tunnel, the entire frame is included, except for the preamble and FCS. The 4-byte VLAN tag field is transmitted as is, but may be overwritten by the egress LER. The option to overwrite the VLAN tag allows two (possibly independently administered) VLAN segments with different VLAN IDs to be treated as a single VLAN.

Establishing LDP LSPs to TLS Tunnel Endpoints

The TLS tunnel endpoint is identified using an IP address configuration parameter, and LDP must set up a tunnel LSP to the configured IP address before Layer-2 traffic can be transported. To ensure that the tunnel LSP is established, both an OSPF route and a MPLS label mapping must be advertised for the configured IP address.

When the peer LSR is also an Extreme switch, the following options are available for ensuring that an OSPF route is advertised for the tunnel endpoint IP address:

- A route is advertised when OSPF is enabled on the VLAN to which the IP address is assigned (using the `configure ospf add vlan` command on the peer switch).
- A route is advertised when the peer switch is configured to distribute direct routes into the OSPF domain (via the `enable ospf export direct` command). The export option should be used when the tunnel LSP needs to cross OSPF area boundaries or when the Extreme Standby Routing Protocol (ESRP) is enabled on the VLAN to which the IP address is assigned.

In either case, LDP must be configured to advertise label mappings for direct routing interfaces.

In some configurations, you may want to enable loopback mode on the VLAN to which the tunnel endpoint IP address is assigned. One situation where loopback mode may be useful is when multiple physical interfaces, associated with different VLANs, are connected to the MPLS backbone. In this case, use of loopback-mode can provide redundancy by enabling TLS traffic to continue even when the physical interfaces associated with the tunnel endpoint IP address VLAN fail.

LSP Selection

By default, a TLS tunnel will use any available LSP to the TLS tunnel endpoint IP address. If there are multiple equal cost LSPs, the TLS tunnel is load shared across up to four LSPs. Optionally, a TLS tunnel can be configured to use a specific RSVP-TE LSP. If the RSVP-TE LSP metric is set higher than its underlying IGP metric, the LSP is not used to forward normal routed IP and is only used to forward TLS VLAN traffic.

Layer-2 VPN Domains

Layer-2 VPN domains can be created by configuring multiple TLS tunnels for a single VLAN. Each TLS tunnel connects the local TLS VLAN instance to an egress LER, to form a Layer-2 VPN domain. Integrated MAC caching is supported on the MPLS module. This allows the switch to learn MAC addresses of devices that are located on the TLS tunnel egress LER. If the destination MAC address is known, the packet is forwarded into the learned TLS tunnel or onto the local VLAN. If the destination MAC is unknown, or the packet is a broadcast or multicast packet, the packet can be flooded in one of two configurable modes.

- Spoke

  Packets received from the local VLAN are flooded into all TLS tunnels. Packets received from a TLS tunnel are retransmitted out every TLS tunnel and the local TLS VLAN, except for the interface that the packets were received.
- Core

  Packets received from the local VLAN are flooded into all TLS tunnels. Packets received from a TLS tunnel are forwarded to the local TLS VLAN and flooded to all spoke TLS tunnels.

MAC Learning

Learned MAC addresses are associated with the TLS tunnel from which the packet was received. The learned MAC address is always inserted into the FDB as though it was learned on the local VLAN (and not the VLAN identified in the dot1q tag in the received TLS tunnel packet). MAC addresses learned from TLS tunnels use the same FDB aging timers as those MAC addresses learned on Ethernet interfaces. Any MAC address associated with a TLS tunnel is automatically cleared from the FDB when the VC label for the TLS tunnel is withdrawn.

MAC addresses may appear to move between TLS tunnels. This can occur for various legitimate reasons. The FDB aging timers will clear stale MAC entries, but in certain redundant configurations, it is possible for MAC addresses to become associated with an incorrect TLS tunnel. To prevent these scenarios from causing lengthy connectivity interruptions, the Extreme switch relearns source MAC addresses on all received packets and withdraws VC labels for the associated TLS tunnels when a local TLS VLAN goes down. By always relearning MAC addresses, MAC addresses are more likely to be associated with the correct TLS tunnel. Withdrawing a VC label when a local TLS VLAN goes down forces the remote LSR to remove stale MAC addresses from its FDB associated with the TLS tunnel of the withdrawn VC label. Thus, all egress LERs are assured of relearning the new location of any MAC address that may have been previously associated with the down VLAN. If the VC label was withdrawn due to a down local TLS VLAN, the VC label is readvertised when at least one other local TLS VLAN port becomes active.

Spanning Tree Protocols

There is some debate as to the benefit of supporting Spanning Tree Protocols (STP) within a Layer-2 VPN. The idea is that STPs could be used to provide redundant VPN data paths that could be unblocked if the STP detects a spanning tree topology failure. In general, it is believed that introducing TLS VPN STPs increases network complexity with very little real benefit. Because each TLS tunnel is carried over an LSP, MPLS already provides a sufficient level redundancy. For example, if a TLS tunnel is using an LDP established LSP, provided there are parallel routed paths to the TLS tunnel endpoint, the TLS tunnel will automatically shift from a withdrawn or failed LSP to the next best available LSP. For tunnel LSPs established using RSVP-TE, secondary LSPs can be configured that can be hot-swapped in the event of a primary LSP failure. Thus, even though the underlying tunnel LSP may have changed, the Layer-2 VPN data plane remains unaffected.

TLS VPN Characteristics

Characteristics of TLS include:

- Use of LDP or RSVP-TE to establish tunnel LSPs.
- Tunnel support for dynamic TLS tunnels using Targeted LDP sessions or static TLS tunnels using configured VC labels.
- Tunnel endpoints are identified via configured IP addresses or specified RSVP-TE LSPs.

VLAN label mappings are configured at both ends of a TLS tunnel. Support for signalling VLAN label to VLAN ID mappings using configured VC ID and Group ID (as specified in the Martini IETF drafts) or using the manually configured ingress and egress VLAN labels.

- All tunneled frames are in tagged Ethernet format.
- Support is provided for tunneling frames received from Ethernet ports or PoS ports running the Bridge Control Protocol (BCP).
- VLAN IDs can be different at each end of a TLS tunnel, the VLAN ID is set by the egress switch to match that of the locally configured VLAN.
- Support for full-mesh and hub-and-spoke VPN architectures with an integrated 256k tunnel MAC cache.
- Support for up to 8 tunnel endpoints per VPN and up to 16k total tunnels per LER.
- Tunnel traffic can be load-shared across up to four equal cost LSPs.

Configuring MPLS Layer-2 VPNs

This section describes how to configure MPLS Layer-2 VPNs, and includes the following topics:

- Adding a TLS Tunnel on page 732
- Deleting a TLS Tunnel on page 734
- Displaying TLS Configuration Information on page 734

Adding a TLS Tunnel

To add a static labeled TLS tunnel, use the following command:

```
configure mpls add tls-tunnel <tunnel_name> [lsp <lsp_name> | <ipaddress>
|<host_name>] <local_vlan_name> tls-labels <ingress_label> <egress_label> {mode [core
|spoke]}
```

To add a dynamic labeled TLS tunnel (martini-draft compliant), use the following command:

```
config mpls add tls-tunnel <tunnel_name> <ipaddress> <local_vlan_name>
```

The `<tunnel_name>` parameter is a character string that is to be used to identify the TLS tunnel within the switch. It must begin with an alphabetic character and can contain up to 31 additional alphanumeric characters.

The `<ipaddress>` parameter identifies the peer LSR that is the endpoint of the tunnel. This IP address should be configured with a 32-bit prefix on the peer LSR. When the peer LSR is also an Extreme switch, either OSPF must also be enabled on the VLAN to which the IP address is assigned (using the `configure ospf add vlan` command on the peer switch), or the peer switch must be configured to distribute direct routes into the OSPF domain (using the `enable ospf export direct` command). The `ospf export` command should be used when the tunnel LSP needs to cross OSPF area boundaries or when ESRP is enabled on the VLAN to which the IP address is assigned.

The TLS tunnel peer may also be specified with the `host_name` parameter. If the tunnel peer LSR is specified using this parameter, the DNS client must be configured so that the host name can first be resolved to an IP address. TLS tunnel endpoints that begin with an alphabetic character are assumed to be host names and DNS resolution is attempted.

The `<lsp_name>` parameter can be used to explicitly identify the RSVP-TE LSP path to the egress TLS LSR. When an LSP name is specified, a targeted LDP session is established across the specified RSVP-TE LSP. The LSP endpoint specified by the associated path is used as the endpoint for the targeted LDP session.

The `<local_vlan_name>` parameter identifies the Layer-2 traffic that is to be transported. All of the local traffic received by the switch for this VLAN is transported across the tunnel.

The `tls-labels` parameters specify the innermost labels of the tunnel label stack and are used to configure static TLS label tunnels. The `<egress_label>` is inserted into the MPLS header of Layer-2 frames forwarded onto the tunnel LSP by this switch, and must be meaningful to the peer TLS node.

All traffic received from the tunnel LSP that contains the `<ingress_label>` is forwarded to the local VLAN identified by the `<local_vlan_name>` parameter.

When ingress traffic is forwarded to the local VLAN, the VLAN ID is set to the VLAN ID of the local VLAN, without regard to the VLAN ID in the MAC header of the frame received from the tunnel LSP. Thus, there is no requirement that all sites of an extended VLAN be configured to use the same VLAN ID. This can simplify network management in some situations.

The `tls-labels` parameters are specified using hexadecimal notation. The value of the `ingress_label` parameter must be unique within the switch (the same `<ingress_label>` value cannot be used for two different tunnels). The valid range of the ingress label parameter is [8C000..8FFFF].

The valid range of the `<egress_label>` parameter is [00010..FFFFF]. If the peer LSR is also an Extreme switch, then the `<egress_label>` must be in the range [8C000..8FFFF].

Because LSPs are unidirectional in nature, coordinated configuration is required at both tunnel endpoint switches. The `<egress_label>` at one tunnel endpoint switch must match the `<ingress_label>` at the other tunnel endpoint switch, and vice versa.

The `<vcid>` and `<groupid>` parameters are used to configure dynamic TLS tunnels when full martini-draft TLS tunnel compliance is desired. The vcid and groupid values are advertised on a targeted LDP session to the specified tunnel endpoint IP address in a martini-draft defined FEC-TLV. Each LER advertises the vcid, groupid, and VLAN label in the Label Mapping message across an LDP session. This three-tuple TLS tunnel information allows each egress LER to dynamically bind the TLS tunnel to a local VLAN. The vcid is a non-zero 32-bit ID that defines the tunnel connection and the optionally specified groupid is a 32-bit value that defines logical virtual tunnel connection group. The groupid value defaults to zero if not explicitly configured.

The optional from parameter defines the <local_endpoint_ipaddress> from which the dynamic TLS tunnel is established. Since dynamic TLS tunnels must first establish an LDP session to the endpoint prior to exchanging tunnel vcid parameters, the TLS endpoint switch must be capable of accepting LDP Targeted Hello messages for the configured TLS tunnel's targeted ipaddress. By default, the local_endpoint_ipaddress is the configured OSPF Router ID. The from parameter must be specified when dynamic TLS tunnels are used in conjunction with ESRP. The local_endpoint_ipaddress should be configured to match the local ESRP VLAN's interface IP address. This allows dynamic TLS tunnels to properly fail over to the slave switch when both the master and the slave switch are configured with the same local_endpoint_ipaddress.

Optionally, the local_endpoint_vlan may be specified in place of the local_endpoint_ipaddress. There is no TLS tunnel functional difference between these two configuration parameters. If the local_endpoint_vlan parameter is specified, the local endpoint IP address used for the TLS tunnel is the IP interface address of the specified local_endpoint_vlan.

The optional mode parameter configures the broadcast and unknown packet-forwarding behavior for the TLS tunnel. The flood mode options are core and spoke. When two or more TLS tunnels are configured for the same TLS VLAN, each configured TLS tunnel and the local TLS VLAN are treated as separate bridge ports within a single L2 broadcast domain. When the mode is configured as spoke, all received flood traffic (for example, broadcast, multicast, and unknown unicast packets) is retransmitted out every TLS tunnel and the local TLS VLAN, except for the interface that the packet was received. When the mode is configured as core, flood traffic received from a TLS tunnel is forwarded to the local TLS VLAN and is flooded to all spoke TLS tunnels. Flood traffic received from the local TLS VLAN is retransmitted onto every TLS tunnel regardless of its configured mode. The default mode is core.

Deleting a TLS Tunnel

To delete one or all TLS tunnels, use the following command:

```
configure mpls delete tls-tunnel [<tunnel_name> | group <groupid> | all]
```

This command deletes the TLS tunnel with the specified tunnel name. Specify the <groupid> if you want to delete all TLS tunnels belonging to a specific group. Use the all keyword to delete all TLS tunnels.

Displaying TLS Configuration Information

To display TLS configuration information, use the following command:

```
show mpls tls-tunnel {summary | detail | <tunnel_name> {detail} | vlan <vlan_name>
{detail}}
```

This command displays configuration and status information for one or all TLS tunnels. The information displayed for each tunnel includes:

- The values of all configuration parameters for the tunnel.
- The current status of the tunnel LSP.

If the optional detail keyword is specified, TLS tunnel information is displayed using the comprehensive detail format. This format includes transmit and receive counts in terms of packets and bytes.

If the optional summary keyword is specified, summary TLS tunnel counts are displayed. The summary counters displayed include the total number of active static and dynamic TLS tunnels.

If the `vlan <vlan name>` keyword is specified, only information about TLS tunnels associated with this local VLAN are displayed

If the `sorted vcid` keyword is specified, the dynamic TLS tunnels are displayed in ascending order based on their vcid.

The example MPLS TLS network configuration provided is based on the routed MPLS network configuration shown in Figure 143.

TLS VPN Configuration Examples

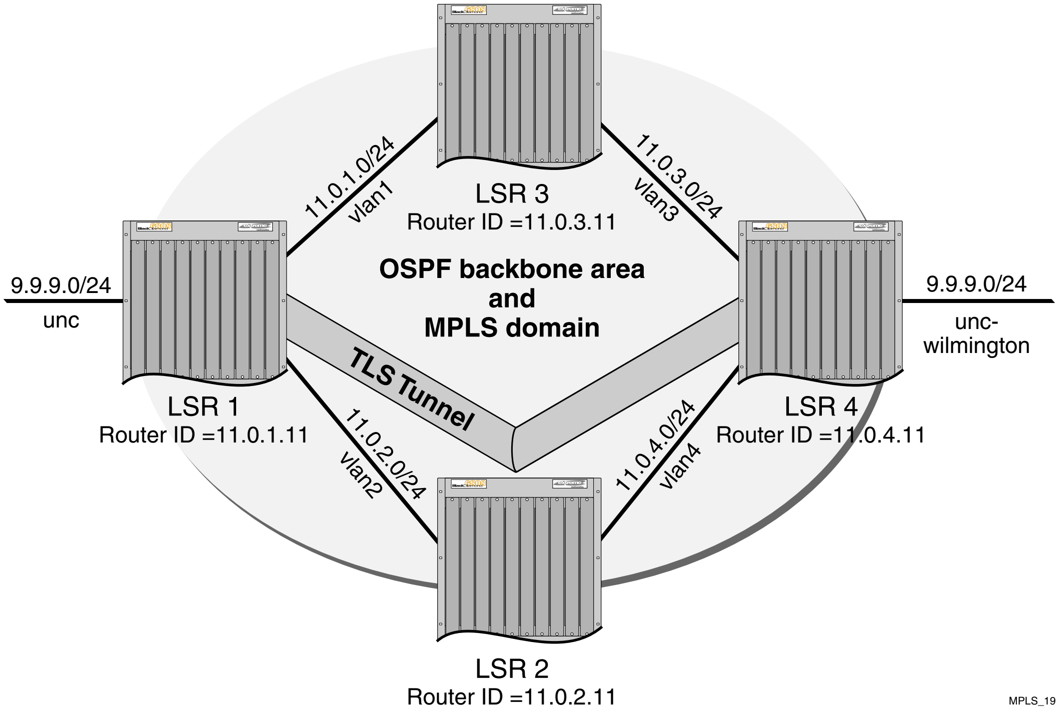
This section provides the following TLS configuration examples:

- Basic MPLS TLS Configuration Example on page 736
- Configuration Example Using PPP Transparent Mode on page 739

Basic MPLS TLS Configuration Example

This MPLS TLS network configuration shown in Figure 143, is based on the routed MPLS network configuration example, shown in Figure 143.

Figure 143: MPLS TLS configuration example



In this configuration example, a new VLAN, *unc-wilmington*, is configured on LSR 4, with a router interface of 9.9.9.1/24. Because TLS provides Layer-2 transport capabilities over MPLS, both TLS VLANs are part of the same IP subnet. Exporting of direct interfaces is disabled so that external OSPF routes are not exported into the backbone area.

The commands used to create a TLS Tunnel between LSR 1 and LSR 4 follow.

The following command creates a TLS tunnel to LSR 4 (11.0.4.11) for traffic originating from VLAN *unc*:

```
configure mpls add tls-tunnel rt40 11.0.4.11 unc tls-labels 8f001 8f004
```

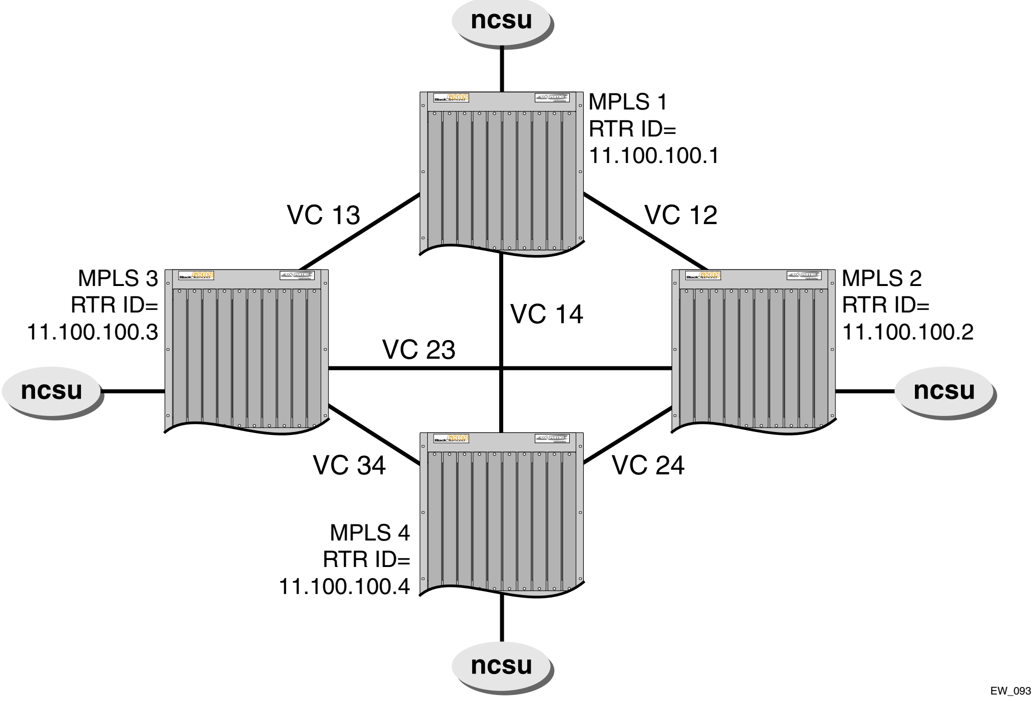
The following command creates a TLS tunnel to LSR 1 (11.0.1.11) for traffic originating from VLAN *unc-wilmington*:

```
> configure mpls add tls-tunnel rt40 11.0.1.11 unc-wilmington tls-labels 8f004 8f001
```

Full Mesh TLS Configuration

The example, shown in Figure 144, configures a four node full-mesh MPLS TLS configuration. Each LER MPLS configuration includes a TLS tunnel to every other LER. The egress VLAN for the VPN is called *ncsu*. The target IP address (e.g. 11.100.100.2) shown in each TLS configuration command must be either a Router ID or Loopback VLAN interface address.

Figure 144: Full mesh Configuration Example



Each of the following commands configure a TLS tunnel to an LER for which the VLAN *ncsu* has a PoP. In order for each TLS tunnel to become active, a matching TLS tunnel definition with the same VC ID must be configured on the target LER.

mpls1

```
configure mpls add tls t12 11.100.100.2 ncsu vcid 1 mode core
configure mpls add tls t13 11.100.100.3 ncsu vcid 1 mode core
configure mpls add tls t14 11.100.100.4 ncsu vcid 1 mode core
```

mpls2

```
configure mpls add tls t12 11.100.100.1 ncsu vcid 1 mode core
configure mpls add tls t23 11.100.100.3 ncsu vcid 1 mode core
configure mpls add tls t24 11.100.100.4 ncsu vcid 1 mode core
```

mpls3

```
configure mpls add tls t13 11.100.100.1 ncsu vcid 1 mode core
configure mpls add tls t23 11.100.100.2 ncsu vcid 1 mode core
configure mpls add tls t34 11.100.100.4 ncsu vcid 1 mode core
```

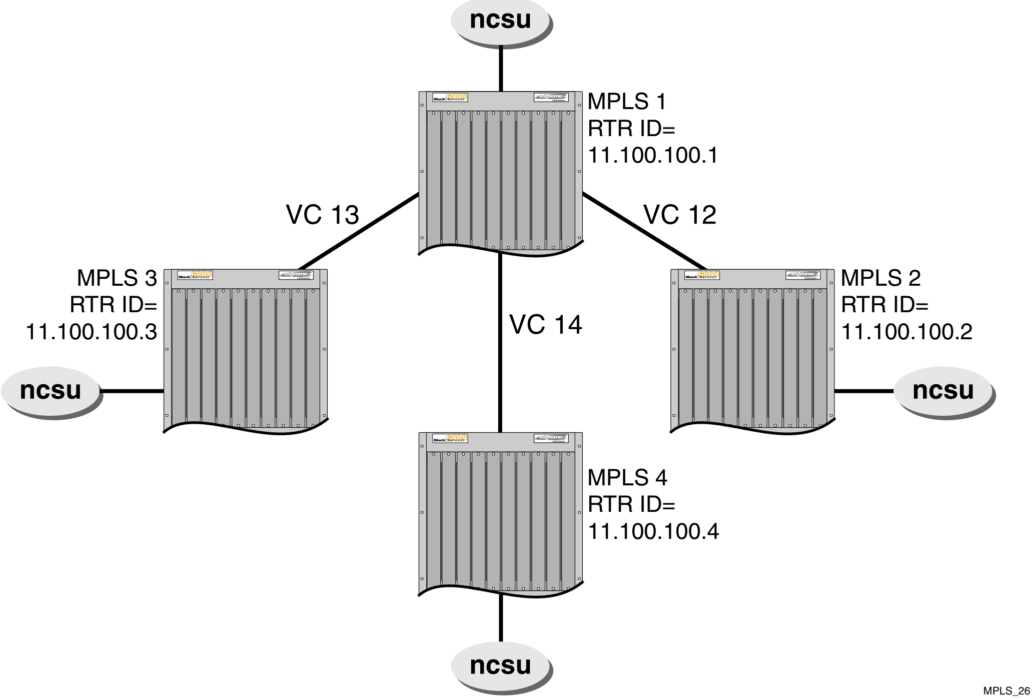
mpls4

```
configure mpls add tls t14 11.100.100.1 ncsu vcid 1 mode core
configure mpls add tls t24 11.100.100.2 ncsu vcid 1 mode core
configure mpls add tls t34 11.100.100.3 ncsu vcid 1 mode core
```

Hub and Spoke TLS Configuration

The following example, shown in Figure 145 , configures a four node hub-and-spoke MPLS TLS configuration. The hub LER MPLS configuration includes a TLS tunnel to every other LER. Each spoke LER MPLS configuration includes a TLS tunnel to only the hub LER. The egress VLAN for the VPN is called ncsu. The target IP address (e.g. 11.100.100.2) shown in each TLS configuration command must be either a Router ID or Loopback VLAN interface address.

Figure 145: Hub and spoke configuration example



Each of the following commands configure a TLS tunnel to an LER for which the VLAN ncsu has a PoP. In order for each TLS tunnel to become active, a matching TLS tunnel definition with the same VC ID must be configured on the target LER.

mpls1

```
configure mpls add tls t12 11.100.100.2 ncsu vcid 1 mode spoke
configure mpls add tls t13 11.100.100.3 ncsu vcid 1 mode spoke
configure mpls add tls t14 11.100.100.4 ncsu vcid 1 mode spoke
```

mpls2

```
configure mpls add tls t12 11.100.100.1 ncsu vcid 1 mode spoke
```

mpls3

```
configure mpls add tls t13 11.100.100.1 ncsu vcid 1 mode spoke
```

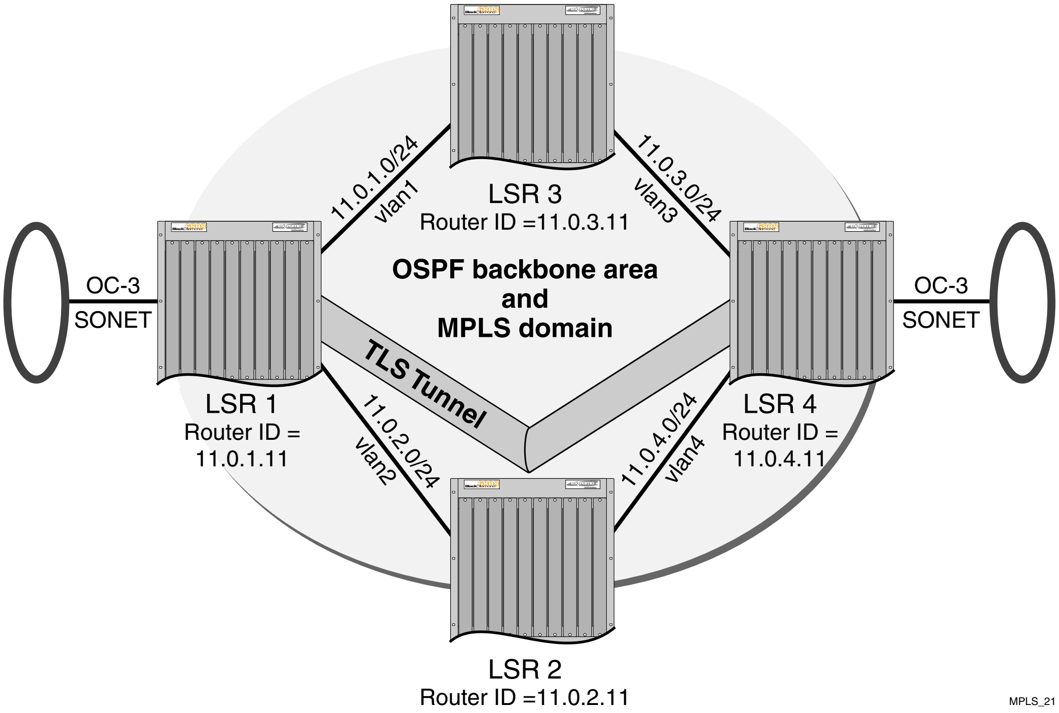
mpls4

```
configure mpls add tls t14 11.100.100.1 ncsu vcid 1 mode spoke
```

Configuration Example Using PPP Transparent Mode

The configuration example, shown in Figure 146, illustrates how to configure a pair of BlackDiamond switches so that SONET PPP traffic is transparently transported across an MPLS domain. If an OC-3 or OC-12 SONET module is installed in the BlackDiamond chassis, PPP traffic received on a SONET port that is a member of a TLS VLAN is transparently transported across the MPLS domain to the destination switch to be transmitted out of a matching SONET interface.

Figure 146: TLS configuration example using PPP transparent mode



The configuration commands for this example follow.

The following command configures the OC-3 module for slot 1:

```
configure slot 1 module oc3
```

The following command creates the VLAN that is used to configure the TLS tunnel for transparently transporting PPP traffic:

```
create vlan sonet
```

The following command adds port 1 of the OC-3 module in slot 1 to the *sonet* VLAN. There is a one-to-one mapping between SONET ports and SONET TLS VLANs, so each SONET TLS VLAN can have only a single SONET port, and no other port, as a member:

```
configure vlan sonet add port 1:1
```

The following commands disable BCP mode and enable POS transparent mode on the OC-3 interface that is a member of the TLS VLAN:

```
configure ppp bcp off port 1:1
configure ppp pos transparent-mode on port 1:1
```

The following command creates the TLS tunnel to LSR 4 for SONET PPP traffic received on VLAN *sonet:*

```
configure mpls add tls-tunnel sonet 11.0.4.11 tls-vlan 8f002 8f005
```

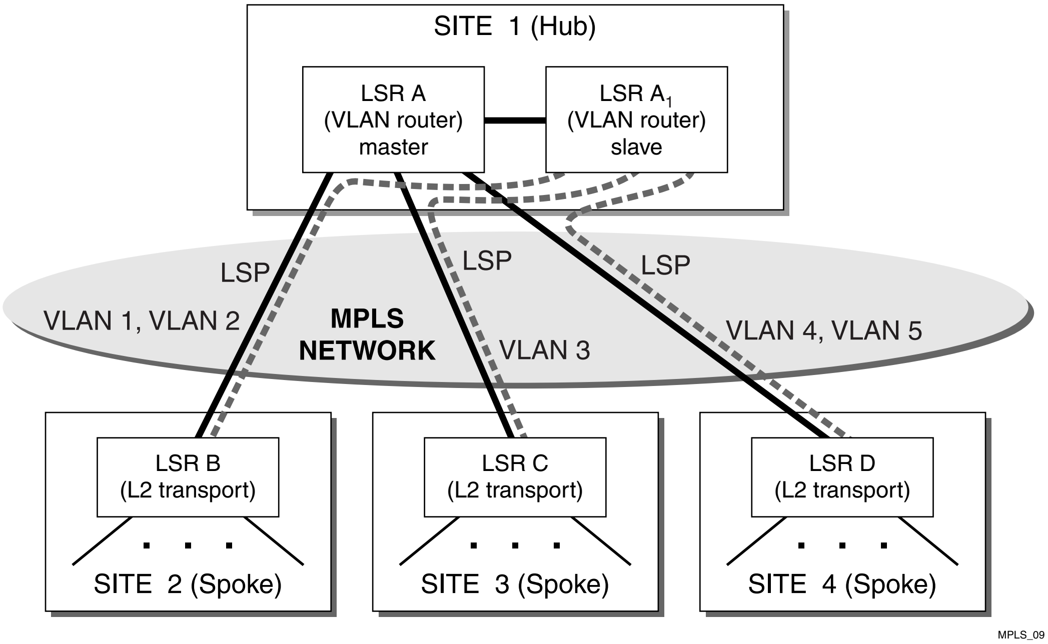
The SONET configuration for LSR 4 is exactly the same as the configuration for LSR 1, but the TLS tunnel is targeted towards LSR 1, as follows:

```
configure mpls add tls-tunnel sonet 11.0.1.11 tls-vlan 8f005 8f002
```

Using ESRP with MPLS TLS

ESRP can be used in conjunction with TLS to provide redundancy. For example, consider adding a second LSR to the hub, as shown in Figure 147.

Figure 147: Using ESRP with TLS



ESRP is run over the Ethernet VLAN connecting the two hub-LSRs, and the redundant IP address configured for ESRP is also being used as the tunnel endpoint address.

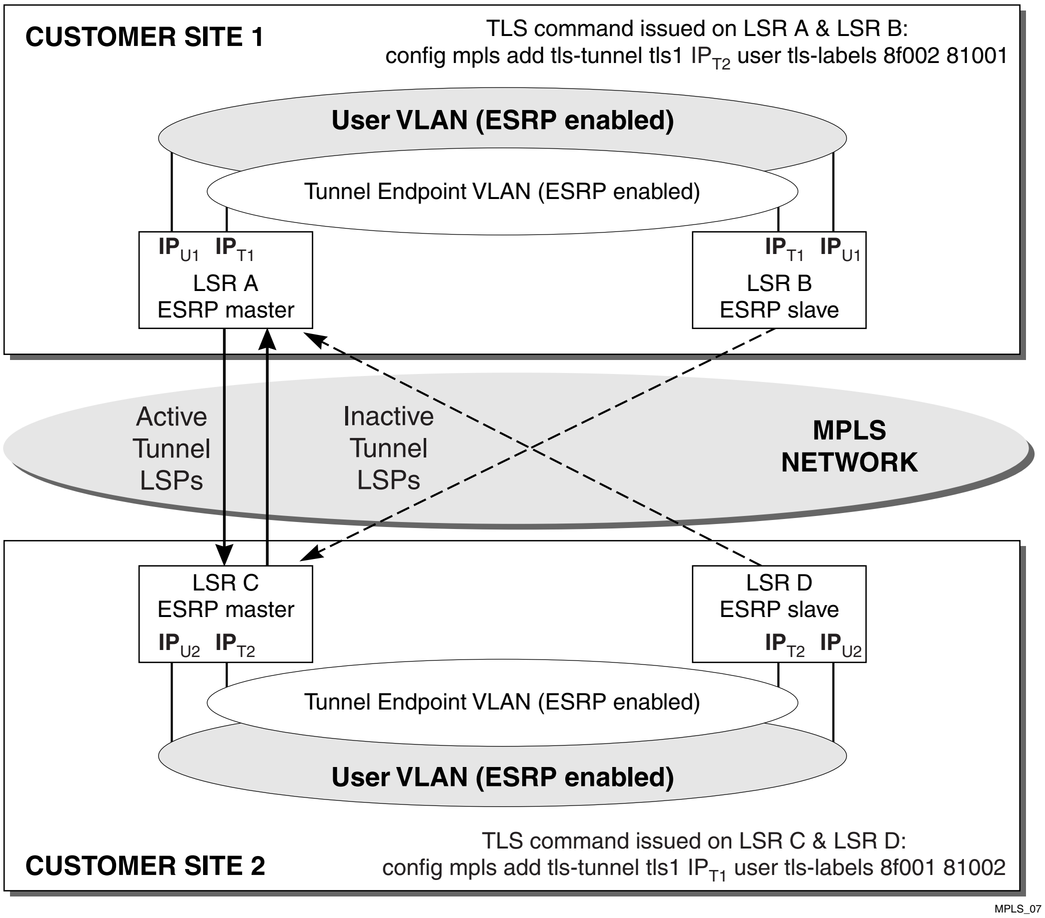
Using this configuration, the LSRs at the spoke sites automatically connect to the active hub-LSR and rapidly adapt to failures. If the master hub-LSR fails, ESRP activates the standby hub-LSR, which then responds by advertising a route and label mapping for the tunnel endpoint IP address.

The LSRs at the spoke sites receive the label mapping and begin using the new tunnel LSP. Loopback mode should not be enabled when ESRP is being used to provide redundancy. Dynamic routing protocols, such as OSPF, run on the master ESRP VLAN. If ESRP elects a new master ESRP VLAN, dynamic routing protocols are run on the new master ESRP VLAN.

Tunnel Endpoint VLANs

Another example of using ESRP is shown in Figure 148.

Figure 148: Tunnel endpoint VLANs


CUSTOMER SITE 1
TLS command issued on LSR A & LSR B:
config mpls add tls-tunnel tls1 IP_{T2} user tls-labels 8f002 81001
User VLAN (ESRP enabled)
Tunnel Endpoint VLAN (ESRP enabled)
IP_{U1} IP_{T1}
LSR A
ESRP master
IP_{T1} IP_{U1}
LSR B
ESRP slave
Active Tunnel LSPs
Inactive Tunnel LSPs
MPLS NETWORK
LSR C
ESRP master
IP_{U2} IP_{T2}
LSR D
ESRP slave
IP_{T2} IP_{U2}
Tunnel Endpoint VLAN (ESRP enabled)
User VLAN (ESRP enabled)
TLS command issued on LSR C & LSR D:
config mpls add tls-tunnel tls1 IP_{T1} user tls-labels 8f001 81002
CUSTOMER SITE 2
MPLS_07

In Figure 148, redundant LSRs are installed at both ends of a TLS tunnel. This example takes advantage of the IP multinetting feature in ExtremeWare by creating an overlay *tunnel endpoint* VLAN that shares the same Ethernet ports as the user VLAN that is extended across the MPLS backbone network. A tunnel endpoint VLAN is created at both sites.

ESRP is enabled on the tunnel endpoint VLANs and the user VLANs. To ensure that the same LSR is selected as the ESRP master for both VLANs, the ESRP configuration of the user VLAN and the associated tunnel endpoint VLAN must be identical. Enabling ESRP on the user VLAN ensures that only one LSR (the ESRP master) forwards traffic for the VLAN at each site.

The redundant IP address configured on the tunnel endpoint VLAN (*IP_{T1}*) is also used as the tunnel endpoint address in the same manner as described for the preceding example. Therefore, it is the ESRP master for the user VLAN that forwards traffic onto the tunnel LSP, and it is the ESRP master for the tunnel endpoint VLAN that forwards traffic received from the tunnel LSP (as a consequence of being the LSR with which the tunnel LSP is established).

The tunnel endpoint VLANs are created specifically to provide fault-tolerant tunnel endpoint IP addresses in a manner that is totally transparent to the user VLAN. ESRP is used to provide the fault-tolerant IP addresses. The tunnel endpoint IP addresses could be defined on the user VLAN instead. However, an OSPF route must be advertised for a tunnel endpoint IP address to ensure that the underlying LSP is established by LDP. By creating the tunnel endpoint VLAN the IP address defined on the user VLAN does not need to be exported into the MPLS backbone (which would expose information about the user VLAN to the MPLS backbone).

IP addresses are defined on the user VLAN (*IP_{U1}*) for ESRP purposes, but these addresses are only used locally at each site. In this example, IP addresses would have to be defined on a different set of VLANs to provide the connectivity to the MPLS backbone. These MPLS VLANs are not depicted in Figure 148. The MPLS VLANs contain a different set of physical ports than the user VLAN, and MPLS must be enabled on the MPLS VLANs.

ESRP standby LSRs preestablish tunnel LSPs to the ESRP master LSR at the other site. The pre-established tunnel LSPs are inactive as long as the LSR is in standby mode, but can expedite recovery from a failure. For example, if LSR A were to fail, LSR B would become the ESRP master at Site 1, and LSR B would already have an LSP established to LSR C. Upon becoming ESRP master, LSR B would advertise an OSPF route and a MPLS label mapping for IP_{T1}, and LSR C would then begin using the new tunnel LSP to LSR B.

The ESRP route table tracking feature is also useful in conjunction with TLS. ESRP route table tracking can be configured to initiate an ESRP failover when no route is available to the tunnel endpoint IP address. For example, LSR A can be configured to initiate a failover to LSR B when its route table does not have an entry for IP_{T2}. Each of the LSRs would be configured to use ESRP route table tracking in a similar manner.

LSP Tracking

LSP tracking provides MPLS with specific ESRP selection criteria for determining the ESRP status of a VLAN. LSP tracking is similar to route tracking and ping tracking in ESRP. As shown in Figure 148, ESRP can be configured to protect the user VLAN from disruptions in the MPLS network core. For example, LSR A and LSR B can be configured to track an established LSP to *IP_{T2}*. If a network disruption causes the LSP from LSR A to LSR C to fail, ESRP detects the condition and fails over to LSR B (provided LSR B has an established LSP to LSR C). This type of LSP protection is especially useful when providing ESRP redundant TLS L2 VPN services using Traffic Engineered LSPs that take completely different paths (for example, LSP from LSR A to LSR C and LSP from LSR B to LSR C).

Using ESRP domains, LSP tracking can be easily scaled to support several TLS VLANs that are tunneled across an L2 VPN using a single LSP. Instead of each TLS VLAN tracking the same LSP, all of the TLS VLANs are placed into an ESRP domain for which there is one non-TLS VLAN, configured to track the state of the LSP. When ESRP detects that the LSP has failed, all of the VLANs in the configured ESRP domain transition to neutral state and the backup LSR becomes the master switch for all of the TLS VLANs.

To configure LSP tracking, use the following commands:

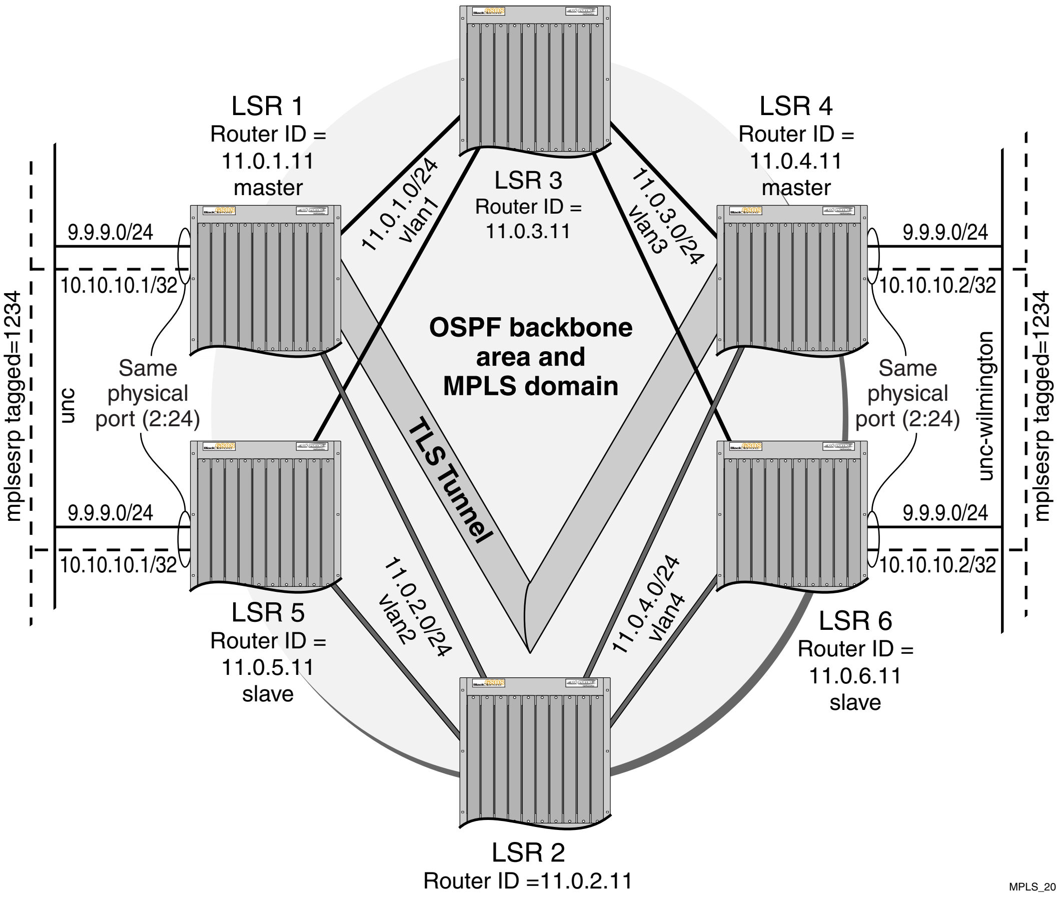
```
configure vlan <vlan name> add track-lsp [<lsp_name> | ipaddress
<ipaddress>/<masklength>]

configure vlan <vlan name> delete track-lsp [<lsp_name> | ipaddress
<ipaddress>/<masklength> | all]
```

This command configures the LSPs tracked by ESRP in order to determine the ESRP state of the specified VLAN. The `add track-lsp` command configures ESRP to track up to eight LSPs. Fail over to the slave switch is based on the total number of established tracked LSPs. The switch with the greatest number of established tracked LSPs is elected the master switch for the specified VLAN. Specifying the parameter `<lsp_name>` instructs ESRP to track the status of an RSVP-TE LSP. Specifying the `ipaddress` keyword instructs ESRP to track the LSP status for the IP prefix as defined by the `<ipaddress/masklength>` parameter. Both types of LSPs can be tracked simultaneously. The `delete track-lsp` command removes an LSP from ESRP tracking for the specified VLAN. If you specify the `all` keyword, all configured LSPs are removed from ESRP tracking for the specified VLAN.

Configuration Example

The MPLS TLS ESRP configuration example, shown in Figure 149, illustrates how to configure a pair of BlackDiamond switches to provide redundant Layer-2 VPN services over an MPLS domain. Two additional switches have been added to the TLS MPLS network configuration example shown in Figure 143, LSR 5 and LSR 6. LSR 5 and LSR 6 provide redundant connectivity for TLS VLANs into the MPLS domain.

Figure 149: TLS configuration example using ERSP



The following sections describe how to configure LSR 1 and LSR 5.

The following commands create a tagged ESRP VLAN over which ESRP control packets flow. Tagging the VLAN separates the customer's local traffic from the ESRP control packets and prevents OSPF routes from the MPLS service provider domain from leaking into the customer's VLAN:

```
create vlan mplsesrp
configure vlan mplsesrp tag 1234
configure vlan mplsesrp ipaddress 10.10.10.1/32
configure vlan mplsesrp add port 2:24 tagged
```

The ESRP VLAN must be OSPF-enabled so that the router interface is advertised into the MPLS domain. The ESRP router interface is used as the LSP destination for the TLS tunnel. By configuring a TLS tunnel using the ESRP VLAN router interface, the TLS tunnel can migrate between switches as switches change ESRP state:

```
configure ospf add vlan mplsesrp area 0.0.0.0
configure ospf vlan mplsesrp cost 10
```

The following command enables ESRP on VLAN *mplsesrp*. The ESRP VLAN and the TLS VLAN must have the same port membership. In this example, port 2:24 is a member of both VLANs:

```
enable esrp vlan mplsesrp
```

The following command creates a TLS tunnel from VLAN *unc* to the master switch providing connectivity for VLAN *unc-wilmington*:

```
configure mpls add tls-tunnel rt40 10.10.10.2 unc vcid 1 from mplsesrp
```

From an ESRP perspective, LSR 5 is configured identically as LSR 1.

LSR 4 and LSR 6 are configured in a very similar manner to LSR 1 and LSR 5. A tagged ESRP control VLAN is created between them and given an IP address. The ESRP VLAN is also OSPF-enabled so that the router interface is advertised into the MPLS domain.

```
create vlan mplsesrp
configure vlan mplsesrp tag 1234
configure vlan mplsesrp ipaddress 10.10.10.2/32
configure vlan mplsesrp add port 2:24 tagged

configure ospf add vlan mplsesrp area 0.0.0.0
configure ospf vlan mplsesrp cost 10

enable esrp vlan mplsesrp
```

And finally, a TLS tunnel is created from VLAN *unc-wilmington* to the master switch providing connectivity for VLAN *unc*. This configuration command is issued on both LSR 4 and LSR 6.

```
configure mpls add tls-tunnel rt40 10.10.10.1 unc-wilmington vcid 1 from mplsesrp
```

29 High Density Gigabit Ethernet Module

The High Density Gigabit Ethernet modules (also known as "3" series modules) are I/O modules for both the Alpine 3800 series and the BlackDiamond 6800 series chassis-based systems. These modules support bi-directional traffic management to control the rate of information that flows into (ingress) or out of (egress) a switched network from one individual network port.

The "3" series modules are designed for metro service providers and enterprise environments. In a service provider environment, service providers can control the flow of data on a per customer basis. In an enterprise environment, businesses can use these modules to control user access or where desktop or server interfaces require high-density Gigabit Ethernet capability.

The "3" series modules also support the QoS functions, commands, and configurations described in Chapter 8.

NOTE

The 10GX3 module does not support the enhanced QoS functions described in this chapter.

This chapter covers the following topics:

- About the High Density Gigabit Ethernet Module on page 747
- Configuring the High Density Gigabit Ethernet Module on page 752
- Configuration Examples on page 761
- Performing Cable Diagnostics on page 762

About the High Density Gigabit Ethernet Module

The High Density Gigabit Ethernet I/O modules support oversubscribed, high-density Gigabit Ethernet interfaces on both the Alpine and BlackDiamond chassis. In addition to oversubscription, you can enable flow control on a per-port basis to stop incoming traffic when too much congestion occurs. You can also configure the receive and transmit data rates on individual ports.

There are eight ingress queues per physical port, and you use the following to classify the queues for the type of traffic being handled by the port:

- VLAN ID

- VLAN priority
- DiffServ code point
- Application examination rules (IP protocol number or TCP/UDP port number)

Table 93 lists the "3" series I/O modules offered by Extreme Networks.

Table 93: "3" series I/O modules

Chassis	Module Name	Description
Alpine		
	GM-16X^3	16 1000BASE-X ports available through 16 mini-GBIC slots
	GM-16T^3	16 1000BASE-T ports available through 16 RJ-45 ports
BlackDiamond		
	G16X^3	16 1000BASE-X ports available through 16 mini-GBIC slots
	G24T^3	24 1000BASE-T ports available through 24 RJ-45 ports

Alpine High Density Gigabit Ethernet Modules

The Alpine 3800 series chassis supports two types of High Density Gigabit Ethernet I/O modules. The GM-16X^3 and the GM-16T^3 ports are oversubscribed 4:1 to the Alpine backplane. Each module has four groups of four ports each, and each group multiplexes traffic into a single full duplex gigabit link to the switch fabric.

To take advantage of this architecture, use a single port in each group before using all of the ports in any particular group. Table 94 lists the port groups for the GM-16X^3 and GM-16T^3 modules.

Table 94: GM-16X^3 and GM-16T^3 port groups

Ports	Group
1, 2, 3, 4	1
5, 6, 7, 8	2
9, 10, 11, 12	3
13, 14, 15, 16	4

Each port group provides fully independent backplane connectivity. To define the maximum amount of over-subscription, you can activate one, two, three, or all four ports within a port group. For example, if you activate two ports in group one, only those two ports share a gigabit link to the backplane.

NOTE

If congestion is detected on a port with flow control enabled, a flow control PAUSE frame is sent out that port. The PAUSE frame is not sent out on the other ports in the group.

For more information about these and other Alpine modules, see the *Extreme Networks Consolidated "i" Series Hardware Installation Guide*.

BlackDiamond High Density Gigabit Ethernet Modules

The BlackDiamond 6800 series switch supports two types of High Density Gigabit Ethernet I/O modules. The G16X^3 and G24T^3 ports are oversubscribed to the module's switch fabric. The G16X^3 has eight groups of two ports each, and the G24T^3 has six groups of four ports each. Each group multiplexes traffic into a single full duplex gigabit link to the switch fabric.

To take advantage of this architecture, use a single port in each group before using all of the ports in any particular group. Table 95 lists the groups for the G16X^3 module, and Table 96 lists the groups for the G24T^3 module.

Table 95: G16X^3 port groups

Ports	Group
1, 2	1
3, 4	2
5, 6	3
7, 8	4
9, 10	5
11, 12	6
13, 14	7
15, 16	8

Table 96: G24T^3 port groups

Ports	Group
1, 2, 3, 4	1
5, 6, 7, 8	2
9, 10, 11, 12	3
13, 14, 15, 16	4
17, 18, 19, 20	5
21, 22, 23, 24	6

NOTE

If congestion is detected on a port with flow control enabled, a flow control PAUSE frame is sent out that port. The PAUSE frame is not sent out on the other port in the group.

For more information about these and other BlackDiamond modules, see the *Extreme Networks Consolidated "i" Series Hardware Installation Guide*.

Summary of Features

The "^{3}" series I/O modules support the following features:

- T-Control—Guarantees any level of bandwidth (from 1 kbps to 1 Gbps) to any port on the module, configures ingress rate limiting and shaping for oversubscription and traffic management
- Access Control Lists (ACL)—Accommodates up to 10,000 hardware-based wire-speed ACLs

- Ingress Quality of Service (IQoS) and Differentiated Services (DiffServ)
  - Eight ingress and eight egress queues per interface
  - Ingress rate shaping and limiting for prioritizing different levels of traffic coming into or going out of the module
  - Random Early Discard (RED) congestion avoidance algorithm
- Two-tier rate limiting
  - Committed Information Rate (CIR)—Tiered rate shaping for guaranteed traffic
  - Peak Rate (PR)—Burst services to ensure bandwidth efficiency
- Wire-speed IP/IPX routing using RIP v1/v2, OSPF, BGP4, PIM, and DVMRP
- Finer granularity (1 kbps precision) egress rate-limiting per port

Summary of Functions

The following sections provide descriptions of the key functions provided by the "3" series modules.

T-Control

Triumph-based T-Control enables per-application traffic classification and tagging to deliver bi-directional traffic management. T-Control supports eight ingress queues, eight egress queues, and a hierarchical egress queue for managing aggregate output traffic on each port. Each queue runs at wire-speed and individually configured to rate-shape traffic. Rate-shaping allows you to control over how much bandwidth each port, user, and application will receive.

With T-Control you can maintain detailed statistics for all in-profile, out-profile, and dropped traffic on each queue. Use this data to track and control port utilization, application behavior, and for service providers, usage-based billing.

Ingress Quality of Service

The "3" series modules support eight ingress queues and eight egress queues per port. The scheduling parameters for these queues (minimum bandwidth, maximum bandwidth, etc.) are controlled by ingress QoS profiles that you can customize for individual ingress or egress queues on a specific "3" series port.

You can assign frames to queues based on IEEE 802.1p priorities, DiffServ code points (DSCPs), or by configuring an ingress QoS profile for the VLAN. You can tailor the DSCP-to-queue mapping on a per-port basis.

The "3" series module also provides flexible support for the RED congestion avoidance algorithm.

The "3" series modules also support the QoS functions and configurations described in Chapter 8. Since the High Density Gigabit Ethernet modules have their own commands to implement ingress rate limiting, you do not need to configure the internal loopback port.

Two-Tier Rate Limiting

T-Control ingress queues accommodate and use a two-tiered method for handling rate limiting. Implementing a two-tier rate limiting mechanism for each queue allows the port to be maximally utilized by allowing applications to burst and still provide guaranteed access for critical applications.

Use the following settings to control the rate of traffic through ingress queues:

- Committed Information Rate (CIR)
- Peak Rate (PR)

The CIR (specified in either bps or a percentage of the link speed) is the rate of traffic guaranteed to reach the backplane (also considered high priority traffic). Depending on conditions, traffic that exceeds the CIR may be dropped.

The PR is a rate equal to or greater than the CIR but less than or equal to the link speed that sets the maximum burst rate that the queue can reach (also considered low priority traffic).

Configuring the High Density Gigabit Ethernet Module

This section describes the ExtremeWare commands that support the "3" series I/O modules. For hardware installation on the Alpine 3800 series switch or the BlackDiamond 6800 series switch, see the *Extreme Networks Consolidated "i" Series Hardware Installation Guide*.

NOTE

Documentation for Extreme Networks products is available on the World Wide Web at the Extreme Networks home page at http://www.extremenetworks.com/.

Configuring Flow Control

You can configure 802.3x flow control on your "3" series module. Because these modules are oversubscribed to the module switch fabric, traffic can congest. Flow control allows you to stop incoming traffic when too much congestion occurs.

Flow control sends a PAUSE frame to the transmitter when traffic approaches the congestion threshold for a specific queue. The PAUSE frame is sent *before* the queue overflows, so throughput is slightly reduced when flow control is enabled. Flow control is auto-negotiated and is disabled if both ports do not support it.

Flow control is disabled by default. To enable 802.3x flow control, use the following command:

```
enable flow-control ports [<portlist> | all]
```

To disable 802.3x flow control, use the following command:

```
disable flow-control ports [<portlist> | all]
```

Use the `all` keyword to specify all configured "3" series ports.

To see the flow control configuration, use the `show ports configuration` command. DSBL indicates that flow control is disabled on that port. ENBL indicates that flow control is enabled while auto-negotiation is off for that port. If flow control and auto-negotiation are both enabled, the negotiated flow control value is displayed.

Configuring VLANs

To configure a VLAN to use a particular ingress QoS profile, use the following command:

```
configure vlan <vlan name> qosprofile ingress [<Ingress QOS profile> | none]
```

where the following is true:

- `vlan name` specifies a VLAN name.
- `Ingress QOS profile` specifies an ingress QoS profile, such as IQP1.
- `none` specifies that traffic from this VLAN is not associated with any ingress queue based on VLAN ID. This is the default setting.

All VLANs are set to the default ingress QoS profile *none*.

Configuring Ingress QoS Functions

You can configure ingress QoS on your "3" series module. Ingress QoS is used to prioritize, rate-limit, and rate-shape traffic received on the "3" series ports. The following sections describe the commands used to configure ingress QoS on your "3" series module.

NOTE

Untagged packets are always dot1q VLAN tagged internally. Therefore, ingress classification based on dot1p is always valid if there are no higher priority classifications that are valid. Configuring the ingress qostype priority for dot1p above any other classification method will effectively disable that classification. Untagged packets get their dot1p VLAN priority bits set to the value configured by `configure vlan <vlan> qosprofile <QoS Profile Name>` *and* `configure port <port> qosprofile <QoS Profile Name>`*. The former command takes precedence over the latter.*

Configuring Ingress QoS Settings

Congestion can cause ingress traffic with different dot1p priority values or different DiffServ code points to be dropped on oversubscribed "3" series I/O modules. Ingress QoS allows received traffic with different VLAN priority values, different DiffServ code points (IP TOS), or from different VLANs to be classified to up to eight different ingress queues. This allows for specified traffic types to be queued separately so they remain unaffected by congestion in other ingress queues. Default ingress QoS settings avoid discards of higher priority traffic (identified by DiffServ code point or VLAN priority) in the presence of ingress congestion.

DiffServ examination is enabled by default on all "3" series ports; DiffServ examination is disabled by default on all other ports.

To configure ingress QoS, use the following command:

```
configure qostype ingress priority [diffserv | dot1p | vlan | application]
<qos-priority (0-15)>
```

where the following is true:

- `diffserv` specifies the ingress priority based on DiffServ information. The default is 3.
- `dot1p` specifies the ingress priority based on dot1p information. The default is 1.
- `vlan` specifies the ingress priority of VLAN ID-based input queue selection. The default is 2.
- `application` specifies the priority of the ingress queue selection based on application examination rules (IP protocol number and TCP/UDP port numbers). The default is 5.
- `priority` range is 0-15 (15 is the highest priority). Each queue selection criteria must have a unique priority (no ties).

Ingress QoS types with a greater value take higher precedence. The queue selection criteria with the highest priority, if enabled in the received packet, is used first, followed by the remaining criteria in descending order.

To restore the default ingress QoS settings, use the following command:

```
unconfigure qostype ingress priority
```

To view the ingress QoS settings on your "3" series module, use the following command:

```
show qostype ingress priority
```

The following is sample output from this command:

```
Ingress QoS Type              Priority
Application                      5
Diffserv                         3
Vlan                             2
Dot1p                            1
```

Configuring Application Examination Rules

Creating application examination rules configures ingress queue classification based on application QoS (IP protocol number, TCP ports, or UDP ports). The command for creating application examination rules is similar to the existing `config diffserv examination` command except that it has more arguments and can overlap on the same ports, so an application name is used to identify each rule. The `none` instead of IQoS profile means that AQoS is not used for queue classification for the matching packets and the next lower ingress qostype priority (queue classification) is used. Precedence is required, since a match on multiple rules is possible. Up to 1,000 application examination rules can be created.

To create application examination rules, use the following command:

```
create application examination <application name> [ip-protocol <number> | [tcp-port |
udp-port] <number> match [source-only | dest-only | source-or-dest] ] [<Ingress QOS
profile> | none] precedence <(1-65000)>
```

where the following is true:

- `application name` specifies the name string to associate with this rule.
- `ip-protocol` specifies that a match will be attempted on the IP protocol number in the received packets.
- `tcp-port` specifies that a match will be attempted on the TCP port numbers in the received packets.
- `udp-port` specifies that a match will be attempted on the UDP port numbers in the received packets.
- `source-only` specifies that when doing TCP or UDP comparisons, only source port numbers will be compared.
- `dest-only` specifies that when doing TCP or UDP comparisons, only destination port numbers will be compared.
- `source-or-dest` specifies that when doing TCP or UDP comparisons, both source and destination port numbers will be compared. The match is successful if either source or destination port equals the specified port number.
- `Ingress QoS profile` specifies an ingress QoS profile name to associate with any ingress packets matching this rule.

- `none` specifies that traffic matching this rule will not be associated with any ingress queue based on application examination.
- `precedence` specifies the precedence value for this rule. If an incoming packets matches multiple rules, the precedence number is used to determine which rule to apply (lower number = higher precedence).

To delete an previously configured application rule, use the following command:

```
delete {application examination} <application name>
```

Up to 60 application examination rules can be associated with each port. To add or delete an application examination rule to or from ports on a specified "3" series module, use the following command:

```
configure {application examination} <application name> [add | delete] ports
[<portlist> | all]
```

To enable or disable application examination rules on specified ports, use the following commands:

```
enable application examination ports [<portlist | all]
disable application examination ports [<portlist | all]
```

To view the configured application examination rules on your "3" series module, use the following command:

```
show {application examination} {<application name>}
```

The following is sample output from this command:

```
                   IP   TCP/UDP
        Name Typ Prt  Port  Match    Q  Prec Ports
============ === === ===== ====== ==== ====== ==================================
       TCP20 tcp   6    20    dst IQP3   100 4:1,  4:2,  4:3,  4:4,  4:5, 4:6
                                             4:7,  4:8,  4:9, 4:10, 4:11, 4:12
                                             4:13, 4:14, 4:15, 4:16, 4:17, 4:18
                                             4:19, 4:20, 4:21, 4:22, 4:23, 4:24
```

Configuring Ingress QoS Profiles

The "3" series modules support eight ingress queues. The scheduling parameters (minimum bandwidth and maximum bandwidth) for these queues are controlled by ingress QoS profiles IQP1 through IQP8, which means queue #0 is controlled by IQP1, queue #1 is controlled by IQP2, and so on.

Define Ingress QoS profiles with the following command:

```
configure qosprofile ingress <Ingress QOS profile> [minbw <percent> % maxbw <percent>
% | committed-rate <bps> [k | m] peak-rate <bps> [k | m]] red-threshold <percent> %
maxbuf <percent> % ports [<portlist> | all]
```

where the following is true:

- `Ingress QoS profile` specifies an ingress QoS profile. Ingress QoS profiles are IQP1 through IQP8.
- `minbw` specifies the minimum percentage of the bandwidth guaranteed to be available to the specified queue for transmissions from the ingress QoS profile.

NOTE

The sum of the committed rate and the equivalent rate for the configured minbw percent for all ingress queues on a port must not exceed 250 mpbs for 4:1 oversubscribed platforms (GM-16T^3, GM-16X^3, and G24T^3) and 500 mbps for 2:1 oversubscribed platforms (G16X^3).

- `maxbw` specifies the maximum percentage of the bandwidth that the specified queue can use for transmissions from the ingress QoS profile. The range is 0-100. The default is 100.
- `committed-rate` specifies the minimum bandwidth for the specified queue in either kbps or mbps.

NOTE

The sum of the committed rate and the equivalent rate for the configured minbw percent for all ingress queues on a port must not exceed 250 mpbs for 4:1 oversubscribed platforms (GM-16T^3, GM-16X^3, and G24T^3) and 500 mbps for 2:1 oversubscribed platforms (G16X^3).

- `peak-rate` specifies the maximum bandwidth for the specified queue in either kbps or mbps. The range is:
  - — kbps: 0 to 1000000
  - — mbps: 0 to 1000
- `red-threshold` specifies the ingress queue fill percentage when the “^{3}” series module begins to randomly discard packets as the queue fill percentage approaches the maximum queue size. The range is 0-100. The default is 100.
- `maxbuf` specifies the ingress queue size as a percentage of the maximum size available. The range is 0-100. The default is 100.
- `portlist` allows ingress QoS profiles to be customized on a port-by-port basis for the “^{3}” series module. If you select the `all` keyword, all “^{3}” series ports are selected.

The “^{3}” series modules support commands for notification of actual or impending ingress traffic loss.

Disable or enable the sending of these traps on a per port basis, by using the following command:

```
disable snmp traps exceed-committed-rate ports <portlist> {<Ingress QOS Profile>}
enable snmp traps exceed-committed-rate ports <portlist> {<Ingress QOS Profile>}
```

By default these traps are disabled on the switch for all ports. Committed and peak rate violations will be written to the syslog when this trap is enabled.

To view the ingress QoS profiles on your “^{3}” series module, use the following command:

```
show qosprofile ingress {<Ingress QOS profile>} {<portlist>}
```

where the following is true:

- `Ingress QOS profile` specifies an optional ingress QoS profile. Ingress QoS profiles are IQP1 through IQP8. If you do not specify an ingress QoS profile, all ingress QoS profiles for the specified ports are displayed.
- `portlist` specifies one or more slots and ports.

The units displayed are the same units that you used when you configured the ingress QoS profile.

Following is sample output from this command:

```
                   MinBw %/         MaxBw %/
 Port Queue  Committed-Rate       Peak-Rate   RED %  MaxBuf %
=============================================================
  1:1  IQP1          1000 k          1000 m   100 %     100 %
       IQP2             0 %           100 %   100 %     100 %
       IQP3             0 %           100 %   100 %     100 %
       IQP4             0 %           100 %   100 %     100 %
       IQP5             0 %           100 %   100 %     100 %
       IQP6             0 %           100 %   100 %     100 %
       IQP7             0 %           100 %   100 %     100 %
       IQP8             0 %           100 %   100 %     100 %
  1:2  IQP1             0 %           100 %   100 %     100 %
       IQP2             0 %           100 %   100 %     100 %
       IQP3             0 %           100 %   100 %     100 %
       IQP4             0 %           100 %   100 %     100 %
       IQP5             0 %           100 %   100 %     100 %
       IQP6             0 %           100 %   100 %     100 %
```

Configuring DiffServ

This section describes the DiffServ commands used and supported for configuring rate limiting on the "3" series modules. Rate limiting allows you to control the rate of information and the amount of bandwidth used for incoming and outgoing traffic in your network. When a packet arrives on a "3" series ingress port, the switch examines the first six of eight TOS bits, called the *code point*. Based on the code point, the switch can assign the ingress QoS profile used for ingress rate limiting and ingress rate shaping. The examination of DiffServ information is enabled by default on "3" series modules but disabled by default for ports on all other I/O modules.

DiffServ Code Point Assignments

Because the code point uses 6 bits, it has 64 possible values. By default, the values are grouped and assigned to the default ingress QoS profiles listed in Table 97.

Table 97: Default code point to ingress QoS profile mapping

Code Point	Ingress QoS Profile
0-7	IQP1
8-15	IQP2
16-23	IQP3
24-31	IQP4
32-39	IQP5
40-47	IQP6
48-55	IQP7
56-63	IQP8

Replacing Ingress DiffServ Code Points

You can configure both low-priority and high-priority traffic values to overwrite the DiffServ code point for ingress traffic. DiffServ ingress replacement is only done on IP Ethernet II (Ethertype) encapsulated frames. Frames that are IPX, LLC, or SNAP encapsulated are passed through with no DiffServ code point alterations. By default, DiffServ ingress replacement is disabled for all queues on all ports.

To configure DiffServ replacement, use the following command:

```
configure diffserv ingress replacement low-priority code-point <number> high-priority
code-point <number> ports [<portlist> | all] {<Ingress QOS profile>}
```

where the following is true:

- `low-priority code-point` specifies the low-priority DiffServ code point (IP TOS) value to use to overwrite low-priority ingress traffic. The default is 0. The range is 0 to 63.
- `high-priority code-point` specifies the high-priority DiffServ code point (IP TOS) value to use to overwrite high-priority ingress traffic. The default is 0. The range is 0 to 63.
- `portlist` specifies one or more "3" series ports. If you specify the `all` keyword, all "3" series ports are selected.
- `Ingress QOS profile` specifies an optional ingress QoS profile. If you do not specify an ingress QoS profile, all ingress QoS profiles for the indicated ports will be affected.

To enable the replacement of ingress DiffServ code points, use the following command:

```
enable diffserv ingress replacement [high-priority | low-priority |
low-and-high-priority] ports [<portlist> | all] {<Ingress QOS profile>}
```

where the following is true:

- `high-priority` enables DiffServ for high-priority traffic (traffic received below the committed rate configured for the ingress QoS profile).
- `low-priority` enables DiffServ for low-priority traffic (traffic received above the committed rate configured for the ingress QoS profile).
- `low-and-high-priority` enables DiffServ for both low-priority and high-priority traffic.
- `portlist` specifies one or more "3" series ports. If you specify the `all` keyword, all "3" series ports are selected.
- `Ingress QOS profile` specifies an optional ingress QoS profile. If you do not specify an ingress QoS profile, all ingress QoS profiles for the indicated ports will be affected.

To verify the DiffServ configuration, use the following command:

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

When you specify the `detail` keyword, the output displays the flow control state and the ingress QoS profile, ingress IPTOS replacement, and egress rate limiting configurations.

To disable the replacement of Ingress DiffServ code points, use the following command:

```
enable diffserv ingress replacement [high-priority | low-priority |
low-and-high-priority] ports [<portlist> | all] {<Ingress QOS profile>}
```

Resetting Ingress DiffServ Code Points

To reset the DiffServ code point for a specified "3" series port, use the following command:

```
unconfigure diffserv ingress replacement ports [<portlist> | all]
```

Configuring Rate Limiting on Egress Ports

You can configure the amount of bandwidth available for outgoing traffic on a “3” series module. The rate you configure is applicable to the aggregate of all outgoing traffic on a port.

NOTE

This setting is independent of any “i” series egress rate-limiting configurations that you have on the switch and is applied to the aggregate bandwidth after the “i” series per-queue egress rate-limiting.

You can configure either the maximum percentage of bandwidth or the maximum speed allowed for egress traffic on a selected port. To configure the maximum egress rate limit on a “3” series port, use the following command:

```
configure ports <portlist> egress-rate-limit [percent <percent> | rate <bps> [k | m]]
```

where the following is true:

- `portlist` specifies one or more “3” series ports.
- `percent` specifies the maximum percentage of bandwidth allowed for all egress traffic for each selected port. The range is 0 to 100. The default is 100.
- `bps` specifies the maximum bandwidth for all egress traffic for each selected ports in either kbps or mbps. The range is:
  - — kbps: 0 to 1000000
  - — mbps: 0 to 1000
- `k` specifies kilobits per second.
- `m` specifies megabits per second.

To display the maximum egress rate limit on the specified “3” series ports, use the following command:

```
show ports {<portlist>} egress-rate-limit
```

The following is sample output from this command:

```
PORT     Egress-Rate
=====================
  2:1          100 %
  2:2          100 %
  2:3          100 %
  2:4         1000 k
  2:5          100 %
  2:6           10 m
  2:7          100 %
  2:8          100 %
  2:9          100 %
 2:10          100 %
 2:11          100 %
 2:12          100 %
 2:13          100 %
 2:14          100 %
 2:15          100 %
 2:16          100 %
```

Egress Rate Limiting Example

In this example, the outbound traffic on slot 4, port 2 of a "3" series module goes into a router that accommodates only 10% of the bandwidth. You can configure an egress rate limit for this traffic.

To configure an egress rate limit for the outbound traffic, use the following command:

```
configure port 4:2 egress-rate-limit percent 10
```

To verify and display the egress rate limit on the specified "3" series ports, use the following command:

```
show ports 4:2 egress-rate-limit
```

Displaying Statistics

To display real-time ingress statistics for one or more "3" series ports, use the following command:

```
show ports {<portlist>} ingress stats {detail}
```

If you do not specify the `detail` keyword, the output indicates the following:

- Port Number
- Link Status—The current status of the link. Options are:
  - Ready (R): The port is ready to accept a link.
  - Active (A): The link is present at this port.
  - Disabled (D): The link is disabled at this port.
  - Not Present (NP): The link is not present at this port.
- High Priority Bytes—Sum, per port, of the bytes forwarded for received high-priority packets (traffic received below the committed rate configured for the ingress QoS profile).
- Low Priority Bytes—Sum, per port, of the bytes forwarded for received low-priority packets (traffic received above the committed rate configured for the ingress QoS profile).
- Received Total Bytes—The total number of bytes that were received by the port.
- Receive Bytes Dropped—Total number of bytes dropped for this port.
- Total Percent Dropped—Percentage of incoming bytes dropped due to oversubscription congestion or ingress rate limiting. Displayed with a precision of 1/100 of a percent.
- Transmit XOFF—Total number of XOFF flow control packets sent from this port.

If you specify the `detail` keyword, the following additional information is displayed per ingress queue:

- Queue—One of eight ingress queue names for this port.
- High Priority Bytes—Sum, per ingress queue, of the bytes forwarded for received high-priority packets.
- Low Priority Bytes—Sum, per ingress queue, of the bytes forwarded for received low-priority packets.
- Total Percent Dropped—Percentage of incoming bytes on this queue dropped due to oversubscription congestion. This is determined using cumulative counters, so is not a rate. This will be displayed with a precision of 1%.
- Byte Rates—The following three rate values will always either add up to 0% or 100%:

- — High Priority Percentage—The ratio of high priority traffic forwarded on this queue to the total bytes received on this queue.
- — Low Priority Percentage—The ratio of low priority traffic forwarded on this queue to the total bytes received on this queue.
- — Dropped Percentage—Percentage of receive bytes dropped by this queue relative to the total number of bytes input to this queue.

Configuration Examples

This section provides configuration examples for the High Density Gigabit Ethernet module.

Configuring Ingress Rate Limiting

In this example, use DiffServ and ingress rate-limiting to guarantee at least 10 mbps of bandwidth for incoming financial services traffic on slot 4, port 1 of a "3" series module in a BlackDiamond switch. Per the DiffServ defaults (as shown in Table 97), the traffic has a DiffServ code point (TOS value) of 23 that corresponds to the ingress QOS profile *IQP3*.

```
configure qosprofile ingress iqp3 committed-rate 10 m peak-rate 1000 m red-threshold
100 % maxbuf 100 % ports 4:1
```

Next change the DiffServ code point from 23 to 60 to allocate the financial services traffic to ingress QoS profile *IQP8* on a second BlackDiamond switch.

```
configure diffserv ingress replacement low-priority code-point 60 high-priority
code-point 60 ports 4:1 iqp3

enable diffserv replacement low-and-high-priority ports 4:1 iqp3
```

To display the port configuration, use the following command:

```
show ports 4:1 info detail
```

To display the ingress QoS profile statistics, use the following command:

```
show ports 4:1 ingress stats detail
```

Configuring Bandwidth Requirements for Multiple Types of Traffic

You can configure your "3" series module to have specific bandwidth requirements for multiple types of incoming traffic. In this example, there are two types of traffic: web and administrative entering the BlackDiamond switch on slot 3, port 1. We want to ensure that the web traffic receives 10 - 20% of the bandwidth only, and the administrative traffic is guaranteed at least 5% of the bandwidth.

This example assumes that you have already created the VLANs *v50* and *v60*.

1. To ensure that critical data is not lost, configure each type of traffic to a specific VLAN and ingress QoS profile:
   - Web—VLAN *v50* with a tag of 6 and an ingress QoS profile of 6
   - Administrative—VLAN *v60* with a tag 7 and an ingress QoS profile of 7

```
configure vlan v50 tag 6
configure vlan v60 tag 7
configure vlan v50 qosprofile ingress iqp6
configure vlan v60 qosprofile ingress iqp7
```

2 Add the ingress port, 3:1, as a tagged port to both VLANs.

```
configure vlan v50 add ports 3:1 tagged
configure vlan v60 add ports 3:1 tagged
```

3 Configure the QoS type ingress priority for VLAN to the highest level.

```
configure qostype ingress priority vlan 10
```

4 Configure the bandwidth requirements for each type of traffic:

- Web—10 - 20%
- Administrative—Guaranteed at least 5%

```
configure iqp6 minbw 10 % maxbw 20 % red-threshold 100 % maxbuf 100 % ports 3:1
configure iqp7 minbw 5 % maxbw 100% red-threshold 100 % maxbuf 100% ports 3:1
```

Performing Cable Diagnostics

This section describes the collection of cable diagnostics for the physical ports on the system. You can manually run cable diagnostics at any time, or you can schedule cable diagnostics to be run automatically. Running cable diagnostics collects the following data for selected ports:

- Time and date of test
- Cable length
- Pair status
- Pair skew
- Pair swap
- Fault length
- Polarity
- Speed

Running Cable Diagnostics

To manually run cable diagnostics, use the following command:

```
run diagnostics cable port [<portlist> | all]
```

This command initiates the Cable Diagnostics Module (CDM) to obtain cable diagnostics values for the physical ports of the system.

To stop a cable diagnostics run that is currently in progress, use the following command:

```
abort diagnostics cable
```

Automatically running diagnostics involves the following two steps:

1. First, create a template for auto diagnostics that specifies the the time at which diagnostics must be started and that also specifies whether a port must be restarted if the diagnostics run results in a failure for a particular port. To create the auto diagnostics template, use the following command:

   ```
   configure diagnostics cable time <time> {reset-port-on-failure [enable | disable]}
   ```

2. Next, enable auto diagnostics for specific ports by using the following command:

   ```
   enable diagnostics cable port [<portlist> | all]
   ```

To disable the automatic running of cable diagnostics for selected physical ports of the system, use the following command:

```
disable diagnostics cable port [<portlist> | all]
```

The `disable diagnostics cable` command also purges the cable diagnostics values for the selected ports from the CDM data structures.

Viewing Cable Diagnostics Data

Use the following command to display cable diagnostics information currently stored in the CDM data structures:

```
show diagnostics cable {ports {<portlist> | all}} {mode {auto | manual | both}
{detail}
```

The `show diagnostics cable` command displays or prints the following cable diagnostics data for each selected port:

- Time and date of test
- Cable length (meters)
- Pair status
- Pair skew
- Pair swap
- Fault length (meters)
- Polarity
- Speed (Mbps)

You can specify that cable diagnostics data should be displayed for the latest automatic diagnostics run, or the latest manual diagnostics run, or both.

The following command displays cable diagnostics information in detail format for ports 1 through 3 on slot 6:

```
show diagnostics cable port 6:1-6:3 detail
```

Following is sample detailed diagnostic output from this command:

```
========================================================

Manual Diagnostics Collected @ Thu Jan 29 02:48:29 2004

========================================================

Port    Speed   Avg Len   Pair  Fault Loc  Skew    Polarity Cable      Pair-Swap    Diagnostic-Mode
        (Mbps)  (meters)        (meters)   (ns)             Status  Chan-AB Chan-CD
---------------------------------------------------------------------------------------------------
 6:1    1000    10        1-2   No Fault   8 ns    Unknown  Ok      No-Swap Unknown Manual
                          3-6   No Fault   0 ns    Unknown  Ok
```

```
                          4-5   No Fault   8 ns    Unknown  Ok
                          7-8   No Fault   8 ns    Unknown  Ok

 6:2    1000    5         1-2   6          Unknown Positive Open    Swap    Unknown Manual
                          3-6   6          Unknown Negative Open
                          4-5   6          Unknown Positive Open
                          7-8   5          Unknown Positive Open

 6:3    1000    6         1-2   0          Unknown Unknown  Imp-Err Unknown Unknown Manual
                          3-6   0          Unknown Unknown  Open
                          4-5   0          Unknown Unknown  Open
                          7-8   0          Unknown Unknown  Open
```

The following command displays cable diagnostics information in summary format for port 1 on slot 6:

```
show diagnostics cable port 6:1
```

Following is sample summary diagnostic output from this command:

```
==========================================================

Manual Diagnostics Collected @ Fri Jan 16 03:41:54 2004

==========================================================

Port    Speed Pair Cable   Diagnostic-Mode
        (MB)       Status
--------------------------------------------
 6:1    1000 1-2   Ok      Manual
             3-6   Ok
             4-5   Ok
             7-8   Ok
```

30 Power Over Ethernet

Power over Ethernet (PoE) is an effective method of supplying 48 VDC power to certain types of powered devices (PDs) through Category 5 or Category 3 twisted pair Ethernet cables. PDs include the Altitude 300 wireless port, IP telephones, laptop computers, web cameras, and other devices. With PoE, a single Ethernet cable supplies power and the data connection, reducing costs associated with separate power cabling and supply. PoE for ExtremeWare includes a method of detection to assure that power is delivered only to devices that meet the IEEE 802.3af specification for PoE.

Summary of PoE Features

The Alpine FM-32Pi PoE Module supports the following PoE features:

- Configuration and control of the power distribution for PoE at the system (slot) level
- Configuration and control of the power distribution for PoE at the port level
- Real time detection of powered devices on the line
- Monitor and control of PoE fault conditions
- Support for configuring and monitoring PoE status at the port level
- Management of an over-subscribed power budget
- LED control for indicating the link state

Port Power Management

When you connect PDs, the Alpine FM-32Pi PoE Module automatically discovers and classifies those that are AF-compliant. The following functions are supported for delivering power to specific ports:

- Enabling the port for discovery and classification
- Enabling power delivery to a discovered device
- Enforcing port power limits by denying power to a device that exceeds the power limit
- Enforcing class limits by denying power to a device that exceeds the class limit
- Reporting and tracking port power faults
- Managing power budgets and allocation

For detailed information about using the PoE command set to configure and manage PoE, see the *ExtremeWare Software Command Reference Guide*.

Port Power Operator Limit

Each port is configured by default to permit AF-compliant devices and to cause a fault for any device that exceeds the power level defined for the device class. You can also use the following command to specify a power limit on a per-port basis:

```
config inline-power violation-precedence [advertised-class | operator-limit |
max-class-operator | none] ports <portlist>
```

Power is allowed up to maximum limit (20 watts). There are several options for defining a violation policy and creating a device fault:

- Class violation—Power is removed if the PD consumes more than the discovered class limit.
- Operator limit—Power is removed if the PD consumes more than the operator-specified limit.
- Maximum of operator limit and class—Power is removed if the PD consumes more than the operator limit or discovered class limit, whichever is greater.
- None—Power is removed if the device exceeds the maximum limit of 20 watts.

Power Budget Management

The Alpine FM-32Pi PoE Module software is responsible for managing overall power consumption to ensure that it does not attempt to deliver more power than is available. You can configure the way in which the Alpine FM-32Pi PoE Module allocates power to devices upon power-up and in the event that available power is reduced.

Reserved Power

You can reserve power for devices connected to a specific port by using the following command:

```
config inline-power reserved budget <milliwatts> ports <portlist>
```

When a new device is discovered, its defined power requirement is first subtracted from the reserved power pool. If there is sufficient reserved power on the port, the device is powered. Otherwise the remaining power is subtracted from the common pool, and the device is powered if there is sufficient reserved plus common power available. Reserved power is subtracted from the common pool and unavailable to other ports. The total reserved power cannot exceed the total available power.

NOTE

A connected device may draw more power than the amount reserved, due to configuration error or oversight. The switch provides notification if this occurs.

Common Power Pool

The common power pool represents the total amount of power available on a per-slot basis, less any power reserved or allocated to currently powered devices. When a new device is discovered, its defined power requirements are subtracted from the common power pool. If the common pool does not have sufficient available power, power is not supplied to the device. In this case, the port is placed in a power-denied state. The device can be powered at a later time if more power becomes available to the common power pool due to another device disconnecting or if previously reserved power becomes available.

If multiple devices are in the denied state and more power becomes available, the devices are powered in order of connection.

Port Connection Order

The Alpine FM32Pi PoE Module software tracks the order of connection for powered devices. The connection order is recorded at the time a device is first discovered and classified. The connection order is reset if the device is disconnected. This connection order is maintained even if the switch is powered down or power is interrupted, and the device must be discovered again.

During system startup, ports are powered initially based only on the connection order. During normal system operations, port power order is determined based on discovery time. The port with the earliest discovery time is powered first.

You can view the connection history for a selected port by using the following command:

```
show inline-power info [port <portlist | detail port <portlist]
```

You can view the port connection order for a selected slot by using the following command:

```
show inline-power stats slot <slotlist>
```

You can clear the connection history for a selected slot by using the following command:

```
clear inline-power connection-history slot <slot_number>
```

Port Power Reset

You can set ports to experience a power-down, discover, power-up cycle without returning the power to the common pool. This allows you to reset powered devices without losing their claim to the common power pool or connection order.

The following command power cycles the specified ports:

```
reset inline-power ports <portlist>
```

Ports are immediately de-powered and re-powered, maintaining current power allocations.

Port Power Events

If a port has sufficient reserved power for a newly discovered and classified device, the device receives power. If additional power is required and the common pool has sufficient available power, the device is powered and the incremental power is subtracted from the common pool. If the port does not have reserved power, but sufficient power is available from the common pool, the power is subtracted from the pool.

Port power budget is determined based upon the maximum class power levels or operator specification, not actual consumed power. For example, if a port is configured with an operator limit of 20 watts and the violation precedence is set to the operator limit, then 20 watts is budgeted for the port even if a 5 watt 802.3af compliant device is connected. The following configuration commands are used to configure the operator limit and violation precedence:

```
config inline-power operator-limit <milliwatts> ports <portlist>
```

```
config inline-power violation-precedence [advertised-class | operator-limit |
max-class-operator | none] ports <portlist>
```

If a sufficient mix of reserved and common power is not available, the port enters a denied state and is not given power.

Ports are powered based upon their discovery time. Ports with the oldest discovery time are powered first.

If a device consumes more power than it is allocated by class type, it is considered a class violation. The device enters a fault state, and unreserved power is returned to the common pool. Power is also returned to the common pool if a port is disconnected. The device stays in the fault state until you explicitly clear the fault, disable the port for power, or disconnect the device.

You can clear a fault by using the following command:

```
clear inline-power fault ports <portlist>
```

You can disable a port for power by using the following command:

```
disable inline-power [ports all | <portlist>]
```

Alpine Power Checking for PoE Modules

PoE modules require more power than other I/O modules. When a chassis containing a PoE module is booted or a new PoE module is inserted, the power drain is calculated. If the chassis is booting up, I/O modules are powered up, beginning with slot 1, until the PoE module. Before the PoE module is powered up, the chassis calculates the power budget and powers up the PoE module only if there is enough power. The chassis then powers up as many additional I/O modules as possible.

If a PoE module is inserted into a chassis, the chassis calculates the power budget and only powers up the PoE module if there is enough power. Installed modules are not affected. However, if you reboot the chassis, power checking proceeds as described in the previous paragraph.

If you remove a PoE module, power is redistributed. If there is now enough power, I/O modules that were not powered up previously are powered up.

Before you install your PoE module, consult your sales team to determine the required power budget.

Configuring Power Over Ethernet

Power Over Ethernet on the Alpine chassis supports a full set of configuration and monitoring commands that allow you to:

- Configure and control power distribution for PoE at the system (slot) level
- Configure and control power distribution for PoE at the port level
- Detect powered devices on the line in real time
- Monitor and control fault conditions

- Configure and monitor status at the port level
- Manage an over-subscribed power budget

Use the inline power commands described in the following sections to configure PoE on Alpine FM32Pi Module ports. For detailed information about using the PoE command set to configure and manage PoE, see the *ExtremeWare Software Command Reference Guide*.

Controlling and Monitoring System and Slot Power

Use the general switch management commands described in this section to control and monitor power at the system level and slot level. The main power supply information and settings apply to the system. System power to the PoE controller is provided by the main PSU (Power-One PALS 400). This unit provides power, temperature, and fan monitoring status.

NOTE

Configuration parameters affecting operational parameters require the port or slot to be first disabled.

Configuring System and Slot Power

Before any port can be powered, the system must be enabled for power and the slot on which the port resides must be enabled for power. Ultimately, the port must also be enabled for power. The PoE command set lets you configure inline power at the system and slot levels. You can perform the following configuration and maintenance tasks at the system and slot levels:

- Control inline power to the system
- Control inline power to selected slots
- Set a power usage alarm threshold
- Configure a backup power source for the 48V external power supply
- Replace the firmware
- Clear the port connection history for a slot

NOTE

You must configure a slot for a PoE module before configuring or downloading a PoE configuration. Downloading a PoE configuration to a switch without a PoE module configured generates an error message similar to the following: Error: slot 8 is not PoE capable! *To avoid this error condition, configure the slot for a PoE module before saving the configuration.*

Controlling Inline Power to the System. You can control whether inline power is provided to the system through a set of enabling and disabling commands. Use the following command to enable inline power provided to the system:

```
enable inline-power
```

Disabling inline power to the system shuts down power currently provided on all slots and all ports in the system. Use the following command to disable inline power to the system:

```
disable inline-power
```

Controlling Inline Power to Slots. You can control whether inline power is provided to selected slots through a set of enabling and disabling commands. Use the following command to enable inline power provided to a particular slot:

```
enable inline-power slots <slot_id>
```

Disabling inline power to selected slots shuts down power currently provided on those slots and all ports in those slots. Use the following command to disable inline power to a particular slot:

```
disable inline-power slots <slot_id>
```

Setting a Power Usage Alarm Threshold. You can set an alarm threshold to issue a warning if system power levels exceed that limit. The limit is expressed as a percentage of measured power to available power. The alarm threshold is shared between the system level utilization and the allocated power budget per slot. (See the `config inline-power reserved budget <milliwatts> ports <portlist>` command.) A warning is issued if either level exceeds the threshold level set by the following command:

```
config inline-power usage-threshold <threshold>
```

To reset the power usage alarm threshold to the default value of 70%, use the following command:

```
unconfig inline-power usage-threshold
```

Configuring a Backup Power Source. You can optionally set up the internal power supply to provide backup power if the external 48V power source loses power. Use the following command to add or remove backup power:

```
config inline-power backup-source [internal | none] slot <slot_number>
```

Using the `internal` keyword selects the internal power supply as the backup power source. Using the `none` keyword removes any backup power supply for the external 48V power source. Use the following command to reset the backup power source to its default value for the specified slot:

```
unconfig inline-power backup-source slot <slot_number>
```

Resetting the backup power source does not take effect until the power is cycled on the slot.

Replacing the Firmware. A version of PoE firmware is built into ExtremeWare to allow easy replacement if necessary. If the current micro controller firmware becomes corrupted, ExtremeWare logs a message in syslog prompting for a firmware upgrade. Use the following command to download the firmware to the selected slot:

```
download firmware slot <slot_number>
```

Clearing Port Connection History for a Slot. You can clear the port connection history for a specified slot by using the following command:

```
clear inline-power connection-history slot <slot_number>
```

Monitoring System and Slot Power

The PoE command set lets you view inline power status for the system and selected slots. You can view the following information:

- System power status

- Slot power status
- Slot power configuration
- Slot power statistics

Displaying System Power Status. Use the following command to view global inline power information for the system:

```
show inline-power
```

This command provides status for the following areas:

- Nominal power available
- Operational status of the main power supply
- Condition of the backup power device
- Configured power usage threshold for the system
- Condition of the firmware

Following is sample output from this command:

```
            Inline Power System Information
   System maximum inline-power: 32 watts
   Power Usage: 70% (22 watts)

Slot       Main PSU Status       Backup PSU Status     Firmware Status
1                OFF          Present, ACTIVATED        Operational
```

Displaying Slot Power Status. Use the following command to view inline power information for the specified slots:

```
show inline-power slot <slotlist>
```

This command provides status for the following areas:

- Configured amount of available common power (configured minus configured reserved)
- Amount of allocated common power
- Amount of configured reserved power
- Amount of utilized reserved power
- Measured power

Following is sample output from this command:

```
        Common Power                    Reserved Power
Slot  Configured    Allocated    Configured    Allocated  Measured Usage
1     22000mW       5400mW       10000mW       10000mW       150 mW
```

Displaying Slot Power Configuration. Use the following command to view inline power configuration information for the specified slots:

```
show inline-power configuration slot <slotlist>
```

This command lets you view the following configuration settings for the specified slots:

- Power status (enabled or disabled)
- Current setting of backup power source (internal or none)
- Power source currently supplying power (internal or external)
- Configured alarm threshold

Following is sample output from this command:

```
Slot  Status  Cfg PSU Backup  PSU Active   Usage Threshold
1     Enabled Internal        Internal     70%
```

Displaying Slot Power Statistics. Use the following command to view inline power statistics for the specified slots:

```
show inline-power stats slot <slotlist>
```

- This command lets you view how many ports are faulted, powered, and waiting for power for the slot. It also lists ports by current connection order. (The maximum is 32 ports for the Alpine FM32Pi PoE Module.)

Following is sample output from this command:

```
PoE firmware status: Operational
PoE firmware revision: 1.6
Connection Order: 3 15
Total ports powered: 1
Total ports waiting for power: 0
Total ports faulted: 0
Total ports disabled: 1
```

Controlling and Monitoring Port Power

Use the commands described in this section to control and monitor power at the port level. Before any port can be powered, the system must be enabled for power and the slot on which the port resides must be enabled for power. Ultimately, the port must also be enabled for power.

Configuring Port Power

The PoE command set lets you configure inline power at the system and slot levels. (See "Configuring System and Slot Power" on page 769.) Power control is also provided on a per port basis. You can perform the following configuration and maintenance tasks for selected ports:

- Control inline power.
- Control the power detection mechanism.
- Set the power limit.
- Set the violation precedence.
- Set the reserved power level.
- Power cycle.
- Clear fault conditions.
- Create user-defined labels.

Controlling Inline Power to Ports. You can control whether inline power is provided to selected ports through a set of enabling and disabling commands. Use the following command to enable inline power provided to selected ports:

```
enable inline-power [ports all | <portlist>]
```

Disabling inline power to selected ports shuts down power currently provided to those ports. Disabling a port providing power to a powered device (PD) will immediately remove power to the PD. The system defaults to enabling power on all 10/100 ports. Use the following command to disable inline power to the system:

```
disable inline-power [ports all | <portlist>]
```

Controlling the Power Detection Mechanism for Selected Ports. You can control the power detection mechanism for selected ports by using the following command:

```
config inline-power detection [auto | discovery-test-only] ports <portlist>
```

Test mode forces power discovery operations; however, power is not supplied to detected PDs.

To reset the power detection scheme to the default, use the following command:

```
unconfig inline-power detection ports <portlist>
```

Setting the Power Limit for Selected Ports. You can set the power limit for specified ports by using the following command:

```
config inline-power operator-limit <milliwatts> ports <portlist>
```

You can set the power limit to the default value (15400 mW minimum according to the IEEE 802.3af specification) or you can specify wattage in the range of 3000 – 20000 mW. This command is used with the violation precedence setting and it has no effect if either `none` or `advertised-class` is selected for the violation precedence. (See “Setting the Violation Precedence for Selected Ports.”)

To reset the operator limit back to the default value, use the following command:

```
unconfig inline-power operator-limit ports <portlist>
```

Setting the Violation Precedence for Selected Ports. You can set the violation precedence for selected ports by using the following command:

```
config inline-power violation-precedence [advertised-class | operator-limit |
max-class-operator | none] ports <portlist>
```

Power will be removed or denied to PDs connected to the selected ports if the PD consumes more power than the entered limit. The default value is `max-class-operator`, which removes or denies power if the PD consumes power beyond the detected class limit or the configured operator limit, whichever is greater.

Limits associated with the available keywords are shown in the following table:

Table 98: Violation Precedence Values

Keyword	Description
advertised-class	Removes or denies power if an IEEE 802.3af-compliant power device (PD) consumes power beyond its advertised class limit.

Table 98: Violation Precedence Values

Keyword	Description
operator-limit	Removes or denies power if the PD consumes power beyond the configured operator limit.
max-class-operator	Removes or denies power if the PD consumes power beyond the detected class limit or the operator limit, whichever is greater. Max-class-operator is the default value.
none	Removes or denies power if the PD exceeds the maximum limit of 20 watts.

The operator limit is configured with the following command:

```
unconfig inline-power operator-limit ports <portlist>
```

To reset the violation precedence to the default value, use the following command:

```
unconfig inline-power violation-precedence ports <portlist>
```

Setting the Reserved Power Level for Selected Ports. You can set the reserved power for selected ports by using the following command:

```
config inline-power reserved budget <milliwatts> ports <portlist>
```

You can specify the default value (0 mW) or you can set the reserved power wattage in the range of 0 or 3000 – 20000 mW. The total power reserved may be up to but not greater than the total power for the module. If all the power available to the module is reserved, then the common power pool is empty.

To reset the reserved budget to the default value, use the following command:

```
unconfig inline-power reserved-budget ports <portlist>
```

Power Cycling Selected Ports. You can power cycle selected ports by using the following command:

```
reset inline-power ports <portlist>
```

Ports are immediately de-powered and re-powered, maintaining current power allocations.

Clearing Fault Conditions and Statistics for Selected Ports. Use the following command to clear the fault condition on the selected ports:

```
clear inline-power fault ports <portlist>
```

Use the following command to clear inline statistics for a selected ports:

```
clear inline-power stats ports <portlist>
```

Using this command clears to zero all the inline statistics for a selected ports displayed by the following command:

```
show inline-power stats ports <portlist>
```

Creating User-Defined Labels for Selected Ports. You can create your own label for a selected power port by using the following command to specify a text string:

```
config inline-power display-string <string> ports <portlist>
```

Monitoring Port Power

The PoE command set lets you view inline power status and configuration settings for selected ports. You can view the following information:

- Port power configuration
- Port power information
- Port power statistics

Displaying Port Power Configuration. Use the following command to view inline power configuration information for the specified ports:

```
show inline-power configuration port <portlist>
```

The command output displays the following inline power configuration information for the specified ports:

- Config—Indicates whether the port is enabled to provide power:
  - — Enabled: The port is available to provide power.
  - — Disabled: The port is not available to provide power.
- Detect—Indicates the detect level:
  - — Auto: The port will power up if there is enough available power.
  - — Test: The port will not power up. Indicates a test mode to determine whether the port can be discovered.
- Rsvd Pwr—Displays the amount of configured reserved power in watts.
- Oper Lmt—Displays the configured operator limit in watts. The operator limit is used only with violation precedence.
- Viol Prec—Displays the violation precedence settings:
  - — ADVERTISED-LIMIT: Removes or denies power if an IEEE 802.3af-compliant powered device (PD) consumes power beyond its advertised class limit.
  - — OPERATOR-LIMIT: Removes or denies power if the PD consumes power beyond the configured operator limit.
  - — MAX-CLASS-OPERATOR: Removes or denies power if the PD consumes power beyond the maximum of the detected class limit or the operator limit.
  - — NONE: Removes or denies power if the PD consumes power in excess of the regulatory maximum allowable wattage.
- Label—Displays a text string, up to 13 characters in length, associated with the port.

Following is sample output from this command:

```
Port Config  Detect  Rsvd Pwr   Oper Lmt   Viol Prec          Label
1:1  enabled auto    0.0        15.4       max-class-operator
1:2  enabled auto    10.0       15.4       advertised-limit   test_port2
1:3  enabled auto    0.0        15.4       max-class-operator
1:4  enabled auto    0.0        15.4       max-class-operator
1:5  enabled auto    0.0        15.4       max-class-operator
1:6  enabled auto    0.0        15.4       max-class-operator test_port6
1:7  enabled auto    0.0        15.4       max-class-operator
```

Displaying Port Power Information. Use the following command to view inline power information for the specified ports:

```
show inline-power info [port <portlist | detail port <portlist]
```

You can use this command to generate a summary report or a detailed report.

Summary output displays the following inline power information for the specified ports:

- State—Displays the port power state:
  - — Disabled
  - — Searching
  - — Discovered
  - — Delivering
  - — Faulted
  - — Disconnected
  - — Other
  - — Denied
- Class—Displays the class type:
  - — "-----": disabled or searching
  - — "class0": class 0 device
  - — "class1": class 1 device
  - — "class2": class 2 device
  - — "class3": class 3 device
- Connect History—Displays the connection order of the port from the connection history (if one exists):
  - — 0: No connection history exists or the port is not in the history list.
  - — 1 – 32: There is a connection history and the port is in the history list.
- Volts—Displays the measured voltage. A value from 0 – 2V is valid for ports that are in a searching or discovered state.
- Curr—Displays the measure current in milli Amps (mA).
- Res—Displays the measured resistance in kilo Ohms (Kohms). A value greater than 100 Kohms indicates an empty port.
- Power—Displays the measured power in watts.
- Fault—Displays the fault value:
  - — 0: No fault
  - — 1: Over voltage
  - — 2: Over voltage spike
  - — 3: Peak over current
  - — 4: Overload
  - — 8: Discovery resistance failed
  - — 9: Class violation

- 10: Disconnect
- 11: Discovery resistance, A2D fail
- 12: Classify, A2D fail
- 13: Sample A2D fail
- 14: Device fault, A2D fail

The detail command lists all inline power information for the selected ports. Detail output displays the following information:

- Configured Admin State
- Inline Power State
- MIB Detect Status
- Label
- Violation Precedence
- Operator Limit
- Detection
- Reserved Power
- Inline Type
- Connect Order
- PD Class
- Max Allowed Power
- Measured Power
- Line Voltage
- Discovered Resistance
- Discovered Capacitance
- Current
- Fault Status

The following example displays summary inline power information for port 1:

```
show inline info port 1:*
```

Following is sample output from the summary form of the command:

```
Port  State      Class   Connect    Volts   Curr    Res     Power    Fault
                         History            (mA)    (Kohms) (Watts)
1:1   searching  -----      0       0.0     0       0.0     0.00     0
```

The following example displays detail inline power information for port 1:

```
show inline info detail port 1:1
```

Following is sample output from detail form of the command:

```
        Configured Admin State: Enabled
            Inline Power State: searching
            MIB Detect SStatus: searching
                         Lable:
          Violation Precedence: max-class-operator
```

```
                Operator Limit: 15400 milliwatts
                     Detection: auto
                Reserved Power: 0 milliwatts
                   Inline Type: other
                 Connect Order: none
                      PD Class:
             Max Allowed Power: 0.0 W
                Measured Power: 0.0 W
                  Line Voltage: 0.0 Volts
        Discovered Resistance: 0.0K ohms
       Discovered Capacitance: 0 uF
                      Current: 0 mA
                  Fault Status: None
```

Displaying Port Power Statistics. Use the following command to view inline power statistics for selected ports:

```
show inline-power stats ports <portlist>
```

The command output displays the following inline power statistics for the specified ports:

- State—Displays the inline power state:
  - — Disabled
  - — Searching
  - — Discovered
  - — Delivering
  - — Faulted
  - — Disconnected
  - — Other
  - — Denied
- Class—Displays the class type:
  - — "-----": disabled or searching
  - — "class0": class 0 device
  - — "class1": class 1 device
  - — "class2": class 2 device
  - — "class3": class 3 device
  - — "class4": class 4 device
- Absent—Displays the number of times the port was disconnected.
- InvSig—Displays the number of times the port had an invalid signature.
- Denied—Displays the number of times the port was denied.
- Over-current—Displays the number of times the port entered an over-current state.
- Short—Displays the number of times the port entered under-current state.

Following is sample output from this command:

```
Port  State      Class    Absent   InvSig   Denied   OverCurrent   Short
1:1   searching  ------   0        0        0        0             0
```

```
1:2   delivering class0  0       0       0       0            0
1:3   searching  ------  0       0       0       0            0
1:4   searching  ------  0       0       0       0            0
1:5   searching  ------  1       0       0       0            0
1:6   delivering class3  0       0       0       0            0
1:7   searching  ------  0       0       0       0            0
1:8   searching  ------  0       0       0       0            0
```

Use the `clear inline-power stats ports <portlist>` command to clear inline statistics displayed by the `show inline-power stats ports <portlist>` command.

:

31 H-VPLS

This chapter describes the following topics:

- VPLS Overview on page 781
- Configuring H-VPLS on page 786

VPLS Overview

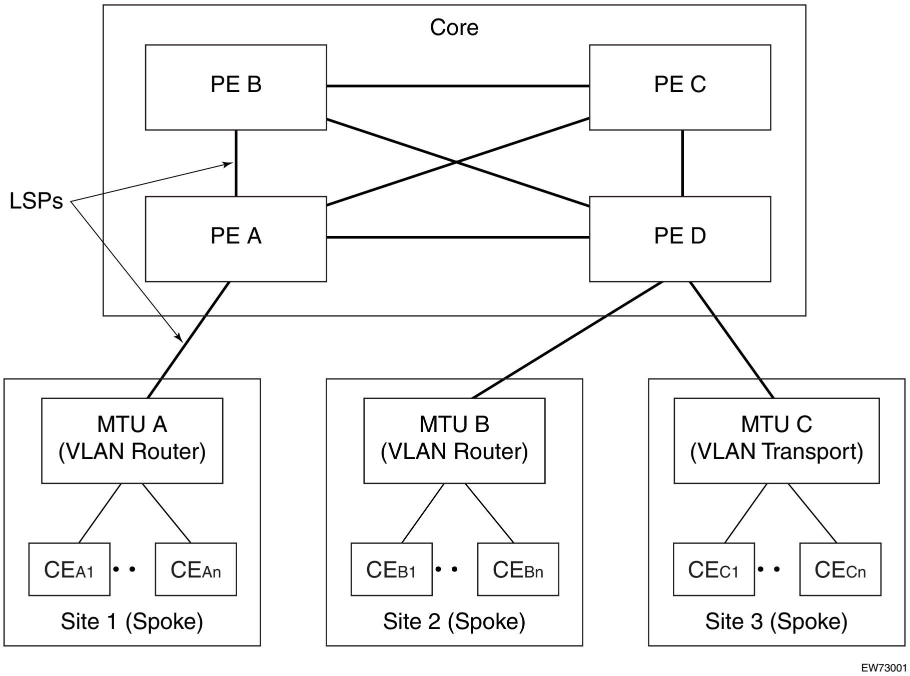
H-VPLS defines an architectural bridging model for interconnecting multiple Ethernet LAN segments over a service provider MPLS network. Unlike VPLS, which requires a full mesh of Virtual Circuits (VCs), H-VPLS specifies a hierarchical architecture to extend spoke VCs to the service provider's network edge. The H-VPLS bridging model is based on standard 802.1D bridging concepts. By implementing standard bridging technology, a protocol agnostic L2 VPN architecture can be implemented independent of the underlying MPLS IP metro core.

VPLS capable routers treat each VPN as a separate Virtual Switching Instance (VSI) and each VC, within a VPLS, as a virtual switch port. In general, normal bridge forwarding and learning rules apply. Received broadcast, multicast, and unknown unicast packets are flooded within a VPLS instance and the source MAC address/VLAN ID is dynamically learned with respect to the VC where the packet was received. From the user perspective, the VPLS appears simply as an Ethernet LAN segment. Each VPLS may be a simple point-to-point connection or a multipoint broadcast domain.

In an H-VPLS model, a full mesh of PE devices is required, as shown in Figure 150. These PE devices represent the edge of the service provider's core network. Each PE is logically connected to other PE nodes, either directly or indirectly through core LSRs (i.e., commonly referred to as P nodes), and to customer access aggregation switches called MTU (Multi-Tenant Unit) switches. Each PE supports multiple VSIs or VPLS instances. Each VPLS instance bridges together multiple VC-LSPs. A VC-LSP is a logical point-to-point connection used to carry Layer 2 PDUs over a tunnel LSP. The VC-LSPs may be either core or spoke. Core VC-LSPs connect to other core PE nodes in a full mesh. Spoke VC-LSPs connect to MTU switches in a hub-and-spoke fashion.

User connection to the service provider network is by way of an MTU. Each MTU supports multiple VPLS instances, one for each customer service. Each VPLS instance on the MTU provides a local customer VPLS interface and nominally, a single uplink VC-LSP connection to a core PE for each VPLS. Optionally, dual-homed uplinks to redundant core PE nodes can be configured. In general, traffic originating from one MTU destined for an egress MTU will traverse one PE if the MTUs are connected to the same PE (e.g., MTU B to MTU C), and traverse two PEs if the MTUs are connected to different PEs (e.g., MTU B to MTU A).

Figure 150: Hierarchical VPLS Model



VPLS interface types offer flexibility in how metro network services are provisioned at the edge of the service provider network. The VPLS interface type is a local configuration parameter and must be provisioned for each customer on each MTU. VPLS interface types include:

- Port: Traffic is VPLS qualified based solely on the packet's ingress port. Traffic is sent across the VPLS unmodified.
- VLAN: Traffic is VPLS qualified based solely on the VLAN ID assigned by the switch at the ingress port. The 802.1Q tag is stripped from the packet before being sent across the VPLS. The 802.1Q tag may be reinserted at VPLS egress.
- Port-qualified VLAN: Traffic is VPLS qualified based on the ingress port and the packet's 802.1Q tag VLAN ID. The 802.1Q tag is stripped from the packet before being sent across the VPLS. The 802.1Q tag may be reinserted at VPLS egress.

Ethernet Layer 2 metro networks are currently provisioned using 802.1Q tags. Conceptually simple to implement, there are various limitations with scaling 802.1Q tagged VLAN architectures. Architectural scaling issues include:

- Limiting the number of VPNs within the provider's network to the number of VLAN IDs,
- Requiring the service provider to coordinate VLAN ID usage between customers,
- Slow network failure recover times by relying on STP to detect and reroute traffic around failed links or nodes, and
- Network destabilization caused by MAC FDB thrashing as the number of learned MAC addresses approaches the core PE device MAC FDB size.

VPLS is designed to solve these Ethernet scaling limitations. However, VPLS does not scale well as the scope of MPLS extends to the edge of the provider's network. H-VPLS overcomes most of these limitations, providing a more scalable easier to manage L2 VPN solution. H-VPLS provides the following benefits:

- Eliminates the need for a full mesh of tunnels and full mesh of VCs per service between all devices participating in the VPLS service,
- Minimizes signaling overhead since fewer VC-LSPs are required for the VPLS service.
- Segments VPLS nodal discovery. MTU nodes need to be aware of only the local PE node, although it is participating in the VPLS service that spans multiple devices. Similarly, VPLS PE nodes need only be aware of MTU nodes that are locally connected (must be aware of all VPLS peer PE nodes).
- Obviates the need to provision existing MTU nodes for new MTU service, although it is necessary to configure new nodes.
- Supports hierarchical connections to create VPLS services that span multiple service provider domains.

Increasing the Number of Supported VPNs

The number of customer VLANs in the metro network does not restrict the number of MPLS L2 VPNs. MPLS L2 VPNs are provider provisioned as a metro-wide resource and are generally identified using a 32-bit integer called the VPN ID. With the larger 32-bit VPN ID space replacing the smaller 12-bit VLAN ID tag space, the theoretical VPN limit far exceeds 4K. The following resources now limit VPN scaling within a provider's metro network. The resources are listed in priority order from highest to lowest.

- VC-LSPs: The number of VC-LSPs is limited to the number of supported TLS or VC-FEC Labels. The number of VC-LSPs implicitly limits the number of VPLS instances that can be supported within a node.
- Targeted LDP sessions (or peers): The number of targeted LDP sessions supported is directly related to the number of available TCP/IP sessions. This absolute limit is based on the number of available TCP/IP sockets. Other applications can impact the number of available TCP/IP sockets, further reducing the number of supported targeted LDP sessions. This resource limits the number of PE and MTU devices a node can peer with.
- Tunnel LSPs: The number of tunnel LSPs is limited to the number of MPLS labels supported. This limits the number of explicitly provisioned LSPs between VPLS nodes.

Eliminating VLAN ID Coordination Between Customers

Ethernet 802.1Q tagged provider networks require each customer's VPN interfaces to be configured with the same VLAN ID. This requires additional management and coordination of the provider's network with each customer. VMAN IDs have been introduced to alleviate this problem, but vendor VMAN implementations are non-standard. For example, Extreme switches require a specially configured VMAN tag Ethertype value (e.g., 0x9100) that is not generally supported by other vendor's equipment. With VPLS, customers VLAN IDs are locally significant to each switch. Because VLAN IDs are locally provisioned, the service provider is not required to correlate VLAN IDs between customers connected to different access switches. If the MTU supports port qualified VLANs, the VLAN IDs are locally significant to each MTU port. Each customer port has its own unique VLAN ID space. No VLAN ID correlation is required, even between customers connected to the same MTU.

VPLS Network Failure Recovery without Requiring STP

Spanning Tree Protocol (STP) was designed to meet the needs of Enterprise bridge networks, but not the fail-over requirements of today's service provider networks. Attempts have been made to standardize optimized STP implementations that improve fail-over times, but industry wide acceptance has been limited. VPLS does not rely on STP to prevent loops or provide link redundancy. The service provider simply configures a set of interconnecting VC-LSPs for each VPLS that provide connectivity to the required MTUs. Redundant VC-LSP connections are not needed since each VC-LSP can be configured to use protected tunnel LSPs. Protected tunnel LSPs provide backup paths to reroute around failed links or nodes and are managed independently of the higher layer VC-LSPs.

Reducing the number of MAC Addresses cached in the Core

Unlike 802.1Q-based VPNs, MPLS VPNs use an IP routed network core. Customer MAC addresses are learned only at H-VPLS nodes. Thus, caching of the customer MAC addresses is limited to the edge of the provider network and H-VPLS core devices. This frees core LSRs to focus on high availability IP routing and MPLS switching features by divorcing the VPLS implementation requirements from the core infrastructure routing topology.

Reducing the Number of Tunnel LSPs

VPLS specifies a full-mesh of VC-LSPs between all peers. As MPLS is pushed to the edge of the network, this requirement presents a number of problems. One problem is the increased number of tunnel LSPs required to service a large set of VPLS domains. With VPLS, each VC-LSP must be established between MTU nodes across the core. This implies that the tunnel LSP must also be established across the core between MTU nodes. Because the tunnel LSPs are established between MTUs, the core must be able to support a bounded set of tunnels LSPs (for a single service class) of m(m-1), where m is the number of MTU devices in the provider network. By introducing a hierarchical design, each MTU is only required to establish a tunnel LSP to a single core PE.

Eliminating Packet Replication by the MTU

Another problem introduced by VPLS is packet replication on the MTU uplink. Until an MTU learns which VC-LSP a MAC address is reachable, unknown unicast frames must be flooded on all VC-LSPs within the VPLS. This is always true for broadcast and multicast traffic. As the number of VPLS peers increases, the packet replication burden on the MTU also increases. Current MTU devices most likely cannot maintain wire-speed forwarding as the number of VPLS peers increases. H-VPLS eliminates MTU packet replication by requiring only a single VC-LSP connection between the MTU and its core PE for each VPLS. Packet replication is pushed to the PE, where it is more suitably handled.

Simplifying Customer Service Provisioning

Provisioning bandwidth between the MTU and the PE is extremely difficult with VPLS. Since each VPLS instance may require multiple tunnel LSPs, the bandwidth requirements for each tunnel LSP must be separately accepted and individually enforced by every PE a tunnel LSP traverses. Since the provider requirement is to manage the provisioned bandwidth for the VPLS and not each tunnel LSP, the MTU has the added responsibility of rate limiting the aggregate egress traffic across multiple tunnel LSPs on the uplink to the PE. Due to packet replication issues described previously, this is not practical.

H-VPLS simplifies bandwidth provisioning and management. Because tunnel LSPs from the MTU are terminated at the core PE, tunnel LSP resources are easily shared and managed between customers. Thus, traffic for multiple VPLS instances can be transported across a single tunnel LSP. In many cases only a single best-effort tunnel LSP is required between the MTU and the PE. Traffic for each customer is carried over a different VC-LSP in the same tunnel LSP. This allows the tunnel LSP to be signaled once, with the desired bandwidth and priority parameters sufficient for providing “best-effort” service for customers connected to the MTU. If a customer upgrades their service or a new customer is connected that requires guaranteed bandwidth, a second tunnel LSP would be signaled with the contracted bandwidth parameters. Once established, the second tunnel LSP would carry traffic for a single customer as a premium service.

Minimizing Tunnel LSP Fail-over Times

Secondary or backup tunnel LSPs are used to provide redundant services. Fail-over times are often dependent on the time required to detect a failed LSP. Once the LSP is torn down, a pre-established backup LSP can quickly take over for a failed LSP. In general though, the more LSRs an LSP traverses, the longer the network will take to completely tear down an LSP and thus the longer the perceived outage. With H-VPLS, tunnel LSPs do not traverse the provider's core network from MTU to MTU. Tunnel LSP failure detection is generally faster and more deterministic, for the following reasons:

- Fewer number of tunnel LSPs are required, thus, the set of established tunnel LSPs may be refreshed at a lower interval, and
- The signaling delay between the LSR that detects the failure, and the ingress LER is minimized by the limited number of LSR hops a tunnel LSPs traverses.

Operational Manageability

Four connectivity service check tools have been integrated into ExtremeWare7.3: LSP ping, LSP trace, VPLS ping and VPLS trace. LSP ping and LSP trace provide connectivity verification and fault isolation for tunnel LSPs, respectively. They both use a modified "ping" packet sent over the specified tunnel LSP. In a similar manner, VPLS ping and VPLS trace provide connectivity verification and fault isolation for VC-LSPs. They both use another type of modified "ping" packet sent over the VC-LSP to the target destination MAC. Within a given H-VPLS, VPLS ping and trace can be used between MTUs, between PEs, and between a MTU and a PE.

H-VPLS Support

The Hierarchical H-VPLS implementation includes support for:

- Operation as either an MTU or PE H-VPLS node,
- Support for both Transparent LAN Service (TLS) and Transparent Port Service (TPS),
- Increased support for up to 32 H-VPLS peers per H-VPLS instance,
- Redundant H-VPLS core access by MTU node,
- Support for Address Withdraw message to remove stale MAC FDB entries,
- Mitigating the affects of network mis-configuration using the VC-FEC TTL field to purge looping packets,
- Increased security provided by LDP peer ACL, and
- Support for VC-LSP traffic aggregation across up to four RSVP-TE LSPs.

Signaling H-VPLS VC LSPs

H-VPLS VC LSPs are signaled using the same general methodology currently implemented for signaling Martini VC-LSPs (i.e., TLS Tunnels). TLS Martini VC-LSP support is still provided. Thus, MTU nodes can continue to signal Martini VC-LSPs that connect to a core H-VPLS PE. When configuring Martini VC-LSPs that terminate at a H-VPLS PE, the configured VC ID must match the VPN ID of the desired H-VPLS instance. The H-VPLS PE node always treats Martini signaled VC-LSPs as spoke connections. Spoke VC-LSPs (either Martini or H-VPLS signaled) must be statically configured on the PE node to extend VPN connectivity to the MTU.

Core VC-LSPs are signaled based on the H-VPLS peer configuration to form a full mesh of core PE nodes for each VSI. Thus, a full-mesh of VC-LSPs between PE nodes is statically configured to provide VPN connectivity across the H-VPLS core.

H-VPLS Interfaces

H-VPLS interfaces are configured locally for each H-VPLS instance. Although the H-VPLS interface configuration option is local to each H-VPLS, every H-VPLS interface in an H-VPLS network must be configured the same.

MPLS LDP Peer Access Authentication

Dynamic VPLS Service signaling creates potential security issues for the core network. Devices attached to the core could methodically signal VPLS services in an attempt to spoof membership into a VPN. As specified in the LDP Specification, security protection can be achieved through the use of an authorized peer access list. When the MPLS peer access list is enabled, the LSR ignores LDP Hellos from any remote LSR for which its source IP address not been configured. This ensures that the LSR establishes LDP TCP connections only with authorized H-VPLS nodes.

Additionally, whenever a remote IP address attempts unauthorized access, the source IP address, access classification type, and the intrusion time are logged and an SNMP trap may be sent. The intrusion notification is repeated every minute for as long as the remote IP address continues unauthorized access attempts.

Configuring H-VPLS

This section describes how to configure H-VPLS. The CLI commands organized under the VPLS keyword are used to configure both VPLS and H-VPLS networks.

VPLS Configuration

To configure a VPLS, use the following command:

```
config mpls add vpls <vpls_name> vpn <vpnid> {from <local_endpoint_ipaddress> |
<local_endpoint_vlan>}
```

To configure MPLS H-VPLS port mode operation, configure the edge service mode using the following command:

```
config mpls slot <slot> edge-service-mode [vlan | port]
```

To configure service for VPLS, use the following command:

```
config mpls vpls <vpls_name> add [vlan <vlan_name> | ports <port-list>]
```

To delete the VPLS with the specified vpls_name, use the following command:

```
config mpls delete vpls [<vpls_name> | all]
```

VPLS Peers

To configure a VPLS peer, use the following command:

```
config mpls vpls <vpls_name> add peer [<ipaddress> | <host_name>] [core-to-core |
spoke-to-core {primary | secondary} | core-to-spoke {vpls | tls {vcid <vcid>} | tps
{vcid <vcid>}}] {lsp <lsp_name>}
```

To delete a VPLS peer, use the following command:

```
config mpls vpls <vpls_name> add peer [<ipaddress> | <host_name>] [core-to-core |
spoke-to-core {primary | secondary} | core-to-spoke {vpls | tls {vcid <vcid>} {dot1q
ethertype <hex_number>}] {lsp <lsp_name>}
```

To configure additional LSPs to a VPLS peer, use the following command:

```
config mpls vpls <vpls_name> peer [<ipaddress> | <host_name>] [add | delete] [lsp
<lsp_name>]
```

LDP ACLs

To enable or disable an MPLS LDP Access Control List (ACL), use the following command:

```
config mpls ldp acl [enabled | disabled]
```

To add an LDP peer to the ACL, use the following command:

```
config mpls ldp acl add [peer <ipaddress> | <host_name>]
```

To delete a configured LDP peer from the ACL, use the following command:

```
config mpls ldp acl delete peer [<ipaddress> | <host_name> | all]
```

Health Check Configuration

To configure an MPLS tunnel LSP service connectivity health check, use the following command:

```
config mpls health-check add mplsping [<ipaddress> | prefix <ipaddress/masklength> |
<host_name> | lsp <lsp_name>]{interval-time <seconds>} {trap-send-holdtime <seconds>}
```

To delete an MPLS tunnel LSP service connectivity health check, use the following command:

```
config mpls health-check delete mplsping [<ipaddress> | prefix <ipaddress/masklength>
| <host_name> | lsp <lsp_name> | all]
```

To configure a VPLS VC-LSP service connectivity health-check, use the following command:

```
config mpls health-check add vplsping <vpls_name> [peer <ipaddress> | mac-address
<macaddress>] {interval-time <seconds>} {trap-send-holdtime <seconds>}
```

To delete a VPLS VC-LSP service connectivity health-check, use the following command:

```
config mpls health-check delete vplsping <vpls_name> [peer <ipaddress> | mac-address
<macaddress> | all]
```

To display the configuration and status for MPLS tunnel LSP health-checks, use the following command:

```
show mpls health-check mplsping {detail | <ipaddress> | prefix <ipaddress/masklength>
| <host_name> | lsp <lsp_name>}
```

To display the configuration and status for VPLS health-checks, use the following command;

```
show mpls health-check vplsping {detail | <vpls_name> {peer <ipaddress> | mac-address
<macaddress>}} {detail}
```

To configure transmit parameters for packets received on the local VPLS interface, use the following command:

```
config mpls vpls <vpls_name> {vman-id <vman_id>} {mtu <number>}
```

Ping and traceroute

To send an MPLS ping packet to a FEC over an LSP, use the following command:

```
mplsping {continuous} [[<ipaddress> | prefix <ipaddress/masklength> | <host_name>]
{next-hop [<ipaddress> | <host_name>]} | lsp <lsp_name>] {from <ipaddress>} {exp
<exp_value>} {ping-address <ipaddress>} {start-size <size> {end-size <size}}
{reply-mode [ip | mpls]}
```

To trace the path an LSP takes, use the following command:

```
mplstrace [[<ipaddress> | prefix <ipaddress/masklength> | <hostname>] {next-hop
[<ipaddress> | <host_name>]}] | lsp <lsp_name>] {from <ipaddress>} {reply-mode [ip |
mpls]} {ttl <max_ttl_value>} {ping-address <ipaddress>} {detail}
```

To send VPLS ping packets to another VPLS node or to a specific destination MAC address, use the following command:

```
vplsping {continuous} <vpls_name> [<ipaddress> | mac-address <macaddress>] {next-hop
[<ipaddress> | <host_name>]} {from <source_macaddress>} {ping-address <ipaddress>}
{start-size <size> {end-size <size}} {reply-mode [ip | mpls | vpls]}
```

To trace the path a packet takes to another VPLS node, or to a specific destination MAC address, use the following command:

```
vplstrace <vpls_name> [<ipaddress> | mac-address <macaddress>]{next-hop [<ipaddress> |
<host_name>]} {ping-address <ipaddress>} {reply-mode [ip | mpls | vpls]} {ttl
<max_ttl_value>} {detail}
```

Show Commands

To display VPLS configuration and status information, use the following command:

```
show mpls ldp acl {<ipaddress> | <host_name>}
```

To display information about all the nodes in the H-VPLS network, use the following command:

```
show mpls vpls {summary | detail | <vpls_name> {detail | | peer [<ipaddress> |
<host_name>]} | peer [<ipaddress> | <host_name>] {detail}}
```

To display information learned for VPLS, use the following command:

```
show fdb vpls {<vpls_name>} {peer [<ipaddress> | <host_name>]}
```

Reset Command

To reset all VPLS counters and statistics, use the following command:

```
clear mpls vpls counters
```

32 Wireless Networking

This chapter describes wireless networking using an Alpine 3800 family switch and the Altitude 300 and includes information on the following topics:

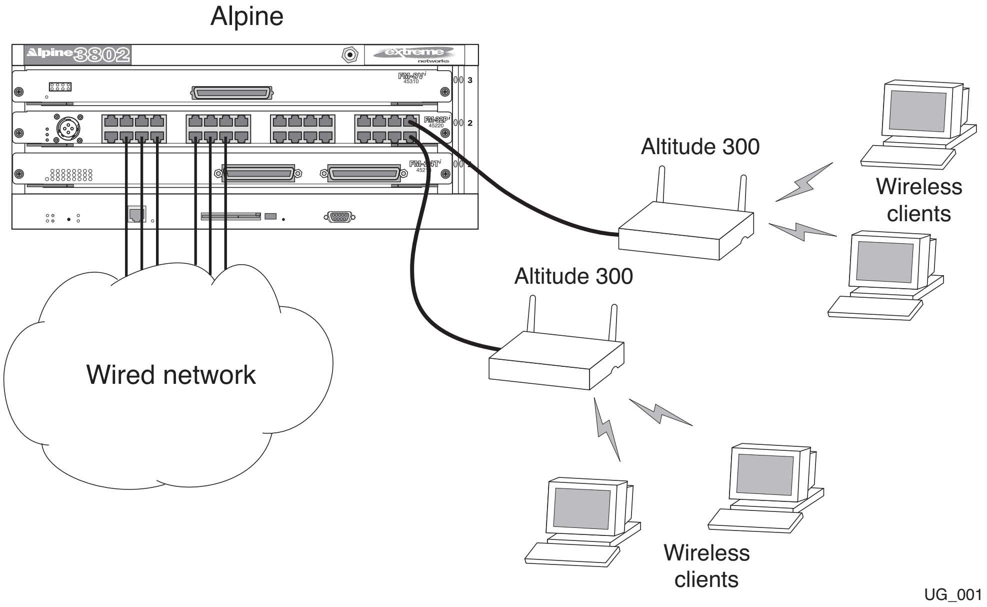
- Overview of Wireless Networking on page 791
- Wireless Devices on page 792
- Bridging on page 793
- Managing the Altitude 300 on page 793
- Configuring RF Properties on page 795
- Configuring RF Monitoring on page 798
- Performing Client Scanning on page 801
- Collecting Client History Statistics on page 804
- Configuring Wireless Switch Properties on page 807
- Configuring Wireless Ports on page 808
- Configuring Wireless Interfaces on page 809
- Configuring Inter-Access Point Protocol (IAPP) on page 811
- Event Logging and Reporting on page 812
- Enabling SVP to Support Voice Over IP on page 812

Overview of Wireless Networking

The Alpine switch and the Altitude 300 extend network service to wireless 802.11a/b/g clients within a fully integrated network infrastructure. Ports on the Alpine switch handle all of the management functions typically associated with an access point. The Altitude 300 serves as the radio transmitter and receiver, inheriting configuration information as soon as it is attached to the switch and as changes are made to the wireless profiles after the system is deployed.

Figure 151 shows a sample network configuration. The Alpine switch provides switching service across the wired and wireless network. Each port on the switch is configured with a “personality” that identifies its function.

Figure 151: Sample integrated wired and wireless network



This arrangement is part of the Extreme Unified Access Architecture, which is designed to support both wired and wireless networks from a single network switch. Because the intelligence normally associated with an access point is maintained in the Alpine switch, the cost of implementing radio access is greatly reduced. The network can still be expanded as needed, but it becomes much easier to maintain security and reliability at reduced cost.

Summary of Wireless Features

The Alpine switch supports the following wireless features:

- Simultaneous support for 802.11A, 802.11B, and 802.11G
- EAP authentication for 802.1X devices—PEAP, EAP-TLS, and EAP-TTLS
- WPA using TKIP and AES
- Detachable Altitude 300-2d antenna
- Integrated Altitude 300-2i antenna
- Per-user VLAN classification
- AccessAdapt™ management
- Remote troubleshooting
- Easy upgrading of wireless ports
- Detailed reports and logging

Wireless Devices

Ports on the Alpine switch adopt the “personality” of the device to be connected. Each port contains separately configurable interfaces for each of its two radios (A and G).

In addition to traditional wired devices, the Alpine switch supports the Altitude 300 and devices that rely on Power over Ethernet (PoE). Third party access points can connect to the Alpine switch as a layer 2 device.

Physical security for the wireless networks ceases to be a problem at the wireless access location, because the Altitude 300 does not store any configuration settings. Information is loaded as needed from the switch. Even if the Altitude 300 is physically moved, it can only be reconnected to another Alpine switch.

You can set network policies at Layers 2 and 3 to cover both the wired and wireless networks. In this way you can block access to individuals suspected of intrusion across the entire network infrastructure.

Altitude 300-2d Detachable Antenna

The detachable Altitude 300-2d antenna is compatible with the Alpine switch. To configure the antenna type as indoor or outdoor, to comply with regulatory requirements, use the following command:

```
configure wireless ports [<portlist> | all] antenna-location <indoor | outdoor>
```

NOTE

You cannot configure an integrated antenna for outdoor use.

The switch automatically detects whether the Altitude 300 has an integrated or detachable antenna. To set the country code, configure the country code on the switch and connect the Altitude 300-2d to the Alpine, just as you would with an Altitude 300-2i. The switch recognizes the correct regulatory-domain Altitude 300-2d and allows the Altitude 300-2d to start operation. The country codes are listed in Table 105 on page 807.

Bridging

Wireless bridging on an Alpine switch allows wireless users within the same VLAN to communicate with other wireless users on the same Alpine switch via layer 2 bridging. Wireless bridging can be enabled or disabled for each interface of a wireless port, and the setting is locally significant on each Altitude 300. This setting does not prevent bridging between wired and wireless MAC addresses in the same VLAN or between remote wireless stations associated with a remote Altitude 300. To configure wireless bridging, use the following command:

```
configure wireless ports <portlist> interface [1 | 2] wireless-bridging [on | off]
```

Managing the Altitude 300

It is not necessary to configure the individual Altitude 300 ports. You set port attributes on the Alpine switch, copying them as needed to new ports that you configure. Each time you make a change to wireless configuration on the switch, that change is implemented in the wireless network. Upgrading wireless software becomes extremely easy, since it is only necessary to upgrade the switch, and not the Altitude 300s.

Device management is flexible. From the management system you can enable and disable individual wireless ports or sets of ports based on time, user, or location. You manage the wireless ports from the wired IP network.

Profiles are available for security and RF parameters. Profiles function as templates, eliminating the need to issue repetitive commands and thereby simplifying the process of updating configuration information over multiple ports. You assign profiles to each interface (A or G) on a port and share the profiles across ports. Unless otherwise specified, a default profile is automatically assigned to each new wireless port.

Follow this process to configure wireless ports on the Alpine switch:

1. Designate a VLAN as the wireless management VLAN, or use the default management VLAN. Make sure that the VLAN port is untagged between the switch and the Altitude 300. Assign IP addresses on this VLAN for each wireless port.
2. Create RF-profiles.
3. Create security profiles and configure security parameters for each. The security profile includes ess-name.
4. Configure wireless ports on the switch by assigning RF profiles and security profiles.
5. Configure a specific channel (determined from a site survey), if desired, on each interface. If you do not configure a specific channel, the switch auto-selects the channel with the least interference.
6. Connect the Altitude 300.

After this process is complete, clients can access your network through the Altitude 300.

Wireless Show Commands

The show commands described in this section can be used to display information on wireless port configuration, RF profiles, security profiles, and stations.

Use the following command to list the data rates and channel for a selected port and interface:

```
show wireless ports [<portlist> | all] interface [1 | 2] rf-status {detail}
```

Each wireless port on the switch contains two interfaces. Interface 1 supports 802.11a, and interface 2 supports 802.11b/g radio signals. The `show wireless port interface rf-status` command allows you to display information about one of the two individual interfaces (1|2) on a port or ports.

Use the following command to list dot1x and network authorization modes for a selected port and interface:

```
show wireless [ports <portlist> | all ] interface [1 |2] security-status {detail}
```

This command displays Wired Equivalent Privacy (WEP) protocol, authentication, dot1x, and ESS name information for the selected port and interface.

Use the following command to check the basic wireless configuration on a switch:

```
show wireless configuration
```

This command displays the country, management VLAN, and gateway.

Use the following command to summarize wireless configuration for a selected port and interface:

```
show wireless ports [<portlist> | all] interface [1 | 2] configuration {detail}
```

You can use this command to show in table or list format the configuration and state of the interface of the selected port or ports.

Use the following command to list 802.11 interface statistics for a selected port and interface:

```
show wireless ports [<portlist> | all] interface [1 |2] stats
```

You can use this command to search for errors on a per interface basis.

Use the following command to display the current state of a selected port and interface:

```
show wireless ports [<portlist> | all] interface [1 |2] status
```

You can use this command to examine RF profiles on a per wireless port basis, and view the log of a specific port or ports, filtering out the switch log.

Configuring RF Properties

RF profiles allow you to group RF parameters for access using a single CLI command. The following rules apply for RF profiles:

- After you have defined a profile, subsequent changes automatically apply to all ports assigned to that profile.
- Each RF profile applies to a specific interface (A, B, or G), so changing a profile only affects the specified interface.
- Each Alpine switch ships with default profiles for each supported wireless port.

Creating an RF Profile

You can use the commands described in this section to create RF profiles.

To create a new RF profile by creating a name and associating it with an interface mode, use the following command:

```
create rf-profile <profile_name> mode [ A | B | B_G | G ]
```

Use this command to create a new RF profile without copying an existing RF profile.

To create a new RF profile by copying an existing RF profile and assigning a new name, use the following command:

```
create rf-profile <profile_name> copy <name>
```

Use this command to create a new profile identified by the string name. The copy argument specifies the name of an existing profile from which to obtain the initial values.

Deleting an RF Profile

You can use the command described in this section to delete RF profiles.

To delete an RF profile, use the following command:

```
delete rf-profile <name>
```

The named profile cannot be attached to any active ports before deletion.

Configuring an RF Profile

You can use the configuration commands described in this section to set RF profile properties to specific values. Changes take effect immediately and are propagated to all ports that share a particular profile. All failures are written to the syslog.

NOTE

ess-name is no longer part of RF-Profile property values. It is now part of Security Profile property values.

Setting the Beacon Frequency Interval

A beacon is a packet that is broadcast by the Altitude 300 wireless port to synchronize the wireless network. The beacon-interval is the time in milliseconds between beacons.

To specify the frequency interval of a beacon in milliseconds for an RF profile, use the following command:

```
configure rf-profile <name> beacon-interval <value>
```

Setting the DTIM Interval

A delivery traffic indication map (DTIM) field is a countdown field informing clients of the next listening window to broadcast and multicast messages. The DTIM count is an integer value that counts down to zero. This value represents the number of beacon frames before the delivery of multicast frames. The DTIM period is the number of beacon frames between multicast frame deliveries. When the wireless port has buffered broadcast or multicast messages, it sends the next DTIM with a DTIM interval value. Its clients hear the beacons and awaken to receive the broadcast and multicast messages.

To specify the interval of the DTIM in number of beacons, use the following command:

```
configure rf-profile <name> dtim-interval <value>
```

Clients achieve greater power savings with larger DTM intervals. However, a larger DTM interval will increase the delay before multicast frames are delivered to all stations.

Setting the Fragment Size

The RF profile fragment size property specifies the maximum size for a packet before data is fragmented into multiple packets. To specify the fragment size in bytes, use the following command:

```
configure rf-profile <name> frag-length <value>
```

The fragment size should remain at its default setting of 2345. If you experience a high packet error rate, you may slightly increase the fragmentation threshold. Setting the fragmentation threshold too low may result in poor network performance. Only minor modifications of this value are recommended.

Setting the RTS Threshold

The wireless port sends request-to-send (RTS) frames to a particular receiving station and negotiates the sending of a data frame. After receiving an RTS, the wireless station responds with a CTS frame to acknowledge the right to begin transmission. Should you encounter inconsistent data flow, only minor modifications are recommended. If a network packet is smaller than the preset RTS threshold size, the RTS and clear-to-send CTS mechanism is not enabled.

To specify the request to send the RTS threshold in bytes, use the following command:

```
configure rf-profile <name> rts-threshold <value>
```

To specify the number of transmission attempts for frames *larger* than the RTS threshold setting in the same RF profile, use the following command:

```
configure rf-profile <name> long-retry <value>
```

The `long-retry` value specifies the number of attempts before a frame will be discarded when a station attempts to retransmit a frame. Long retry applies to frames longer than the RTS threshold and it is set to 7 by default. A frame requiring RTS/CTS clearing is retransmitted seven times before being discarded.

To specify a the number of transmission attempts of a frame *smaller* than the RTS threshold, use the following command:

```
configure rf-profile <name> short-retry <value>
```

Setting the Packet Preamble

You can configure the RF profile for 802.11b using the `long` packet preamble. Configure the RF profile for 802.11a and 802.11g using the `short` packet preamble.To specify the size of the packet preamble, use the following command:

```
configure rf-profile <name> preamble [short | long]
```

Viewing RF Profile Properties

To display configuration attributes for a particular RF profile or all RF profiles, use the following command:

```
show rf-profile {<profile_name>}
```

Displayed RF profile properties are described in Table 99.

Table 99: RF Profile Property Values

Property	Default	Allowed Values	Description
beacon-interval	40	20-1000	Indicates the frequency interval of the beacon in milliseconds. A beacon is a packet broadcasted by the wireless port to synchronize the wireless network.
frag-length	2345	256-2345	Identifies fragment size in bytes. This value should remain at its default setting of 2345. It specifies the maximum size for a packet before data is fragmented into multiple packets. If you experience a high packet error rate, you may slightly increase the fragmentation threshold. Setting the fragmentation threshold too low may result in poor network performance. Only minor modifications of this value are recommended.
dtim-interval	2	1-100	Indicates the interval of the delivery traffic indication message (DTIM) in number of beacon frames. A DTIM field is a countdown field informing clients of the next window for listening to broadcast and multicast messages. When the wireless port has buffered broadcast or multicast messages, it sends the next DTIM with a DTIM Interval value. Its clients hear the beacons and awaken to receive the broadcast and multicast messages.

Table 99: RF Profile Property Values (Continued)

Property	Default	Allowed Values	Description
rts-threshold	2330	0-2347	Identifies request-to-send (RTS) threshold in bytes. Should you encounter inconsistent data flow, only minor modifications are recommended. If a network packet is smaller than the preset RTS threshold size, the RTS and clear-to-send (CTS) mechanism is not enabled. The wireless port sends RTS frames to a particular receiving station and negotiates the sending of a data frame. After receiving an RTS, the wireless station responds with a CTS frame to acknowledge the right to begin transmission.
preamble	short for A profile; long for B_G profile	short | long	Reports the size of the packet preamble.
short-retry	4	1-255	Indicates the number of transmission attempts of a frame, the length of which is less than or equal to `rts-threshold,` made before a failure condition is indicated.
long-retry	7	1-255	Indicates the number of transmission attempts of a frame, the length of which is greater than `rts-threshold`, made before a failure condition is indicated.
noise floor			Indicates the level above which energy will be interpreted as a signal. The value is a negative number representing dBm. Values closer to zero indicate more noise on the interface.

Configuring RF Monitoring

RF monitoring provides a mechanism to collect network statistics about link utilization and channel activity. RF monitoring can provide information on the following network events:

- Rogue access point detection, including alarm conditions
- RF overlap levels to determine network efficiency
- Notifications of newly discovered access points (APs)
- Client detection upon interaction with the Altitude 300, including client state changes, and error messages

AP Detection

Access point (AP) detection can be configured to use either of two methods: passive scan or active scan. During a passive scan, the Altitude 300 simply listens for beacons and other broadcast traffic and uses the collected information to create a database of stations it recognizes. In active scan mode, the Altitude 300 sends a probe request to elicit responses from other APs within its area.

The Altitude 300 support both active and passive scans on the current operating channel. During scans operating on the current channel, the Altitude 300 continues to carry user traffic. During an “off-channel” scan, the Altitude 300 is not be available for user traffic. The effect of an off-channel scan is to disable the radio for a user-defined period of time, during which the Altitude 300 will scan other channels. All associated clients will lose connections and need to reassociate. Once the scan is complete, the radio will be returned to its previous state. You can set the scan to occur on all channels, or on a specific subset of channels at specified scheduled times.

Enabling and Disabling AP Scan

The commands described in this section are used to enable and disable access point (AP) detection.

To start a wireless port on-channel scan for the indicated port or ports and interface for the Altitude 300, use the following command:

```
enable wireless ports <portlist> interface [1 |2] ap-scan
```

The Altitude 300 continues to carry user traffic during scans operating on the current channel ("on-channel" scans).

To stop an on-channel wireless port scan for the indicated port or ports and interface for the Altitude 300, use the following command:

```
disable wireless ports <portlist> interface [1 |2] ap-scan
```

To start the access point (AP) scan on the indicated interface at the specified time, use the following command:

```
enable wireless ports <portlist> interface [1 | 2] ap-scan off-channel [at | every]
<time>
```

During an "off-channel" scan, the Altitude 300 is not available for user traffic.

To schedule the stopping of the access point (AP) scan on the indicated interface at the specified time, use the following command:

```
disable wireless ports <portlist> interface [1 | 2] ap-scan off-channel [at | every]
<time>
```

Configuring AP Scan

The commands described in this section are used to configure access point (AP) detection.

To add or remove specific channels for the off-channel AP scan, use the following command:

```
configure wireless ports [<portlist> | all] interface [1 | 2] ap-scan off-channel [add
| del] {current-channel | all-channels | every-channel}
```

Use this command when the AP scan must be started on a particular interface.

To enable the sending of probes for active scanning, use the following command:

```
configure wireless ports [<portlist> | all] interface [1 | 2] ap-scan send-probe [on
|off]
```

To configure the interval between probe request packets for active off-channel scanning, use the following command:

```
configure wireless ports [<portlist> | all] interface [1 | 2] ap-scan probe-interval
<msec>
```

Use this command to send probe requests at particular intervals on a selected channel during an AP scan.

To set the maximum time an off-channel scan waits at a particular channel, use the following command:

```
configure wireless ports [<portlist> | all] interface [1 | 2] ap-scan off-channel
max-wait <num>
```

To set the minimum time an off-channel scan waits at a particular channel, use the following command:

```
configure wireless ports [<portlist> | all] interface [1 | 2] ap-scan off-channel
min-wait <num>
```

To have the AP scan to send an SNMP trap when new stations are added to the results table, use the following command:

```
configure wireless ports [<portlist> | all] interface [1 | 2] ap-scan added-trap [on |
off]
```

Use this command when an SNMP-based remote management application is used to monitor the network.

To have the AP scan to send an SNMP trap when new stations are removed from the results table, use the following command:

```
configure wireless ports [<portlist> | all] interface [1 | 2] ap-scan removed-trap [on
| off]
```

Use this command to see a trap when stations are removed from the results table.

To configure the AP scan to send an SNMP trap when information about an AP has changed, use the following command:

```
configure wireless ports [<portlist> | all] interface [1 | 2] ap-scan updated-trap [on
|off]
```

To set the number of elements that the wireless interface stores, use the following command:

```
configure wireless ports [<portlist> | all] interface [1 | 2] ap-scan results size
<num>
```

Use this command to specify the size of the results table.

To set the timeout threshold that sets when entries are aged out from the table, use the following command:

```
configure wireless ports [<portlist> | all] interface [1 | 2] ap-scan results timeout
<time>
```

Viewing AP Scan Properties and Results

The commands described in this section are used to display access point (AP) scan properties.

To display the current configuration of the scan feature for the selected ports and interface, use the following command:

```
show wireless ports [<portlist> | all] interface [1 |2] ap-scan configuration {detail}
```

To display a switch-wide, correlated view of the results of the access point (AP) scan, use the following command:

```
show wireless ap-scan results {detail}
```

Use this command to see the results of an AP scan. Use the optional keyword, `detail`, to see all of the fields in Table 100.

Table 100: AP Scan Results (Alphabetized)

Data Value	Description
APMAC	MAC address of the discovered AP

Table 100: AP Scan Results (Alphabetized) (Continued)

Data Value	Description
Capability	Capability field from a received information packet (in detail output only)
Channel	The channel on which this AP was discovered
ESS Name	String ESS ID I.E.
Last Change	Time value at which this entry was updated
Min/Max/Avg RSS	Received Signal Strength statistics
Network Type	Ad-hoc or BSSID network (in detail output only)
Number of beacons	Count of beacon packets seen from this AP (in detail output only)
Number of probe resp	Count of PROBE RESP packets sent from the AP (in detail output only)
Supported Rate Set	List of supported rates
WEP required/WEP authentication supported	WEP information from beacon and probe packets
WPA	WPA information, including authentication and supported encryption algorithms
First Seen	First discovered.

To display information about the AP MAC-address that is entered, use the following command:

```
show wireless ap-scan results <mac_address>
```

To display the status of the AP scan for the port and the interface, use the following command:

```
show wireless ports [<portlist> | all] interface [1 | 2] ap-scan status
```

To display information about the results of an AP scan from the port perspective, use the following command:

```
show wireless ports [<portlist> | all] interface [1 | 2] results {detail}
```

To clear the AP scan results table on any interface, use the following command:

```
clear wireless ports [<portlist> | all] interface [1 | 2] ap-scan results
```

Performing Client Scanning

The client scan feature enables the management layer to receive and process PROBE REQ messages from clients. The management layer then creates an entry in the probe information table for each client it receives PROBE REQ packets from. The management layer can, optionally, send an asynchronous notification when a new entry is added to the table. Entries in the probe information table are timed out if new PROBE REQ packets are not received in some configurable window. The client scan table can be configured by network administrator to optimize memory performance.

Enabling and Disabling Client Scanning

The commands described in this section are used to enable and disable client scanning.

To enable the client scan feature on the specified wireless interface, use the following command:

```
enable wireless ports [<portlist> | all] interface [1 | 2] client-scan
```

To disable the client scan feature on the specified wireless interface, use the following command:

```
disable wireless ports <portlist> interface [1 | 2] client-scan
```

Configuring Client Scanning

The commands described in this section are used to configure client scanning.

To configure the maximum number of entries in the client scan information table, use the following command:

```
configure wireless ports [<portlist> | all] interface [1 | 2] client-scan results size
<value>
```

To configure the timeout period for entries in the client scan information table, use the following command:

```
configure wireless ports <portlist> interface [1 | 2] client-scan results timeout
<number>
```

To enable or disable traps from the client-scan feature when a new client is detected, use the following command:

```
configure wireless ports [<portlist> | all] interface [1 | 2] client-scan addeded-trap
[on |off]
```

Enabling traps can saturate management stations if an area is heavily populated.

To enable or disable traps from the client-scan feature when a new client has aged-out of the table, use the following command:

```
configure wireless ports [<portlist> | all] interface [1 | 2] client-scan removed-trap
[on |off]
```

Viewing Client Scanning Properties and Results

The commands described in this section are used to display client scanning properties and scan results and to clear information from the client scan table. .

Displaying Client Scanning Information

To display the current configuration of the client scan feature, use the following command:

```
show wireless ports [<portlist> | all] interface [1 | 2] client-scan configuration
```

Displays the current configuration of the client scan feature, including:

Port:	The port number used in the scan
Interface:	1 or 2
Enabled:	Y (yes) N (no)
Send Added:	on ｜ off
Send Removed:	on ｜ off
Timeout:	Parameter specified for scan timeouts

Max Size: Parameter specified for the number of entries for the table

To display the current contents of the probe information table, use the following command:

```
show wireless ports [<portlist> | all] interface [1 | 2] client-scan results
```

The output of this command displays the probe information table, which has the following fields:

Table 101: Client Scan Results

Variable	Description
Intf	Wireless port and interface on which this client is seen
MAC address of the source	MAC address of the source
Probe REQs	Number of PROBE REQ packets seen from this source
Last RSS	RSSI of last received PROBE REQ packet
Channel	Channel on which last PROBE REQ was received
Last Seen	Time last PROBE REQ was seen from this source
Client	Client is associated to the Altitude 300 (Y I N)

To display the details about the specified client MAC address, use the following command:

```
show wireless ports [<portlist> | all] interface [1 | 2] client-scan results
<mac_address>
```

Use this command to check details about the clients in the client scan table.

To display the overall operation of the client scan results, use the following command:

```
show wireless ports [<portlist> | all] interface [1 | 2] client-scan status
```

The output of this command displays the performance results for the following variables on a per wireless interface basis.

Table 102: Client Scan Performance Results Per Wireless Interface

Variable	Description
CurrentTableSize	The current size of the table (in entries)
TableWatermark	The maximum size the table has been since the last reset of the historical statistics
TotalOverflows	The number of times an entry has been overwritten because the table is full
TotalTimeouts	The number of times an entry has been aged out from the table
LastElement	The last time an element was added to the table
TotalProbes	The total number of probes received on this interface

Clearing Client Scanning Information

To clear the statistics associated with a particular client or with all clients, use the following command:

```
clear wireless ports [<portlist> | all] interface [1 | 2] client-scan counters
[<hexoctet> | all]
```

Use this command to clear client scan counters on any interface: 1 or 2.

To clear the contents of the client scan information table or for a specific client MAC address, use the following command:

```
clear wireless ports [<portlist> | all] interface [1 | 2] client-scan results
[<hexoctet> | all]
```

Use this command to clear the client scan results on any interface: 1 or 2.

Collecting Client History Statistics

Client information is collected from stations when sending frames to the Altitude 300. Based on the frames the client exchanges with the Altitude 300, three types of information are collected. These types are listed below:

- **Current state:** Current condition of the client. It is limited to clients that have sent this station an authentication request.
- **MAC layer**: Information about the operation of the MAC transport layer as it affects this particular **client.** This information can be used to detect problems with Altitude 300 placement, link utilization, etc.
- **Historical information**: View of a station through time. State transitions are preserved through a series of counters. This information can be used to debug various configuration problems.

Client Current State

Client current state information is available for all clients that have sent an authentication message to the Altitude 300. Information in this table is timed out if no packets have been received from the client by the configurable period of time set by the administrator.

To displays the current wireless client state of a selected port or ports and interface, use the following command:

```
show wireless ports [<portlist> | all] interface [1 | 2] clients {detail}
```

The fields of the client state table displayed with this command are shown in Table 103:

Table 103: Client Current State Details

Value	Description
Client MAC	MAC address of the client adapter
Current State	DETECTED, AUTHED, ASSOC, or FORWARD. Indicates which part of the state machine the client is currently in.
Last state change	The system time when the client last changed states
Encryption Type	Type of MAC-level encryption the client is using. This is negotiated during the association state machine, so is only valid if client state is FORWARDING.
Authentication Type	Last type of authentication the client tried. In the case of a client in FORWARDING, indicates the type of authentication that granted access to the network.
ESSID	Extended service set identifier of the network
Wireless Port	Wireless switch port serving the client
Client VLAN	VLAN assigned to this client by a radius VSA or other mechanism. This is only valid for clients in FORWARDING.

Table 103: Client Current State Details (Continued)

Value	Description
Client Priority	Quality of service (QoS) level for the client
Tx Frames	Number of frames transferred to the client
Rx Frames	Number of frames returned by the client
Tx Bytes	Number of bytes transferred to the client
Rx Bytes	Number of bytes returned by the client
RSS	Received signal strength

Client History Information

The commands described in this section support debugging of individual client problems. They are designed to provide the information to assist debugging client connectivity problems that stem from non-physical layer problems (that is, WEP configuration problems).

Enabling and Disabling Client History

The commands described in this section are used to enable and disable client history collection.

To set the Altitude 300 to log client historical information, use the following command:

```
enable wireless ports [portlist | all] interface [1 | 2] client-history
```

Use this command to get the detail status about each associated client.

To disable logging of client historical information, use the following command:

```
disable wireless ports [portlist | all] interface [1 | 2] client-history
```

Configuring Client History

The commands described in this section are used to configure client history collection.

To configure the client history size, use the following command:

```
configure wireless ports [<portlist> | all] interface [1 | 2] client-history size
<integer>
```

To configure the client history timeout interval, use the following command:

```
configure wireless ports [<portlist> | all] interface [1 | 2] client-history timeout
<number>
```

Use this command to specify the timeout interval for the clients in the client history table.

Viewing Client History

The commands described in this section are used to display client history information.

To display the current configuration of the client history and diagnostic features, use the following command:

```
show wireless ports [<portlist> | all] interface [1 | 2] client-history configuration
```

To display counters and errors the information collected on a per-client basis, use the following command:

```
show wireless ports [<portlist> | all] interface [1 | 2] client-history diagnostics
<mac_address>
```

Use this command to display diagnostic counters and error information contained in the extremeWirelessClientDiagTable.

To display 802.11 MAC layer information collected on a per-client basis, use the following command:

```
show wireless ports [<portlist> | all] interface [1 | 2] client-history mac-layer
<mac_address>
```

Use this command to display information on the operation of the 802.11 MAC layer.

To display the current status of the historical client information, use the following command:

```
show wireless ports [<portlist> | all] interface [1 | 2] client-history status
```

This command displays information about the client diagnostic and history database. The output has the fields shown Table 104:

Table 104: Client Diagnostic and History Information

Variable	Description
Enable	This value indicates if historical information is being collected on this interface or not.
TableSize	This is the number of entries allowed in each of the historical client tables.
Timeout	This is the time, in seconds, that entries will persist in the historical client tables after the referenced client is removed from the SIB.
CurrentSize	The current number of entries in the historical client database
Watermark	The maximum number of entries which have ever been in the historical client database.
Overflows	Number of entries which have been overwritten in order to make room for a new entry.
AgeOuts	Number of entries which have been aged out of the table

To clear the counters for a specific MAC address or for all clients, use the following command:

```
clear wireless ports [<portlist> | all] interface [1 | 2] client-history
[<mac-address> | all]
```

Although this command clears the counters, client entries are not removed from the client information database.

Client Aging

Client aging allows you to configure an aging timer for wireless stations. When a specified period of time elapses with no data traffic from the client to the Altitude 300, the client is de-authenticated and removed from all client station tables for that interface. After a client is aged out, it can reassociate and re-authenticate to the Altitude 300. Age-out information can be collected from such events as client station failures, station idle-timeouts, or a client abruptly leaving the wireless network without notifying the associated Altitude 300.

To configure client aging parameters, use the following command:

```
configure wireless ports [<portlist> | all] detected-station-timeout <seconds>
```

The timeout value is configured for each port and affects both interfaces 1 and 2.

Configuring Wireless Switch Properties

This section describes the wireless configuration commands that apply to the switch as a whole.

Configuring Country Codes

To configure the country identifier for the switch, use the following command:

```
configure wireless country-code <code>
```

When the Alpine 3800 is set to factory defaults, you must configure the correct country code using the country code properties listed in the following table. The country code feature allows you to configure the approved 802.11a or 802.11b/g “channels” applicable to each of the supported countries.

Table 105: Country Codes

Australia	Austria	Belgium	Canada	China	Denmark
extreme_default	Finland	France	Germany	Greece	Hong_Kong
Iceland	Ireland	Italy	Japan	Korea_Republic	Liechtenstein
Luxembourg	Mexico	Netherlands	Norway	Portugal	Spain
Sweden	Switzerland	Taiwan	Thailand	UK	USA

Extreme Networks ships the Alpine 3800 to be programmed with Extreme Network's special `extreme_default` country code, which brings up only the B/G radio in channel 6, and turns off the A radio. When an Altitude 300 wireless port is connected and the Alpine 3800 is unable to determine the country for which the Altitude is programmed, then the `extreme_default` country code is used. You must program the country code on the Alpine 3800 to enable the remaining channels for the desired country.

The Altitude 300 wireless port is shipped with a pre-programmed code for the following countries:

- North America (United States, Canada, Hong Kong)
- Japan
- Taiwan
- European Union and the Rest of the World.

If you do not program the country code in the Alpine 3800, then the switch inherits the country code of the first Altitude 300 wireless port that connects to it, if the Altitude is not programmed for the 'European Union and the Rest of World.

If there is a mismatch between the country codes between the Altitude 300 wireless port and the code programmed on the Alpine 3800, the Altitude 300 wireless port is not allowed to come up.

Configuring the Default Gateway

To configure the default gateway IP address, use the following command:

```
configure wireless default-gateway <ip_address>
```

The wireless default gateway IP address is usually set to the wireless management VLAN address. This address is used by all wireless client traffic whose destination is upstream switches.

Configuring the Management VLAN

To identify the VLAN on which the Altitude 300 wireless port communicates with the switch, use the following command:

```
configure wireless management-vlan <vlan name>
```

Identifying the VLAN on which the Altitude 300 wireless port communicates with the switch is required before wireless features can work. This VLAN can be the default VLAN and it can either have a public or private IP address. This VLAN is a tagged or untagged VLAN on which all the Altitude 300 devices are connected to untagged ports.

Configuring Wireless Ports

This section describes the wireless configuration commands that apply to a particular port or set of ports.

Enabling and Disabling Wireless Ports

The commands described in this section are used to enable and disable wireless port properties.

To administratively enable a wireless port for use, use the following command:

```
enable wireless ports <portlist>
```

To administratively disable a wireless port for use, use the following command:

```
disable wireless ports <portlist>
```

To enable the specified port or ports every day at the specified hour, use the following command:

```
enable wireless ports <portlist> every <hour>
```

Use this command to automatically enable wireless ports according to a daily schedule. The selected port or ports will be enabled each day on the specified hour.

To disable the specified port or ports every day at the specified hour, use the following command:

```
disable wireless ports <portlist> every <hour>
```

To enable the specified ports at a particular date and hour, use the following command:

```
enable wireless ports <portlist> time <date> <hour>
```

To disable the specified ports at a particular date and hour, use the following command:

```
disable wireless ports <portlist> time <date> <hour>
```

To cancel previously scheduled enable or disable scheduling commands for the port, use the following command:

```
disable wireless ports <portlist> cancel-scheduler
```

Configuring Wireless Port Properties

The commands described in this section are used to configure the wireless port properties listed in Table 106:

Table 106: Wireless Port Configuration Property Values

Property	Default	Allowed Values	Description
health-check	on	off | on	Indicates whether the health check reset function is on or off. This determines whether the port should be reset if the health check timer expires.
location	"Unknown Location"	N/A	Identifies the location to be configured.

To configure whether the health check reset function is on or off for the specified port or ports, use the following command:

```
configure wireless ports [<portlist> | all] health-check [on | off]
```

This command determines whether the port is reset if the health check timer expires.

To configure the physical location of the AP for the specified port or ports, use the following command:

```
configure wireless ports <portlist> location <location_name>
```

Use this command to indicate the physical location of the AP for the specified port or ports. For example, you could designate a physical location as follows: `bldg 1, pole 14, cube 7`. Funk Radius can use this attribute for authentication.

To reset selected wireless ports to their default values, use the following command:

```
reset wireless ports <portlist>
```

Use this command to return a port the default values. (See Table 106 for default values.)

Force disassociation permits client user disassociation based on a recurring schedule, a date and time, or a particular MAC address. You can also disassociate a user immediately. You can specify access based on a preferred time periods, such as during off-hours, weekends, and holidays. You can also set up a user policy on a RADIUS server to allow user authentication based on time of day.

To configure the client force-disassociation capability, use the following command:

```
configure wireless ports <portlist> force-disassociation [all-clients [every <hour
<0-23>> <minute <0-59>> | time <month <1-12>> <day> <year <yyyy>> <hour <0-23>>
<minute <0-59>>] | cancel-scheduler | <mac-address>]
```

Configuring Wireless Interfaces

Each wireless port on the Alpine switch contains two interfaces. Interface 1 (A radio) supports 802.11a, and interface 2 (B radio) supports 802.11b and 802.11g radio signals. The `configure wireless` `interface` commands allow you to configure one of the two individual interfaces (1|2) on a port or ports. You can move an interface from one profile to another without having to shut it down.

Enabling and Disabling Wireless Interfaces

The commands described in this section are used to enable and disable wireless port interface properties.

To enable a specified port interface, use the following command:

```
enable wireless ports <portlist> interface [1 | 2]
```

To disable a specified port interface, use the following command:

```
disable wireless ports <portlist> interface [1 | 2]
```

Configuring Wireless Interfaces

The commands described in this section are used to configure wireless port interface properties.

To attach a port or ports and interface to an RF profile, use the following command:

```
configure wireless ports <portlist> interface [1 | 2] rf-profile <name>
```

All ports in the port list must have the same wireless port version.

To set the maximum number of clients that can connect simultaneously to a wireless interface, use the following command:

```
configure wireless ports [<portlist> | all] interface [1 | 2] max-clients <value>
```

Valid `max-client` values range from 0 (zero) to 128.

To configure the power-level for a specified interface, use the following command:

```
configure wireless ports <portlist> interface [1 | 2] power-level <level>
```

Valid power level values are:

- Full
- Half
- Quarter
- One-eighth
- Min (minimum)

If there is radio interference from other devices, then you can adjust the power level to an appropriate level below full power.

To attach a port or ports and interface to a security profile, use the following command:

```
configure wireless ports <portlist> interface [1 | 2] security-profile <name>
```

All ports in the port list must have the same wireless port version.

To configure a transmission rate for the specified port, use the following command:

```
configure wireless ports <portlist> interface [1 | 2] transmit-rate <rate>
```

Valid transmission rate values are shown in Table 107.

Table 107: Valid transmission rate values

Mode	Valid Transmission Rate
A	6, 9, 12, 18, 24, 36, 48, 54, auto
B	1, 2, 5.5, 11, auto
G	1, 2, 5.5, 6, 9, 11, 12, 18, 24, 36, 48, 54, auto

To configure a channel for a specified interface, use the following command:

```
configure wireless ports <portlist> interface [1 | 2] channel {0 | <channel>}
```

Valid channel values are shown in Table 108.

Table 108: Valid wireless interface channel values

WLAN Standard	Valid Channels
802.11a	0 (auto), 36, 40, 44, 48, 52, 56, 60, 64, 149, 153, 157, 161, 165, 169, (34, 38, 42, 46 for Japan)
802.11b and 802.11g	0 (auto), 1-14 (Must be valid entry for the country code range; e.g., valid range for USA is 1-11.)

To force the wireless port interface to reset, use the following command:

```
reset wireless ports <portlist> interface [1 | 2]
```

Configuring Inter-Access Point Protocol (IAPP)

Inter-Access Point Protocol (IAPP) facilitates seamless roaming of wireless stations between access points (APs). IAPP operations are not configurable. Control is limited to enabling or disabling IAPP on a per interface basis. Debug tracing can be enabled for IAPP to troubleshoot IAPP scenarios.

To enable IAPP on a per interface basis, use the following command:

```
enable wireless ports [<portlist> | all] interface [1 | 2] iapp
```

IAPP uses layer 2 updates to allow connected layer 2 devices to update forwarding tables with the address of the client. The AP sends the updates on behalf of the clients by inserting the MAC address of the mobile station in the source address. The switch looks up the UDP request packet on the local subnet that contains the AP MAC address which contains the needed IP address. All APs on the subnet receive this message. The AP with the matching MAC address sends a unicast response packet with its IP address.

To disable IAPP on a per interface basis, use the following command:

```
disable wireless ports [<portlist> | all] interface [1 | 2] iapp
```

To enable debug tracing for IAPP on a per interface basis to troubleshoot IAPP scenarios, use the following command:

```
configure debug-trace wireless ports [<portlist> | all] iapp <debug-level>
```

The valid debug level range is 0 (off) to 7, corresponding to increasing levels of debug detail.

Event Logging and Reporting

The Alpine switch supports the following enhancements for wireless event logging and reporting with respect to the Altitude 300 local log, which is filtered on a per port basis:

- Enumerated type fields are included in syslog messages for filtering by external tools.
- An additional CLI command is included for more granularity, as described below

To display the local Altitude 300 event log of the selected port or ports, use the following command:

```
show wireless ports [<portlist>| all] log
```

You can use this command to display the Altitude 300 local log for debugging errors.

Enabling SVP to Support Voice Over IP

SpectraLink Voice Priority (SVP) is a voice over IP (VoIP) protocol that ensures acceptable audio quality in a mixed voice and data environment. It overcomes limitations of the 802.11 Standard by handling RTP packets between the SVP gateway and handset in a manner that is optimized for VoIP traffic over a wireless LAN (WLAN). SVP does this by:

- Prioritizing voice packets on the wireless network through a packet classification scheme based on the IP protocol number for SpectraLink Radio Protocol (119).
- Assigning filtered packets to high-priority outbound queues on each interface.
- Disabling random backoff for voice packets, setting the backoff window to zero.
- Queuing packets for Power Saving (PS) devices for the interval specified in the Listen Interval.

NOTE

Queued packets must be properly signaled in the TIM of Beacons. VoIP handsets must be able to enter PS mode by setting the PS bit in any uplink packet.

SVP control is maintained at the virtual-interface level. It can be turned on or off for each virtual interface. A separate transmit queue for SVP packet handling should be maintained for each interface.

To enable the QoS protocol, SpectraLink Voice Protocol (SVP), for VoIP on the specified port and interface., use the following command:

```
enable wireless ports [<portlist> | all] interface [1 | 2] svp
```

To disable SVP for VoIP on the specified port and interface., use the following command:

```
disable wireless ports [<portlist> | all] interface [1 | 2] svp
```

Part 4
Appendixes

A Software Upgrade and Boot Options

This appendix describes the following topics:

- Downloading a New Image on page 815
- Saving Configuration Changes on page 819
- Using TFTP to Download the Configuration on page 821
- Synchronizing MSMs on page 822
- Upgrading and Accessing BootROM on page 823
- Configuring Dual-Mode Default Configuration on page 824

Downloading a New Image

The image file contains the executable code that runs on the switch. It comes preinstalled from the factory. As new versions of the image are released, you should upgrade the software running on your system.

The image is upgraded by using a download procedure from either a Trivial File Transfer Protocol (TFTP) server on the network or from a PC connected to the serial port using the XMODEM protocol. Downloading a new image involves the following steps:

- Load the new image onto a TFTP server on your network (if you will be using TFTP).
- Load the new image onto a PC (if you will be using XMODEM).
- Download the new image to the switch using the following command:

  ```
  download image [<hostname> | <ipaddress>] [<filename> | all-images
  <filename_prefix> {image-type [non-ssh | ssh]}] {primary | secondary} {slot
  <slot>}
  ```

  where the following is true:

  `hostname`—Is the hostname of the TFTP server. (You must enable DNS to use this option.)

  `ipaddress`—Is the IP address of the TFTP server.

  `filename`—Is the filename of the new image.

  `primary`—Indicates the primary image.

  `secondary`—Indicates the secondary image.

Selecting a Primary or a Secondary Image

The switch can store up to two images: a primary and a secondary. When you download a new image, you must select into which image space (primary or secondary) the new image should be placed. If not indicated, the next selected boot-up image space is used. This is the primary image space by default, but it can be changed with the following command:

```
use image [primary | secondary] {slot <slot>}
```

If two MSMs are installed in the BlackDiamond switch, the downloaded image is saved to the same location on each one.

You can select which image the switch will load on the next reboot by using the `use image` command:

Downloading Images to Slots and Modules

To download an image to an individual slot on an Alpine switch, use the following command:

```
download image [<hostname> | <ipaddress>] [<filename> | all-images <filename_prefix>
{image-type [non-ssh | ssh]}] {primary | secondary} {slot <slot>}
```

If you have modules that run a software image in the Alpine or BlackDiamond chassis, and you want to download an image to all installed modules, use the following command:

```
download image [<hostname> | <ipaddress>] [<filename> | all-images <filename_prefix>
{image-type [non-ssh | ssh]}] {primary | secondary} {slot <slot>}
```

- Use the `all-images <filename_prefix>` parameter to download the operational images for all installed modules.
  - `filename_prefix`—Specifies the filename prefix (the filename without the image extension) of the new image.
  - All of the operational images files must be located in the same directory on the TFTP server and they must have the same filename prefix.
- Enter the filename prefix, not the filename, to successfully download the software.
  - For example, if you enter `v700b68.xtr`, the command fails because the file extension (.xtr) is included, and `v700b68.xtr.xtr` is not found.
  - If you enter `v700b68`, without the file extension, the command executes.
- By default, if the ExtremeWare version currently running contains security features that are subject to export restrictions (for example, SSH2), the image downloaded contains the security features.

  To download an image type different from the type currently running, specify the optional `image-type` keyword followed by either `non-ssh` or `ssh`.
  - `non-ssh`—Specifies an ExtremeWare image without export-restricted security features
  - `ssh`—Specifies an ExtremeWare image containing export-restricted security features
- The main ExtremeWare image always downloads first.

  The download image process proceeds with each slot starting at slot 1.
  - If the main ExtremeWare image cannot be found, the download image process is discontinued.
  - If a specific image file is not found for a specific module, an error is displayed and the download process continues to the next module.
- Slots with modules that do not support separate operational images (for example, the G8Xi or the GM-4Ti module) are skipped.

Table 109 lists the supported modules and operational images:

Table 109: Supported modules and operational images

Module Name	Image Extension	Image Description
MSM, SMMi	xtr	ExtremeWare image
MSM	Gxtr	6816 ExtremeWare image
MSM, SMMi	Sxtr	SSH ExtremeWare image
MSM	SGxtr	SSH 6816 ExtremeWare image
ARM	arm	ARM image
A3cSi	atm3	ATM OC-3 image
P3cSi, P3cMi	oc3	PoS OC-3 image
P12cSi, P12cMi	oc12	PoS OC-12 image
MPLS	mpls	MPLS image
WM-4E1i	e1	E1 WAN image
WM-4T1i	t1	T1 WAN image
WM-1T3i	t3	T3 WAN image

Understanding the Image Version String

The image version string contains build information for each version of ExtremeWare. You can use either the `show version` or `show switch` command to display the ExtremeWare version running on your switch.

Depending on the CLI command, the output is structured as follows:

- `show version`

  Version <major>.<sub_major>.<minor> (Build<build>) {[branch | beta | tech | patch]{<image_version>}.<image_description>-r<branch_revision>}

- `show switch`

  <major>.<sub_major>.<minor>b<build>{[branch | beta | tech | patch]{<image_version>}.<image_description>-r<branch_revision>}

Table 110 describes the image version fields.

Table 110: Image version fields

Field	Description
major	Specifies the ExtremeWare Major version number.
sub_major	Specifies the ExtremeWare Sub-major version number.
minor	Specifies the ExtremeWare Minor version number.
build	Specifies the ExtremeWare build number. This value is reset to zero for each new Major and Minor release.
image_version	Identifies the Technology Release or Beta image version. The image version number is zero for all but Technology Releases and Beta releases.

Table 110: Image version fields (Continued)

Field	Description
image_description	Identifies a specific Patch, Beta Release, Technology Release, or Development Branch Release.
branch_revision	Indicates an incremental build on a specific branch. The branch revision number is zero for General Availability and Sustaining releases.

Table 111 displays sample `show version` and `show switch` output for various ExtremeWare versions.

Table 111: Sample show output

Release Type	Show Version Command	Show Switch Command
Major	`Version 7.0.0 (Build 61)`	`7.0.0b61`
Minor	`Version 7.0.1 (Build 4)`	`7.0.1b4`
Sustaining	`Version 7.0.0 (Build 68)`	`7.0.0b68`
Patch	`Version 7.0.0 (Build 61) patch.030131-01-r1`	`7.0.0b61 patch.030131-01-r1`
Technology	`Version 7.0.0 (Build 68) tech2.ipv6-r4`	`7.0.0b68 tech2.ipv6-r4`
Beta	`Version 7.0.1 (Build 3) beta1.triumph-r4`	`7.0.1b3 beta1.triumph-r4`
Development Branch	`Version 7.0.0 (Build 67) branch.triumph-r5`	`7.0.0b67 branch.triumph-r5`

Software Signatures

Each ExtremeWare image contains a unique signature. The BootROM checks for signature compatibility and denies an incompatible software upgrade. In addition, the software checks both the installed BootROM and software and also denies an incompatible upgrade.

ExtremeWare 6.2.2 build 56 is the first ExtremeWare release to incorporate software signatures. You must upgrade to ExtremeWare 6.2.2 build 56 before upgrading to later ExtremeWare builds.

Rebooting the Switch

To reboot the switch, use the following command:

```
reboot {time <date> <time> | cancel} {slot <slot number> | msm-a | msm-b}
```

where `date` is the date and `time` is the time (using a 24-hour clock format) when the switch will be rebooted. The values use the following format:

```
mm/dd/yyyy hh:mm:ss
```

If you do not specify a reboot time, the reboot occurs immediately following the command, and any previously schedule reboots are cancelled. To cancel a previously scheduled reboot, use the `cancel` option.

To reboot the Alpine 3802, use the following command:

```
reboot {time <date> <time> | cancel} {slot <slot number> | msm-a | msm-b}
```

Rebooting a Module

To reboot a module in a specific slot, rather than rebooting the switch, use the following command:

```
reboot {time <date> <time> | cancel} {slot <slot number> | msm-a | msm-b}
```

with the additional options available:

- `slot number`— Specifies the slot where the module is installed
- `msm-a`—Specifies a BlackDiamond MSM module installed in slot A
- `msm-b`—Specifies a BlackDiamond MSM module installed in slot B

In general, the modules that can be rebooted have separate images from the ExtremeWare image for the switch. The following modules can be rebooted:

- E1
- T1
- T3
- ARM
- ATM
- MPLS
- PoS
- Slave or switch fabric MSM modules

NOTE

When you configure a timed reboot of an MSM, there is no show output in the CLI to view the configuration.

The E1, T1, and T3 `reboot slot` command does not support the `time` or `cancel` keywords, so this command can only be executed immediately.

Saving Configuration Changes

The configuration is the customized set of parameters that you have selected to run on the switch. As you make configuration changes, the new settings are stored in run-time memory. Settings that are stored in run-time memory are not retained by the switch when the switch is rebooted. To retain the settings, and have them load when you reboot the switch, you must save the configuration to nonvolatile storage.

The switch can store two different configurations: a primary and a secondary. When you save configuration changes, you can select to which configuration you want the changes saved. If you do not specify, the changes are saved to the configuration area currently in use.

To save the configuration, use the following command:

```
save configuration {primary | secondary}
```

To use the configuration, use the following command:

```
use configuration [primary | secondary] [slot <slot_number> | all]
```

The configuration takes effect on the next reboot.

NOTE

If the switch is rebooted while in the middle of a configuration save, the switch boots to factory default settings. The configuration that is not in the process of being saved is unaffected.

Returning to Factory Defaults

To return the switch configuration to factory defaults, use the following command:

```
unconfigure switch
```

This command resets the entire configuration, with the exception of user accounts and passwords that have been configured, and the date and time.

To erase the currently selected configuration image and reset all switch parameters, use the following command:

```
unconfigure switch all
```

Using TFTP to Upload the Configuration

You can upload the current configuration to a TFTP server on your network. The uploaded ASCII file retains the command-line interface (CLI) format. This allows you to:

- Modify the configuration using a text editor, and later download a copy of the file to the same switch, or to one or more different switches.
- Send a copy of the configuration file to the Extreme Networks Technical Support department for problem-solving purposes.
- Automatically upload the configuration file every day, so that the TFTP server can archive the configuration on a daily basis. Because the filename is not changed, the configured file stored in the TFTP server is overwritten every day.

To upload the configuration, use the following command:

```
upload configuration [<ip address> | <hostname>] <filename> {every <time>}
```

where the following is true:

- `ipaddress`—Is the IP address of the TFTP server.
- `hostname`—Is the hostname of the TFTP server. (You must enable DNS to use this option.)
- `filename`—Is the name of the ASCII file. The filename can be up to 255 characters long, and cannot include any spaces, commas, quotation marks, or special characters.
- `every <time>`—Specifies the time of day you want the configuration automatically uploaded on a daily basis. If not specified, the current configuration is immediately uploaded to the TFTP server.

To cancel a previously scheduled configuration upload, use the following command:

```
upload configuration cancel
```

NOTE

If you do not configure any slots or VLANs, and you upload the configuration, reboot the switch, and download the configuration, then all ports are deleted from the default VLANs. To preserve the ports, first configure slots or create a VLAN before you upload the configuration.

Using TFTP to Download the Configuration

You can download ASCII files that contain CLI commands to the switch to modify the switch configuration. Three types of configuration scenarios that can be downloaded:

- Complete configuration
- Incremental configuration
- Scheduled incremental configuration

Configurations created in a chassis are not supported in a different model chassis. For example, a configuration from a BlackDiamond 6808 is not supported in a BlackDiamond 6804. Configurations for different models generate error messages for any line in the configuration that concerns unavailable slots.

If you load a configuration from a different model, you can safely write the correct configuration over the unsupported configuration.

Downloading a Complete Configuration

Downloading a complete configuration replicates or restores the entire configuration to the switch. You typically use this type of download in conjunction with the `upload configuration` command, which generates a complete switch configuration in an ASCII format. As part of the complete configuration download, the switch is automatically rebooted.

To download a complete configuration, use the `download configuration` command using the following syntax:

```
download configuration [<ip address> | <hostname>] <filename>
```

After the ASCII configuration is downloaded by way of TFTP, you are prompted to reboot the switch. The downloaded configuration file is stored in current switch memory during the rebooting process, and is not retained if the switch has a power failure.

When the switch completes booting, it treats the downloaded configuration file as a script of CLI commands, and automatically executes the commands. If your CLI connection is through a Telnet connection (and not the console port), your connection is terminated when the switch reboots, but the command executes normally.

Downloading an Incremental Configuration

A partial or incremental change to the switch configuration may be accomplished by downloaded ASCII files that contain CLI commands. These commands are interpreted as a script of CLI commands, and take effect at the time of the download, without requiring a reboot of the switch.

To download an incremental configuration, use the following command:

```
download configuration [<ip address> | <hostname>] <filename> {incremental}
```

Do not download an incremental configuration when you have time-critical applications running. When you download an incremental configuration, the switch immediately processes the changes, which can affect the processing of other tasks. We recommend that you either download small incremental configurations, or schedule downloads during maintenance windows.

Scheduled Incremental Configuration Download

You can schedule the switch to download a partial or incremental configuration on a regular basis. You could use this feature to update the configuration of the switch regularly from a centrally administered TFTP server. As part of the scheduled incremental download, you can optionally configure a backup TFTP server.

To configure the primary and/or secondary TFTP server and filename, use the following command:

```
configure download server [primary | secondary] [<ip address> | <hostname>] <filename>
```

To enable scheduled incremental downloads, use the following command:

```
download configuration every <time>
```

To display scheduled download information, use the following command:

```
show switch
```

To cancel scheduled incremental downloads, use the following command:

```
download configuration cancel
```

Remember to Save

Regardless of which download option is used, configurations are downloaded into switch runtime memory, only. The configuration is saved only when the `save` command is issued, or if the configuration file, itself, contains the `save` command.

If the configuration currently running in the switch does not match the configuration that the switch used when it originally booted, an asterisk (*) appears before the command line prompt when using the CLI.

Synchronizing MSMs

On the BlackDiamond switch, you can take the master MSM configurations and images and replicate them on the slave MSM using the following command:

```
synchronize
```

In addition to replicating the configuration settings and images, this command also replicates which configuration or image the MSM should use on subsequent reboots. This command does not replicate the run-time configuration. You must use the `save configuration` command to store the run-time configuration first.

Upgrading and Accessing BootROM

The BootROM of the switch initializes certain important switch variables during the boot process. If necessary, BootROM can be upgraded, after the switch has booted, using TFTP. In the event the switch does not boot properly, some boot option functions can be accessed through a special BootROM menu.

Upgrading BootROM

Upgrading BootROM is done using TFTP (from the CLI), after the switch has booted. Upgrade the BootROM only when asked to do so by an Extreme Networks technical representative. To upgrade the BootROM, use the following command:

```
download bootrom [<ip address> | <hostname>] <filename> {slot <slot>}
```

Accessing the BootROM Menu

Interaction with the BootROM menu is only required under special circumstances, and should be done only under the direction of Extreme Networks Customer Support. The necessity of using these functions implies a non-standard problem which requires the assistance of Extreme Networks Customer Support.

To access the BootROM menu, follow these steps:

1 Attach a serial cable to the console port of the switch.

2 Attach the other end of the serial cable to a properly configured terminal or terminal emulator, power cycle the switch while depressing the spacebar on the keyboard of the terminal.

As soon as you see the `BootROM->` prompt, release the spacebar. You can see a simple help menu by pressing `h` . Options in the menu include

— Selecting the image to boot from

— Booting to factory default configuration

— Performing a serial download of an image

For example, to change the image that the switch boots from in flash memory, press `1` for the image stored in primary or `2` for the image stored in secondary. Then, press the `f` key to boot from newly selected on-board flash memory.

To boot to factory default configuration, press the `d` key for default and the `f` key to boot from the configured on-board flash.

To perform a serial download, you can optionally change the baud rate to 38.4K using the `b` command, and then press the `s` key to prepare the switch for an image to be sent from your terminal using the XMODEM protocol. After this has completed, select the `g` command, to boot the image that is currently in RAM. The switch restores the console port to 9600 bps, and begins the boot process.

NOTE

Doing a serial download does not store an image into flash, it only allows the switch to boot an operational image so that a normal TFTP upgrade from the CLI can then be performed.

Configuring Dual-Mode Default Configuration

Extremeware supports dual mode default configuration. The standard default Extremeware configuration brings up the switch with all ports in the forwarding mode; an "enhanced" default configuration mode allows you to bring up the switch with all ports disabled.

NOTE

ExtremeWare products are shipped from the factory set with the standard default configuration mode, with the switch configured to startup with all ports in forwarding mode.

To configure the default startup configuration for the switch, use the following command:

```
configure configuration-mode <standard | enhanced>
```

In standard mode, all ports will be set to forwarding mode when the switch comes up. In enhanced mode, the default configuration wil have all ports disabled.

To remove an enhanced mode configuration and reset the configuration to the default standard configuration mode, use the following command:

```
unconfigure configuration-mode
```

This command lets you remove the effect of the previous configuration mode selection command. This will clear the NVRAM bit location, setting the configuration mode to standard.

To reset the configuration to factory defaults, but without erasing the configuration and rebooting, use the following command:

```
unconfigure switch {all} {enhanced}
```

This command preserves users account information such as date and time settings. Include the parameter `all` to clear the entire current configuration, including all switch parameters, and reboot using the last used image and configuration.

Include the parameter `enhanced` to clear the entire current configuration, with the exception of the default configuration mode, which will be set to enhanced. In enhanced mode, the switch boots with all ports disabled. If the `enhanced` parameter is not entered, the default configuration mode will be reset to the standard mode, in which the switch boots with all ports in forwarding mode.

To display current switch information, including the default configuration mode (standard or enhanced), use the following command:

```
show switch
```

B Troubleshooting

If you encounter problems when using the switch, this appendix may be helpful. If you have a problem not listed here or in the release notes, contact your local technical support representative.

LEDs

Power LED does not light:

Check that the power cable is firmly connected to the device and to the supply outlet.

On powering-up, the MGMT LED lights yellow:

The device has failed its Power On Self Test (POST) and you should contact your supplier for advice.

A link is connected, but the Status LED does not light:

Check that:

- All connections are secure.
- Cables are free from damage.
- The devices at both ends of the link are powered-up.
- Both ends of the Gigabit link are set to the same autonegotiation state.

  The Gigabit link must be enabled or disabled on both sides. If the two sides are different, typically the side with autonegotiation disabled will have the link LED lit, and the side with autonegotiation enabled will not be lit. The default configuration for a Gigabit port is autonegotiation enabled. This can be verified by entering the following command:

  ```
  show ports {mgmt | <portlist>} configuration
  ```

On power-on, some I/O modules do not boot:

Check if you are using 110V power input. The BlackDiamond switch powers only up to four modules if it is connected to a 110V outlet.

Error LED on the MSM turns amber:

Check the syslog message for a “critical” software errors.

Status LED on the I/O module turns amber:

Check the syslog message for a related I/O module error. If the error is an inserted an I/O module that conflicts with the software configuration, use one of the following commands to reset the slot configuration:

```
clear slot
```

```
configure slot <slot> module <module name>
```

Otherwise, contact Extreme Networks for further assistance.

ENV LED on the MSM turns amber:

Check each of the power supplies and all of the fans. Additionally, the status of these is indicated in the `show switch` display. Look for the “Temperature” and “Power Supply” entries in the display.

Switch does not power up:

All products manufactured by Extreme Networks use digital power supplies with surge protection. In the event of a power surge, the protection circuits shut down the power supply. To reset, unplug the switch for 1 minute, plug it back in, and attempt to power up the switch.

If this does not work, try using a different power source (different power strip/outlet) and power cord.

Using the Command-Line Interface

The initial welcome prompt does not display:

Check that your terminal or terminal emulator is correctly configured.

For console port access, you may need to press [Return] several times before the welcome prompt appears.

Check the settings on your terminal or terminal emulator. The settings are 9600 baud, 8 data bits, 1 stop bit, no parity, XON/OFF flow control enabled.

The SNMP Network Manager cannot access the device:

Check that the device IP address, subnet mask, and default router are correctly configured, and that the device has been reset.

Check that the device IP address is correctly recorded by the SNMP Network Manager (refer to the user documentation for the Network Manager).

Check that the community strings configured for the system and Network Manager are the same.

Check that the SNMPv3 USM, Auth, and VACM configured fore the system and Network Manager are the same.

Check that SNMP access was not disabled for the system.

The Telnet workstation cannot access the device:

Check that the device IP address, subnet mask and default router are correctly configured, and that the device has been reset. Ensure that you enter the IP address of the switch correctly when invoking the Telnet facility. Check that Telnet access was not disabled for the switch. If you attempt to log in and the maximum number of Telnet sessions are being used, you should receive an error message indicating so.

Traps are not received by the SNMP Network Manager:

Check that the SNMP Network Manager's IP address and community string are correctly configured, and that the IP address of the Trap Receiver is configured properly on the system.

The SNMP Network Manager or Telnet workstation can no longer access the device:

Check that Telnet access or SNMP access is enabled.

Check that the port through which you are trying to access the device has not been disabled. If it is enabled, check the connections and network cabling at the port.

Check that the port through which you are trying to access the device is in a correctly configured VLAN.

Try accessing the device through a different port. If you can now access the device, a problem with the original port is indicated. Re-examine the connections and cabling.

A network problem may be preventing you accessing the device over the network. Try accessing the device through the console port.

Check that the community strings configured for the device and the Network Manager are the same.

Check that SNMP access was not disabled for the system.

Permanent entries remain in the FDB:

If you have made a permanent entry in the FDB (which requires you to specify the VLAN to which it belongs and then delete the VLAN), the FDB entry will remain. Though causing no harm, you must manually delete the entry from the FDB if you want to remove it.

Default and Static Routes:

If you have defined static or default routes, those routes will remain in the configuration independent of whether the VLAN and VLAN IP address that used them remains. You should manually delete the routes if no VLAN IP address is capable of using them.

You forget your password and cannot log in:

If you are not an administrator, another user having administrator access level can log in, delete your user name, and create a new user name for you, with a new password.

Alternatively, another user having administrator access level can log in and initialize the device. This will return all configuration information (including passwords) to the initial values.

In the case where no one knows a password for an administrator level user, contact your supplier.

Port Configuration

No link light on 10/100 Base port:

If patching from a hub or switch to another hub or switch, ensure that you are using a CAT5 cross-over cable. This is a CAT5 cable that has pins 1&2 on one end connected to pins 3&6 on the other end.

Excessive RX CRC errors:

When a device that has auto-negotiation disabled is connected to a Extreme switch that has auto-negotiation enabled, the Extreme switch links at the correct speed, but in half duplex mode. The Extreme switch 10/100 physical interface uses a method called *parallel detection* to bring up the link. Because the other network device is not participating in auto-negotiation (and does not advertise its capabilities), parallel detection on the Extreme switch is only able to sense 10Mbps versus 100Mbps speed, and not the duplex mode. Therefore, the switch establishes the link in half duplex mode using the correct speed.

The only way to establish a full duplex link is to either force it at both sides, or run auto-negotiation on both sides (using full duplex as an advertised capability, which is the default setting on the Extreme switch).

NOTE

A mismatch of duplex mode between the Extreme switch and another network device will cause poor network performance. Viewing statistics using the `show ports rxerrors` *command on the Extreme switch may display a constant increment of CRC errors. This is characteristic of a duplex mismatch between devices. This is NOT a problem with the Extreme switch.*

Always verify that the Extreme switch and the network device match in configuration for speed and duplex.

No link light on Gigabit fiber port:

Check to ensure that the transmit fiber goes to the receive fiber side of the other device, and vice-versa. All gigabit fiber cables are of the cross-over type.

The Extreme switch has auto-negotiation set to on by default for gigabit ports. These ports need to be set to auto off (using the command `configure port <port #> auto off`) if you are connecting it to devices that do not support auto-negotiation.

Ensure that you are using multi-mode fiber (MMF) when using a 1000BASE-SX GBIC, and single mode fiber (SMF) when using a 1000BASE-LX GBIC. 1000BASE-SX does not work with SMF. 1000BASE-LX works with MMF, but requires the use of a mode conditioning patchcord (MCP).

VLANs

You cannot add a port to a VLAN:

If you attempt to add a port to a VLAN and get an error message similar to

```
localhost:7 # configure vlan marketing add port 1:1,1:2
ERROR: Protocol conflict on port 1:5
```

you already have a VLAN using untagged traffic on a port. Only one VLAN using untagged traffic can be configured on a single physical port.

VLAN configuration can be verified by using the following command:

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

The solution for this error is to remove ports 1 and 2 from the VLAN currently using untagged traffic on those ports. If this were the “default” VLAN, the command would be

```
localhost:23 # configure vlan default del port 1:1,1:2
```

which should now allow you to re-enter the previous command without error as follows:

```
localhost:26 # configure vlan red add port 1:1,1:2
```

VLAN names:

There are restrictions on VLAN names. They cannot contain whitespaces and cannot start with a numeric value unless you use quotation marks around the name. If a name contains whitespaces, starts with a number, or contains non-alphabetical characters, you must use quotation marks whenever referring to the VLAN name.

802.1Q links do not work correctly:

Remember that VLAN names are only locally significant through the command-line interface. For two switches to communicate across a 802.1Q link, the VLAN ID for the VLAN on one switch should have a corresponding VLAN ID for the VLAN on the other switch.

If you are connecting to a third-party device and have checked that the VLAN IDs are the same, the Ethertype field used to identify packets as 802.1Q packets may differ between the devices. The default value used by the switch is 8100. If the third-party device differs from this and cannot be changed, you may change the 802.1Q Ethertype used by the switch with the following command:

```
configure dot1q ethertype <ethertype>
```

Changing this parameter changes how the system recognizes all tagged frames received, as well as the value it inserts in all tagged frames it transmits.

VLANs, IP Addresses and default routes:

The system can have an IP address for each configured VLAN. It is necessary to have an IP address associated with a VLAN if you intend to manage (Telnet, SNMP, ping) through that VLAN or route IP traffic. You can also configure multiple default routes for the system. The system first tries the default route with the lowest cost metric.

STP

You have connected an endstation directly to the switch and the endstation fails to boot correctly:

The switch has STP enabled, and the endstation is booting before the STP initialization process is complete. Specify that STP has been disabled for that VLAN, or turn off STP for the switch ports of the endstation and devices to which it is attempting to connect, and then reboot the endstation.

The switch keeps aging out endstation entries in the switch Forwarding Database (FDB):

Reduce the number of topology changes by disabling STP on those systems that do not use redundant paths.

Specify that the endstation entries are static or permanent.

Debug Tracing/Debug Mode

In ExtremeWare version 7.1.0, the Event Management System (EMS) facility was added to ExtremeWare. EMS provides a standardized way to filter and store messages generated by the switch. Many of the systems in ExtremeWare are moving into EMS. As a system is converted to EMS, the corresponding debug trace command associated with that system is removed. With EMS, you must enable debug mode to display debug information. To enable or disable debug mode for EMS, use the following commands:

```
enable log debug-mode
disable log debug-mode
```

Once debug mode is enabled, you can configure EMS to capture specific debug information from the switch. Details of EMS can be found in Chapter 11, "Status Monitoring and Statistics" on page 213.

For the systems not yet converted to EMS, ExtremeWare includes a debug tracing facility for the switch. The `show debug-trace` command can be applied to one or all VLANs, as follows:

```
show debug-trace {vlan <vlan name>}
```

The `debug` commands should only be used under the guidance of Extreme Networks technical personnel.

To reset all debug-tracing to the default level, use the following command:

```
clear debug-trace
```

To change the debug tracing facility for a certain system to a specified debug level, use the following command:

```
configure debug-trace <system> <level> vlan <vlan name>
```

Some of the debug trace systems commands can be applied to a particular VLAN, some apply to the switch as a whole, so the `vlan` option is not available with all systems.

To display the debug tracing configuration, use the following command:

```
show debug-trace <system> vlan <vlan name>
```

Again, the `vlan` option is not available with every system.

TOP Command

The `top` command is a utility that indicates CPU utilization by process.

System Health Check

The system health check tests both the backplane and the CPU by periodically forwarding packets and checking for the validity of these packets. All error messages are logged in the syslog and the diagnostics CLI show output. A "CRIT" message will be posted to the log if any of the packet tests fail. If you observe a failure, please contact Extreme Technical Support.

To enable system health check, use the following command:

```
enable sys-health-check
```

System health check is enabled by default.

To disable the system health checker, use the following command:

```
disable sys-health-check
```

To configure the system health checker, use the following command:

```
configure sys-health-check alarm-level [log | system-down | traps | default |
auto-recovery <number of tries> [online | offline]]
```

This command allows you to configure the switch's reaction to a failed health check, and provides the following options:

- `log`—posts a CRIT message to the log
- `traps`—posts a CRIT message to the log and sends a trap
- `card-down`—posts a CRIT message to the log, sends a trap, and brings the module down
- `system-down`—posts a CRIT message to the log, sends a trap, and brings the system down

The default option is log.

To view the status of the system health checker, use this command:

```
show diagnostics
```

System Memory Dump

You can download the entire contents of memory through the Ethernet management port. This is used only for troubleshooting, and should not be used without assistance from Extreme Networks technical support.

To transfer the dump, use the following command:

```
upload system-dump [<ip address>]
```

If you do not specify an IP address, the configured system-dump server IP address is used.

To specify the IP address to which to transfer a dump if the `system-dump` option is specified in the configuration, use the following command:

```
configure system-dump server <ip address>
```

This address is also used if no address is provided in the `upload system-dump` command. The default is 0 or "no IP".

To set an optional timeout for the dump transfer, use the following command:

```
configure system-dump timeout <seconds>
```

The default is 0. The minimum non-zero value is 120 seconds. The minimum recommended value is 480 seconds.

To return the system-dump configuration to the defaults, use the following command:

```
unconfigure system-dump
```

To display the system-dump server IP and dump-timeout, use the following command:

```
show system-dump
```

To specify a memory dump if a task generates a software exception, use the following command:

```
configure sys-recovery-level [none | [all | critical] [msm-failover | reboot |
shutdown | system-dump [maintenance-mode | msm-failover | reboot | shutdown]]]
```

The four options specify the action taken when the dump transfer is complete. The actions occur whether or not the dump was successful. The `maintenance-mode` option leaves the switch in whatever state it was in before the dump.

System Odometer

Each field replaceable component contains a system odometer counter in EEPROM. You can use the `show switch` command to see how long an individual component has been in service since it was manufactured. The odometer is supported on the following components:

Alpine

- SMMi
- Baseboard
- All modules
- PSU

BlackDiamond

- Master MSM and slave MSM
- Backplane
- All modules

Summit7i

- CPU
- Baseboard
- I/O boards

Summit48i

- CPU

- Daughter card

Summit5i

- CPU
- Daughter card

Summit1i

- CPU

Memory Scanning and Memory Mapping

Memory scanning and memory mapping identify and correct fabric checksum issues. Sometimes referred to as EDP checksums, today Extreme Networks recognizes all these issues under the general category of checksum errors.

Hard drives use disk scanning tools to map out bad sectors in order to allow the drive to remain operational with no adverse effect on performance, capacity, or reliability. Memory scanning and memory mapping function similarly.

Memory scanning is designed to help isolate one of the major root causes for checksum errors. Memory scanning detects with a high probability all current single bit permanent failures in the switch memory that would result in checksum errors.

Memory mapping can correct up to 8 of these detected permanent single bit errors by reconfiguring the memory maps around the problem areas. Memory scanning and memory mapping are two separate functions. Scanning detects the faulted portion of the memory. Mapping re-maps the memory to remove the faulted memory section.

Modes of Operation

The memory scanning feature has two modes of operation: manual mode, which is the default and recommended mode; and automatic mode, which is only used in redundant networks.

Memory scanning is supported on the following modules and platforms:

- BlackDiamond 6816, BlackDiamond 6808, and BlackDiamond 6804
- BlackDiamond modules - MSM, F96Ti, F48Ti, G8Xi, G8Ti, G12SXi, G16Xi, G16Ti, 10G XENPAK
- Alpine 3808, Alpine 3804, and Alpine 3802
- Summit48i, Summit7i, Summit5i, Summit1i, and Summit48si

Manual Mode

Manual mode is initiated by the following command:

```
run diagnostics packet-memory
```

NOTE

This command is available on ExtremeWare 6.2.1 for BlackDiamond I/O modules, and ExtremeWare 6.2.2 and higher for BlackDiamond MSM, Alpine, and stackables. The command is only executed on one module at a time, although you can queue up two run diagnostics commands at a time.

Automatic Mode (Auto Scan)

Automatic mode for initiating memory scanning is set up after the auto-recovery option is enabled under the system health check configuration. This is done using the following commands:

For stackable and Alpine switches:

```
configure sys-health-check alarm-level [log | system-down | traps | default |
auto-recovery <number of tries> [online | offline]]
```

For BlackDiamond switches:

```
configure sys-health-check alarm-level [log | system-down | traps | default |
auto-recovery <number of tries> [online | offline]]
```

Automatic mode status is listed in the `show switch` output sys-health-check field.

Once auto-recovery mode is enabled, an automated background polling task checks every 20 seconds to see if any checksums have occurred. Three consecutive samples must be corrupted for any module to invoke autoscan. If autoscan is invoked, regardless of platform type or number of errors, there is an initial period where the device is taken offline so the scan can be run.

Memory Scanning and Memory Mapping Functions

Once initiated (either automatically or by manual control) the memory scanning feature takes the selected module offline, and initiates a thorough memory write-read operation to detect any permanent single bit errors within the module's memory. This takes approximately 90 seconds and the module remains offline for the duration of the scan.

Memory scanning and memory mapping behavior differs based on the platform, the mode you configure (online or offline), and whether you configure auto-recovery or run the diagnostics manually.

Table 112 describes the behavior of the switch if you configure auto-recovery using the `configure sys-health-check` command. The behavior differs based on the hardware configuration, the mode selected (online or offline), and the number of errors detected.

Table 112: Auto-recovery memory scanning and memory mapping behavior

Platform	Online	Offline	New Errors Detected	Behavior
Alpine	P		0	Switch kept online.
	P		1-7	Errors mapped, switch kept online.
	P		>7	Errors not mapped, switch kept online.
		P	0	Switch enters limited commands mode.
		P	1-7	Errors mapped, switch kept online.
		P	>7	Errors not mapped, switch enters limited commands mode.
Summit	P		0	Switch kept online.
	P		1-7	Errors mapped, switch kept online.
	P		>7	Errors not mapped, switch kept online.
		P	0	Switch enters limited commands mode.
		P	1-7	Errors mapped, switch kept online.
		P	>7	Errors not mapped, switch enters limited commands mode.
BlackDiamond with one MSM (or slave MSM is offline)	P		0	Switch kept online.
	P		1-7	Errors mapped, switch kept online.
	P		>7	Errors not mapped, switch kept online.
		P	0	Switch enters limited commands mode.
		P	1-7	Errors mapped, switch kept online.
		P	>7	Errors not mapped, switch enters limited commands mode.
BlackDiamond with two MSM's, errors on Master	P		0	MSM kept online.
	P		1-7	Errors mapped, MSM kept online.
	P		>7	Errors not mapped, MSM kept online.
		P	0	Master MSM fails over.
		P	1-7	Errors mapped, MSM kept online.
		P	>7	Errors not mapped, Master MSM fails over.
BlackDiamond with two MSM's, errors on Slave	P		0	MSM kept online.
	P		1-7	Errors mapped, MSM kept online.
	P		>7	Errors not mapped, MSM kept online.
		P	0	Slave MSM taken offline.
		P	1-7	Errors mapped, MSM kept online.
		P	>7	Errors not mapped, Slave MSM taken offline.

Table 112: Auto-recovery memory scanning and memory mapping behavior (Continued)

Platform	Online	Offline	New Errors Detected	Behavior
BlackDiamond with two MSM's, errors on both	P		0	Both kept online.
	P		1-7	Errors mapped, both kept online.
	P		>7	Errors not mapped, both kept online.
		P	0	Both enter limited commands mode.
		P	1-7	Errors mapped, both kept online.
		P	>7	Errors not mapped, both enter limited commands mode.
BlackDiamond 6816 MSM's in slots C and D	P		0	MSM kept online.
	P		1-7	Errors mapped, MSM kept online.
	P		>7	Errors not mapped, MSM kept online.
		P	0	MSM taken offline
		P	1-7	Errors mapped, MSM kept online.
		P	>7	Errors not mapped, MSM taken offline.
Alpine and BlackDiamond "*i*" series I/O modules	P		0	Module kept online.
	P		1-7	Errors mapped, module kept online.
	P		>7	Errors not mapped, module kept online.
		P	0	Module taken offline
		P	1-7	Errors mapped, module kept online.
		P	>7	Errors not mapped, module taken offline.

Table 113 describes the behavior of the switch if you run diagnostics manually using the `run diagnostics` command with the `normal` option. The behavior differs based on the hardware configuration, the mode selected (online or offline) using the `configure sys-health-check` command, and the number of errors detected.

Table 113: Manual diagnostics memory scanning and memory mapping behavior, normal

Platform	Online	Offline	New Errors Detected	Behavior
Alpine	P		0	Switch kept online.
	P		1-7	Errors mapped, switch kept online.
	P		>7	Errors not mapped, switch kept online.
		P	0	Switch kept online.
		P	1-7	Errors mapped, switch kept online.
		P	>7	Errors not mapped, switch enters limited commands mode.
Summit	P		0	Switch kept online.
	P		1-7	Errors mapped, switch kept online.
	P		>7	Errors not mapped, switch kept online.
		P	0	Switch kept online.
		P	1-7	Errors mapped, switch kept online.
		P	>7	Errors not mapped, switch enters limited commands mode.

Table 113: Manual diagnostics memory scanning and memory mapping behavior, normal (Continued)

Platform	Online	Offline	New Errors Detected	Behavior
BlackDiamond with one MSM (or slave MSM is offline)	P		0	Switch kept online.
	P		1-7	Errors mapped, switch kept online.
	P		>7	Errors not mapped, switch kept online.
		P	0	Switch kept online.
		P	1-7	Errors mapped, switch kept online.
		P	>7	Errors not mapped, switch enters limited commands mode.
BlackDiamond with two MSM's, errors on Master	P		0	MSM kept online.
	P		1-7	Errors mapped, MSM kept online.
	P		>7	Errors not mapped, MSM kept online.
		P	0	MSM kept online.
		P	1-7	Errors mapped, MSM kept online.
		P	>7	Errors not mapped, Master MSM fails over.
BlackDiamond with two MSM's, errors on Slave	P		0	MSM kept online.
	P		1-7	Errors mapped, MSM kept online.
	P		>7	Errors not mapped, MSM kept online.
		P	0	MSM kept online.
		P	1-7	Errors mapped, MSM kept online.
		P	>7	Errors not mapped, Slave MSM enters limited commands mode.
BlackDiamond 6816 MSM's in slots C and D	P		0	MSM kept online.
	P		1-7	Errors mapped, MSM kept online.
	P		>7	Errors not mapped, MSM kept online.
		P	0	MSM kept online.
		P	1-7	Errors mapped, MSM kept online.
		P	>7	Errors not mapped, MSM taken offline.
Alpine and BlackDiamond "*i*" series I/O modules	P		0	Module kept online.
	P		1-7	Errors mapped, module kept online.
	P		>7	Errors not mapped, module kept online.
		P	0	Module kept online.
		P	1-7	Errors mapped, module kept online.
		P	>7	Errors not mapped, module taken offline.

Table 114 describes the behavior of the switch if you run diagnostics manually using the `run diagnostics` command with the `extended` option. The behavior differs based on the hardware configuration and whether errors are detected (the mode selected has no effect).

Table 114: Manual diagnostics memory scanning and memory mapping behavior, extended

Platform	Errors Detected?	Behavior
Alpine	Y	Switch enters limited commands mode.
	N	Switch kept online.

Table 114: Manual diagnostics memory scanning and memory mapping behavior, extended (Continued)

Platform	Errors Detected?	Behavior
Summit	Y	Switch enters limited commands mode.
	N	Switch kept online.
BlackDiamond with one MSM (or slave MSM is offline)	Y	Switch enters limited commands mode.
	N	Switch kept online.
BlackDiamond with two MSM's, errors on Master	Y	Master MSM fails over.
	N	MSM kept online.
BlackDiamond with two MSM's, errors on Slave	Y	MSM taken offline.
	N	MSM kept online.
BlackDiamond 6816 MSM's in slots C and D	Y	Module taken offline.
	N	Module kept online.
Alpine and BlackDiamond "*i*" series I/O modules	Y	Module taken offline.
	N	Module kept online.
BlackDiamond non-"*i*" series I/O modules	Y	Module taken offline.
	N	Module kept online.

Limited Commands Mode

Both manual and automatic diagnostics results can put the switch into limited commands mode. In limited commands mode, all tasks are suspended, I/O modules are powered down, and a limited set of commands are available for troubleshooting or corrective action. The available commands are:

- clear log
- configure diagnostics
- configure iparp
- configure iproute add default
- configure vlan ipaddress
- download bootrom
- download configuration
- download image
- ping
- reboot
- show iparp
- show iproute
- show log
- show version
- show vlan
- unconfigure switch
- use configuration
- use image
- show diagnostics

Effects of Running Memory Scanning on the Switch

During the scanning period, the module is taken offline. Expect a minimum offline time of 90 seconds. Up to eight correctable single bit errors are corrected, with minimal loss to the total memory buffers.

In extremely rare cases, non-correctable errors are detected by memory scanning. In these circumstances the condition is noted, but no corrective action is possible. In manual mode the module is returned to online service after all possible corrective actions have been taken.

During the memory scan the CPU utilization is high and mostly dedicated to executing the diagnostics as is normal for running any diagnostic on the modules. During this time other network activities where this system is expected to be a timely participant could be adversely affected, for example, STP, OSPF.

Using Memory Scanning

If the system has checksum error messages occurring consistently over any period of time, manually initiate a memory scan within a network maintenance window that allows for total unavailability of the entire system.

The targeted I/O module is offline for the duration of the manually initiated scan, and the entire system can be adversely affected due to the CPU utilization being almost totally dedicated to the diagnostic memory scan. Memory scanning can also be run during a stage in process for new modules and or systems.

It is extremely unlikely that more than 8 detectable errors are ever detected on any module; however if this does occur the module may be permanently marked down (if offline option is enabled). With the offline option enabled, it is left in a non-operational state and cannot be used in a system running ExtremeWare 6.2.2 version or higher software. If that happens, the module needs to be replaced.

Online options can bring the module online even with 8 or more detectable errors, but the module must still be replaced.

Recommended Mode

Extreme Networks strongly recommends that only manual mode memory scanning be used and that appropriate maintenance windows be arranged for the entire system, not just the intended I/O module paths. In addition to packet memory scan, extended diagnostics must also be run during this window as together these tests can detect not only problems with the packet memory but any other problems with the module. Further, the BlackDiamond chassis must be isolated either physically or logically from the network during the diagnostics run. This ensures that various network features converge properly.

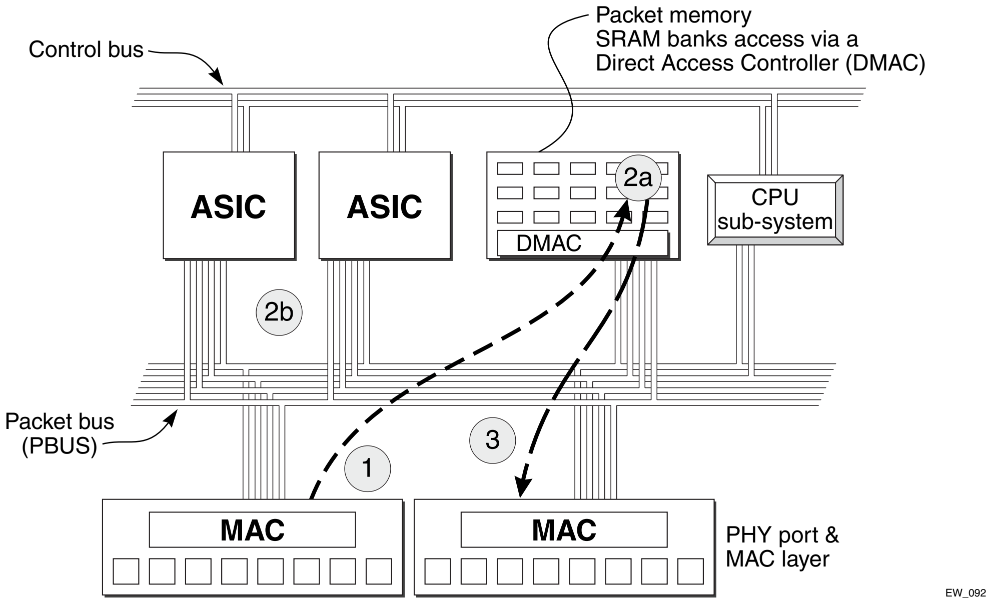
We also recommend that, if possible, memory scanning be performed while actual fabric checksums are being reported in the log. Although this is not an absolute requirement, and in fact is not a factor in the actual memory scan, by executing manual memory scanning while there are checksums occurring provides the best correlation between this diagnostic and the actual event.

Memory Scanning and Fabric Checksums

Memory scanning can only address fabric checksum attributed to errors in the memory area of the switching fabric. In this specific regard it can detect several error conditions in the memory, however it only corrects a maximum of eight of these single bit error instances.

Other types of checksum can occur and are signaled under the general checksum log message. These are not detected or corrected by memory scanning. Within an Extreme Networks switch, the following high-level diagram represents the basic data path for packets ingressing and egressing the switch fabric.

Figure 152: Switch Fabric



A switch fabric is essentially an extremely high-speed data path between multiple ports, which has a certain degree of flexibility through a forwarding database, to examine and switch packets intelligently between their ingress ports and their egress ports.

Data typically enters the switch fabric after passing through the PHY ports and the MAC device layers. From the ingress point of the MAC the data is moved to temporary storage in the packet memory. Checksums are applied at the point of entry to the switch fabric, and these checksums are validated upon exit of the switch fabric. If the checksum does not evaluate correctly to the contents of the packet then some corruption has occurred to that packet.

Corruption can occur anywhere along the data path and storage. These corruptions are extremely rare but with a high traffic switch fabric even a temporary PBUS or memory problem can lead to a large amount of individual packet corruptions.

If packet corruption occurs in the switch fabric it must occur frequently or consistently to be considered a problem. Nonetheless, log messages are generated to signal when any fabric checksums occur. Consistent checksum log messages indicate a problem. ExtremeWare also protects the CPU from corrupted packets by evaluating the checksums placed by the MAC devices whenever these packets are sent up to the CPU for processing.

Using Memory Scanning to Screen I/O Modules

Memory scanning is available in ExtremeWare 6.2.2 or higher. To check modules supported by the memory scanning feature, you can screen existing or new modules without having to upgrade or certify new software on your networks. No particular configuration or traffic load is needed to execute memory scanning on the supported modules. Simply load the latest ExtremeWare onto a spare chassis with a default configuration and scan the modules as needed

If your environment does not support a spare chassis or it would be impractical to rotate through the installed modules, then consider temporarily upgrading to the latest ExtremeWare during an extended maintenance window to perform memory scanning on modules in the field.

To do this, schedule an extended maintenance window and prepare the system for a temporary upgrade. Do not convert or save the configuration on the switch. It is not possible to correctly run an ExtremeWare 6.2.2 (or later) configuration on an older version of ExtremeWare.

In temporarily upgrading your systems, plan to roll back the systems to the original working code image and configuration. This means you need the original ExtremeWare code version accessible by TFTP server from the switch. You also need the latest saved configuration accessible to download back to the switch from a TFTP server.

No particular configuration is needed to support running memory scanning. You can use the existing default configuration to scan the supported modules and then restore the system to the original ExtremeWare version and configuration.

If you must support a large campus environment with several BlackDiamond or Alpine systems for this screening operation, you can temporarily dedicate a single MSM to the latest version of ExtremeWare for the exercise and manually move this around to each system to scan the modules. For stackable platforms, you must load the latest ExtremeWare on every switch to run this test.

Be aware that any memory defect found and mapped out under this exercise does not remain mapped out when those modules are returned to a pervious version of ExtremeWare. ExtremeWare does not have the capability to use the mapped out information located in the detected module's EEPROM. The validity of this temporary screening exercise is limited to identifying modules with memory defects.

Reboot Loop Protection

If the system reboots due to a failure that remains after the reboot, it reboots when it detects the failure again. To protect against continuous reboot loops, you can configure reboot loop protection using the following command:

```
configure reboot-loop-protection threshold <time-interval> <count>
```

If the switch reboots the specified number of times within the specified time interval, it stops rebooting and comes up in minimal mode. If you reboot the switch manually or use the `run msm-failover` or `run diagnostics` commands, the time interval and count are both reset to 0.

Minimal Mode

In minimal mode, only the CPU, NVRAM, management port, and minimal tasks are active. The following commands are supported in minimal mode:

- reboot
- unconfigure switch all
- unconfigure switch
- use image
- use configuration
- download bootrom
- download image

- download configuration
- configure iparp
- configure vlan ipaddress
- configure iproute add default
- configure diagnostics
- show iproute
- show iparp
- show vlan
- show version
- show log
- ping
- clear log
- clear log diag-status

Contacting Extreme Technical Support

If you have a network issue that you are unable to resolve, contact Extreme Networks technical support. Extreme Networks maintains several Technical Assistance Centers (TACs) around the world to answer networking questions and resolve network problems. You can contact technical support by phone at:

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

or by email at:

- support@extremenetworks.com

You can also visit the support website at:

http://www.extremenetworks.com/services/resources/

to download software updates (requires a service contract) and documentation (including a .pdf version of this manual).

C Supported Protocols, MIBs, and Standards

The following is a list of software standards and protocols supported by ExtremeWare.

General Routing and Switching

RFC 1812 Requirements for IP Version 4 Routers

RFC 1519 An Architecture for IP Address Allocation with CIDR

RFC 1256 IPv4 ICMP Router Discovery (IRDP)

RFC 783 TFTP Protocol (revision 2)

RFC 951 Bootstrap Protocol (BootP)

RFC 1542 Clarifications and Extensions for the Bootstrap Protocol

RFC 2131 BOOTP/DHCP relay agent and Dynamic Host Configuration Protocol (DHCP) server

RFC 1591 Domain Name System (DNS) Structure and Delegation

RFC 1122 Requirements for Internet Hosts - Communication Layers

RFC 768 User Datagram Protocol (UDP)

RFC 791 Internet Protocol (IP)

RFC 792 Internet Control Message Protocol (ICMP)

RFC 793 Transmission Control Protocol (TCP)

RFC 826 Ethernet Address Resolution Protocol (ARP): Or converting network protocol addresses to 48.bit Ethernet address for transmission on Ethernet hardware

RFC 894 IP over Ethernet

RFC 1027 Proxy ARP

RFC 2338 Virtual Router Redundancy Protocol

Extreme Standby Router Protocol (ESRP)

IPX RIP/SAP Router specification

Static Unicast Routes

IEEE 802.1D-1998 Spanning Tree Protocol (STP)

Multiple Instances of Spanning Tree (PVST+ compatible, 802.1Q interoperable)

IEEE 802.1W - 2001 Rapid Reconfiguration for STP, RSTP

IEEE 802.1Q - 1998 Virtual Bridged Local Area Networks

RFC 3619 Ethernet Automatic Protection Switching (EAPS) and EAPSv2

Software Redundant Ports

VLANs

IEEE 802.1Q VLAN Tagging

IEEE 802.3ad Static configuration and dynamic (LACP)

IEEE 802.1v VLAN classification by Protocol and Port

Port-based VLANs

MAC-based VLANs

Protocol-based VLANs

Multiple STP domains per VLAN

RFC 3069 VLAN Aggregation for Efficient IP Address Allocation

Virtual MANs

VLAN Translation

Quality of Service

IEEE 802.1D -1998 (802.1p) Packet Priority

RFC 2598 An Expedited Forwarding PHB

RFC 2597 Assured Forwarding PHB Group

RFC 2474 Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers

Bi-directional Rate Shaping

RFC 2475 An Architecture for Differentiated Service

Layer 1-4, Layer 7 (user name) Policy-Based Mapping

Policy-Based Mapping/Overwriting of DiffServ code points, .1p priority

DLCS (Dynamic Link Context System, WINS snooping) for integration with EPICenter Policy Manager

RIP

RFC 1058 Routing Information Protocol (RIP) v1

RFC 2453 RIP v2

OSPF

RFC 2328 OSPF v2 (including MD5 authentication)

RFC 1587 OSPF NSSA Option

RFC 1765 OSPF Database Overflow

RFC 2370 OSPF Opaque LSA Option

IS-IS

RFC 1142 (ISO 10589), IS-IS protocol

RFC 1195 Use of OSI IS-IS for routing in TCP/IP and dual environments

RFC 2104 HMAC: Keyed-Hashing for Message Authentication

IS-IS HMAC-MD5 Authentication

ISO 10589 OSI IS-IS Intra-Domain Routing Protocol (Replicated as RFC 1142)

RFC 2763 (Dynamic Host Name Exchange for IS-IS)

BGP4

RFC 1771 Border Gateway Protocol 4 (BGP-4)

RFC 1965 Autonomous System Confederations for BGP

RFC 2796 BGP Route Reflection - An Alternative to Full Mesh IBGP (supersedes RFC 1966)

RFC 1997 BGP Communities Attribute

RFC 1745 BGP4/IDRP for IP---OSPF Interaction

RFC 2385 Protection of BGP Sessions via the TCP MD5 Signature Option

RFC 2439 BGP Route Flap Dampening

IP Multicast

RFC 2362 Protocol Independent Multicast-Sparse Mode (PIM-SM): Protocol Specification

PIM-DM Draft IETF PIM Dense Mode v2-dm-03

DVMRP v3 draft IETF DVMRP v3-07

RFC 1112 Internet Group Management Protocol (IGMP) v1, Host extensions for IP multicasting

RFC 2236 Internet Group Management Protocol (IGMP) v2

IGMP Snooping with Configurable Router Registration Forwarding

Static IGMP Membership

Static Multicast Routes

IGMP Filters

Mtrace, draft-letf-idmr-traceroute-imp-07

Mrinfo

Management - SNMP & MIBs

RFC 1155 Structure and identification of Management Information (SMIv1) for TCP/IP-based internets

RFC 1157 Simple Network Management Protocol (SNMP) v1

RFC 1212 Concise MIB definitions

RFC 1213 Management Information Base for Network Management of TCP/IP-based internets: MIB-II

RFC 1215 Convention for defining traps for use with the SNMP

RFC 1573 Evolution of Interface

RFC 1901 Introduction to Community-based SNMPv2

RFC 1902 Structure of Management Information for Version 2 of the Simple Network Management Protocol (SNMPv2)

RFC 1903 Textual Conventions for Version 2 of the Simple Network Management Protocol (SNMPv2)

RFC 1904 Conformance Statements for Version 2 of the Simple Network Management Protocol (SNMPv2)

RFC 1905 Protocol Operations for Version 2 of the Simple Network Management Protocol (SNMPv2)

RFC 1906 Transport Mappings for Version 2 of the Simple Network Management Protocol (SNMPv2)

RFC 1907 Management Information Base for Version 2 of the Simple Network Management Protocol (SNMPv2)

RFC 1908 Coexistence between Version 1 and Version 2 of the Internet-standard Network Management Framework

RFC 2570 – 2575 SNMPv3, user based security, encryption and authentication

RFC 2576 Coexistence between SNMP Version 1, Version 2 and Version 3

ExtremeWare vendor MIB (includes ACL, MAC FDB, IP FDB, MAC Address Security, Software Redundant Port, DoS-Protect MIB, QoS policy, VLAN config, vMAN, VLAN Translation and VLAN Aggregation MIBs)

RFC 1757 Remote Network Monitoring Management Information Base - RMON 4 groups: Stats, History, Alarms and Events

RFC 2021 Remote Network Monitoring Management Information Base Version 2 (RMON2) using SMIv2

RFC 2613 Remote Network Monitoring MIB Extensions for Switched Networks Version 1.0

RFC 2233 Evolution of the Interfaces Group of MIB-II

RFC 2096 IP Forwarding Table MIB

RFC 1724 RIP Version 2 MIB Extension

RFC 1850 OSPF Version 2 Management Information Base

RFC 1406 Definitions of Managed Objects for the DS1 and E1 Interface types

RFC 1407 Definitions of Managed Objects for the DS3/E3 Interface Type

RFC 1493 Definitions of Managed Objects for Bridges

Draft-letf-bridge-rstpmib-03.txt – Definitions of Managed Objects for Bridges with Rapid Spanning Tree Protocol

RFC 1354 IPv4 Forwarding Table MIB

RFC 2037 Entity MIB

RFC 1650 Definitions of Managed Objects for the Ethernet-like Interface Types using SMIv2

RFC 1657 Definitions of Managed Objects for the Fourth Version of the Border Gateway Protocol (BGP-4) using SMIv2

RFC 2665 Definitions of Managed Objects for the Ethernet-like Interface Types

RFC 2668 Definitions of Managed Objects for IEEE 802.3 Medium Attachment Units (MAUs)

RFC 2737 Entity MIB, Version 2

RFC 2674 Definitions of Managed Objects for Bridges with Traffic Classes, Multicast Filtering, and Virtual LAN Extensions

RFC 2787 Definitions of Managed Objects for the Virtual Router Redundancy Protocol (VRRP)

RFC 2925 Definitions of Managed Objects for Remote Ping, Traceroute, and Lookup Operations

draft-ieft-bridge-8021x-01.txt (IEEE8021-PAE-MIB)
IEEE 802.1X – 2001 MIB

RFC 1643 Ethernet MIB

IEEE-802.1x MIB

Extreme extensions to 802.1x-MIB

Management - Other:

RFC 1866 Hypertext Markup Language (HTML) - 2.0

RFC 2068 Hypertext Transfer Protocol — HTTP/1.1

RFC 854 Telnet Protocol Specification

HTML/ HTTP management

Secure Shell 2 (SSHv2) client and server, and Telnet management

Telnet and SSHv2 clients and servers

Secure Copy 2 (SCPv2) client and server

Secure FTP (SFTP) server

SFlow version 5

NetFlow version 1 export

Configuration logging

Multiple Images, Multiple Configs

BSD System Logging Protocol (SYSLOG), with Multiple Syslog Servers

999 Local Messages (criticals stored across reboots)

RFC 2030 Simple Network Time Protocol (SNTP) Version 4 for IPv4, IPv6 and OSI

Security

Routing protocol authentication (see above)

Secure Shell (SSHv2) Secure Copy (SCPv2) and SFTP with encryption/authentication

SNMPv3 user based security, with encryption/authentication

RFC 1492 TACACS+

RFC 2138 Remote Authentication Dial In User Service (RADIUS)

RFC 2139 RADIUS Accounting

RADIUS Per-command Authentication

Access Profiles on All Routing Protocols

Access Profiles on All Management Methods

Network Login (web-based DHCP / RADIUS mechanism)

SSL/TLS for webbased Network Login

IEEE 802.1x – 2001 Port-Based Network Access Control for Network Login

Multiple supplicants for Network Login (web-based and 802.1x modes)

MAC Address Security - Lockdown and Limit

IP Address Security with DHCP Option 82, DHCP Enforce / Duplicate IP Protection

Network Address Translation (NAT)

Layer 2/3/4/7 Access Control Lists (ACLs)

MPLS - Standards and MIBs

RFC 2212 Specification of Guaranteed Quality of Service

RFC 2961 RSVP Overhead Refresh Reduction Extensions

RFC 3032 MPLS Label Stack Encoding

RFC 3031 Multiprotocol Label Switching Architecture

RFC 3036 LDP Specification

Martini drafts: draft-martini-circuit-encap-mpls-04.txt and draft-martini-l2circuit-trans-mpls-08.txt

RSVP-TE LSP tunnel draft: draft-ietf-mpls-rsvp-lsp-tunnel-09.txt

Traffic Engineering Extensions to OSPF: draft-katz-yeung-ospf-traffic-06.txt

The Extreme MPLS implementation provides read-only (GET but not SET) support for a subset of the MPLS LSR MIB, as defined in the Internet Draft *draft-ietf-mpls-lsr-mib-07.txt*, and a subset of the MPLS LDP MIB, as defined in the Internet Draft *draft-ietf-mpls-ldp-mib-07.txt*.

MPLS (BlackDiamond 6800 MPLS Blade)

RFC 2205 Reservation Protocol (RSVP)

RFC 2212 Specification of Guaranteed Quality of Service

RFC 2961 RSVP Overhead Refresh Reduction Extensions

RFC 3031 Multiprotocol Label Switching Architecture

RFC 3032 MPLS Label Stack Encoding

RFC 3036 LDP Specification

RFC 3209 RSVP-TE: Extensions to RSVP for LSP Tunnels

Martini drafts: draft-martini-circuit-encap-mpls-04.txt and draft-martini-12circuit-trans-mpls-09.txt

H-VPLS draft: draft-ietf-ppvpn-vpls-ldp-00.txt

OAM drafts: draft-ietf-mpls-lsp-ping-03.txt, draft-stokes-vkompella-ppvpn-hvpls-oam-02.txt

Traffic Engineering Extensions to OSPF: draft-katz-yeung-ospf-traffic-06.txt

MIBs: The Extreme MPLS implementation provides read-only (GET but not SET) support for a subset of the MPLS LSR MIB, as defined in the Internet Draft *draft-ietf-mpls-lsr-mib-07.txt*, and a subset of the MPLS LDP MIB, as defined in the Internet Draft *draft-ietf-mpls-ldp-mib-07.txt*

Denial of Service Protection

RFC 2267 Network Ingress Filtering: Defeating Denial of Service Attacks which employ IP Source Address Spoofing

RPF (Unicast Reverse Path Forwarding) Control via ACLs

Wire-speed ACLs

Rate Limiting by ACLs

IP Broadcast Forwarding Control

ICMP and IP-Option Response Control

Server Load Balancing with Layer 3,4 Protection of Servers

SYN attack protection

FDB table resource protection / IPDA Subnet Lookup

Traffic ratelimiting to management CPU / Enhanced DoS Protect

Uni-directional Session Control

ATM - Standards and MIBs

The interface counters in MIB-II (RFC 1213) are supported for ATM.

Support for read-only operations (GET operations, but not SET operations) is provided for selected objects in the standard ATM MIB (RFC 2515). Additional MIB objects to support ATM have also been added to the Extreme Networks private MIB.

Robust against common Network Attacks	
CERT (http://www.cert.org) • CA-2003-04: "SQL Slammer" • CA-2002-36: "SSHredder" • CA-2002-03: SNMP vulnerabilities • CA-98-13-tcp-denial-of-service • CA-98.01.smurf • CA-97.28.Teardrop_Land -Teardrop and "LAND" attack • IP Options Attack • CA-96.26.ping • CA-96.21.tcp_syn_flooding • CA-96.01.UDP_service_denial • CA-95.01.IP_Spoofing_Attacks_and_Hijacked_ Terminal_Connections CPU DOS protection with ACL integration: Identifies packet floods to CPU and sets an ACL automatically, configurable	Host Attacks • teardrop • boink • opentear • jolt2 • newtear • nestea • syndrop • smurf • fraggle • papasmurf • synk4 • raped • winfreeze • ping –f • ping of death • pepsi5 • Latierra • Winnuke • Simping • Sping • Ascend • Stream • Land • Octopus

SONET/SDH - Standards and MIBs	
GR-253-CORE, Synchronous Optical Network (SONET) Transport Systems: Common Generic Criteria, Bellcore, Issue 2, Revision 2, January 1999. ANSI T1.105.02-1995, Synchronous Optical Network (SONET)—Payload Mappings, American National Standards Institute, 1995. ITU-T G.707 (03/96), Network Node Interfaces for the Synchronous Digital Hierarchy (SDH), March 1996.	A subset of RFC 2558, *Definitions of Managed Objects for the SONET/SDH Interface Type*, has been implemented. The Virtual Tributary (VT) group and the Section/Line/Path interval tables were not implemented. Read-only support (GET operations, but not SET operations) has been implemented for the remainder of the MIB.

DiffServ - Standards and MIBs	
RFC 2474 Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers RFC 2475 An Architecture for Differentiated Services RFC 2597 Assured Forwarding PHB Group RFC 2598 An Expedited Forwarding PHB	The Extreme Networks implementation of RED is based on the well-known paper *Random Early Detection Gateways for Congestion Avoidance*, by Sally Floyd and Van Jacobson. The Extreme Networks implementation of RED also complies with the recommendations published in RFC 2309, *Recommendations on Queue Management and Congestion Avoidance in the Internet*.

PPP - Standards and MIBs	
RFC 1661 The Point-to-Point Protocol (PPP) RFC 1662 PPP in HDLC-like Framing RFC 2615 PPP over SONET/SDH RFC 1334 PPP Authentication Protocols RFC 1994 PPP Challenge Handshake Authentication Protocol (CHAP) RFC 1989 An Application of the BGP Community Attribute in Multi-home Routing RFC 1332 The PPP Internet Protocol Control Protocol (IPCP) RFC 2878 PPP Bridging Control Protocol (BCP) RFC 1191 Path MTU Discovery RFC 3032 MPLS Label Stack Encoding	The interface counters in MIB-II (RFC 1213) are supported for PPP. Support for read-only operations (GET operations, but not SET operations) is provided for the following PPP MIBs: • RFC 1471 The Definitions of Managed Objects for the Link Control Protocol of the Point-to-Point Protocol • RFC 1472 The Definitions of Managed Objects for the Security Protocols of the Point-to-Point Protocol • RFC 1474 The Definitions of Managed Objects for the Bridge Network Control Protocol of the Point-to-Point Protocol • RFC 1473 The Definitions of Managed Objects for the IP Network Control Protocol of the Point-to-Point Protocol

Flow Statistics- Standards and MIBs	
Because no standard MIBs are defined for managing the NetFlow function, Extreme Networks has defined and implemented an enterprise MIB that provides read-only support (GET but not SET operations) for NetFlow configuration parameters and status information. Any of the parameters that can be set with the `configure flowstats` commands can be accessed through using the MIB, and any of the status information displayed by the `show flowstats` command can also be read using the MIB. You can download the NetFlow enterprise MIB from the Extreme Networks World Wide Web site at the following URL: http://www.extremenetworks.com/services/documentation/	

APS - Standards and MIBs	
GR-253-CORE, Synchronous Optical Network (SONET) Transport Systems: Common Generic Criteria, Bellcore, Issue 2, Revision 2, January 1999. ANSI T1.105.01-1998, Synchronous Optical Networks (SONET)—Automatic Protection Switching, American National Standards Institute, 1998. ITU-T G.783 (04/97), Characteristics of Synchronous Digital Hierarchy (SDH) Equipment Functional Blocks, April 1997.	Because no standard MIBs are defined for managing the APS function, Extreme Networks has defined and implemented an enterprise MIB that provides read-only support (GET but not SET operations) for APS configuration parameters and status information. Any of the parameters that can be set with the configure aps commands can be accessed through using the MIB, and any of the status information displayed by the show aps command can also be read using the MIB. You can download the APS enterprise MIB from the Extreme Networks World Wide Web site at the following URL: http://www.extremenetworks.com/services/software/

Index

Numerics

- 1d mode, STP 375
- 3DNS 207
- 802.11a, 802.11b, 802.11g 792
- 802.1p 673
  - command support 567, 615
  - slow path traffic 164
- 802.1Q
  - command support 567, 615
  - encapsulation, BCP 673
  - encapsulation, TLS 729, 730
- 802.1x authentication 264
  - co-existence with web-based 265
  - requirements 264
- 802.1x/EAP 281
- 802.3ad load sharing 92

A

- AAL-5 553
- access control lists 254
- access levels 49
- access list support for ATM module 582
- access list support for PoS modules 661
- access lists
  - Alpine switch maximum entries 257
  - BlackDiamond switch maximum entries 257
  - default QoS profile 256
  - default rule 256
  - deleting 257
  - description 254
  - examples 258
  - ICMP filter example 260
  - ICMP traffic 255
  - maximum entries 257
  - `permit-established` example 258
  - `permit-established` keyword 257
  - precedence number 255
  - restrictions 257
  - Summit switch maximum entries 257
  - verifying settings 257
- access profile, configuration 533
- access profiles
  - ExtremeWare Vista 61
  - reverse mask 309
  - SNMP 66
  - Telnet 59
- AccessAdapt management 792
- Accounting and Routing Module. *See* ARM
- accounting bin configuration 528, 531
- accounting configuration commands (table) 528
- accounting statistics 531
  - CLI, retrieving statistics 544
  - SNMP, retrieving statistics 545
- accounts
  - creating 51
  - deleting 52
  - viewing 51
- ACL, installed by DoS protect 326
- ACLs 254
- active scan 798
- Address Resolution Protocol. *See* ARP
- `admin` account 50
- Adspec 710
- Advanced Encryption Standard. *See* AES
- advertising labels 684, 698
- AES 792
- agent circuit ID sub-option 459
- agent remote ID sub-option 459
- aging entries, FDB 148
- AIS-L event counter (SONET) 564, 600
- AIS-P event counter (SONET) 564, 600
- alarm actions 251
- alarm indication signal—line (AIS-L) 565, 601
- alarm indication signal—path (AIS-P) 565, 601
- alarms 664
- Alarms, RMON 250
- Alpine 3802 mode of operation 86
- Alpine switch
  - access list maximum entries 257
  - system temperature 218
- alternate mark inversion (AMI) 666
- Alternative Queue Management 81
- Altitude 300 791
- Altitude 300 antenna 792
- Altitude 300-2d antenna 793
- Altitude 300-2i 793
- Alt-Queue Management 81
- AMI linecoding 666
- antenna, Altitude 300 792
- antenna, Altitude 300-2d 793
- AP detection 798
- AP scan

  - configuring 799
  - enabling and disabling 799
  - results (table) 800
  - viewing results 800
- APMAC 800
- APS
  - authentication, configuring 650
  - configuration examples 593
  - configuration overview 639
  - configuration parameter values, resetting 654
  - configuration quickstart 593
  - enabling and disabling 649
  - hello timers, configuring 652
  - line group
    - creating and deleting 649
    - forced switch mode, configuring 653
    - lockout, configuring 652
    - manual switch mode, configuring 654
    - port, adding 649
    - port, deleting 650
    - status information, displaying 655
  - module redundancy 593
  - nonrevertive mode, configuring 651
  - port redundancy 593
  - revertive mode, configuring 651
  - single-module port redundancy example 593
  - summary of support 588
  - switch redundancy 593
  - two-module port redundancy example 594
  - two-switch redundancy example 594
- area 0, OSPF 472
- areas, OSPF 472
- ARM 525
- ARP
  - and VLAN aggregation 463
  - communicating with devices outside subnet 447
  - configuring proxy ARP 447
  - disabling additions on superVLAN 464
  - incapable device 447
  - proxy ARP between subnets 447
  - proxy ARP, description of 447
  - responding to ARP requests 447
  - subVLANs 464
  - superVLANs 464
  - table, displaying 449
- Assured Forwarding (AF) PHB 577, 625
- Asynchrononous Transfer Mode. *See* ATM
- atestReceivedEngineTime 71
- ATM 553
  - overview 553
  - port status information, displaying 558
  - receive statistics, summary (table) 558
  - transmit statistics, summary (table) 558
- ATM Adaption Layer. *See* AAL-5
- ATM module, feature summary 550
- ATM scrambling, configuring 559
- authentication 280, 673
  - APS, configuring 650
  - location-based 281
  - PPP
    - local database entry, creating 609
    - port name and password, configuring 608
    - protocol, configuring 608
  - time-based 281
  - web-based & 802.1x 264
- authentication methods 266
  - 802.1x/EAP 281
  - open 280
  - WEP 281
- authentication type 804
- AuthnoPriv 73
- AuthPriv 73
- Automatic Protection Switching. *See* APS
- autonegotiation
  - added and deleted loopback ports 671
  - description 87
- autonomous system, description 491
- autopolarity 89

B

- B8ZS linecoding 666
- backbone area, OSPF 472
- bandwidth, controlling port aggregate 102
- basic configuration tasks 589
- BCP
  - basic configuration tasks 590
  - configuring 610
  - default configuration for bridging 590
  - encapsulation 673
  - Legacy 674
  - OC-3 port pairs 589
  - overview 585, 604
  - TLS and 732
- beacon interval 796, 797
- beacons, number of 801
- BGP 546, 582
  - attributes 492
  - autonomous system 491
  - autonomous system path 492
  - cluster 493
  - community 492
  - description 491
  - features 492
  - IGP synchronization 497
  - loopback interface 497
  - peer groups
    - creating 497
    - description 497
    - mandatory parameters 497
    - neighbors 498
  - redistributing to OSPF 501
  - route aggregation 496
  - route maps 322
  - route reflectors 493
  - route selection 501
  - routing access policies 317
- BGP Next Hop 705
- Bi-directional rate shaping 170
  - limitations 173
  - loopback port 171
  - maximum bandwidth settings 171
  - maximum bandwidth settings (table) 171
  - minimum bandwidth settings 172
  - minimum bandwidth settings (table) 172
- binding labels, description of 688
- bipolar eight zero suppression (B8ZS) 666
- BlackDiamond switch
  - access list maximum entries 257

default slot configuration 553, 589
MSMs, synchronizing 822
port configuration 87
system temperature 218
blackhole entries, FDB 149, 261
blue alarms 664
BOOTP
and UDP-Forwarding 460
using 57
BOOTP relay, configuring 459
BootROM
menu, accessing 823
prompt 823
upgrading 823
Border Gateway Protocol. *See* BGP
BPDU tunneling 375
bridged PPP links 673
bridging
over PoS ports 590
wireless 793
Bridging Control Protocol. *See* BCP
browser
controls 63
fonts 62
setting up 61

C

cable diagnostics 762
cable length 665
campus mode 270
campus mode authentication 266
Capability 801
C-bit T3 line framing 666
certificates and kets, pre-generated 290
Challenge Handshake Authentication Protocol (CHAP) 673
Challenge Handshake Authentication Protocol. *See* CHAP
channel 801
CHAP 673
configuring 608
MD5 hash algorithm 603
overview 585, 603
cipher suites 282
CIR, defined 752
clearing the client scan table 802
CLI
accounting statistics, retrieving 544
command history 47
command shortcuts 44
line-editing keys 46
named components 45
numerical ranges, BlackDiamond switch 45
numerical ranges, Summit switch 45
symbols 46
syntax helper 44
using 43
client
aging 806
collecting history information 804
configuration commands 290
current state 804
current state details (table) 804
diagnostic and history information (table) 806
history information 805
scan 801
scan performance results (table) 803
scan results (table) 803
wireless 290
client MAC 804
client priority 805
client scan table, clearing 802
client scanning
clearing client scan table 802
configuring 802
enabling and disabling 801
overview 801
viewing properties 802
viewing scan results 802
client VLAN 804
clock source 665
code points
assignments, changing 572, 620
class selector 578, 626
default 578, 626
ingress, replacing 758
mapping tables, resetting 574, 622
mapping, configuring 573, 621
replacing 574, 622
command
history 47
shortcuts 44
syntax, understanding 43
Command Line Interface. *See* CLI
Committed Information Rate *See* CIR
common commands (table) 47
common power pool 766
communicating with devices outside subnet 447
complete configuration download 821
component intialization messages 229
component serial number 229
concatenated mode 583
configuration
downloading 821
downloading complete 821
downloading incremental 821
logging 237
network login 270
primary and secondary 819
saving changes 819
schedule download 822
security options (table) 285
uploading to file 820
wireless ports 808
configuring 270
accounting bins 528, 531
E1 port 664
encapsulation 674
label advertisement filters 700
LDP 699
LDP label propagation filters 699
LDP session timers 700
MPLS interfaces 692
MTU 692
PHP 693
PoE 768
QoS mappings 694
resetting parameters 695
T1 port 664
TLS tunnel 732

  TTL propagation 693
conservative hitless upgrade, performing 117
conservative label retention mode 685
console connection 56
controlling Telnet access 59
conventions
  notice icons, About This Guide 30
  text, About This Guide 30
country codes
  configuring 807
  list of countries (table) 807
CRC 551
CRC4 E1 line framing 666
creating VLAN IDs 530
customer VLAN IDs 530
Cyclic Redundancy Check. *See* CRC

D

database applications, and QoS 157
database overflow, OSPF 471
debug trace support for ARM modules 546
default
  gateway 431
  passwords 50
  settings 40
  settings, SONET (table) 560, 591
  slot configuration 553, 589
  STP domain 374
  users 50
default gateway 808
default VLAN 130
delayed-down-time interval (PPP), configuring 612
deleting a session 59
delivery traffic indication message (DTIM) 796, 797
denial of service protection
  enhanced 326
  overview 323
destination-sensitive accounting, definition of 690
DHCP
  network login and 264
  relay agent option (option 82) 459
  relay, configuring 459
  requirement for web-based network login 264
  server, used as part of network login 273
  UDP-Forwarding and 460
diagnostics
  cable 762
  display IP routing table 545
Differentiated Services Code Points. *See* DSCP
Differentiated Services. *See* DiffServ
DiffServ
  code points
    assignments, changing 572, 620
    Assured Forwarding 578, 626
    Class Selector 578, 626
    default 578, 626
    Expedited Forwarding 578, 626
    ingress, replacement, enabling 758
    mapping tables, configuring 573, 621
    mapping tables, resetting 574, 622
    QoS profile mapping assignments (table) 572, 620
    replacement, enabling 574, 622
  configuring 164, 572, 620
  mapping PHBs to QoS profiles (table) 578, 626
direct LSP 702
disabling a switch port 87
disabling route advertising (RIP) 470
disconnecting a Telnet session 59
displaying accounting statistics 531
displaying MPLS information 695
Distance Vector Multicast Routing Protocol. *See* DVMRP
distance-vector protocol, description 468
DLCS
  description 173
  guidelines 173
  limitations 174
DNS, description 52
documentation, viewing online 31
Domain Name Service. *See* DNS
domains, STP 374
DoS protection, enhanced 326
downloading incremental configuration 821
downstream unsolicited (DU), definition of 683
downstream unsolicited mode 684
downstream-on-demand mode 684
drop probability (RED), configuring 575, 622
DSCP 551, 751
DSCP mapping 552
DTIM 796, 797
DVMRP 546, 582
  description 504
  routing access policies 315
dynamic entries, FDB 148, 261
dynamic routes 445, 518

E

E1 port
  clock source 665
  configuring 664
  framing 666
EAP-MD5 792
EAPOL and DHCP 265
EAPS
  common link 363
  domain, creating and deleting 356
  enabling and disabling a domain 359
  enabling and disabling on a switch 359
  polling timers, configuring 356
  ring port, unconfiguring 360
  shared port
    configuration rules 369
    configuring the domain ID 366
    creating and deleting 365
    defining the mode 365
  shared port, common link failure 364
  shared ports 363
  show eaps display fields (table) 361, 367
  show eaps shared-port display fields (table) 367
  status information, displaying 360, 366
  switch mode, defining 356
EAP-TLS 792
EAP-TLS (Transport Layer Security) 281
EAP-TTLS 792
EAP-TTLS (Tunneled TLS) 281
ECMP. *See* IP route sharing
EDP 98
EDPCP 585, 606
ELRP

  - description 416
  - loop detection 419
  - master
    - behavior 417
  - pre-master
    - behavior 417
  - standalone 419
  - terms 416
- ELSM
  - configuring 425
  - debug tracing 429
  - disabling 425
  - enabling 425
  - ESRP, using with 428
  - hello packets 425
  - hello time 426
  - monitoring 428
  - receive port 426
  - timers 426
  - transmit port 427
- EMISTP
  - description 375
  - example 379
  - rules 380
- enabling a switch port 87
- encapsulation
  - BCP 673
  - configuring 674
  - IPCP 673
- encryption 281
- encryption type 804
- Enhanced DoS Protection 326
- equal cost LSPs 704
- Equal Cost Multi-Path (ECMP) routing. *See* IP route sharing
- errors, port 217
- ESF (Extended Super Frame) T1 line framing 666
- ESRP
  - activating standby hub 741
  - and IP multinetting 424
  - and STP 424
  - and TLS 740
  - and VLAN aggregation 410
  - BGP tracking 408
  - configuration example (figure) 744
  - description 399
  - diagnostic tracking 406
  - direct link 402
  - domains 412
  - don’t count 412
  - environment tracking 406
  - ESLM, using with 428
  - example 421
  - failover 742
  - failover time 404
  - groups 413
  - host attach 411
  - linking switches 402
  - load sharing and 94, 412
  - master
    - behavior 403
    - definition 401
    - determining 403
    - electing 404
    - election algorithms 404
  - multiple VLANs sharing a host port 402
  - OSPF tracking 407
  - ping tracking 407
  - port restart 410
  - pre-master
    - behavior 403
  - redundancy 741
  - restarting ports 410
  - RIP tracking 408
  - route table tracking 407, 742
  - selective forwarding 414
  - slave mode
    - behavior 403
    - definition 401
  - super-VLAN 410
  - terms 400
  - tracking, description 405
  - tunnel endpoint VLAN 741
- ESS name 801
- ESSID 804
- establishing a Telnet session 57
- Events, RMON 250
- examples
  - security configuration 293
  - wireless configuration 291
- EXP field 687
- Expedited Forwarding (EF) PHB 577, 625
- explicit route 716
- export restrictions 40
- Extended Service Set Identifier. *See* ESSID
- Extensible Authentication Protocol. *See* EAP
- Extreme Discovery Protocol Control Protocol. *See* EDPCP
- Extreme Discovery Protocol *See* EDP
- Extreme Link Status Monitoring. *See* ELSM
- Extreme Loop Recovery Protocol. *See* ELRP
- Extreme Standby Router Protocol. *See* ESRP
- Extreme Unified Access Architecture 792
- ExtremeWare
  - factory defaults 40
  - features 35
- ExtremeWare Vista
  - accessing 62
  - browser controls 63
  - browser setup 61
  - capturing screen output 65
  - controlling access 61
  - fonts 62
  - home page 60, 62
  - navigating 62
  - saving changes 64
  - screen layout 62
  - screen resolution 61
  - status messages 63
  - VLAN configuration 60

F

- facility data link 665
- failover, ESRP 742
- failover, RSVP 717
- FDB 569, 617
  - adding an entry 147
  - aging entries 148
  - blackhole entries 149
  - contents 147

- creating a permanent entry example 153
- displaying 154
- dynamic entries 148
- dynamic entries, limiting 261
- entries 147
- limiting entries 153, 261
- non-aging entries 148
- permanent entries 149
- prioritizing entries 154, 261
- QoS profile association 150
- scanning 151

- FEC
  - binding labels 688
  - definition of 681, 683
  - propagating labels 698
- file server applications, and QoS 158
- filters
  - label advertisement 700
  - label propagation 699
- fixed filter reservation style 712
- flow control 88
- flow redirection 208
- flow statistics
  - configuration overview 237, 629
  - configuration parameters, resetting 245, 638
  - enabling and disabling 241, 633
  - flow record filter
    - configuring 242, 635
    - enabling and disabling 244, 637
  - flow record timeout, configuring 242, 634
  - ping-check function, configuring 244, 637
  - source IP address, configuring 242, 634
  - status information, displaying 245, 638
- fonts, browser 62
- force disassociation 809
- Forwarding Database. *See* FDB
- Forwarding Equivalence Class. *See* FEC
- forwarding modes, SLB 188
- fragment length 796, 797
- fragment size 796, 797
- fragmentation 693
- framing 666
  - C-bit 666
  - CRC4 666
  - ESF (Extended Super Frame) 666
  - M13 666
  - SF (Super Frame) 666
- full L3 functionality 39

G

- gateway, default 808
- GoGo mode, SLB 192
- Greenwich Mean Time Offsets (table) 80
- groups 72
- GVRP 569, 617

H

- HDLC
- HDLC, tunneling 656
- health check reset 809
- hello packets, ELSM 425
- hello timer, ELSM 426
- high drop precedence 578, 626
- High-Level Data Link Control. *See* HDLC
- `history` command 47
- History, RMON 250
- hitless upgrade
  - conservative 115
  - standard 115
- home page 60, 62
- HTTP clients 287
- HTTPS 287

I

- ICMP attacks 326
- ICMP, access lists 255
- IEEE 802.1Q 124
- IEEE 802.1x, comparison with web-based authentication 265
- IEEE 802.3ad load sharing 92
- ifAdminStatus 66
- IGMP
  - description 508
  - snooping 508
  - static 508
  - support for ATM module 582
- IGP path cost, overriding 705
- image
  - downloading 815
  - primary and secondary 816
  - upgrading 815
- implicit NULL labels 688
- independent LSP control 685
- indirect LSP 702
- ingress QoS, functions 751
- Inter-Access Point Protocol. *See* IAPP
- interfaces
  - configuring 810
  - configuring wireless 809
  - enabling 810
- interfaces, router 444, 515
- Interframe Gap 89
- Internet Group Management Protocol. *See* IGMP
- interoperability requirements 267
- Interpacket Gap 89
- Intra-Subnet QoS. *See* ISQ
- IP address, entering 58
- IP Control Protocol. *See* IPCP
- IP multicast routing
  - configuring 510
  - description 38, 503
  - DVMRP 504
  - example 512
  - IGMP
    - description 508
    - snooping 508
  - PIM
    - mode interoperation 505
    - multicast border router (PMBR) 505
    - snooping 505
  - PIM-DM 504
  - PIM-SM 504
- IP multinetting
  - description 451
  - example 458
  - primary VLAN interface 457
  - secondary VLAN interface 457
  - using 457

IP phone 277
IP proprietary multinetting 456
IP route sharing 446
IP routing table 545
IP standard multinetting 451
IP unicast forwarding 526
  described 690
  longest prefix match 690
  throughput 690
IP unicast packets, routing 702
IP unicast routing
  BOOTP relay 459
  configuration examples 449
  configuring 449
  default gateway 443
  description 37
  DHCP relay 459
  ECMP
  enabling 449
  IP route sharing 446
  multinetting, description 451
  multinetting, example 458
  proprietary multinetting, description 456
  proxy ARP 447
  route maps 446
  router interfaces 444
  routing table
    dynamic routes 445
    multiple routes 445
    populating 444
    static routes 445
  standard multinetting, description 451
  verifying the configuration 449
IPCP
  basic configuration for routing 591
  configuring 610
  encapsulation 673
  overview 585, 603
IPFDB
  learning qualifer, configuring 328
  thrashing, preventing 326
IPX 582
  configuration example 521
  configuring 519
  load sharing 517
  protocol filters 520
  protocol-based VLANs 520
  router interfaces 515
  routing access policies 313
  routing table
    dynamic routes 518
    populating 518
    static routes 518
  tagged VLANs 517
  verifying router configuration 520
IPX/RIP
  routing table,populating 518
IPX/RIP, configuring 519
IPX/SAP
  configuring 519
IS-IS, redistributing routes 476
ISP mode 266, 270
ISQ 580

J

jumbo frame support 546, 551, 586
  LCP MRU 659
  MTU 660
jumbo frames
  description 90
  enabling 90
  IP fragmentation 91
  path MTU discovery 91
jumbo frames, supporting 689, 693

K

keys
  line-editing 46
  port monitoring 218

L

Label Edge Router. *See* LER
label object 714
label processing by the NP data path (table) 689
label retention modes 685
label space partitioning (table) 688
label stack
  definition of 683, 687
  encapsulation 687
Label Switch Path. *See* LSP
Label Switch Router. *See* LSR
labels
  advertising 698
  advertising modes 684
  and route maps 700
  binding 688
  configuring label advertisement filters 700
  configuring propagation filters 699
  definition of 681, 683
  displaying mappings 697
  length 682
  locally assigned 688
  NULL label, advertising 698
  popping 689
  propagating 698
  remotely assigned 688
  retention modes 685
  space partitioning 688
  swapping 682, 683, 689
label-switch forwarding algorithms 682
LACP 92
last state changed 804
LCP
  jumbo frame MRU 659
  Quality Report option 603
  support 585, 603
LDP
  advertising label mappings in TLS 730
  configuring filters 699
  definition of 683, 698
  hello-adjacency 698
  message exchange 698
  neighbor discovery protocol 698
  propagation filters
    configuring 699, 700
    route maps 699, 700
  session timers, configuring 700

  - targeted sessions 698
- Legacy BCP 674
- LER
  - definition of 683
  - described 685
- liberal label retention mode 685
- license keys 39
- licensing
  - basic functionality 38
  - description 38
  - full L3 functionality 39
  - license keys 39
  - ordering 39
  - verifying 39
- line parity errors (SONET) 564, 600
- linecoding 666
  - AMI 666
  - B8ZS 666
- line-editing keys 46
- Link Control Protocol. *See* LCP
- Link Quality Monitoring. *See* LQM
- Link Quality Report Protocol. *See* LQR
- link types, configuring in RSTP 385
- link up and link down traps 67
- link-state database 470
- link-state protocol, description 468
- load balancing methods, SLB 193
- load sharing
  - algorithms 93
  - configuring 94
  - description 92
  - dynamic 92
  - ESRP
    - don’t count 94, 412
    - host attach 94, 412
  - load-sharing group, description 92
  - master port 94
  - static 92
  - verifying the configuration 96
- load-sharing 704
- local routing database 709
- locally assigned labels 688
- location, wireless 809
- location-based authentication 281
- LOF event counter (SONET) 564, 600
- logging
  - configuration changes 237
  - QoS monitor 169
  - wireless events 812
- logging in 51
- Logical Link Control. *See* LLC
- long retry 797, 798
- longest prefix match 690
- loop detection, using standalone ELRP 419
- loop tests, using standalone ELRP 419
- loopback detection 666
- loopback port 171
- loopback port, autonegotiation preservation 671
- LOP event counter (SONET) 564, 600
- LOS event counter (SONET) 564, 600
- loss of frame (LOF) 565, 600
- loss of pointer (LOP) 565, 601
- loss of signal (LOS) 565, 600
- low drop precedence 578, 626
- LPS, tunnel, definition of 684
- LQM
  - configuring 607
  - overview 603
- LQR 585, 603
- LSM, timers 426
- LSP
  - and TLS 730
  - and TLS tunnels 704
  - control modes 685
  - definition of 683
  - direct 702
  - equal cost 704
  - indirect 702
  - load-sharing 704
  - multivendor support for indirect 705
  - overriding IGP path cost 705
  - precedence 704
  - routing 702
  - scaling 717
- LSR
  - definition of 683
  - egress, definition of 685
  - functions (table) 686
  - ingress, definition of 685
  - LER, description of 685
  - locally assigned labels 688
  - remotely assigned labels 688

M

- M13 T3 line framing 666
- MAC RADIUS, unified access 290
- MAC-based security 153, 261
- MAC-based VLANs 566, 614
  - description 136, 254
  - example 137
  - groups 136
  - guidelines 136
  - limitations 137
  - timed configuration download 137
- maintenance mode, SLB 207
- management access 49
- management port 56
- Management Switch Fabric Module. *See* MSM
- management VLAN, configuring 808
- master port, load sharing 94
- maximum receive unit. *See* MRU
- maximum Telnet session 57
- maximum transmission unit (MTU) 713
- Maximum Transmission Unit. *See* MTU
- MD5 hash algorithm 288, 603
- medium drop precedence 578, 626
- *mgmt* VLAN 56
- MIBs 66
- minimum queue length threshold (RED), configuring 577, 624
- MLPPP 671
- modular switch
  - configuring load sharing 94
  - enabling and disabling ports 87
  - jumbo frames 90
  - load sharing example 95
  - port number 87
  - port-mirroring, virtual port 97

  slot configuration 85
  verifying load sharing 96
monitoring the switch 213
MPLS
  and OSPF AS 702
  configuration example (figure) 706
  configuring interfaces 692
  definition of 681, 682, 683, 691
  displaying information 695
  label stack 687
  overview 585
  packet classification 619
  resetting configuration parameters 695
  routing IP unicast packets 702
  sample network (figure) 682
  shim layer 686
  terms and acronyms (table) 683
MPLSCP
  configuration 605
  overview 605
MRU 659
MSM 56
MTU 660
  configuring 692
  fragmentation 693
  jumbo frames, supporting 693
multilink group
  adding to VLAN 672
  creating 672
Multilink PPP (MLPPP) 671
multinetting
  proprietary 456
  standard 451
multinetting. *See* IP multinetting
multiple routes 445
MultiProtocol Label Switch. *See* MPLS
MultiProtocol Label Switching Control Protocol. *See* MPLSCP
MultiProtocol Label Switching. *See* MPLS

N

names, VLANs 130
NAT
  creating rules 180
  rule matching 180
native VLAN, PVST+ 382
NCP
  BCP, configuring 610
  configuring 610
  default configuration 589
  IPCP, configuring 610
neighbor discovery protocol, LDP 698
NetFlow statistics support 587
Network Address Translation. *See* NAT
Network Control Protocol. *See* NCP
network login 77, 264, 270
  campus mode
    user login 272
  configuration commands 274
  configuration commands (table) 274
  DHCP server as part of 273
  disabling 275
  settings, displaying 274
network policies 793
network security policies 282
network type 801
Next Hop Label Forward Entry (NHLFE), definition of 683
noAuthnoPriv 73
noise floor 798
non-aging entries, FDB 148
Not-So-Stubby_Area. *See* NSSA
npcard debug log messages (table) 547
NSSA. *See* OSPF

O

OAM 553
off-channel scan 798
online, viewing PDF files 31
opaque LSAs, OSPF 471
open authentication 280
Open Shortest Path First. *See* OSPF
opening a Telnet session 57
Operations, Administrations and Maintenance. *See* OAM
optical interfaces
  OC-12 multimode 583
  OC-12 single-mode 583
  OC-3 multimode 583
  OC-3 single-mode 583
  OC-3c/STM-1 single-mode 549
option 82, DHCP relay agent 459
ordered LSP control 685
OSPF 546, 582
  advantages 468
  area 0 472
  areas 472
  backbone area 472
  configuration example 481
  consistency 471
  database overflow 471
  description 468, 470
  display filtering 483
  link type 475
  link-state database 470
  MPLS domain 702
  normal area 473
  NSSA 473
  opaque LSAs 471
  point-to-point links 475
  redistributing routes 476
  redistributing to BGP 501
  router types 472
  routing access policies 313
  settings, displaying 483
  SFP algorithm 703
  SPF recalculation 703
  stub area 473
  virtual link 473
  wait interval, configuring 480
OSPF passive 471
OUI 277

P

packet fragment size 796, 797
packet memory scanning 215
packet preamble 797, 798
PAP 673
  configuring 608

overview 585, 603
partial hitless failover 107
passive scan 798
Password Authentication Protocol. *See* PAP
passwords
  default 50
  forgetting 51
path error message 711
path message 710
path MTU discovery 91
path parity errors (SONET) 564, 600
path payload label mismatch (PLM-P) 566, 601
path tear message 711
payload data scrambling 559, 606
payload data scrambling, configuring 559
PDF files, viewing 31
PEAP 792
PEAP (protected EAP) 281
Penultimate Hop Popping. *See* PHP
per-hop behaviors. *See* PHBs
permanent entries, FDB 149
Permanent Virtual Circuits. *See* PVC
`permit-established` keyword 257
persistence, SLB 199
Per-VLAN Spanning Tree. *See* PVST+
PHBs
  Assured Forwarding (AF) 577, 625
  Assured Forwarding classes (table) 578, 626
  Class Selector 578, 626
  Default 578, 626
  drop precedence levels (table) 578, 626
  Expedited Forwarding (EF) 577, 625
  support and configuration 577, 625
PHP
  configuring 693
  definition of 683, 688
  implicit NULL labels 688
PIM 546, 582
  mode interoperation 505
  multicast border router (PMBR) 505
  snooping 505
PIM-DM
  description 504
PIM-SM
  description 504
  rendezvous point 504
`ping` command 53
ping-check 206
PLM-P event counter (SONET) 564, 600
PoE
  configuring 768
  configuring slot before downloading configuration 769
  features 765
  power checking 768
Point-to-Point Protocol (PPP) 671
Point-to-Point Protocol. *See* PPP
poison reverse 469
policy examples 283
port
  autonegotiation 87
  BlackDiamond switch 87
  configuring on BlackDiamond switch 87
  enabling and disabling 87
  errors,viewing 217
  loopback 171
  monitoring display keys 218
  network login 264
  personality 792
  priority, STP 394
  receive errors 217
  software-controlled redundant
    configuring 101
    description 98
  statistics, viewing 216
  STP state, displaying 397
  STPD membership 374
  transmit errors 217
port aggregate bandwidth control 102
port connection order 767
port mode 375, 394
port power management 765
port power operator limit 766
port power reset 767
port translation mode, SLB 191
port tunnel
  PoS port tunnel, configuring 657
port tunneling 587, 656
  Ethernet module, configuring 658
  MPLS tls- tunnel, configuring 658
port-based VLANs 122
port-mirroring
  and protocol analyzers 97
  description 97
  modular switch example 97
  stand-alone switch example 98
  tagged and untagged frames 97
  virtual port 97
ports
  disabling wireless 808
  enabling wireless 808
PoS module
  feature summary 584
  optical interface characteristics 583
power
  budget management 766
  common pool 766
  consuming more than allocated 768
  operator limit 766
  port 765
  port connection order 767
  port reset 767
  power events 767
  reserved 766
power checking, PoE modules 768
power events 767
PPP 671
  authentication database entry, creating 609
  authentication, configuring 608
  BCP 585, 604
  CHAP 585, 603
  configuration parameter values, resetting 614
  delayed-down-time interval, configuring 612
  EDPCP 585, 606
  Frame Check Sequence (FCS), configuring 606
  IPCP 585, 603
  LCP 585, 603
  Link Quality Monitoring (LQM), configuring 607
  LQR 585, 603

  - maximum receive unit (MRU) 659
  - MPLSCP 605
  - NCP
    - BCP, configuring 610
    - IPCP, configuring 610
  - overview 585, 602
  - PAP 585, 603
  - payload data scrambling, configuring 606
  - port name and password, configuring 608
  - port status information, displaying 612
  - PoS checksum, configuring 606
  - PoS scrambling, configuring 606
- PPP links
  - bridged 673
  - routed 673
- PPP user accounts 673
- PPP username 673
- PR 752
- preamble 797, 798
- precedence levels 578, 626
- pre-generated certificates and keys 290
- primary image 816
- priority, slow path traffic 164
- privacy 281
- *private* community, SNMP 67
- private keys 288
- PROBE REQ messages 801
- probe resp packets, number of 801
- profile
  - RF 794
  - security 794
- profiles, QoS 159
- profiles, RF 795
- propagating labels 698
- proprietary multinetting 456
- protocol analyzers, use with port-mirroring 97
- protocol filters 128
- protocol filters, IPX 520
- Protocol Independent Multicast- Dense Mode. *See* PIM-DM
- Protocol Independent Multicast- Sparse Mode. *See* PIM-SM
- protocol-based VLANs 127, 566, 614
- proxy ARP
  - communicating with devices outside subnet 447
  - conditions 447
  - configuring 447
  - MAC address in response 447
  - responding to requests 447
  - subnets 447
- proxy ARP, description 447
- *public* community, SNMP 67
- PVC, port status information, displaying 559
- PVST+
  - description 382
  - native VLAN 382
  - VLAN mapping 382
- PVST+ mode 375

Q

- QoS
  - 802.1p and 802.1Q support 567, 615
  - 802.1p priority 163
  - and RSVP 709
  - applications 156
  - blackhole 161
  - buffer 159
  - configuring 569, 617
  - configuring mapping 694
  - database applications 157
  - default QoS profiles 159
  - description 37, 155
  - DiffServ model 686
  - DiffServ support 569, 617
  - DiffServ, configuring 164
  - displaying mapping information 697
  - dot1p-to-exp 694
  - examples
    - MAC address 161
    - source port 167
    - VLAN 168
  - EXP bits 686
  - exp-to-dot1p 694
  - FDB entry association 150
  - file server applications 158
  - functions 551, 569, 586, 617
  - maximum bandwidth 159
  - minimum bandwidth 159
  - priority 159
  - profile, configuring 570, 618
  - profiles
    - default 159
    - description 158
    - parameters 159
  - Random Early Detection (RED) 156
  - RED support 569, 617
  - support overview 550, 584
  - traffic groupings 160
    - blackhole 161
    - broadcast/unknown rate limiting 162
    - description 158
    - explicit packet marking 162
    - IP address 160
    - MAC address 161
    - source port 167
    - VLAN 168
  - traffic groupings (table) 160
  - verifying 170
  - video applications 157
  - voice applications 157
  - web browsing applications 157
- QoS monitor 580, 629
  - description 169
  - logging 169
  - real-time display 169
- QoS traffic grouping priorities, resetting 169
- Quality of Servce. *See* QoS 156
- Quality of Service. *See* QoS
- Quality Report option 603

R

- Radio Frequency *See* RF
- RADIUS
  - and TACACS+ 77, 332
  - client configuration 334
  - description 77, 332
  - Merit server configuration (example) 336
  - per-command authentication 334
  - per-command configuration (example) 337
  - request attributes (table) 283

- RFC 2138 attributes 334
- servers 332
- TCP port 334
- wireless attributes 283

Random Early Detection (RED) 156

Random Early Detection. *See* RED

rapid root failover 375

Rapid Spanning Tree Protocol. *See* RSTP

rate limiting 326

rate shaping 326

Rate shaping, bi-directional. *See* Bi-directional rate shaping

RDI-L event counter (SONET) 564, 600

RDI-P event counter (SONET) 564, 600

receive errors 217

received signal strength 805

RED
- configuration information, displaying 580, 629
- drop probability, configuring 575, 622
- enhancements for ATM support 574
- enhancements for PoS support 622
- minimum queue length threshold, configuring 577, 624
- operation compared to WRED (figure) 575, 623
- PHB support 577, 625
- ports, enabling and disabling 576, 624

red alarms 664

redundancy 741

redundant LSPs 716

redundant ports, software-controlled
- configuring 101
- description 98
- typical configurations 99

REI-L event counter (SONET) 564, 600

REI-P event counter (SONET) 564, 600

relay agent option, DHCP option 82 459

remote defect indicator—line (RDI-L) 565, 601

remote defect indicator—path (RDI-P) 565, 601

remote error indicator—line (REI-L) 565, 601

remote error indicator—path (REI-P) 565, 601

Remote Monitoring. *See* RMON

remotely assigned label 688

renaming a VLAN 130

request to send (RTS) threshold 796, 798

reservation attributes and styles (table) 712

reservation confirmation message 711

reservation error message 711

reservation message 711

reservation requests 709

reservation styles 712

reservation tear message 711

reserved power 766

reset to factory defaults 820

resetting wireless port properties 809

Resource ReserVation Protocol. *See* RSVP

responding to ARP requests 447

reverse mask 309

RF
- monitoring 798
- profiles 795
- properties 795

RF profile 794
- configuring 796
- creating 795
- deleting 795
- property values (table) 797
- viewing properties 797

RFC 1332 673

RFC 1638 674

RFC 2878 673

RFC listing (tables) 843

RIP 546, 582
- advantages 468
- configuration example 478
- description 468, 469
- disabling route advertising 470
- enabling 449
- limitations 468
- poison reverse 469
- redistributing routes 476
- redistributing to BGP 501
- routing access policies 312
- routing table entries 469
- split horizon 469
- triggered updates 469
- version 2 470

RMON
- alarm actions 251
- Alarms group 250
- Events group 250
- features supported 249
- History group 250
- probe 249
- Statistics group 249

route map
- and LDP propagation filters 699, 700
- labels 700

route maps
- BGP 322
- changing 322
- creating 318
- description 318
- example 321
- goto entries 319
- IP unicast routing 446
- match entries 319
- match operation keywords (table) 319
- processing 321
- set entries 319
- set operation keywords (table) 320

route recording, RSVP 715

route sharing. *See* IP route sharing

route table tracking, ESRP 742

routed PPP links 673

router interfaces 444, 515

router licensing
- basic functionality 38
- description 38
- full L3 functionality 39
- license keys 39
- ordering 39
- verifying 39

router types, OSPF 472

routing access policies
- access profile
  - applying 311
  - changing 317
  - configuring 309
  - creating 308
  - types 309

- BGP 317
- deny 309
- DVMRP 315
- examples
  - DVMRP 316
  - OSPF 315
  - PIM 316
  - RIP 312
- IPX 313
- none 309
- OSPF 313
- permit 309
- PIM 316
- removing 318
- RIP 312
- using 308

Routing Information Protocol. *See* RIP
routing IP unicast packets 702
routing over PoS ports 591
routing table, populating 444
routing table, populating IPX 518
routing. *See* IP unicast routing
RSS 805
RSS statistics 801
RSTP
- alternate port 384
- auto link 384
- backup port 384
- broadcast link 384
- configuring link types 385
- designated port 384
- designated port rapid behavior 388
- edge link 384
- edge ports 384
- operation 386
- overview 382
- point-to-point link 384
- port roles 384
- propogating topology information 388
- receiving bridge behavior 388
- root port 384
- root port rapid behavior 387
- terms 383
- timers 385

RSVP
- alternate paths 716
- and QoS 709
- bandwidth accounting 713
- definition of 683, 709
- explicit route 715, 716
- fixed filter reservation style 712
- label 714
- label request 714
- LSP scaling 717
- message types 710
- objects 714
- path error message 711
- path message 710
- path tear message 711
- ping health checking 717
- record route 715
- redundant LSPs 716
- reservation confirmation message 711
- reservation error message 711
- reservation message 711
- reservation requests 709
- reservation styles 712
- reservation tear message 711
- route recording 715
- RSVP-TE 709
- RSVP-TE, definition of 683
- session attribute 715
- shared explicit reservation style 712
- state 713
- traffic engineering extensions 709
- tunneling 714
- wildcard reservation style 712

RSVP-TE, definition of 683
RTS, threshold 796, 798
Rx bytes 805
Rx frames 805

S

sample configuration 271
SAP 582
saving changes using ExtremeWare Vista 64
saving configuration changes 819
scan for AP detection 798
scanning the FDB 151
scheduling configuration download 822
screen resolution, ExtremeWare Vista 61
SD BER event counter (SONET) 565, 600
SDH 550, 585
secondary address, upgrading to 7.3.0 456
secondary image 816
section parity errors (SONET) 564, 600
secure web login access 287
security
- authentication 280
- certificates 288
- configuration examples 293
- configuration options (table) 285
- options (table) 280

security licensing
- description 40
- obtaining 40

security name 72
security policies 282
- and RADIUS support 283
- design 282

security profile 794
security profiles
- authentication 285
- configuring 286
- copying 284
- creating 284
- deleting 284
- encryption 285
- general properties, configuring 286
- viewing 287
- WEP properties, configuring 287
- WPA properties, configuring 286

serial number, in checksum error messages 229
Server Load Balancing *See* SLB
Server Load Balancing. *See* SLB
service provide 683
service-check 206
sessions, deleting 59

SF (Super Frame) T1 line framing 666
SF BER event counter (SONET) 564, 600
shared explicit reservation style 712
shim header 683
- described 686
- illustration 686

shim layer 686
short retry 797, 798
shortcuts, command 44
showing MPLS information 695
signal degrade bit error rate (SD BER) 566, 601
signal failure bit error rate (SF BER) 566, 601
Simple Network Management Protocol. *See* SNMP
SLB
- 3DNS support 207
- active-active 202
- active-active operation 202
- client persistence 199
- components 184
- description 183
- failover 202
- forwarding mode 188
- gateway ping-checking 202
- GoGo mode 192
- health checking 206
- high availability 200
- host-route 186
- least connections 194
- load balancing methods 193
- maintenance mode 207
- manual fail-back 205
- nodes 184
- persistence 199
- ping-check 206
- pools 185
- port translation mode 191
- priority mode 194
- proxy ARP 186
- proxy client persistence 199
- ratio 193
- round-robin 193
- service-check 206
- standard virtual servers 185
- sticky persistence 199
- subnet-route 186
- tcp-port-check 206
- traffic type 187
- translation mode 190
- transparent mode 188
- VIPs 185
- virtual servers 185
- wildcard virtual servers 185

slot
- automatic configuration 85
- clearing 86
- manually configuring 85
- mismatch 86
- packet memory scanning 215

slow path traffic 164
smart redundancy 99
SNAP protocol 129
SNMP
- accounting statistics, retrieving 545
- community strings 67
- configuring 66
- controlling access 66
- read access 66
- read/write access 66
- settings, displaying 67
- supported MIBs 66
- system contact 67
- system location 67
- system name 67
- trap receivers 66
- using 65

SNMP ifAdminStatus MIB value 66
SNMPEngineBoots 71
snmpEngineID 71
SNMPEngineTime 71
SNTP
- configuring 78
- Daylight Savings Time 78
- description 78
- example 81
- Greenwich Mean Time offset 78
- Greenwich Mean Time Offsets (table) 80
- NTP servers 78

software licensing
- security features 40
- SSH2 protocol 40

software rate shaping 326
software-controlled redundant ports
- typical configuration 99

SONET
- clock source 560, 561, 591, 597
- configuration parameter values, resetting 564, 599
- configuration parameter values, summary (table) 560, 591
- error and alarm events (table) 565, 600
- framing type 560, 561, 591, 596
- overview 550, 585
- Path Trace identifier 560, 563, 591, 598
- port status information, displaying 564, 599
- Section Trace byte 560, 562, 591, 598
- Section Trace identifier 560, 562, 591, 598
- Signal Degrade threshold 560, 562, 591, 597
- Signal Fail threshold 560, 561, 591, 597
- Signal Label 560, 563, 591, 599
- statistics (table) 564, 600

space partitioning, labels 688
Spanning Tree Protocol. *See* STP
speed, ports 88
split horizon 469
SSH2 protocol
- authentication key 343
- description 40, 60, 342
- enabling 343
- predefined clients 343
- TCP port number 343

stand-alone switch
- enabling and disabling ports 87
- jumbo frames 90
- load sharing 94
- load sharing example 96
- port-mirroring, virtual port 97
- verifying load sharing 96

standard hitless upgrade
- performing 115

standard multinetting 451
static IGMP 508
static routes 445, 518
statistics
  port 216
  VLAN, per port 133
Statistics, RMON 249
status monitoring 213
STP
  1D mode 375
  advanced example 379
  and ESRP 424
  and VLANs 374
  and VRRP 436
  basic configuration example 376
  BPDU tunneling 375
  bridge priority 394
  configurable parameters 393
  configuration examples 394
  configuring 393
  description 37
  displaying settings 397
  domains 374
  EMISTP
    description 375
    example 379
    rules 380
  ExtremeWare commands 569, 617
  forward delay 393
  hello time 393
  max age 393
  overview 373
  path cost 394
  port mode 394
  port modes 375
  port priority 394
  port state, displaying 397
  PVST+
    description 382
    mode 375
  rapid root failover 375
  rules and restrictions 393
  StpdID 375, 394
  support 569, 617
STPD modes 374
stub area, OSPF 473
sub-options, DHCP relay agent option 459
sub-VLAN 462
Summit switch
  access list maximum entries 257
super-VLAN 410, 462
supplicant side requirements 267
supported rate set 801
SVC 553
SVP, enabling to support VoIP 812
switch
  monitoring 213
  RMON features 249
switch properties, configuring wireless 807
Switched Virtual Connection. *See* SVC
Symmetric ciphers 288
synchronizing MSMs 822
Synchronous Digital Hierarchy. *See* SDH
Synchronous Optical Network. *See* SONET
syntax, understanding 43
system contact, SNMP 67
system location, SNMP 67
system name, SNMP 67
system temperature 218

T

T1 port
  cable length 665
  clock source 665
  configuring 664
  facility data link 665
  framing 666
  linecoding 666
  loopback detection 666
TACACS+
  and RADIUS 77, 332
  description 77, 338
  servers, specifying 338
tag mapping 567, 615
tag nesting 568, 616
tagging, VLAN 124
T-Control 750
tcp-port-check 206
technical support 842
Telnet
  connecting to another host 57
  controlling access 59
  disconnecting a session 59
  maximum sessions 57
  opening a session 57
  using 57
Temporal Key Integrity Protocol. *See* TKIP
Terminal Access Controller Access Control System Plus. *See* TACACS+
TFTP
  server 815
  using 820
thrashing, IPFDB, preventing 326
threshold, RTS 796, 798
time-based authentication 281
timed configuration download, MAC-based VLANs 137
TKIP 792
TLS
  802.1Q encapsulation 729, 730
  advertising label mappings 730
  and BCP 732
  and ESRP 740
  and LSPs 730
  basic configuration example (figure) 736
  characteristics 732
  configuration example using ESRP (figure) 744
  configuration example using PPP transparent mode (figure) 739
  definition of 684, 729
  deleting tunnels 734
  displaying configuration information 734
  loopback mode 730
  OSPF routes 730
  tunnel endpoint VLAN 741
  tunnel endpoints, configuring 730
  tunnel labels 730
  tunnel, definition of 684
  tunnels and LSP 704

- tunnels, configuring 732
- VLAN IDs 732
- VLAN label mappings 732
- VLAN labels 732

traceroute 53
`traceroute` command 53
traffic engineering (TE), definition of 683
traffic groupings 160
translation mode, SLB 190
transmit errors 217
Transparent LAN Services. *See* TLS
transparent mode, SLB 188
triggered updates 469
trunks 125
Trusted MAC 277
Trusted Organizational Unique Identifier. *See* OUI
trusted OUI 277
Tspec object 709, 710
T-Sync, defined 105
tunnel endpoint VLAN 741
tunnel labels 730
tunneling 134, 714
Tx bytes 805
Tx frames 805

U

UA security
- configuring security profiles 286
- copying security profiles 284
- creating security profiles 284
- deleting security profiles 284

UDP-Forwarding
- and BOOTP 460
- and DHCP 460
- configuring 461
- description 460
- example 461
- profiles 461
- VLANs 461

unified access security 279
upgrading the image 815
uploading the configuration 820
URL redirection 265
user accounts, PPP 673
user documentation, viewing online 31
user name 72
username, PPP 673
users
- access levels 49
- accounts 266
- authenticating 77, 332
- creating 51
- default 50
- viewing 51

V

VC 553
VC tunnel, definition of 684
vendor ID 267
Vendor Specific Attribute (VSA) 267
vendor specific attributes (table) 284
video applications, and QoS 157
viewing accounts 51
VIPs, SLB 185
virtual circuit identifier 553
virtual circuit, definition of 684
Virtual Circuit. *See* VC
Virtual LANs. *See* VLANs
virtual link, OSPF 473
virtual path identifier 553
virtual private LAN (VPN), definition of 684
virtual router, VRRP 432
VLAN
- labels 732
- management 808
- tagging 124

VLAN aggregation
- description 462
- limitations 464
- properties 463
- proxy ARP 464
- secondary IP address 462
- sub-VLAN 462
- super-VLAN 462

VLAN IDs, creating 530
VLAN tags 673
VLANs
- and ExtremeWare Vista 60
- and STP 374
- assigning a tag 125
- benefits 121
- configuration examples 131
- configuring 131
- *default* 130
- description 36
- disabling route advertising 470
- displaying settings 132
- IP fragmentation 92
- MAC-based
  - description 136, 254
  - example 137
  - groups 136
  - guidelines 136
  - limitations 137
  - timed configuration download 137
- *mgmt* 56
- mixing port-based and tagged 127
- names 130
- network login 264
- port-based 122
- protocol filters 128
- protocol-based 127
- protocol-based, IPX 520
- renaming 130
- routing 449, 519
- statistics, per port 133
- tag mapping 567, 615
- tag nesting 568, 616
- tagged 124
- tagged VLAN 802.1p and 802.1Q functions 567, 615
- trunks 125
- tunneling 134
- types 122
- UDP-Forwarding 461

vMAN tunneling
- configuring 134, 676
- description 134

- example 134
- voice applications, QoS 157
- VPLS, definition of 684
- VRRP
  - advertisement interval 435, 439
  - and Spanning Tree 436
  - backup router 432
  - configuration parameters (table) 439
  - default gateway 431
  - description 431
  - electing the master 435
  - examples 440
  - interfaces 432
  - IP address 432, 439
  - IP address owner 432
  - MAC address 432
  - master
    - determining 432
  - master down interval 435, 439
  - master router 432
  - multicast address 435
  - operation 436
  - ping tracking 433
  - port restart 436
  - preempt mode 439
  - priority 432, 435, 439
  - redundancy 437
  - restarting ports 436
  - route table tracking 433
  - skew time 435, 439
  - tracking, description 432
  - virtual router 432
  - virtual router identifier (VRID) 432, 439
  - virtual router MAC address 432, 435, 437
  - VLAN tracking 433
  - VRRP router 432
- VSA definitions
  - for network login (table) 267

W

- Web access, controlling 61
- web browsing applications, and QoS 157
- web login access 287
- web-based and 802.1x authentication 265
- web-based authentication 264
- Weighted RED. *See* WRED
- WEP authentication supported 801
- WEP properties, configuring 287
- WEP required 801
- Wi-Fi protected access (WPA) 282
- wi-fi security cipher suites (table) 282
- wildcard reservation style 712
- wired equivalent privacy (WEP) authentication 281
- wireless
  - bridging 793
  - client aging 806
  - client current state 804
  - client history information 805
  - client history statistics 804
  - client scanning 801
  - clients 290
  - configuration examples 291, 292
  - configuring interfaces 809
  - country codes 807
  - default gateway 808
  - device management 793
  - enabling SVP 812
  - event logging and reporting 812
  - example network 792
  - features 792
  - health check reset 809
  - interfaces, configuring 810
  - interfaces, enabling 810
  - location 809
  - management VLAN 808
  - network policies 793
  - networking overview 791
  - port 804
  - ports
    - configuration process 794
    - configuration property values (table) 809
    - configuring 808
    - managing 793
  - ports, enabling 808
  - reset port properties 809
  - RF profile
    - configuring 796
    - creating 795
    - deleting 795
  - security profiles
    - configuring 286
    - copying 284
    - creating 284
    - deleting 284
  - show commands 794
  - switch properties, configuring 807
  - user access security 280
- WPA 792, 801
- WPA properties, configuring 286
- WRED
  - drop probability 573, 574, 575, 621, 622, 623
  - operation compared to RED (figure) 575, 623

X

- xmodem 815

Y

- yellow alarms 664

Index of Commands

A

abort diagnostics cable 762

C

clear accounting counters 528
clear counters 234, 337
clear debug-trace 830
clear elsm auto-restart ports 427
clear elsm counters ports 429
clear fdb 161
clear fdb remap 221
clear inline-power connection-history slot 767, 770
clear inline-power fault ports 768, 774
clear inline-power stats ports 774, 779
clear ipmc cache 326
clear log counters 234
clear session 47, 59
clear slot 86, 826
clear transceiver-test 224
clear wireless ports interface ap-scan results 801
clear wireless ports interface client-scan counters 803
clear wireless ports interface client-scan results 804
config inline-power backup-source 770
config inline-power detection 773
config inline-power display-string 774
config inline-power operator-limit 768
config inline-power operator-limt 773
config inline-power reserved budget 766, 770, 774
config inline-power usage-threshold 770
config inline-power violation-precedence 766, 768, 773
config netlogin 274
config vlan dhcp-address-range 274
config vlan dhcp-lease-timer 274
config vlan dhcp-options 274
config vlan netlogin-lease-timer 274
configure access-profile add 309
configure access-profile delete 311
configure access-profile mode 309
configure account 47
configure application examination ports 755
configure aps 651
configure aps add 649
configure aps authenticate 650
configure aps delete 650
configure aps force 653
configure aps lockout 652
configure aps manual 654
configure aps timers 652
configure atm add pvc 553, 554, 557
configure atm delete pvc 557
configure atm scrambling 559
configure backplane-ls-policy 96, 510
configure banner 47
configure banner netlogin 47
configure bgp add aggregate-address 497
configure bgp add network 502
configure bgp neighbor as-path-filter 317
configure bgp neighbor dampening 499
configure bgp neighbor nlri-filter 317
configure bgp neighbor peer-group 498
configure bgp peer-group no dampening 499
configure bootprelay add 459
configure bootprelay delete 459
configure bootprelay dhcp-agent information check 460
configure bootprelay dhcp-agent information option 459
configure bootprelay dhcp-agent information policy 460
configure configuration-mode 824
configure cpu-dos-protect 323
configure cpu-dos-protect trusted-ports 325
configure debug elsm-port 429
configure debug elsm-system 429
configure debug-trace accounting 546
configure debug-trace npcard 547
configure debug-trace wireless ports iapp 811
configure diagnostics 214

configure diagnostics cable 763
configure diffserv dscp-mapping 573, 621
configure diffserv examanation code-point qosprofile ports 572
configure diffserv examination code-point 166, 572, 620
configure diffserv ingress replacement ports 758
configure diffserv replacement 166
configure diffserv replacement priority 574, 622
configure dns-client add 52
configure dns-client default-domain 52
configure dot1p type 164, 567, 571, 615, 695
configure dot1p_priority 619
configure dot1q ethertype 567, 615, 829
configure dot1q tagmapping ports 567, 615
configure dot1q tagnesting 616
configure dot1q tagnesting ports 567, 568, 615
configure download server 137, 822
configure dvmrp add vlan 511
configure dvmrp vlan trusted-gateway 315, 316
configure eaps add protect vlan 359
configure eaps failtime 356
configure eaps failtime expiry-action 357
configure eaps hellotime 356
configure eaps mode 356
configure eaps primary port 358
configure eaps secondary port 358
configure eaps shared-port domain 366
configure eaps shared-port mode 366
configure elrp-client one-shot 421
configure elrp-client periodic 421
configure elsm hellotime 426
configure elsm hold-threshold 426
configure enhanced-dos-protect ipfdb agingtime 329
configure enhanced-dos-protect ipfdb cache-size 329
configure enhanced-dos-protect ipfdb learn-limit 329
configure enhanced-dos-protect ipfdb learn-window 329
configure enhanced-dos-protect ports 327, 329
configure enhanced-dos-protect rate-limit 327, 328
configure esrp port-mode ports 412
configure fdb agingtime 153
configure fdb-scan failure-action 152
configure fdb-scan period 152
configure flow-redirect add next-hop 454
configure flowstats export 241, 634
configure flowstats filter ports 242, 635
configure flowstats source 242
configure flowstats source ipaddress 634
configure flowstats timeout ports 242, 635
configure gvrp 569, 617
configure igmp snooping add static group 508
configure igmp snooping add static router 508
configure igmp snooping delete static group 509
configure igmp snooping delete static router 509
configure igmp snooping filter 509
configure iparp add proxy 447
configure ip-mtu vlan 90, 91, 693
configure iproute add default 56, 59, 449
configure iproute priority 449
configure iproute route-map 446, 527, 534
configure iproute-map 528
configure ipxrip delete 518
configure ipxrip vlan export-filter 313
configure ipxrip vlan import-filter 313
configure ipxroute add 518
configure ipxsap export-filter 313
configure ipxsap import filter 313
configure ipxservice add 519
configure isis add vlan area 612
configure jumbo-frame size 90
configure log display 236
configure log filter 229
configure log filter events match 232
configure log target filter 227, 231
configure log target format 233
configure log target match 230
configure mirroring add 581, 659
configure mpls add tls-tunnel 732
configure mpls add tls-tunnel vcid 732
configure mpls add vlan 611, 692, 699, 718
configure mpls delete tls-tunnel 734
configure mpls delete vlan 699, 718
configure mpls hello-hold-time 700
configure mpls ldp advertise 700
configure mpls php 693
configure mpls propagate-ip-ttl 693
configure mpls qos-mapping 619, 694
configure mpls rsvp-te add lsp 721, 722
configure mpls rsvp-te add path 719
configure mpls rsvp-te add profile 721
configure mpls rsvp-te delete lsp 722, 723
configure mpls rsvp-te delete path 719
configure mpls rsvp-te delete profile 722
configure mpls rsvp-te lsp add path 723
configure mpls rsvp-te path add ero 720
configure mpls rsvp-te path delete ero 721
configure mpls rsvp-te profile 722
configure mpls rsvp-te vlan 718
configure mpls vlan ip-mtu 692
configure mpls vlan ldp propagate 699
configure mroute add 514
configure mroute delete 514
configure msm-failover esrp-failover-mode 113
configure msm-failover link-action 110
configure msm-failover slave-config 110
configure msm-failover timeout 111
configure multilink add ports 672
configure nat add vlan map source 178, 179, 180

configure nat vlan 176
configure netlogin base-url 276
configure netlogin redirect-page 276
configure osfp area nssa 473
configure osfp area stub 473
configure osfp ase-limit 471
configure ospf add vlan 733
configure ospf area interarea-filter 313
configure ospf asbr-filter 314
configure ospf direct-filter 477
configure ospf routerid 705
configure ospf vlan area 472
configure ospf vlan timer 478, 480
configure packet-mem-scan-recovery-mode slot 215
configure pim add vlan 511
configure pim vlan trusted-gateway 316
configure port aggregate-bandwidth 103
configure port interpacket-gap 90
configure ports auto off 47, 88, 581, 659
configure ports auto on 88, 581, 659
configure ports auto-polarity off 89
configure ports auto-polarity on 89
configure ports clock source 665
configure ports e1 framing 666
configure ports e1 receivergain 667
configure ports e1 timeslots 667
configure ports egress-rate-limit 759
configure ports limit-learning 262
configure ports link-detection-level 89
configure ports lock-learning 263
configure ports monitor vlan 133
configure ports qosprofile 167, 571, 619, 620
configure ports redundant 101
configure ports snmp alert 667
configure ports t1 cablelength 665
configure ports t1 fd1 666
configure ports t1 framing 666
configure ports t1 lbdetect 666
configure ports t1 linecoding 666
configure ports t1 yellow 667
configure ports t3 cablelength 665
configure ports t3 framing 666
configure ports tunnel hdlc 656
configure ports unlimited-learning 262
configure ports unlock-learning 264
configure ports vds1 88
configure ppp 610, 674
configure ppp authentication 608, 673
configure ppp delayed-down-time 612
configure ppp echo 607
configure ppp pos checksum 606
configure ppp pos scrambling 606
configure ppp quality 608
configure ppp user 609, 673
configure protocol add 129
configure qosprofile 570, 618
configure qosprofile ingress 755
configure qostype ingress priority 753
configure qostype priority 168
configure radius server client-ip 332
configure radius shared-secret 333
configure radius timeout 332
configure radius-accounting 333
configure radius-accounting timeout 333
configure reboot-loop-protection threshold 841
configure red 575, 623
configure red min-threshold ports 577, 625
configure rf-profile beacon-interval 796
configure rf-profile dtim-interval 796
configure rf-profile frag-length 796
configure rf-profile long-retry 797
configure rf-profile preamble 797
configure rf-profile rts-threshold 797
configure rf-profile short-retry 797
configure rip export direct 186
configure rip export vip 186
configure rip vlan import-filter 312
configure rip vlan trusted-gateway 312
configure route-map add 318, 319, 532
configure route-map add goto 319
configure route-map set accounting-index 527, 529
configure route-map set accounting-index 1 value 533
configure route-map set iphost-routing 533
configure route-map set lpm-routing 528, 533
configure security-profile default-user-vlan 286
configure security-profile dot11-auth network-auth encryption 285
configure security-profile dot1x-wpa group-update-timer 286
configure security-profile dot1x-wpa pairwise-update-timer 287
configure security-profile dot1x-wpa reauth-period 287
configure security-profile ess-name 286
configure security-profile ssid-in-beacon 286
configure security-profile use-dynamic-vlan 286
configure security-profile wep default-key-index 287
configure security-profile wep key add hex plainstring 287
configure security-profile wep key delete 287
configure security-profile wpa-psk 287
configure sflow agent 247
configure sflow backoff-threshold 248
configure sflow collector 247
configure sflow poll-interval 248
configure sflow sample-rate 248
configure sharing address-based 93
configure slb failover unit local-ipaddress 203

configure slot module 48, 85, 826
configure snmp add community 66
configure snmp add trapreceiver community 66
configure snmp add trapreceiver community trap-group 68
configure snmp delete trapreceiver 66
configure snmp readonly access-profile 66
configure snmp readwrite access-profile 67
configure snmpv3 add access 72
configure snmpv3 add filter subtree type 76
configure snmpv3 add filter-profile param 76
configure snmpv3 add group user 72
configure snmpv3 add mib-view 74
configure snmpv3 add mib-view subtree 74
configure snmpv3 add notify tag 76
configure snmpv3 add target-addr param ipaddress 75
configure snmpv3 add target-params 71
configure snmpv3 add user 72
configure snmpv3 delete access 73
configure snmpv3 delete filter 76
configure snmpv3 delete filter-profile 76
configure snmpv3 delete group user 73
configure snmpv3 delete mib-view 74
configure snmpv3 delete notify 76
configure snmpv3 delete target-addr 75
configure snmpv3 delete target-params 75
configure snmpv3 delete user 72
configure snmpv3 engine-boots 71
configure snmpv3 engine-id 71
configure snmpv3 target-params user mp-model 75
configure sntp-client 79
configure sntp-client update-interval 79
configure sonet clocking 561, 597
configure sonet framing 561
configure sonet framing ports 596
configure sonet loop 596
configure sonet signal label 563, 599
configure sonet threshold signal degrade 562, 597
configure sonet threshold signal fail 561, 597
configure sonet trace path 563, 598
configure sonet trace section 562, 598
configure ssh2 key 48, 343
configure ssh2 key pregenerated 343
configure ssl certificate pregenerated 290
configure ssl certificate prikeylen country organization common-name 288
configure ssl privkey pregenerated 290
configure stpd add vlan 393
configure stpd mode 374
configure stpd port link-type 385
configure switch 86
configure sys-health-check alarm-level 219, 831, 834
configure sys-health-check auto-recovery 220
configure sys-health-check scan-recovery 220
configure syslog 236
configure sys-recovery-level 48, 224, 832
configure sys-recovery-level msm-failover 109
configure system-dump server 831
configure system-dump timeout 832
configure time 48
configure timezone 48, 78
configure transceiver-test failure-action 223
configure transceiver-test period 222
configure transceiver-test threshold 222
configure transceiver-test window 223
configure vlan add elrp-poll ports 418
configure vlan add esrp elrp-poll ports 419
configure vlan add multilink 672
configure vlan add ports 517, 566, 567, 592, 611, 612, 614
configure vlan add ports no-restart 410, 436
configure vlan add ports restart 410, 436
configure vlan add secondary-ip 455
configure vlan add track-bgp 408
configure vlan add track-environment failover 406
configure vlan add track-iproute 407, 433
configure vlan add track-lsp 743
configure vlan add track-ospf 408
configure vlan add track-ping 407, 433
configure vlan add track-route 407
configure vlan add track-vlan 407, 433
configure vlan delete esrp elrp-poll ports 418
configure vlan delete port 566, 614
configure vlan delete secondary-ip 455
configure vlan delete track-bgp 408
configure vlan delete track-lsp 743
configure vlan delete track-ospf 408
configure vlan delete track-route 407
configure vlan delete track-vlan 407, 433
configure vlan esrp elrp-master-poll enable 418
configure vlan esrp elrp-premaster-poll disable 418
configure vlan esrp elrp-premaster-poll enable 418
configure vlan esrp esrp-election 406
configure vlan esrp esrp-premaster-timeout 404
configure vlan esrp group add esrp-aware-ports 414
configure vlan esrp group delete esrp-aware-ports 415
configure vlan esrp priority 406
configure vlan ipaddress 58, 449, 592, 611, 612
configure vlan ipadress 48
configure vlan name 130
configure vlan netlogin-lease-timer 273
configure vlan priority 164
configure vlan protocol 566, 614
configure vlan protocol any 567, 614
configure vlan qosprofile 168, 571, 619, 620
configure vlan qosprofile ingress 752
configure vlan subvlan-address-range 464
configure vlan tag 517
configure vlan xnetid 517, 519

configure web login-timeout 61
configure wireless country-code 807
configure wireless default-gateway 808
configure wireless management-vlan 808
configure wireless port interface ap-scan added-trap 800
configure wireless ports antenna-location 793
configure wireless ports client-scan removed-trap 802
configure wireless ports detected-station-timeout 807
configure wireless ports force-disassociation 809
configure wireless ports health-check 809
configure wireless ports interface ap-scan off-channel 799
configure wireless ports interface ap-scan off-channel max-wait 799
configure wireless ports interface ap-scan off-channel min-wait 800
configure wireless ports interface ap-scan probe-interval 799
configure wireless ports interface ap-scan removed-trap 800
configure wireless ports interface ap-scan results size 800
configure wireless ports interface ap-scan results timeout 800
configure wireless ports interface ap-scan send-probe 799
configure wireless ports interface ap-scan updated-trap 800
configure wireless ports interface channel 811
configure wireless ports interface client-history size 805
configure wireless ports interface client-history timeout 805
configure wireless ports interface client-scan added-trap 802
configure wireless ports interface client-scan results size 802
configure wireless ports interface client-scan results timeout 802
configure wireless ports interface max-clients 810
configure wireless ports interface power-level 810
configure wireless ports interface rf-profile 810
configure wireless ports interface security-profile 810
configure wireless ports interface transmit-rate 810
configure wireless ports interface wireless-bridging 793
configure wireless ports location 809
create access-list icmp 260
create access-profile type 309
create account 48, 51
create account pppuser 606, 609, 673
create application examination 754
create aps 649
create bgp neighbor peer-group 498
create bgp peer-group 497
create eaps 356
create eaps shared-port 365
create fdbentry vlan blackhole 162
create fdbentry vlan dynamic 150, 161
create fdbentry vlan ports 150, 161
create isis area 485
create log filter 229
create multilink 672
create ospf area 473
create protocol 128
create rf-profile copy 795
create rf-profile mode 795
create route-map 318, 532
create security-profile 284
create stpd 393
create trusted-mac-address 278
create vlan 48, 530, 592, 611, 612
create vlan add ports 530
create vlan tag 530

D
delete access-list 257
delete account 48, 52
delete application examination 755
delete aps 649
delete bgp peer-group 497
delete eaps 356
delete eaps shared-port 365, 366
delete fdbentry 262
delete rf-profile 795
delete security-profile 284
delete trusted-mac-address 278
delete vlan 48
disable accounting 529
disable alt-queue-management 82
disable application examination ports 755
disable aps 649
disable bgp export 502
disable bootp vlan 48
disable cli-config-logging 48, 237
disable clipaging 48
disable cpu-dos-protect 324
disable dhcp ports vlan 273, 274
disable diagnostics cable 763
disable diffserv examanation ports 571, 619
disable diffserv ingress replacement ports 758
disable eaps 359
disable edp ports 98
disable elrp-client 420
disable elsm auto-restart ports 427
disable elsm ports 425
disable enhanced-dos-protect 326, 328

disable fdb-scan 151
disable flooding ports 150
disable flow-control ports 752
disable flowstats filter ports 244, 637
disable flowstats ping-check 244, 638
disable flowstats ports 241, 633
disable idletimeouts 48
disable ignore-bpdu 375
disable inline-power 769
disable inline-power ports 768, 773
disable inline-power slots 770
disable ipforwarding 337, 530
disable ipforwarding fast-direct-broadcast 446
disable ipforwarding ignore-broadcast 447
disable ipforwarding lpm-routing 526, 528, 532
disable ipxsap gns-reply 519
disable isis ignore-attached-bit 489
disable learning ports 149, 581, 659
disable log debug-mode 830
disable log display 236
disable log target 226, 236
disable lpm 528, 532
disable nat 181
disable netlogin 274, 276
disable netlogin logout-privilege 276
disable netlogin ports vlan 274, 275
disable netlogin session-refresh 276
disable ospf capability opaque-lsa 471
disable ospf export 445
disable ospf export rip 477
disable ospf export static 477
disable ospf export vip 477
disable pim snooping 507
disable ports 48, 87
disable ports loopback 671
disable radius 333
disable radius-accounting 333
disable red ports 576, 624
disable rip export 445, 477
disable rmon 250
disable sflow 247
disable sflow ports 247, 248
disable sharing 94, 95
disable slb 3dns iquery-client 207
disable smartredundancy 101
disable snmp access 65
disable snmp traps exceed-committed-rate ports 67, 756
disable snmp traps mac-security 67, 262
disable snmp traps port-up-down ports 67
disable ssh2 48
disable stpd rapid-root-failover 376
disable subvlan-proxy-arp vlan 464, 465
disable sys-health-check 219, 831
disable telnet 48, 60
disable temperature-logging 219
disable transceiver-test 222
disable trusted-mac-address 278
disable udp-echo-server 462
disable web 48, 61
disable web http 288
disable web https 288
disable wireless pors interface client-scan 802
disable wireless ports 808
disable wireless ports cancel-scheduler 809
disable wireless ports every 808
disable wireless ports interface 810
disable wireless ports interface ap-scan 799
disable wireless ports interface ap-scan off-channel 799
disable wireless ports interface client-history 805
disable wireless ports interface iapp 811
disable wireless ports interface svp 812
disable wireless ports time 808
download bootrom 52, 823
download configuration 52, 138, 821, 822
download configuration cancel 822
download configuration every 138, 822
download firmware slot 770
download image 52, 815, 816
download ssl certificate 289
download ssl privkey 289

E

enable accounting 529
enable alt-queue-management 82
enable application examination ports 755
enable aps 649
enable bgp aggregation 497
enable bgp export 502
enable bgp neighbor remove-private-as-numbers 501
enable bootp vlan 48, 57
enable bootprelay 459
enable cli-config-logging 48, 237
enable clipaging 48
enable cpu-dos-protect 324, 325
enable cpu-dos-protect simulated 324
enable dhcp ports vlan 273, 274
enable diagnostics cable 763
enable diffserv examination ports 165, 571, 572, 619, 620
enable diffserv ingress replacement ports 758
enable diffserv replacement ports 166, 574, 622
enable dot1p replacement ports 164, 166
enable dvmrp rxmode vlan 511
enable dvmrp txmode vlan 511
enable eaps 359
enable edp ports 98
enable elrp-client 420

enable elsm auto-restart ports 427
enable elsm ports 425
enable enhanced-dos-protect 326, 328
enable fdb-scan 151
enable fdb-scan slot 151
enable flooding ports 149
enable flow-control ports 752
enable flowstats 241
enable flowstats filter ports 244, 637
enable flowstats ping-check 244, 637
enable flowstats ports 241, 633
enable idletimeouts 49
enable ignore-bpdu 375
enable ignore-stp vlan 554
enable inline-power 769
enable inline-power ports 773
enable inline-power slots 770
enable ipforwarding 449, 457, 530
enable ipforwarding fast-direct-broadcast 446
enable ipforwarding ignore-broadcast 447
enable ipforwarding lpm routing 526
enable ipforwarding lpm-routing 528, 531
enable ipmcforwarding 510
enable isis 486
enable isis ignore-attached-bit 488
enable jumbo-frame ports 90
enable license 49
enable log debug-mode 235, 830
enable log display 236
enable log target 225, 233, 236
enable log target session 233
enable lpm 528, 532, 542
enable mac-vlan mac-group port 566, 614
enable mirroring 581, 659
enable mpls 692
enable multilink 672
enable multinetting 457
enable nat 178
enable netlogin 274, 276
enable netlogin logout-privilege 276
enable netlogin ports vlan 274
enable netlogin session-refresh 276
enable ospf 449
enable ospf capability opaque-lsa 471
enable ospf export direct 730, 733
enable ospf export rip 477
enable ospf export static 445, 477
enable ospf export vip 477
enable pim 511
enable pim snooping 507
enable ports 87
enable ports loopback 671
enable ports loopback remote 671
enable ports t1 loopback network payload 671
enable radius 333
enable radius-accounting 333
enable red ports 576, 624
enable rip 449
enable rip export 477
enable rip export cost 445
enable rmon 250
enable route sharing 446
enable sflow 247
enable sflow backoff-threshold 248
enable sflow ports 247
enable sharing 581, 659
enable sharing grouping 94, 95
enable smartredundancy 101, 581, 659
enable snmp access 65
enable snmp traps 67
enable snmp traps exceed-committed-rate ports 67, 756
enable snmp traps mac-security 67, 262
enable sntp-client 79
enable ssh2 49, 343
enable stpd 393
enable stpd rapid-root-failver 376
enable sys-health-check 219, 831
enable telnet 49, 59, 60
enable temperature-logging 218, 219
enable transceiver-test 221
enable trusted-mac-address 278
enable udp-echo-server 461
enable vman termination 677
enable web 49, 61
enable web http 288
enable web http access-profile 288
enable web https 288
enable web https access-profile 288
enable wireless ports 808
enable wireless ports every 808
enable wireless ports interface 810
enable wireless ports interface ap-scan 799
enable wireless ports interface ap-scan off-channel 799
enable wireless ports interface client-history 805
enable wireless ports interface client-scan 801
enable wireless ports interface iapp 811
enable wireless ports interface svp 812
enable wireless ports time 808

H

history 47, 49

L

logout 59

M

mrinfo 509

mtrace 510

N
nslookup 52

P
PAE 290
ping 50, 52, 53
Port Authentication Entity (PAE) 290

Q
quit 59

R
reboot 118, 818, 819
reset inline-power ports 767, 774
reset wireless ports 809
reset wireless ports interface 811
restart multilink 672
restart ports 672
run diagnostics 214, 836, 837, 841
run diagnostics cable 762
run diagnostics packet-memory 215
run msm-failover 118, 841

S
save configuration 59, 819, 822
scp2 345
show {application examination} {} 755
show access-list 257
show access-list-monitor 258
show accounting 529, 531, 538, 540, 544
show accounts 51
show application examination 755
show aps 655
show atm 558
show atm pvc 559
show banner 49
show bgp neighbor 499
show bgp peer-group 499
show configuration 89
show cpu-dos-protect 324
show debug-trace 830
show debug-trace vlan 830
show debug-tracing 830
show diagnostics 215, 220, 223, 831
show diagnostics cable 763
show diagnostics packet-memory slot 215
show eaps 360
show eaps shared-port 366
show eaps summary 360
show edp 98
show elrp 419
show elsm 428
show elsm ports 428
show enhanced-dos-protect 326, 327, 328, 329
show esrp 114, 407, 411, 415
show esrp vlan 416
show esrp-aware vlan 402, 416
show esrp-aware-ports 415
show fdb 150, 154, 221
show fdb permanent 162, 170
show flow-redirect 256
show flowstats 245, 638
show igmp snooping filter 509
show igmp snooping static group 509
show inline-power 771
show inline-power configuration port 775
show inline-power configuration slot 771
show inline-power info 767, 776
show inline-power slot 771
show inline-power stats ports 767, 774, 778, 779
show inline-power stats slot 772
show iparp 449, 465
show ipconfig 449, 460, 520
show ipfdb 446, 449
show iproute 449, 520, 543, 545
show iproute route-map 446
show ipxconfig 520
show ipxrip 520
show ipxroute 520
show ipxsap 520
show ipxservice 520
show log 218, 219, 234
show log components 228
show log configuration filter 230
show log configuration target 226
show log counters 234
show log events 228
show lpm 528, 533
show management 60, 61, 67, 288, 337
show mpls 696
show mpls forwarding 696
show mpls interface 696
show mpls label 697
show mpls ldp 701
show mpls qos-mapping 697
show mpls rsvp-te 723
show mpls rsvp-te lsp 724
show mpls rsvp-te path 724
show mpls rsvp-te profile 724
show mpls tls-tunnel 734
show mroute 514
show msm-failover 111, 119
show nat 176
show nat rules 180
show netlogin 274, 276

show netlogin vlan 274
show ospf 477, 483
show ospf area 483
show ospf interfaces 483
show ospf lsdb 483
show ospf lsdb area lstype 483
show packet-msm-scan-recovery-mode 216
show pim snooping 507
show ports collisions 581, 659
show ports configuration 752, 825
show ports egress-rate-limit 759
show ports info 89, 103, 167, 168, 170, 401, 574, 577, 580, 622, 625, 629, 758
show ports info detail 262
show ports ingress stats 760
show ports qosmonitor 169, 580
show ports rxerrors 217
show ports sharing 96
show ports stats 216
show ports txerrors 217
show ports vlan statistics 133
show ppp 613
show protocol 134
show qosprofile 162, 168, 170
show qosprofile ingress 756
show qostype ingress priority 754
show qostype priority 169
show rf-profile 797
show security-profile 287
show session 59, 288
show sflow configuration 248
show sflow statistics 248
show sharing address-based 94
show slb 3dns members 207
show slot 86, 545
show snmpv3 access 72
show snmpv3 filter 76
show snmpv3 filter-profile 76
show snmpv3 group 73
show snmpv3 mib-view 74
show snmpv3 notify 76
show snmpv3 target-addr 75
show snmpv3 target-params 75
show snmpv3 user 72
show sntp client 79
show sonet 563, 564, 599
show ssl 289
show stpd 376, 397
show stpd ports 385, 397
show switch 78, 79, 138, 170, 222, 337, 459, 817, 818, 822, 824, 826, 832, 834
show system-dump 832
show trusted-mac-address 278
show version 817, 818
show vlan 132, 168, 170, 273, 411, 415, 464, 465, 518, 520, 543, 829
show vlan dhcp-address-allocation 274
show vlan dhcp-config 274
show vlan security 262
show vlan stats 133
show vlan stpd 397
show vrrp 433
show wireless ap-scan results 800
show wireless ap-scan results mac_address 801
show wireless configuration 794
show wireless ports interface ap-scan configuration 801
show wireless ports interface ap-scan status 801
show wireless ports interface client-history configuration 805
show wireless ports interface client-history diagnostics 806
show wireless ports interface client-history mac-layer 806
show wireless ports interface client-history status 806
show wireless ports interface clients 291, 804
show wireless ports interface client-scan configuration 802
show wireless ports interface client-scan results 803
show wireless ports interface client-scan results mac-address 803
show wireless ports interface client-scan status 803
show wireless ports interface configuration 794
show wireless ports interface pae-diagnostics 291
show wireless ports interface pae-statistics 291
show wireless ports interface rf-status 794
show wireless ports interface security-status 794
show wireless ports interface stats 795
show wireless ports interface status 795
show wireless ports log 812
ssh2 345
synchronize 822

T

telnet 52, 57
traceroute 52, 53

U

unconfig inline-power backup-source slot 770
unconfig inline-power detection ports 773
unconfig inline-power operator-limit ports 773, 774
unconfig inline-power reserved-budget ports 774
unconfig inline-power usage-threshold 770
unconfig inline-power violation-precedence ports 774
unconfigure aps 654
unconfigure bootprelay dhcp-agent information check 460
unconfigure bootprelay dhcp-agent information option

459
unconfigure bootprelay dhcp-agent information policy 460
unconfigure configuration-mode 824
unconfigure cpu-dos-protect 324
unconfigure diffserv dscp-mapping ports 574, 622
unconfigure diffserv ingress replacement ports 758
unconfigure eaps primary port 360
unconfigure eaps secondary port 360
unconfigure eaps shared-port link-id 366
unconfigure eaps shared-port mode 366
unconfigure elrp-client 421
unconfigure enhanced-dos-protect rate-limit 327, 328
unconfigure fdb-scan failure-action 152
unconfigure fdb-scan period 152
unconfigure flowstats ports 245, 638
unconfigure mpls 695, 701
unconfigure mpls qos-mapping 695
unconfigure msm-failover 111
unconfigure packet-mem-scan-recovery-mode slot 216
unconfigure port aggregate-bandwidth 103
unconfigure port redundant 101
unconfigure ports monitor vlan 133
unconfigure ppp ports 590, 614
unconfigure qostype ingress priority 754
unconfigure qostype priority 169
unconfigure sflow agent 247
unconfigure sflow backoff-threshold 248
unconfigure sflow collector 247
unconfigure sonet ports 564, 599
unconfigure switch 49, 820, 824
unconfigure system-dump 832
unconfigure transceiver-test failure-action 223
unconfigure transceiver-test period 222
unconfigure transceiver-test threshold 223
unconfigure transceiver-test window 223
upload configuration 52, 820, 821
upload configuration cancel 820
upload log 234
upload system-dump 831
use configuration 820
use image 816