SIEMENS

Edition 07/2022

Configuration Manual

SIMATIC NET

Rugged Multi Service Platforms

RUGGEDCOM ROX II v2.15 CLI

For RX1400

https://www.siemens.com/ruggedcom

SIEMENS

SIMATIC NET

Rugged Multi Service Platforms RUGGEDCOM ROX II v2.15 CLI

Configuration Manual

For RX1400

Preface

Introduction 1

Using RUGGEDCOM ROX II 2

Getting Started 3

Device Management 4

System Administration 5

Security 6

IP Address Assignment 7

Layer 2 8

Serial Server 9

WAN and Wireless 10

Tunneling and VPNs 11

Unicast and Multicast Routing 12

Network Redundancy 13

Network Discovery and Management 14

Traffic Control and Classification 15

Time Services 16

Continued on next page

07/2022
C79000-G8976-1529-03

Digital Industries
Process Automation
300 Applewood Crescent
Concord, Ontario, L4K 4E5
Canada

C79000-G8976-1529-03
© 07/2022 Subject to change

Copyright © Siemens 2022
All rights reserved

SIEMENS

Continued

Virtualization 17

Applications 18

Troubleshooting 19

Reference 20

SIMATIC NET

Rugged Multi Service Platforms RUGGEDCOM ROX II v2.15 CLI

Configuration Manual

For RX1400

07/2022
C79000-G8976-1529-03

Digital Industries
Process Automation
300 Applewood Crescent
Concord, Ontario, L4K 4E5
Canada

C79000-G8976-1529-03
© 07/2022 Subject to change

Copyright © Siemens 2022
All rights reserved

Legal Information

Warning Notice System

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER
indicates that death or severe personal injury will result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury may result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

⚠ NOTICE
indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper Use of Siemens Products

Note the following:

⚠ WARNING
Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

Trademarks

All names identified by ® are registered trademarks of Siemens Canada Ltd.. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

Digital Industries
Process Automation
300 Applewood Crescent
Concord, Ontario, L4K 4E5
Canada

C79000-
G8976-1529-03
© 07/2022
Subject to change

Copyright © Siemens 2022
All rights reserved

Digital Industries
Process Automation
300 Applewood Crescent
Concord, Ontario, L4K 4E5
Canada

C79000-
G8976-1529-03
© 07/2022
Subject to change

Copyright © Siemens 2022
All rights reserved

Table of Contents

Preface xxxix
Security Information xxxix
Firmware/Software Support Model xl
CLI Command Syntax xl
Related Documents xli
SIMATIC NET Glossary xliii
System Requirements xliii
Accessing Documentation xliii
License Conditions xliii
Registered Trademarks xliv
Warranty xliv
Training xliv
Customer Support xliv
Contacting Siemens xlv

1 Introduction 1

1.1 Features and Benefits 1
1.2 Feature Keys 7
1.3 Security Recommendations 9
1.4 Available Services by Port 13
1.5 User Permissions 14
1.6 Removable Memory 17
1.7 Logged Events 18
1.7.1 Structure of a Syslog Event 18
1.7.2 Syslog Event Types 19
1.7.3 Logged Security Events 19

2 Using RUGGEDCOM ROX II 25

2.1 Default User Names and Passwords 25
2.2 Logging In 25
2.3 Logging Out 26
2.4 Using Network Utilities 27
2.4.1 Pinging an IPv4 Address or Host 27
2.4.2 Pinging an IPv6 Address or Host 27
2.4.3 Pinging MPLS Endpoints 28
2.4.4 Pinging VRF Endpoints 28
2.4.5 Tracing a Route to an IPv4 Host 28
2.4.6 Tracing a Route to an IPv6 Host 29
2.4.7 Tracing a Route to an MPLS Endpoint 29
2.4.8 Tracing a Route to a VRF Endpoint 29
2.4.9 Capturing Packets from a Network Interface 29

2.4.10 Capturing Packets from a VRF Network Interface 31
2.5 Using the Command Line Interface 31
2.5.1 Accessing Different CLI Modes 32
2.5.2 Using Command Line Completion 32
2.5.3 Displaying Available Commands 33
2.5.4 Editing Commands 33
2.5.5 Using Double Quotes 35
2.5.6 Using Output Redirects 35
2.5.7 Using Regular Expressions 42
2.5.8 Using CLI Utilities 43
2.5.9 Specifying a Range 43
2.5.10 Common Commands 44
2.5.10.1 Basic CLI Commands 44
2.5.10.2 File Commands 45
2.5.10.3 Interface and Services Commands 53
2.5.10.4 Administration Commands 54
2.5.10.5 Configuration Mode General Commands 56
2.6 Configuring the CLI Interface 62
2.7 Accessing Different Modes 63
2.7.1 Accessing BIST Mode 63
2.7.2 Accessing Service Mode 65
2.7.3 Accessing Maintenance Mode 67
2.7.4 Enabling/Disabling SSH Access in Maintenance Mode 68
2.7.5 Managing Maintenance Mode Authorization 68
2.7.5.1 Temporarily Enabling Maintenance Mode Authorization 69
2.7.5.2 Permanently Enabling Maintenance Mode Authorization 70
2.7.5.3 Disabling Maintenance Mode Authorization 70
3 Getting Started 73
3.1 Connecting to RUGGEDCOM ROX II 73
3.1.1 Default IP Address 73
3.1.2 Connecting Directly via Serial Console 73
3.1.3 Connecting Remotely via SSH 74
3.2 Configuring a Basic Network 75
3.2.1 Configuring a Basic IPv4 Network 75
3.2.2 Configuring a Basic IPv6 Network 76
4 Device Management 77
4.1 Displaying Device and Software Information 77
4.2 Determining the GPS Location of the Device 78
4.3 Viewing Chassis Information and Status 78
4.3.1 Viewing the Slot Hardware 78
4.3.2 Viewing Flash Card Storage Utilization 79
4.3.3 Viewing CPU/RAM Utilization 80
4.3.4 Viewing the Slot Status 80
4.3.5 Viewing the Slot Sensor Status 81

4.4 Viewing the Parts List 82
4.5 Shutting Down the Device 83
4.6 Rebooting the Device 83
4.7 Restoring Factory Defaults 83
4.8 Decommissioning the Device 84
4.9 Viewing a List of Line Module Configurations 85
4.10 Managing Feature Keys 85
4.10.1 Viewing the Contents of a Feature Key 86
4.10.2 Installing Feature Keys 86
4.11 Managing Files 88
4.11.1 Installing Files 88
4.11.2 Backing Up Files 89
4.12 Managing Logs 90
4.12.1 Viewing Logs 91
4.12.2 Deleting Logs 91
4.12.3 Configuring Secure Remote Syslog 92
4.12.3.1 Enabling/Disabling Secure Remote Syslog 92
4.12.3.2 Viewing a List of Permitted Peers 93
4.12.3.3 Adding a Permitted Peer 93
4.12.3.4 Deleting a Permitted Peer 93
4.12.3.5 Configuring a Source IP Address for Remote Syslog Messages 94
4.12.4 Managing Diagnostic Logs 94
4.12.4.1 Enabling/Disabling the Developer's Log 95
4.12.4.2 Enabling/Disabling the SNMP Log 95
4.12.4.3 Enabling/Disabling the NETCONF Summary Log 96
4.12.4.4 Enabling/Disabling the NETCONF Trace Log 97
4.12.4.5 Enabling/Disabling the XPATH Trace Log 98
4.12.4.6 Enabling/Disabling the WebUI Trace Log 98
4.12.5 Managing Remote Syslog Servers 99
4.12.5.1 Viewing a List of Remote Servers 99
4.12.5.2 Adding a Remote Server 100
4.12.5.3 Deleting a Remote Server 100
4.12.6 Managing Remote Server Selectors 101
4.12.6.1 Viewing a List of Remote Server Selectors 101
4.12.6.2 Adding a Remote Server Selector 101
4.12.6.3 Deleting a Remote Server Selector 102
4.13 Managing the Software Configuration 103
4.13.1 Backing Up the Software Configuration 103
4.13.2 Saving the Configuration 103
4.13.3 Loading a Configuration 105
4.13.4 Managing Automatic Configuration Loading 105
4.13.4.1 Enabling/Disabling Automatic Configuration Loading 105
4.13.4.2 Automatically Loading a Configuration File from a Removable Drive 106
4.13.4.3 Overriding Factory Settings Using a Removable Drive 107
4.13.4.4 Deleting an Automatic Configuration File 108

4.14 Managing Upgrade Servers 108
4.14.1 Understanding Upgrade Servers 108
4.14.2 Configuring the Upgrade Server 109
4.15 Managing Software Versions 109
4.15.1 Understanding Upgrades/Downgrades 110
4.15.2 Upgrading/Downgrading Software 110
4.15.2.1 Determining the Current Software Partition and Version 111
4.15.2.2 Obtaining a Software Release 111
4.15.2.3 Stopping/Declining a Software Upgrade 112
4.15.2.4 Upgrading the Software and Retaining the Configuration 113
4.15.2.5 Upgrading the Software and Resetting the Configuration 115
4.15.2.6 Downgrading Software 118
4.15.2.7 Rolling Back a Software Upgrade 120
4.15.2.8 Monitoring Software Upgrades/Downgrades 120
4.16 Monitoring Firmware Integrity 121
4.16.1 Enabling/Disabling the Boot Time Firmware Integrity 121
4.16.2 Checking the Firmware Integrity 122
4.16.3 Scheduling a Recurring Firmware Integrity Check 122
4.16.4 Viewing the Status of the Firmware Integrity Check 122
4.17 Managing SFP Transceivers 123
4.17.1 SFP Transceiver Support 123
4.17.2 Viewing SFP Information 124
4.17.3 Enabling/Disabling Smart SFP Mode 125
5 System Administration 127
5.1 Configuring the System Name and Location 127
5.2 Configuring the Host Name 127
5.3 Customizing the Welcome Screen 128
5.4 Setting the Maximum Number of Sessions 128
5.5 Enabling and Configuring WWW Interface Sessions 129
5.6 Enabling/Disabling Remote Access Through a VRF Interface 130
5.7 Managing Alarms 132
5.7.1 Pre-Configured Alarms 132
5.7.2 Viewing a List of Active Alarms 134
5.7.3 Clearing and Acknowledging Alarms 135
5.7.3.1 Clearing Alarms 135
5.7.3.2 Acknowledging Alarms 135
5.7.4 Configuring an Alarm 136
5.7.5 List of Alarms 137
5.8 Managing Users 137
5.8.1 Viewing a List of Users 138
5.8.2 Adding a User 138
5.8.3 Deleting a User 139
5.8.4 Monitoring Users 139
5.8.4.1 Kicking Users from the Network 139

5.8.4.2 Sending Messages to Users 140

5.9 Managing Passwords and Passphrases 140
5.9.1 Configuring Password/Passphrase Complexity Rules 141
5.9.2 Setting a User Password/Passphrase 142
5.9.3 Setting the Boot Password/Passphrase 143
5.9.4 Setting the Maintenance Password/Passphrase 143
5.9.5 Resetting the Admin Password/Passphrase 144
5.9.6 Resetting the Boot Password/Passphrase 146
5.9.7 Resetting the Maintenance Password/Passphrase 146

5.10 Scheduling Jobs 147
5.10.1 Viewing a List of Scheduled Jobs 148
5.10.2 Adding a Scheduled Job 148
5.10.3 Deleting a Scheduled Job 150

6 Security 151

6.1 Enabling and Configuring CLI Sessions 151

6.2 Enabling/Disabling Brute Force Attack Protection 152

6.3 Enabling/Disabling SYN Cookies 154

6.4 Managing SFTP Sessions 154
6.4.1 Enabling and Configuring SFTP Sessions 154
6.4.2 Adding an SFTP Server's Public Key 155

6.5 Managing Port Security 156
6.5.1 Port Security Concepts 156
6.5.1.1 Static MAC Address-Based Authentication 156
6.5.1.2 Static MAC Address-Based Authentication in an MRP Ring 157
6.5.1.3 IEEE 802.1x Authentication 157
6.5.1.4 IEEE 802.1X Authentication with MAC Address-Based Authentication 158
6.5.1.5 Assigning VLANS with Tunnel Attributes 159
6.5.2 Configuring Port Security 159
6.5.3 Viewing the Security Status of Switched Ethernet Ports 162

6.6 Managing User Authentication 162
6.6.1 Setting the User Authentication Mode 163
6.6.2 Managing User Authentication Keys 164
6.6.2.1 Determining Which Keys are Associated to a User 164
6.6.2.2 Adding a User Authentication Key 164
6.6.2.3 Deleting a User Authentication Key 165
6.6.2.4 Associating/Disassociating a User Authentication Key 166
6.6.3 Managing RADIUS Authentication 167
6.6.3.1 Configuring RADIUS Authentication for LOGIN Services 168
6.6.3.2 Configuring RADIUS Authentication for PPP Services 169
6.6.3.3 Configuring RADIUS Authentication for Switched Ethernet Ports 170
6.6.4 Configuring TACACS+ Authentication 170

6.7 Managing Certificates and Keys 172
6.7.1 Viewing the Local Host SSH/RSA Public Key 172
6.7.2 Configuring Session Security 172
6.7.3 Managing the Trusted Certificate Store 173

6.7.3.1 Configuring the Trusted Certificate Store 174
6.7.3.2 Enabling/Disabling the Trusted Certificate Store 174
6.7.3.3 List of Root Certificates in the Trusted Certificate Store 174
6.7.4 Managing CA Certificates for the Trusted Certificate Store 197
6.7.4.1 Viewing a List of CA Certificates Added to the Trusted Certificate Store 197
6.7.4.2 Adding a CA Certificate to the Trusted Certificate Store 197
6.7.4.3 Deleting a CA Certificate from the Trusted Certificate Store 198
6.7.5 Managing CA Certificates and CRLs 198
6.7.5.1 Viewing a List of CA Certificates and CRLs 198
6.7.5.2 Viewing the Status of a CA Certificate and CRL 199
6.7.5.3 Adding a CA Certificate and CRL 200
6.7.5.4 Deleting a CA Certificate and CRL 201
6.7.6 Managing Private Keys 201
6.7.6.1 Viewing a List of Private Keys 202
6.7.6.2 Adding a Private Key 202
6.7.6.3 Deleting a Private Key 203
6.7.7 Managing Public Keys 203
6.7.7.1 Viewing a List of Public Keys 203
6.7.7.2 Adding a Public Key 204
6.7.7.3 Adding an IPSec-Formatted Public Key 205
6.7.7.4 Deleting a Public Key 205
6.7.8 Managing Certificates 206
6.7.8.1 Viewing a List of Certificates 206
6.7.8.2 Viewing the Status of a Certificate 206
6.7.8.3 Adding a Certificate 207
6.7.8.4 Deleting a Certificate 208
6.7.9 Managing Known Hosts 208
6.7.9.1 Viewing a List of Known Hosts 209
6.7.9.2 Adding a Known Host 209
6.7.9.3 Deleting a Known Host 210
6.7.10 Managing SCEP 210
6.7.10.1 Understanding SCEP 210
6.7.10.2 Configuring SCEP 211
6.7.10.3 Configuring the SCEP Client 212
6.7.10.4 Configuring the SCEP Certificate Signing Requests 213
6.7.10.5 Retrieving an SCEP CA Certificate 215
6.7.10.6 Retrieving an SCEP Certificate 215
6.7.10.7 Configuring Automatic Certificate Renewal 216
6.7.10.8 Renewing an Expired SCEP Certificate 216
6.7.10.9 Renewing an SCEP CA Certificate 216
6.8 Managing Firewalls 217
6.8.1 Firewall Concepts 217
6.8.1.1 Stateless vs. Stateful Firewalls 217
6.8.1.2 Linux netfilter 218
6.8.1.3 Network Address Translation 218
6.8.1.4 Port Forwarding 219
6.8.1.5 Protecting Against a SYN Flood Attack 219
6.8.1.6 Protecting Against IP Spoofing 220
6.8.1.7 Active and Working Firewall Configurations 220

6.8.2 Viewing a List of Firewalls 220
6.8.3 Adding a Firewall 221
6.8.4 Deleting a Firewall 222
6.8.5 Working with Multiple Firewall Configurations 222
6.8.6 Configuring the Firewall for a VPN 223
6.8.7 Configuring the Firewall for a VPN in a DMZ 224
6.8.8 Configuring Netfilter 225
6.8.9 Managing Zones 225
6.8.9.1 Viewing a List of Zones 225
6.8.9.2 Adding a Zone 226
6.8.9.3 Deleting a Zone 227
6.8.10 Managing Interfaces 227
6.8.10.1 Viewing a List of Interfaces 227
6.8.10.2 Adding an Interface 228
6.8.10.3 Associating an Interface with a Zone 229
6.8.10.4 Configuring a Broadcast Address 230
6.8.10.5 Deleting an Interface 230
6.8.11 Managing Hosts 230
6.8.11.1 Viewing a List of Hosts 231
6.8.11.2 Adding a Host 231
6.8.11.3 Deleting a Host 232
6.8.12 Managing Policies 233
6.8.12.1 Viewing a List of Policies 233
6.8.12.2 Adding a Policy 234
6.8.12.3 Configuring the Source Zone 235
6.8.12.4 Configuring the Destination Zone 235
6.8.12.5 Deleting a Policy 235
6.8.13 Managing Network Address Translation Settings 236
6.8.13.1 Viewing a List of NAT Settings 236
6.8.13.2 Adding a NAT Setting 237
6.8.13.3 Deleting a NAT Setting 237
6.8.14 Managing Masquerade and SNAT Settings 238
6.8.14.1 Viewing a List of Masquerade and SNAT Settings 238
6.8.14.2 Adding Masquerade or SNAT Settings 239
6.8.14.3 Deleting a Masquerade or SNAT Setting 240
6.8.15 Managing Rules 240
6.8.15.1 Viewing a List of Rules 240
6.8.15.2 Adding a Rule 241
6.8.15.3 Configuring the Source Zone 243
6.8.15.4 Configuring the Destination Zone 244
6.8.15.5 Deleting a Rule 245
6.8.16 Validating a Firewall Configuration 245
6.8.17 Enabling/Disabling a Firewall 245
6.9 Restricting Management Access to Specific Interfaces 246
7 IP Address Assignment 249
7.1 Managing IP Addresses for Routable Interfaces 249
7.1.1 Configuring Costing for Routable Interfaces 249
7.1.2 Viewing Statistics for Routable Interfaces 249

7.1.3 Managing IPv4 Addresses 250
7.1.3.1 Viewing a List of IPv4 Addresses 251
7.1.3.2 Adding an IPv4 Address 251
7.1.3.3 Deleting an IPv4 Address 252
7.1.4 Managing IPv6 Addresses 252
7.1.4.1 Viewing a List of IPv6 Addresses 252
7.1.4.2 Adding an IPv6 Address 252
7.1.4.3 Deleting an IPv6 Address 253
7.1.5 Configuring IPv6 Neighbor Discovery 253
7.1.6 Managing IPv6 Network Prefixes 255
7.1.6.1 Adding an IPv6 Network Prefix 256
7.1.6.2 Deleting an IPv6 Network Prefix 256

7.2 Managing the DHCP Relay Agent 257
7.2.1 Configuring the DHCP Relay Agent 258
7.2.2 Assigning a DHCP Server Address 258
7.2.3 Viewing a List of DHCP Client Ports 258
7.2.4 Adding a DHCP Client Port 259
7.2.5 Deleting a DHCP Client Port 259
7.2.6 Example: Configuring the Device as a Relay Agent 259

7.3 Managing the DHCP Server 261
7.3.1 Viewing a List of Active Leases 261
7.3.2 Configuring the DHCP Server 262
7.3.3 Enabling/Disabling the DHCP Server 263
7.3.4 Configuring DHCP Server Options 263
7.3.5 Managing DHCP Client Configuration Options 265
7.3.5.1 Configuring Standard DHCP Client Configuration Options (IPv4) 265
7.3.5.2 Configuring Standard DHCP Client Configuration Options (IPv6) 266
7.3.5.3 Viewing a List of Custom DHCP Client Configuration Options 267
7.3.5.4 Adding a Custom DHCP Client Configuration Option 268
7.3.5.5 Deleting a Custom DHCP Client Configuration Option 269
7.3.6 Managing DHCP Listen Interfaces 270
7.3.6.1 Viewing a List of DHCP Listen Interfaces 270
7.3.6.2 Adding a DHCP Listen Interface 271
7.3.6.3 Deleting a DHCP Listen Interface 271
7.3.7 Managing Shared Networks 271
7.3.7.1 Viewing a List of Shared Networks 272
7.3.7.2 Adding a Shared Network 272
7.3.7.3 Configuring Shared Network Options 273
7.3.7.4 Deleting a Shared Network 274
7.3.8 Managing Subnets 275
7.3.8.1 Viewing a List of Subnets 275
7.3.8.2 Adding a Subnet 275
7.3.8.3 Configuring Subnet Options 276
7.3.8.4 Deleting a Subnet 278
7.3.9 Managing Host Groups 279
7.3.9.1 Viewing a List of Host Groups 279
7.3.9.2 Adding a Host Group 280
7.3.9.3 Configuring Host Group Options 280

7.3.9.4 Deleting a Host Group 282
7.3.10 Managing DHCP Hosts 282
7.3.10.1 Viewing a List of Hosts 282
7.3.10.2 Adding a Host 283
7.3.10.3 Configuring Host Options 283
7.3.10.4 Deleting Hosts 285
7.3.11 Managing Address Pools (IPv4) 286
7.3.11.1 Viewing a List of Address Pools (IPv4) 286
7.3.11.2 Adding an Address Pool (IPv4) 286
7.3.11.3 Deleting an Address Pool (IPv4) 287
7.3.12 Managing Address Pools (IPv6) 288
7.3.12.1 Viewing a List of Address Pools (IPv6) 288
7.3.12.2 Adding an Address Pool (IPv6) 288
7.3.12.3 Deleting an Address Pool (IPv6) 289
7.3.13 Managing IP Ranges (IPv4) 290
7.3.13.1 Viewing a List of IP Ranges (IPv4) 290
7.3.13.2 Adding an IP Range (IPv4) 291
7.3.13.3 Deleting an IP Range (IPv4) 291
7.3.14 Managing IP Ranges (IPv6) 292
7.3.14.1 Viewing a List of IP Ranges (IPv6) 292
7.3.14.2 Adding an IP Range (IPv6) 293
7.3.14.3 Deleting an IP Range (IPv6) 293
7.3.15 Managing IPv6 Prefixes 294
7.3.15.1 Viewing a List of IPv6 Prefixes 294
7.3.15.2 Adding an IPv6 Prefix 295
7.3.15.3 Deleting an IPv6 Prefix 295
7.3.16 Managing Temporary Subnets 296
7.3.16.1 Viewing a List of Temporary Subnets 296
7.3.16.2 Adding a Temporary Subnet 296
7.3.16.3 Deleting a Temporary Subnet 297
7.3.17 Managing IPv6 Subnets 297
7.3.17.1 Viewing a List of IPv6 Subnets 297
7.3.17.2 Adding a IPv6 Subnet 298
7.3.17.3 Deleting an IPv6 Subnet 298
7.3.18 Managing Option 82 Classes for Address Pools 299
7.3.18.1 Viewing a List of Option 82 Classes for Address Pools 299
7.3.18.2 Adding an Option 82 Class to an Address Pool 300
7.3.18.3 Deleting an Option 82 Class From an Address Pool 300
7.3.19 Example: Configuring the Device as a DHCP Server to Support a Relay Agent 301
7.4 Managing Static DNS 305
7.4.1 Managing Domain Names 305
7.4.1.1 Viewing a List of Domain Names 305
7.4.1.2 Adding a Domain Name 306
7.4.1.3 Deleting a Domain Name 306
7.4.2 Managing Domain Name Servers 306
7.4.2.1 Viewing a List of Domain Name Servers 306
7.4.2.2 Adding a Domain Name Server 307
7.4.2.3 Deleting a Domain Name Server 307

7.5 Managing Dynamic DNS 307
7.5.1 Enabling and Configuring Dynamic DNS 308
7.5.2 Managing Dynamic DNS Servers 309
7.5.2.1 Viewing a List of Dynamic DNS Servers 309
7.5.2.2 Viewing the Status of a Dynamic DNS Server 309
7.5.2.3 Adding a Dynamic DNS Server 310
7.5.2.4 Deleting a Dynamic DNS Server 310
7.5.3 Managing Dynamic DNS Server Host Names 311
7.5.3.1 Viewing a List of Host Names 311
7.5.3.2 Adding a Host Name 311
7.5.3.3 Deleting a Host Name 312

8 Layer 2 313

8.1 Managing Switched Ethernet Ports 313
8.1.1 Viewing a List of Switched Ethernet Ports 313
8.1.2 Configuring a Switched Ethernet Port 314
8.1.3 Configuring RMON Threshold Alerts 318
8.1.4 Viewing Switched Ethernet Port Statistics 320
8.1.5 Viewing the Status of a Switched Ethernet Port 321
8.1.6 Viewing RMON Port Statistics 322
8.1.7 Clearing Switched Ethernet Port Statistics 325
8.1.8 Resetting a Switched Ethernet Port 325
8.1.9 Testing Switched Ethernet Port Cables 326
8.1.9.1 Running a Cable Diagnostic Test 326
8.1.9.2 Viewing Cable Diagnostic Statistics 327
8.1.9.3 Clearing Cable Diagnostic Statistics 328

8.2 Managing Ethernet Trunk Interfaces 328
8.2.1 Viewing a List of Ethernet Trunk Interfaces 329
8.2.2 Adding an Ethernet Trunk Interface 329
8.2.3 Deleting an Ethernet Trunk Interface 331
8.2.4 Managing Ethernet Trunk Ports 332
8.2.4.1 Viewing a List of Ethernet Trunk Ports 332
8.2.4.2 Adding an Ethernet Trunk Port 332
8.2.4.3 Deleting an Ethernet Trunk Port 333

8.3 Managing MAC Addresses 333
8.3.1 Viewing a Dynamic List of MAC Addresses 333
8.3.2 Purging the Dynamic MAC Address List 334
8.3.3 Configuring MAC Address Learning Options 334
8.3.4 Managing Static MAC Addresses 335
8.3.4.1 Viewing a List of Static MAC Addresses 335
8.3.4.2 Adding a Static MAC Address 336
8.3.4.3 Deleting a Static MAC Address 337

8.4 Managing Multicast Filtering 337
8.4.1 Multicast Filtering Concepts 337
8.4.1.1 IGMP 337
8.4.1.2 GMRP (GARP Multicast Registration Protocol) 342
8.4.2 Enabling and Configuring GMRP 345
8.4.3 Managing IGMP Snooping 345

8.4.3.1 Configuring IGMP Snooping 346
8.4.3.2 Viewing a List of Router Ports 347
8.4.3.3 Adding a Router Port 347
8.4.3.4 Deleting a Router Port 347
8.4.4 Managing the Static Multicast Group Table 348
8.4.4.1 Viewing a List of Static Multicast Group Entries 348
8.4.4.2 Adding a Static Multicast Group Entry 348
8.4.4.3 Deleting a Static Multicast Group Entry 349
8.4.5 Managing Egress Ports for Multicast Groups 349
8.4.5.1 Viewing a List of Egress Ports 349
8.4.5.2 Adding an Egress Port 350
8.4.5.3 Deleting an Egress Port 350
8.4.6 Viewing a Summary of Multicast Groups 351
8.4.7 Viewing a List of IP Multicast Groups 352

8.5 Managing VLANs 352
8.5.1 VLAN Concepts 353
8.5.1.1 Tagged vs. Untagged Frames 353
8.5.1.2 Native VLAN 353
8.5.1.3 Edge and Trunk Port Types 353
8.5.1.4 Ingress Filtering 354
8.5.1.5 Forbidden Ports List 354
8.5.1.6 VLAN-Aware Mode of Operation 355
8.5.1.7 GARP VLAN Registration Protocol (GVRP) 355
8.5.1.8 PVLAN Edge 357
8.5.1.9 Restricted VLANs 357
8.5.1.10 VLAN Advantages 358
8.5.2 Configuring the Internal VLAN Range 359
8.5.3 Enabling/Disabling Ingress Filtering 361
8.5.4 Managing VLANs for Switched Ethernet Ports 361
8.5.4.1 Viewing VLAN Assignments for Switched Ethernet Ports 361
8.5.4.2 Configuring VLANs for Switched Ethernet Ports 362
8.5.5 Managing Static VLANs 363
8.5.5.1 Viewing a List of Static VLANs 363
8.5.5.2 Adding a Static VLAN 363
8.5.5.3 Deleting a Static VLAN 364
8.5.6 Managing Forbidden Ports 364
8.5.6.1 Viewing a List of Forbidden Ports 364
8.5.6.2 Adding a Forbidden Port 365
8.5.6.3 Deleting a Forbidden Port 365
8.5.7 Managing VLANs for Interfaces and Tunnels 365

9 Serial Server 367

9.1 Managing Serial Ports 367
9.1.1 Viewing a List of Serial Ports 367
9.1.2 Viewing Serial Port Statistics 367
9.1.3 Viewing Transport Connection Statistics 368
9.1.4 Viewing DNP Device Table Statistics 369
9.1.5 Clearing Serial Port Statistics 370
9.1.6 Configuring a Serial Port 370

9.1.7 Restarting the Serial Server 371
9.1.8 Resetting a Serial Port 371
9.2 Managing Serial Port Protocols 371
9.2.1 Serial Port Protocol Concepts 372
9.2.1.1 Raw Socket Applications 372
9.2.1.2 Modbus TCP Applications 373
9.2.1.3 DNP Applications 374
9.2.1.4 MicroLok Applications 375
9.2.1.5 Incoming/Outgoing Serial Connections 377
9.2.2 Viewing a List of Serial Port Protocols 377
9.2.3 Adding a Serial Port Protocol 378
9.2.4 Configuring the DNP Protocol 378
9.2.5 Configuring the Modbus TCP Protocol 379
9.2.6 Configuring the Raw Socket Protocol 380
9.2.7 Configuring the MicroLok Protocol 381
9.2.8 Deleting a Serial Port Protocol 382
9.3 Managing DNP Device Address Tables 383
9.3.1 Viewing a List of DNP Device Address Tables 383
9.3.2 Adding a DNP Device Address Table 383
9.3.3 Deleting a Device Address Table 384
9.4 Managing MicroLok Device Address Tables 384
9.4.1 Viewing a List of MicroLok Device Address Tables 384
9.4.2 Adding a MicroLok Device Address Table 385
9.4.3 Deleting a MicroLok Device Address Table 386
9.5 Managing Serial Multicast Streaming 386
9.5.1 Understanding Serial Multicast Streaming 386
9.5.1.1 Sink vs. Source Ports 386
9.5.1.2 Multicast Streaming Examples 387
9.5.2 Configuring Serial Multicast Streaming 388
9.5.3 Example: Serial Interfaces Configured as a Sink for Multicast Streams 388
9.5.4 Example: Serial Interfaces Configured as a Source for Multicast Streams 391
9.5.5 Example: Serial Interfaces Configured as a Source and Sink for Multicast Streams .. 394
9.6 Managing Remote Hosts 396
9.6.1 Viewing a List of Remote Hosts 396
9.6.2 Adding a Remote Host 397
9.6.3 Deleting a Remote Host 398
9.7 Managing Local Hosts 398
9.7.1 Viewing a List of Local Hosts 399
9.7.2 Adding a Local Host 399
9.7.3 Deleting a Local Host 400
9.8 Managing Remote Host Interfaces 400
9.8.1 Viewing a List of Remote Host Interfaces 400
9.8.2 Adding a Remote Host Interface 401
9.8.3 Deleting a Remote Host Interface 402
9.9 Managing Local Host Interfaces 402

9.9.1 Viewing a List of Local Host Interfaces 402
9.9.2 Adding a Local Host Interface 403
9.9.3 Deleting a Local Host Interface 403

10 WAN and Wireless 405

10.1 Managing the WLAN Interface 405
10.1.1 Enabling and Configuring the WLAN Interface 405
10.1.2 Managing Wireless Access Points 407
10.1.2.1 Viewing a List of Wireless Access Points 407
10.1.2.2 Viewing the Status of Wireless Access Points 408
10.1.2.3 Viewing the Status of WLAN Client Associations 409
10.1.2.4 Adding a Wireless Access Point 410
10.1.2.5 Configuring WPA-EAP 411
10.1.2.6 Deleting a Wireless Access Point 412
10.1.3 Managing WLAN Clients 412
10.1.3.1 Viewing a List of WLAN Clients 412
10.1.3.2 Viewing the Status of the WLAN Clients 412
10.1.3.3 Adding a WLAN Client 413
10.1.3.4 Configuring WPA-EAP Authentication 414
10.1.3.5 Adding a CA Certificate for WPA-EAP Authentication 415
10.1.3.6 Deleting a WLAN Client 416
10.1.3.7 Scanning for WLAN Clients 416
10.1.4 Example: Configuring a WLAN with a Firewall 417

10.2 Managing Cellular Modem Interfaces 420
10.2.1 Enabling/Disabling Cellular Modem Interfaces 420
10.2.2 Configuring a Cellular Modem Interface 421
10.2.3 Activating Dual SIM Cards 421
10.2.4 Viewing a List of Cellular Modem Interfaces 422
10.2.5 Viewing the Status of a Cellular Modem Interface 422
10.2.6 Viewing PPP Interface Statistics 422

10.3 Running AT Commands 423

10.4 Connecting as a PPP Client 424

10.5 Managing GSM Profiles 424
10.5.1 Viewing a List of GSM Profiles 424
10.5.2 Adding a GSM Profile 425
10.5.3 Deleting a GSM Profile 426

10.6 Managing the LTE Modem 427
10.6.1 Viewing LTE Cellular Modem Information 427
10.6.2 Configuring the LTE Modem 428
10.6.3 Enabling/Disabling the LTE Modem 430
10.6.4 Resetting the Cellular Modem 430
10.6.4.1 Performing a Manual Soft Reset 431
10.6.4.2 Enabling/Disabling a Hard Reset 431
10.6.5 Enabling/Disabling GPS 432
10.6.6 Viewing the Configured GPS Mode 432
10.6.7 Enabling and Configuring GPS NMEA Data Streams 432
10.6.8 Changing the Active SIM Card 433

10.6.9 Managing Firmware Updates 434
10.6.9.1 Viewing the Firmware Update Status 434
10.6.9.2 Configuring the Firmware Update Mode and Source 435
10.6.9.3 Launching a Firmware Update 436
10.7 Managing PPPoE 437
10.7.1 Understanding PPPoE 438
10.7.2 Managing PPPoE Profiles 439
10.7.2.1 Viewing a List of PPPoE Profiles 439
10.7.2.2 Adding PPPoE Profile 439
10.7.2.3 Deleting a PPPoE Profile 441
10.7.3 Managing PPPoE Interfaces 441
10.7.3.1 Configuring a PPPoE Interface 441
10.7.3.2 Viewing PPPoE Statistics 442
10.7.4 Example: Configuring a PPPoE Connection with an ISP 442
11 Tunneling and VPNs 445
11.1 Managing Virtual Switches 445
11.1.1 Viewing a List of Virtual Switches 446
11.1.2 Adding a Virtual Switch 446
11.1.3 Deleting a Virtual Switch 448
11.1.4 Managing Virtual Switch Interfaces 448
11.1.4.1 Viewing a List of Virtual Switch Interfaces 448
11.1.4.2 Adding a Virtual Switch Interface 449
11.1.4.3 Deleting a Virtual Switch Interface 449
11.1.5 Filtering Virtual Switch Traffic 450
11.1.5.1 Enabling/Disabling Virtual Switch Filtering 450
11.1.5.2 Viewing a List of Virtual Switch Filters 451
11.1.5.3 Adding a Virtual Switch Filter 451
11.1.5.4 Deleting a Virtual Switch Filter 452
11.1.6 Managing Filtering Rules 452
11.1.6.1 Viewing a List of Rules 452
11.1.6.2 Viewing a List of Rules Assigned to a Virtual Switch Filter 452
11.1.6.3 Adding a Rule 453
11.1.6.4 Adding a Rule to a Virtual Switch Filter 454
11.1.6.5 Deleting a Rule 454
11.1.6.6 Deleting a Rule from a Virtual Switch Filter 455
11.1.7 Managing In/Out Interfaces 455
11.1.7.1 Viewing a List of In/Out Interfaces 455
11.1.7.2 Adding an In/Out Interface 456
11.1.7.3 Deleting an In/Out Interface 456
11.1.8 Managing VLANs for Virtual Switches 456
11.1.8.1 Viewing a List of Virtual Switch VLANs 457
11.1.8.2 Adding a Virtual Switch VLAN 457
11.1.8.3 Deleting a Virtual Switch VLAN 458
11.2 Managing the Layer2 Tunnel Daemon 458
11.2.1 Viewing Round Trip Time Statistics 458
11.2.2 Configuring the Layer 2 Tunnel Daemon 459
11.3 Managing L2TP Tunnels 460

11.3.1 Configuring L2TP Tunnels 460
11.3.2 Configuring DNS Servers 461
11.3.3 Configuring PPP Options 461
11.3.4 Configuring WINS Servers 462

11.4 Managing L2TPv3 Tunnels 462
11.4.1 L2TPv3 Tunnel Scenarios 463
11.4.2 Creating an L2TPv3 Tunnel 464
11.4.3 Managing Static L2TPv3 Tunnels 465
11.4.3.1 Enabling/Disabling Static L2TPv3 Tunnels 465
11.4.3.2 Viewing a List of Static L2TPv3 Tunnels 466
11.4.3.3 Adding a Static L2TPv3 Tunnel 466
11.4.3.4 Deleting a Static L2TPv3 Tunnel 467
11.4.4 Managing Dynamic L2TPv3 Tunnels 468
11.4.4.1 Enabling and Configuring Dynamic L2TPv3 Tunnels 468
11.4.4.2 Viewing a List of Dynamic L2TPv3 Tunnels 469
11.4.4.3 Adding a Dynamic L2TPv3 Tunnel 469
11.4.4.4 Deleting a Dynamic L2TPv3 Tunnel 471
11.4.5 Managing Sessions for L2TPv3 Tunnels 471
11.4.5.1 Viewing a List of Sessions 471
11.4.5.2 Adding a Session 472
11.4.5.3 Deleting a Session 474
11.4.6 Managing VLANs for L2TPv3 Tunnels 474
11.4.6.1 Viewing a List of VLANs 474
11.4.6.2 Adding a VLAN 475
11.4.6.3 Deleting a VLAN 475
11.4.7 Example: Establishing an L2TPv3 Tunnel Between Routers 475

11.5 Managing GOOSE Tunnels 478
11.5.1 Viewing the GOOSE Tunnel Statistics 479
11.5.2 Viewing a List of GOOSE Tunnels 480
11.5.3 Adding a GOOSE Tunnel 480
11.5.4 Deleting a GOOSE Tunnel 480
11.5.5 Managing Remote Daemons for GOOSE Tunnels 481
11.5.5.1 Viewing a List of Remote Daemons 481
11.5.5.2 Adding a Remote Daemon 481
11.5.5.3 Deleting a Remote Daemon 482
11.5.6 Example: Establishing a GOOSE Tunnel Between Routers 482

11.6 Managing Generic Tunnels 483
11.6.1 Viewing the Generic Tunnel Statistics 484
11.6.2 Viewing a List of Generic Tunnels 485
11.6.3 Adding a Generic Tunnel 485
11.6.4 Deleting a Generic Tunnel 486
11.6.5 Managing Remote Daemon IP Addresses for Generic Tunnels 486
11.6.5.1 Viewing a List of IP Addresses 486
11.6.5.2 Adding an IP Address 487
11.6.5.3 Deleting an IP Address 487
11.6.6 Managing Remote Daemon Egress Interfaces for Generic Tunnels 488
11.6.6.1 Viewing a List of Egress Interfaces 488
11.6.6.2 Adding an Egress Interface 488

11.6.6.3 Deleting an Egress Interface 488
11.6.7 Managing Ethernet Types for Generic Tunnels 489
11.6.7.1 Viewing a List of Ethernet Types 489
11.6.7.2 Adding an Ethernet Type 489
11.6.7.3 Deleting an Ethernet Type 490
11.7 Managing Generic Routing Encapsulation Tunnels 490
11.7.1 Viewing Statistics for GRE Tunnels 491
11.7.2 Viewing a List of GRE Tunnels 492
11.7.3 Adding a GRE Tunnel 492
11.7.4 Configuring a DSCP Marking for GRE Tunnel Traffic 494
11.7.5 Enabling/Disabling Keepalive Messages 495
11.7.6 Deleting a GRE Tunnel 496
11.7.7 Example: Configuring a GRE Tunnel with IPsec 496
11.8 Managing IPsec Tunnels 502
11.8.1 IPsec Tunneling Concepts 503
11.8.1.1 IPsec Modes 503
11.8.1.2 Supported Encryption Protocols 504
11.8.1.3 Public and Secret Key Cryptography 504
11.8.1.4 X509 Certificates 504
11.8.1.5 NAT Traversal 505
11.8.1.6 Remote IPsec Client Support 505
11.8.1.7 IPsec and Router Interfaces 505
11.8.2 Configuring IPsec Tunnels 505
11.8.3 Configuring Certificates and Keys 506
11.8.4 Viewing the IPsec Tunnel Status 507
11.8.5 Managing Pre-Shared Keys 509
11.8.5.1 Viewing a List of Pre-Shared Keys 509
11.8.5.2 Adding a Pre-Shared Key 509
11.8.5.3 Deleting a Pre-Shared Key 510
11.8.6 Managing Connections 510
11.8.6.1 Viewing a List of Connections 510
11.8.6.2 Adding a Connection 511
11.8.6.3 Configuring Dead Peer Detection 513
11.8.6.4 Deleting a Connection 514
11.8.6.5 Viewing the Status of a Connection 515
11.8.7 Managing the Internet Key Exchange (IKE) Protocol 515
11.8.7.1 Viewing a List of IKE Algorithms 515
11.8.7.2 Adding an IKE Algorithm 516
11.8.7.3 Deleting an IKE Algorithm 517
11.8.8 Managing the Encapsulated Security Payload (ESP) Protocol 517
11.8.8.1 Configuring ESP Encryption 517
11.8.8.2 Viewing a List of ESP Algorithms 518
11.8.8.3 Adding an ESP Algorithm 518
11.8.8.4 Deleting an ESP Algorithm 519
11.8.9 Managing Connection Ends 519
11.8.9.1 Configuring the Public IP Address for a Connection End 520
11.8.9.2 Configuring the System Public Key for a Connection End 520
11.8.9.3 Configuring the System Identifier for a Connection End 521

11.8.9.4 Configuring the Next Hop for a Connection End 521
11.8.9.5 Configuring the NAT Traversal Negotiation Method for a Connection End 522
11.8.10 Managing Private Subnets 523
11.8.10.1 Viewing a List of Addresses for Private Subnets 523
11.8.10.2 Adding an Address for a Private Subnet 523
11.8.10.3 Deleting an Address for a Private Subnet 524
11.8.11 Example: Configuring an Encrypted VPN Tunnel 524
11.8.12 Example: Configuring an IPsec Tunnel to Use SCEP Certificates 528

11.9 Managing 6in4 and 4in6 Tunnels 529
11.9.1 Enabling/Disabling 6in4 or 4in6 Tunnels 529
11.9.2 Viewing a List of 6in4 or 4in6 Tunnels 530
11.9.3 Viewing the Status of 6in4/4in6 Tunnels 530
11.9.4 Adding a 6in4 or 4in6 Tunnel 530
11.9.5 Deleting a 6in4 or 4in6 Tunnel 531

11.10 Managing DMVPN 531
11.10.1 Understanding DMVPN 531
11.10.2 Configuring DMVPN 533
11.10.3 Managing DMVPN Interfaces 534
11.10.3.1 Viewing a List of DMVPN Interfaces 534
11.10.3.2 Adding a DMVPN Interface 534
11.10.3.3 Deleting a DMVPN Interface 535
11.10.4 Viewing the Status of DMVPN 536

12 Unicast and Multicast Routing 539

12.1 Viewing the Status of IPv4 Routes 539

12.2 Viewing the Status of IPv6 Routes 540

12.3 Viewing the Memory Statistics 541

12.4 Configuring ICMP 541

12.5 Managing Event Trackers 542
12.5.1 Viewing a List of Event Trackers 542
12.5.2 Viewing Event Tracker Statistics 543
12.5.3 Adding an Event Tracker 544
12.5.4 Deleting an Event Tracker 544

12.6 Managing IS-IS 545
12.6.1 IS-IS Concepts 545
12.6.1.1 IS-IS Routers 545
12.6.1.2 Network Entity Title (NET) Addresses 546
12.6.1.3 Advantages and Disadvantages of Using IS-IS 546
12.6.2 Configuring IS-IS 547
12.6.3 Viewing the Status of Neighbors 548
12.6.4 Viewing the Status of the Link-State Database 548
12.6.5 Managing Area Tags 550
12.6.5.1 Viewing a List of Area Tags 550
12.6.5.2 Adding an Area Tag 551
12.6.5.3 Deleting an Area Tag 552
12.6.6 Managing Interfaces 553

12.6.6.1 Viewing a List of Interfaces 553
12.6.6.2 Configuring an Interface 553
12.6.7 Managing LSP Generation 555
12.6.7.1 Viewing a List of LSP Generation Intervals 555
12.6.7.2 Adding an LSP Generation Interval 555
12.6.7.3 Deleting an LSP Generation Interval 556
12.6.8 Managing SPF Calculations 556
12.6.8.1 Viewing a List of SPF Calculation Intervals 557
12.6.8.2 Adding an SPF Calculation Interval 557
12.6.8.3 Deleting an SPF Calculation Interval 557
12.6.9 Managing the Lifetime of LSPs 558
12.6.9.1 Viewing a List of LSP Lifetime Intervals 558
12.6.9.2 Adding an LSP Lifetime Interval 559
12.6.9.3 Deleting an LSP Lifetime Interval 559
12.6.10 Managing LSP Refresh Intervals 560
12.6.10.1 Viewing a List of LSP Refresh Intervals 560
12.6.10.2 Adding an LSP Refresh Interval 561
12.6.10.3 Deleting an LSP Refresh Interval 561
12.6.11 Managing Network Entity Titles (NETs) 562
12.6.11.1 Viewing a List of NETs 562
12.6.11.2 Adding a NET 563
12.6.11.3 Deleting a NET 563
12.6.12 Managing Redistribution Metrics 563
12.6.12.1 Viewing a List of Redistribution Metrics 564
12.6.12.2 Adding a Redistribution Metric 564
12.6.12.3 Deleting a Redistribution Metric 565

12.7 Managing RIP 565
12.7.1 Configuring RIP 566
12.7.2 Viewing the Status of Dynamic RIP Routes 567
12.7.3 Managing Prefix Lists and Entries 569
12.7.3.1 Viewing a List of Prefix Lists 569
12.7.3.2 Viewing a List of Prefix Entries 570
12.7.3.3 Adding a Prefix List 570
12.7.3.4 Adding a Prefix Entry 571
12.7.3.5 Deleting a Prefix List 571
12.7.3.6 Deleting a Prefix Entry 572
12.7.4 Managing Networks 572
12.7.4.1 Configuring a Network 572
12.7.4.2 Tracking Commands 573
12.7.5 Managing Network IP Addresses 573
12.7.5.1 Viewing a List of Network IP Addresses 573
12.7.5.2 Adding a Network IP Address 574
12.7.5.3 Deleting a Network IP Address 574
12.7.6 Managing Network Interfaces 574
12.7.6.1 Viewing a List of Network Interfaces 574
12.7.6.2 Adding a Network Interface 575
12.7.6.3 Deleting a Network Interface 575
12.7.7 Managing Neighbors 575
12.7.7.1 Viewing a List of Neighbors 576

12.7.7.2 Adding a Neighbor 576
12.7.7.3 Deleting a Neighbor 576
12.7.8 Managing the Prefix List Distribution 577
12.7.8.1 Viewing a List of Prefix List Distribution Paths 577
12.7.8.2 Adding a Prefix List Distribution Path 577
12.7.8.3 Deleting a Prefix List Distribution Path 578
12.7.9 Managing Key Chains and Keys 578
12.7.9.1 Viewing a List of Key Chains 578
12.7.9.2 Viewing a List of Keys 579
12.7.9.3 Adding a Key Chain 579
12.7.9.4 Adding a Key 579
12.7.9.5 Deleting a Key Chain 580
12.7.9.6 Deleting a Key 581
12.7.10 Managing Redistribution Metrics 581
12.7.10.1 Viewing a List of Redistribution Metrics 581
12.7.10.2 Adding a Redistribution Metric 582
12.7.10.3 Deleting a Redistribution Metric 582
12.7.11 Managing Routing Interfaces 582
12.7.11.1 Viewing a List of Routing Interfaces 582
12.7.11.2 Configuring a Routing Interface 583

12.8 Managing BGP 584
12.8.1 Configuring BGP 584
12.8.2 Managing Route Maps 585
12.8.2.1 Viewing a List of Route Map Filters 585
12.8.2.2 Viewing a List of Route Map Filter Entries 586
12.8.2.3 Adding a Route Map Filter 586
12.8.2.4 Adding a Route Map Filter Entry 587
12.8.2.5 Deleting a Route Map Filter 588
12.8.2.6 Deleting a Route Map Filter Entry 588
12.8.2.7 Configuring Match Rules 588
12.8.2.8 Configuring a Set 589
12.8.3 Managing Prepended and Excluded Autonomous System Path Filters 590
12.8.3.1 Viewing a List of Prepended Autonomous System Path Filters 591
12.8.3.2 Viewing a List of Excluded Autonomous System Paths 591
12.8.3.3 Adding a Prepended Autonomous System Path Filter 592
12.8.3.4 Adding an Excluded Autonomous System Path filter 592
12.8.3.5 Deleting a Prepended Autonomous System Path Filter 593
12.8.3.6 Deleting an Excluded Autonomous System Path Filter 593
12.8.4 Managing Prefix Lists and Entries 594
12.8.4.1 Viewing a List of Prefix Lists 594
12.8.4.2 Viewing a List of Prefix Entries 594
12.8.4.3 Adding a Prefix List 595
12.8.4.4 Adding a Prefix Entry 595
12.8.4.5 Deleting a Prefix List 596
12.8.4.6 Deleting a Prefix Entry 596
12.8.5 Managing Autonomous System Paths and Entries 597
12.8.5.1 Viewing a List of Autonomous System Paths 597
12.8.5.2 Viewing a List of Autonomous System Path Entries 597
12.8.5.3 Adding an Autonomous System Path Filter 598

12.8.5.4 Adding an Autonomous System Path Filter Entry 598
12.8.5.5 Deleting an Autonomous System Path 598
12.8.5.6 Deleting an Autonomous System Path Filter Entry 599
12.8.6 Managing Neighbors 599
12.8.6.1 Viewing a List of Neighbors 599
12.8.6.2 Adding a Neighbor 600
12.8.6.3 Configuring the Distribution of Prefix Lists 601
12.8.6.4 Tracking Commands for BGP Neighbors 602
12.8.6.5 Deleting a Neighbor 602
12.8.7 Managing Networks 603
12.8.7.1 Viewing a List of Networks 603
12.8.7.2 Adding a Network 603
12.8.7.3 Tracking Commands for a BGP Network 604
12.8.7.4 Deleting a Network 604
12.8.8 Managing Aggregate Addresses 605
12.8.8.1 Viewing a List of Aggregate Addresses 605
12.8.8.2 Adding an Aggregate Address 605
12.8.8.3 Deleting an Aggregate Address 606
12.8.9 Managing Aggregate Address Options 606
12.8.9.1 Viewing a List of Aggregate Address Options 606
12.8.9.2 Adding an Aggregate Address Option 606
12.8.9.3 Deleting an Aggregate Address Option 607
12.8.10 Managing Redistribution Metrics 607
12.8.10.1 Viewing a List of Redistribution Metrics 607
12.8.10.2 Adding a Redistribution Metric 608
12.8.10.3 Deleting a Redistribution Metric 608
12.8.11 Managing Route Reflector Options 608
12.8.11.1 Understanding Route Reflectors 608
12.8.11.2 Configuring the Device as a Route Reflector 611
12.8.11.3 Configuring BGP Neighbors as Clients 612
12.8.11.4 Example: Basic Route Reflection 613
12.8.11.5 Example: Linking Clusters 615
12.8.11.6 Example: Clusters in Clusters 617
12.8.11.7 Example: Route Reflection in a VRF Instance 619
12.8.11.8 Example: Route Reflection with VPNv4 Clients 622
12.8.12 Viewing the Status of Dynamic BGP Routes 622
12.8.13 Resetting a BGP Session 624
12.9 Managing OSPF 626
12.9.1 OSPF Concepts 626
12.9.2 Configuring OSPF 627
12.9.3 Viewing the Status of Dynamic OSPF Routes 629
12.9.4 Managing Prefix Lists and Entries 632
12.9.4.1 Viewing a List of Prefix Lists 632
12.9.4.2 Viewing a List of Prefix Entries 633
12.9.4.3 Adding a Prefix List 634
12.9.4.4 Adding a Prefix Entry 634
12.9.4.5 Deleting a Prefix List 635
12.9.4.6 Deleting a Prefix Entry 636
12.9.5 Managing Areas 636

12.9.5.1 Viewing a List of Areas 636
12.9.5.2 Adding an Area 637
12.9.5.3 Deleting an Area 638
12.9.6 Managing Route Maps 638
12.9.6.1 Viewing a List of Route Map Filters 639
12.9.6.2 Viewing a List of Route Map Filter Entries 639
12.9.6.3 Adding a Route Map Filter 640
12.9.6.4 Adding a Route Map Filter Entry 640
12.9.6.5 Deleting a Route Map Filter 641
12.9.6.6 Deleting a Route Map Filter Entry 642
12.9.6.7 Configuring Match Rules 642
12.9.7 Managing Incoming Route Filters 643
12.9.7.1 Viewing List of Incoming Route Filters 643
12.9.7.2 Adding an Incoming Route Filter 644
12.9.7.3 Deleting an Incoming Route Filter 644
12.9.8 Managing Redistribution Metrics 645
12.9.8.1 Viewing a List of Redistribution Metrics 645
12.9.8.2 Adding a Redistribution Metric 645
12.9.8.3 Deleting a Redistribution Metric 646
12.9.9 Managing Routing Interfaces 647
12.9.9.1 Viewing a List of Routing Interfaces 647
12.9.9.2 Configuring a Routing Interface 647
12.9.10 Managing Message Digest Keys 649
12.9.10.1 Viewing a List of Message Digest Keys 650
12.9.10.2 Adding a Message Digest Key 650
12.9.10.3 Deleting a Message Digest Key 651
12.9.11 Managing ABR Route Summarization 651
12.9.11.1 Understanding ABR Route Summarization 652
12.9.11.2 Viewing a List of Summary Routes 652
12.9.11.3 Adding a Summary Route 652
12.9.11.4 Deleting a Summary Route 653
12.9.11.5 Example: Basic Route Summarization 653

12.10 Managing MPLS 655
12.10.1 Viewing the Status of IP Binding 655
12.10.2 Viewing the Status of the Forwarding Table 656
12.10.3 Enabling/Disabling MPLS 657
12.10.4 Managing the MPLS Interfaces 657
12.10.4.1 Viewing the Status of MPLS Interfaces 657
12.10.4.2 Viewing a List of MPLS Interfaces 658
12.10.4.3 Enabling/Disabling an MPLS Interface 659
12.10.5 Managing Static Label Binding 659
12.10.5.1 Viewing the Status of Static Label Binding 659
12.10.5.2 Viewing a List of Static Labels 660
12.10.5.3 Adding a Static Label 660
12.10.5.4 Deleting a Static Label 661
12.10.6 Managing Static Cross-Connects 661
12.10.6.1 Viewing the Status of Static Cross-Connects 662
12.10.6.2 Viewing a List of Static Cross-Connects 662
12.10.6.3 Adding a Static Cross-Connect 663

12.10.6.4 Deleting a Static Cross-Connect 663
12.10.7 Managing LDP 664
12.10.7.1 Viewing the Status of LDP Binding 664
12.10.7.2 Viewing the Status of the LDP Discovery Interfaces 665
12.10.7.3 Viewing the Status of the LDP Neighbor Local Node Information 665
12.10.7.4 Viewing the Status of the LDP Neighbor Connection Information 666
12.10.7.5 Viewing the Status of the LDP Neighbor Discovery Information 666
12.10.7.6 Configuring LDP 667
12.10.7.7 Configuring Neighbor Discovery 668
12.10.7.8 Viewing a List of LDP Interfaces 668
12.10.7.9 Enabling/Disabling an LDP Interface 669

12.11 Managing Virtual Routing and Forwarding (VRF) 669
12.11.1 VRF Concepts 670
12.11.1.1 VRF and VRF-Lite 670
12.11.1.2 Advantages and Disadvantages of Using VRF 670
12.11.2 Viewing VRF Interface Statistics 671
12.11.3 Configuring VRF 671
12.11.4 Configuring a VRF Interface 672
12.11.5 Managing VRF Definitions 673
12.11.5.1 Viewing a List of VRF Definitions 673
12.11.5.2 Adding a VRF Definition 674
12.11.5.3 Deleting a VRF Definition 674
12.11.6 Managing Route Targets 675
12.11.6.1 Viewing a List of Route Targets 675
12.11.6.2 Adding a Route Target 676
12.11.6.3 Deleting a Route Target 676
12.11.7 Managing VRF Instances and OSPF 676
12.11.7.1 Viewing a List of VRF Instances 677
12.11.7.2 Adding a VRF Instance and Configuring OSPF 677
12.11.7.3 Deleting a VRF Instance 683
12.11.8 Managing IP/VPN Tunnels 683
12.11.8.1 Viewing a List of IP/VPN Tunnels 683
12.11.8.2 Adding an IP/VPN Tunnel 684
12.11.8.3 Deleting an IP/VPN Tunnels 684
12.11.9 Managing VPNv4 Neighbors 684
12.11.9.1 Viewing a List of Neighbors 685
12.11.9.2 Adding a Neighbor 685
12.11.9.3 Deleting a Neighbor 686
12.11.10 Managing IPv4 Address Families 686
12.11.10.1 Viewing a List of IPv4 Address Families 686
12.11.10.2 Adding an IPv4 Address Family 687
12.11.10.3 Deleting an IPv4 Address Family 687
12.11.11 Managing Redistribution for IPv4 Address Families 687
12.11.11.1 Viewing a List of Redistributions 688
12.11.11.2 Adding a Redistribution 688
12.11.11.3 Deleting a Redistribution 689
12.11.12 Managing Neighbors for IPv4 Address Families 689
12.11.12.1 Viewing a List of Neighbors 689
12.11.12.2 Adding a Neighbor 690

12.11.12.3 Configuring the Distribution of Prefix Lists 691
12.11.12.4 Tracking Commands 692
12.11.12.5 Deleting a Neighbor 692
12.11.13 Managing Static VRF Routes 693
12.11.13.1 Viewing a List of Static VRF Routes 693
12.11.13.2 Adding a Static VRF Route 693
12.11.13.3 Configuring a Black Hole Connection for a Static VRF Route 694
12.11.13.4 Deleting a Static VRF Route 695
12.11.14 Managing Gateways for Static VRF Routes 695
12.11.14.1 Viewing a List of Gateways for Static VRF Routes 695
12.11.14.2 Adding a Gateway for a Static VRF Route 695
12.11.14.3 Deleting a Gateway for a Static VRF Route 696
12.11.15 Managing Interfaces for Static VRF Routes 696
12.11.15.1 Viewing a List of Interfaces for Static VRF Routes 697
12.11.15.2 Adding an Interface for a Static VRF Route 697
12.11.15.3 Deleting a Gateway for a Static VRF Route 698
12.11.16 Example: Configuring OSPF on a VRF-Lite Instance 698
12.11.17 Example: Configuring BGP on a VRF-Lite Instance 701

12.12 Managing Static Routing 704
12.12.1 Viewing a List of Static Routes 704
12.12.2 Adding an IPv4 Static Route 704
12.12.3 Adding an IPv6 Static Route 705
12.12.4 Deleting a Static Route 706
12.12.5 Configuring a Black Hole Connection for an IPv4 Static Route 706
12.12.6 Managing Gateways for Static Routes 706
12.12.6.1 Configuring Gateways for IPv6 Static Routes 707
12.12.6.2 Viewing a List of Gateways for IPv4 Static Routes 707
12.12.6.3 Adding a Gateway for an IPv4 Static Route 707
12.12.6.4 Deleting a Gateway for an IPv4 Static Route 708
12.12.7 Managing Interfaces for Static Routes 708
12.12.7.1 Configuring Interfaces for IPv6 Static Routes 708
12.12.7.2 Viewing a List of Interfaces for IPv4 Static Routes 709
12.12.7.3 Adding an Interface for an IPv4 Static Route 709
12.12.7.4 Deleting an Interface for an IPv4 Static Route 710

12.13 Managing Static Multicast Routing 710
12.13.1 Enabling/Disabling Static Multicast Routing 710
12.13.2 Managing Static Multicast Groups 711
12.13.2.1 Viewing a List of Static Multicast Groups 711
12.13.2.2 Adding a Static Multicast Group 711
12.13.2.3 Deleting a Static Multicast Group 712
12.13.3 Managing Out-Interfaces 713
12.13.3.1 Viewing a List of Out-Interfaces 713
12.13.3.2 Adding an Out-Interface 713
12.13.3.3 Deleting an Out-Interface 713

12.14 Managing Dynamic Multicast Routing 714
12.14.1 Understanding Protocol Independent Multicast 714
12.14.1.1 PIM-SM Concepts 714
12.14.1.2 Internet Group Management Protocol 716

12.14.1.3 PIM-SSM 717
12.14.2 Viewing the Status of PIM-SM 717
12.14.3 Viewing the Status of Dynamic Multicast Routing 722
12.14.4 Configuring PIM-SM 722
12.14.5 Setting the Device as a BSR Candidate 723
12.14.6 Setting the Device as an RP Candidate 723
12.14.7 Managing PIM-SM Interfaces 724
12.14.7.1 Viewing a List of PIM-SM Interfaces 724
12.14.7.2 Enabling/Disabling a PIM-SM Interface 725
12.14.8 Managing Static RP Addresses 726
12.14.8.1 Viewing a List of Static RP Addresses 726
12.14.8.2 Adding a Static RP Address 726
12.14.8.3 Deleting a Static RP Address 727
12.14.9 Managing Multicast Group Prefixes 727
12.14.9.1 Viewing a List of Multicast Group Prefixes 727
12.14.9.2 Adding a Multicast Group Prefix 728
12.14.9.3 Deleting a Multicast Group Prefix 728
12.14.10 Example: Configuring Protocol Independent Multicast 728

13 Network Redundancy 735

13.1 Managing VRRP 735
13.1.1 VRRP Concepts 735
13.1.1.1 Static Routing vs. VRRP 735
13.1.1.2 VRRP Terminology 736
13.1.1.3 Connection Synchronization 739
13.1.2 Viewing the Status of VRRP 739
13.1.3 Enabling/Disabling VRRP 740
13.1.4 Managing VRRP Trackers 740
13.1.4.1 Viewing a List of VRRP Trackers 741
13.1.4.2 Adding a VRRP Tracker 741
13.1.4.3 Deleting a VRRP Tracker 742
13.1.5 Managing VRRP Groups 742
13.1.5.1 Viewing a List of VRRP Groups 743
13.1.5.2 Adding a VRRP Group 743
13.1.5.3 Deleting a VRRP Group 743
13.1.6 Managing VRRP Instances 744
13.1.6.1 Viewing a List of VRRP Instances 744
13.1.6.2 Adding a VRRP Instance 744
13.1.6.3 Deleting a VRRP Instance 746
13.1.7 Managing VRRP Monitors 747
13.1.7.1 Viewing a List of VRRP Monitors 747
13.1.7.2 Adding a VRRP Monitor 747
13.1.7.3 Deleting a VRRP Monitor 748
13.1.8 Managing Track Scripts 748
13.1.8.1 Viewing a List of Track Scripts 748
13.1.8.2 Adding a Track Script 749
13.1.8.3 Deleting a Track Script 749
13.1.9 Managing Virtual IP Addresses 750
13.1.9.1 Viewing a List of Virtual IP Addresses 750

13.1.9.2 Adding a Virtual IP Address 750
13.1.9.3 Deleting a Virtual IP Address 751
13.1.10 Managing Connection Synchronization 751
13.1.10.1 Configuring Connection Synchronization 751
13.1.10.2 Enabling/Disabling Connection Synchronization 752
13.1.10.3 Viewing a List of Dedicated LInks 752
13.1.10.4 Adding a Dedicated Link 753
13.1.10.5 Deleting a Dedicated Link 754
13.1.10.6 Selecting a Default Dedicated Link 754
13.1.10.7 Viewing the Status of Each Dedicated Link 754

13.2 Managing VRRP within VRF 755
13.2.1 Configuring VRRP within VRF 755
13.2.2 Viewing the VRRP Status for a VRF 756
13.2.3 Configuring VRRP Service for a VRF 757
13.2.3.1 Viewing a List of VRFs Configured with VRRP Service 757
13.2.3.2 Adding VRRP Service to a VRF 757
13.2.3.3 Deleting VRRP Service from a VRF 758
13.2.4 Managing VRRP Trackers for a VRF 758
13.2.4.1 Viewing a List of VRRP Trackers for a VRF 759
13.2.4.2 Adding a VRRP Tracker for a VRF 759
13.2.4.3 Deleting a VRRP Tracker for a VRF 760
13.2.5 Managing VRRP Groups for a VRF 760
13.2.5.1 Viewing a List of VRRP Groups for a VRF 760
13.2.5.2 Adding a VRRP Group for a VRF 761
13.2.5.3 Deleting a VRRP Group 761
13.2.6 Managing VRRP Instances for a VRF 762
13.2.6.1 Viewing a List of VRRP Instances for a VRF 762
13.2.6.2 Adding a VRRP Instance for a VRF 762
13.2.6.3 Deleting a VRRP Instance for a VRF 764
13.2.7 Managing VRRP Monitors for a VRF 764
13.2.7.1 Viewing a List of VRRP Monitors for a VRF 764
13.2.7.2 Adding a VRRP Monitor to a VRF 765
13.2.7.3 Deleting a VRRP Monitor from a VRF 765
13.2.8 Managing VRRP Track Scripts for a VRF 766
13.2.8.1 Viewing a List of VRRP Track Scripts for a VRF 766
13.2.8.2 Adding a VRRP Track Script to a VRF 766
13.2.8.3 Deleting a VRRP Track Script from a VRF 767
13.2.9 Managing Virtual IP Addresses for a VRF 767
13.2.9.1 Viewing a List of Virtual IP Addresses 767
13.2.9.2 Adding a Virtual IP Address to a VRF 768
13.2.9.3 Deleting a Virtual IP Address from a VRF 768
13.2.10 Example: Configuring VRRP within a VRF 769

13.3 Managing Link Failover Protection 772
13.3.1 Viewing the Link Failover Log 772
13.3.2 Viewing the Link Failover Status 773
13.3.3 Managing Link Failover Parameters 774
13.3.3.1 Viewing a List of Link Failover Parameters 774
13.3.3.2 Adding a Link Failover Parameter 774

13.3.3.3 Deleting a Link Failover Parameter 775
13.3.4 Managing Link Failover Backup Interfaces 776
13.3.4.1 Viewing a List of Link Failover Backup Interfaces 776
13.3.4.2 Adding a Link Failover Backup Interface 776
13.3.4.3 Deleting a Link Failover Backup Interface 777
13.3.5 Managing Link Failover Ping Targets 778
13.3.5.1 Viewing a List of Link Failover Ping Targets 778
13.3.5.2 Adding a Link Failover Ping Target 778
13.3.5.3 Deleting a Link Failover Ping target 779
13.3.6 Testing Link Failover 779
13.3.7 Canceling a Link Failover Test 780

13.4 Managing Spanning Tree Protocol 780
13.4.1 RSTP Operation 780
13.4.1.1 RSTP States and Roles 781
13.4.1.2 Edge Ports 782
13.4.1.3 Point-to-Point and Multipoint Links 783
13.4.1.4 Path and Port Costs 783
13.4.1.5 Bridge Diameter 784
13.4.1.6 eRSTP 784
13.4.1.7 Fast Root Failover 785
13.4.2 RSTP Applications 786
13.4.2.1 RSTP in Structured Wiring Configurations 786
13.4.2.2 RSTP in Ring Backbone Configurations 787
13.4.2.3 RSTP Port Redundancy 789
13.4.3 MSTP Operation 789
13.4.3.1 MSTP Regions and Interoperability 790
13.4.3.2 MSTP Bridge and Port Roles 791
13.4.3.3 Benefits of MSTP 792
13.4.3.4 Implementing MSTP on a Bridged Network 793
13.4.4 Configuring STP Globally 794
13.4.5 Configuring STP for Switched Ethernet Ports and Ethernet Trunk Interfaces 797
13.4.6 Managing Multiple Spanning Tree Instances Globally 798
13.4.6.1 Viewing Statistics for Multiple Spanning Tree Instances 799
13.4.6.2 Viewing a List of Multiple Spanning Tree Instances 800
13.4.6.3 Adding a Multiple Spanning Tree Instance 801
13.4.6.4 Deleting a Multiple Spanning Tree Instance 801
13.4.7 Managing Multiple Spanning Tree Instances Per-Port 802
13.4.7.1 Viewing Per-Port Multiple Spanning Tree Instance Statistics 802
13.4.7.2 Viewing a List of Per-Port Multiple Spanning Tree Instances 804
13.4.7.3 Adding a Port-Specific Multiple Spanning Tree Instance 805
13.4.7.4 Deleting a Port-Specific Multiple Spanning Tree Instances 806
13.4.8 Viewing the Status of RSTP 807
13.4.9 Viewing RSTP Per-Port Statistics 809
13.4.10 Clearing Spanning Tree Protocol Statistics 811

13.5 Managing the Media Redundancy Protocol (MRP) 811
13.5.1 Understanding MRP 811
13.5.1.1 MRP Operation 812
13.5.1.2 MRA 813

13.5.1.3 MRP Instances 813
13.5.1.4 Requirements and Restrictions 814
13.5.2 Configuring MRP Globally 814
13.5.3 Enabling/Disabling SNMP Traps for MRP 814
13.5.4 Viewing the List of MRP Instances 815
13.5.5 Adding an MRP Instance 815
13.5.6 Deleting an MRP Instance 818
13.5.7 Viewing the Status of MRP Instances 818
13.5.8 Example: Configuring an MRP Ring 820

14 Network Discovery and Management 823

14.1 Managing LLDP 823
14.1.1 Configuring LLDP 824
14.1.2 Viewing Global Statistics and Advertised System Information 825
14.1.3 Viewing Statistics for LLDP Neighbors 828
14.1.4 Viewing Statistics for LLDP Ports 833

14.2 Managing SNMP 834
14.2.1 Enabling and Configuring SNMP Sessions 835
14.2.2 Viewing Statistics for SNMP 837
14.2.3 Discovering SNMP Engine IDs 838
14.2.4 Managing SNMP Communities 838
14.2.4.1 Viewing a List of SNMP Communities 838
14.2.4.2 Adding an SNMP Community 839
14.2.4.3 Deleting an SNMP Community 839
14.2.5 Managing SNMP Target Addresses 839
14.2.5.1 Viewing a List of SNMP Target Addresses 840
14.2.5.2 Adding an SNMP Target Address 840
14.2.5.3 Deleting an SNMP Target Address 842
14.2.6 Managing SNMP Users 842
14.2.6.1 Viewing a List of SNMP Users 843
14.2.6.2 Adding an SNMP User 843
14.2.6.3 Deleting an SNMP User 844
14.2.7 Managing SNMP Security Model Mapping 845
14.2.7.1 Viewing a List of SNMP Security Models 845
14.2.7.2 Adding an SNMP Security Model 845
14.2.7.3 Deleting an SNMP Security Model 846
14.2.8 Managing SNMP Group Access 846
14.2.8.1 Viewing a List of SNMP Groups 846
14.2.8.2 Adding an SNMP Group 847
14.2.8.3 Deleting an SNMP Group 848

14.3 Managing NETCONF 849
14.3.1 Enabling and Configuring NETCONF Sessions 849
14.3.2 Viewing NETCONF Statistics 851

14.4 Managing IPv4 Neighbors 851
14.4.1 IPv4 Neighbor Concepts 852
14.4.2 Viewing IPv4 Neighbors 852
14.4.3 Clearing IPv4 Neighbors 854

15 Traffic Control and Classification 855

15.1 Managing Port Mirroring 855
15.1.1 Configuring Port Mirroring 855
15.1.2 Managing Egress Source Ports 856
15.1.2.1 Viewing a List of Egress Source Ports 856
15.1.2.2 Adding an Egress Source Port 857
15.1.2.3 Deleting an Egress Source Port 857
15.1.3 Managing Ingress Source Ports 857
15.1.3.1 Viewing a List of Ingress Source Ports 858
15.1.3.2 Adding an Ingress Source Port 858
15.1.3.3 Deleting an Ingress Source Port 858

15.2 Managing Traffic Control 859
15.2.1 Enabling and Configuring Traffic Control 859
15.2.2 Managing Traffic Control Interfaces 861
15.2.2.1 Viewing a List of Traffic Control Interfaces 861
15.2.2.2 Adding a Traffic Control Interface 861
15.2.2.3 Deleting a Traffic Control Interface 862
15.2.3 Managing Traffic Control Priorities 863
15.2.3.1 Viewing a List of Traffic Control Priorities 863
15.2.3.2 Adding a Traffic Control Priority 864
15.2.3.3 Deleting a Traffic Control Priority 865
15.2.4 Managing Traffic Control Classes 865
15.2.4.1 Viewing a List of Traffic Control Classes 865
15.2.4.2 Adding a Traffic Control Class 866
15.2.4.3 Deleting a Traffic Control Class 867
15.2.5 Managing Traffic Control Devices 868
15.2.5.1 Viewing a List of Traffic Control Devices 868
15.2.5.2 Adding a Traffic Control Device 868
15.2.5.3 Deleting a Traffic Control Device 869
15.2.6 Managing Traffic Control Rules 870
15.2.6.1 Viewing a List of Traffic Control Rules 870
15.2.6.2 Adding a Traffic Control Rule 870
15.2.6.3 Configuring QoS Marking 872
15.2.6.4 Deleting aTraffic Control Rule 876
15.2.7 Managing QoS Mapping for VLANs 876
15.2.7.1 Viewing a List of QoS Maps for VLANs 876
15.2.7.2 Adding a QoS Map 877
15.2.7.3 Deleting a QoS Map 878
15.2.8 Managing Egress Markers for QoS Maps 879
15.2.8.1 Viewing a List of Egress Marks 879
15.2.8.2 Adding an Egress Mark 880
15.2.8.3 Deleting an Egress Mark 880
15.2.9 Viewing QoS Statistics 881

15.3 Managing Classes of Service 882
15.3.1 Configuring Classes of Service 883
15.3.2 Managing Priority-to-CoS Mapping 884
15.3.2.1 Viewing a List of Priority-to-CoS Mapping Entries 884
15.3.2.2 Adding a Priority-to-CoS Mapping Entry 884

15.3.2.3 Deleting a Priority-to-CoS Mapping Entry 885
15.3.3 Managing DSCP-to-CoS Mapping 885
15.3.3.1 Viewing a List of DSCP-to-CoS Mapping Entries 885
15.3.3.2 Adding a DSCP-to-CoS Mapping Entry 886
15.3.3.3 Deleting a DSCP-to-CoS Mapping Entry 886

15.4 Managing NetFlow Data Export 886
15.4.1 Understanding NetFlow Data Export 887
15.4.1.1 Flow Records 888
15.4.2 Configuring NetFlow Data Export 888
15.4.3 Enabling/Disabling NetFlow 889
15.4.4 Setting the NetFlow Engine ID 889
15.4.5 Controlling the NetFlow Cache 890
15.4.6 Controlling Active/Inactive Flows 890
15.4.7 Managing NetFlow Interfaces 891
15.4.7.1 Viewing a List of NetFlow Interfaces 891
15.4.7.2 Adding a NetFlow Interface 891
15.4.7.3 Deleting a NetFlow Interface 892
15.4.8 Managing NetFlow Collectors 892
15.4.8.1 Viewing a List of NetFlow Collectors 892
15.4.8.2 Adding a NetFlow Collector 892
15.4.8.3 Enabling/Disabling a NetFlow Collector 893
15.4.8.4 Deleting a NetFlow Collector 893
15.4.9 Viewing the Status of NetFlow 894
15.4.10 Example: Exporting Flows to Multiple Collectors 894

15.5 Managing Port Rate Limiting 896
15.5.1 Understanding Port Rate Limiting 896
15.5.2 Configuring Port Rate Limiting 896

16 Time Services 899

16.1 Configuring the Time Synchronization Settings 899

16.2 Configuring the System Time and Date 900

16.3 Configuring the System Time Zone 900

16.4 Configuring the Local Time Settings 900

16.5 Enabling and Configuring the NTP Service 901

16.6 Viewing the NTP Service Status 902

16.7 Viewing the Status of Reference Clocks 903

16.8 Managing NTP Servers 904
16.8.1 Viewing a List of NTP Servers 904
16.8.2 Monitoring Subscribers 905
16.8.3 Adding an NTP Server 906
16.8.4 Deleting an NTP Server 907
16.8.5 Managing Server Keys 907
16.8.5.1 Viewing a List of Server Keys 908
16.8.5.2 Adding a Server Key 908
16.8.5.3 Deleting a Server Key 908

16.8.6 Managing Server Restrictions 909
16.8.6.1 Viewing a List of Server Restrictions 909
16.8.6.2 Adding a Server Restriction 909
16.8.6.3 Deleting a Server Restriction 910
16.9 Managing NTP Broadcast/Multicast Clients 911
16.9.1 Enabling and Configuring NTP Multicast Clients 911
16.9.2 Enabling and Configuring NTP Broadcast Clients 912
16.9.3 Managing NTP Broadcast/Multicast Addresses 912
16.9.3.1 Viewing a List of Broadcast/Multicast Addresses 912
16.9.3.2 Adding a Broadcast/Multicast Address 913
16.9.3.3 Deleting a Broadcast/Multicast Address 913
17 Virtualization 915
17.1 Configuring Virtualization 916
17.2 Enabling/Disabling the Virtualization Service 916
17.3 Configuring Global Settings 917
17.4 Issuing VM Commands 917
17.5 Assigning a Network Interface 918
17.6 Accessing the Active Virtual Machine 919
17.7 Querying the Device Serial Number 919
17.8 Managing Virtual Machines 920
17.8.1 Building/Obtaining a Virtual Machine Image 920
17.8.2 Determining the Active Virtual Machine 920
17.8.3 Viewing a List of Virtual Machine Names 921
17.8.4 Adding a Virtual Machine 922
17.8.5 Extracting a Virtual Machine Archive 923
17.8.6 Loading an Existing Virtual Machine Image 923
17.8.7 Deleting a Virtual Machine 924
17.8.8 Deleting a Virtual Machine Archive 924
17.8.9 Starting a Virtual Machine 924
17.8.10 Stopping a Virtual Machine 925
17.9 Managing Serial Port Assignments 925
17.9.1 Assigning a Serial Port 925
17.9.2 Unassigning a Serial Port 926
17.10 Managing Virtual Interfaces 926
17.10.1 Viewing a List of Virtual Interfaces 926
17.10.2 Adding a Virtual Interface 927
17.10.3 Enabling/Disabling the VPE Network Interface 927
17.10.4 Deleting a Virtual Interface 927
17.11 Managing VPE Adapters 928
17.11.1 Viewing the Status of the VPE Adapter 928
17.11.2 Configuring a VPE Adapter 929
17.11.3 Starting/Stopping a VPE Adapter 930

17.12 Example: Enabling a Virtual Machine to Access a WLAN via a WLAN Client Interface 930
18 Applications 937
18.1 Viewing a List of Installed Applications 937
18.2 Installing an Application 937
18.3 Upgrading an Application 938
18.4 Uninstalling an Application 938
19 Troubleshooting 939
19.1 Ethernet Ports 939
19.2 Multicast Filtering 939
19.3 Spanning Tree 940
19.4 VLANs 942
19.5 Firmware Updates 943
20 Reference 945
20.1 Supported MIBs 945
20.2 Standard SNMP Traps 1005
20.3 Proprietary SNMP Traps 1007

Preface

This document describes the CLI user interface for RUGGEDCOM ROX II v2.15 running on the RUGGEDCOM RX1400. It contains instructions and guidelines on how to use the software, as well as some general theory.

It is intended for use by network technical support personnel who are familiar with the operation of networks. It is also recommended for use by network and system planners, system programmers, and line technicians.

Note
This document is updated to match the version of RUGGEDCOM ROX II v2.15 available at the time of publication, including minor releases (e.g. 2.15.1, 2.15.2, etc.). To determine the current release of RUGGEDCOM ROX II v2.15, refer to Siemens Industrial Online Support:

- **Product Notes**

  https://support.industry.siemens.com/cs/search?search=ROX&type=ProductNote&o=0

- **Downloads**

  https://support.industry.siemens.com/cs/search?search=ROX&type=Download&o=0

Users can also set up a daily or weekly e-mail notification to inform of them of recent releases/updates. For more information, refer to the Siemens Industrial Online Support [https://support.industry.siemens.com] website.

Note
Some of the parameters and options described may not be available depending on variations in the device hardware. While every attempt is made to accurately describe the specific parameters and options available, this document should be used as a companion to the Help text included in the software.

Security Information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent

such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit https://www.siemens.com/industrialsecurity.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under https://www.siemens.com/cert.

Firmware/Software Support Model

Siemens only monitors the latest firmware version for security vulnerabilities. Therefore, bug and security fixes are provided only for the latest released firmware version.

CLI Command Syntax

This document details CLI commands. A CLI command consists of a key command, parameters, options and/or user variables.

Elements of a CLI Command

In the following CLI command, `interface` is the key command, { name } is a user-defined value, `vlan` and `type` are parameters, and `access` and `trunk` are fixed options.

```
interface  { name }  vlan type [ access | trunk ]
```

Command Formatting

CLI commands are displayed in this document according to the following syntax rules:

Convention	Description	Example
Font	All commands, parameters, and options are displayed in a monospace font.	`command  parameter`
User-Defined Values	Some parameters require a user-defined value. Values that need to be defined by you are wrapped in braces (curly brackets). The value can be a string, such as a name or description. The value may be a system component, such as an ID or interface.	`command  parameter { value }`

Convention	Description	Example
	In all cases, the key word between the braces indicates the type of value to enter.	
Number Ranges	When the value of a parameter is a number within a specific range, the range is enclosed in braces (curly brackets).	`command parameter { 0 - 10 }`
Options	When multiple choices are available for the value of a parameter, all choices are wrapped in square brackets. Choices are often comprised of fixed values, but may also include user-defined values and/or number ranges.	`command parameter [ option1 | option2 | { value } | { 0 - 10 } ]`

Related Documents

The following are other documents related to this product that may be of interest. Unless indicated otherwise, each document is available on the Siemens Industry Online Support (SIOS) [https://support.industry.siemens.com] website.

Note
Documents listed are those available at the time of publication. Newer versions of these documents or their associated products may be available. For more information, visit SIOS or consult a Siemens Customer Support representative.

Product Notes

Product notes are available online via SIOS [https://support.industry.siemens.com/cs/ca/en/ps/15989/pm].

Configuration/Reference Manuals

Document Title	Link
RUGGEDCOM ROX II v2.15 Web Interface Configuration Manual	https://support.industry.siemens.com/cs/ww/en/view/109481696
RUGGEDCOM ROX II NETCONF Reference Manual	https://support.industry.siemens.com/cs/ww/en/view/109737085
SINEC NMS Operating Instructions	https://support.industry.siemens.com/cs/ca/en/view/109762749
SINEC PNI Operating Instructions	https://support.industry.siemens.com/cs/attachments/109804190/BA_SINEC-PNI_76.pdf
CloudConnect for RUGGEDCOM ROX II	https://support.industry.siemens.com/cs/us/en/view/109763521

Catalogs

Document Title	Link
RUGGEDCOM SFP Transceivers Catalog	https://support.industry.siemens.com/cs/ww/en/view/109482309

FAQs/Application Examples

Document Title	Link
How to Upgrade the U-Boot Binary?	https://support.industry.siemens.com/cs/ww/en/view/109738243
Mean Time Between Failures (MTBF) – List for RUGGEDCOM Products	https://support.industry.siemens.com/cs/ww/en/view/109479200
How Can You Upgrade the GNU C Library? (Security Advisory SSA-994726)	https://support.industry.siemens.com/cs/ww/en/view/109474273
How Do You Calculate the Latency on a Switched Ethernet Network with RUGGEDCOM Switches or Routers?	https://support.industry.siemens.com/cs/ww/en/view/94772587
What Should You Watch Out For When Configuring a Link Aggregation Between SCALANCE X Switches and RUGGEDCOM Switches?	https://support.industry.siemens.com/cs/ww/en/view/76798136
What Should You Watch Out For When Ordering and Installing Interface Modules For RUGGEDCOM Switches?	https://support.industry.siemens.com/cs/ww/en/view/77896782
What Options Do You Have For Connecting an (R)STP Segment To a Ring Structure and How Can You Reduce the Ring Reconfiguration Time Through the EPLC Procedure?	https://support.industry.siemens.com/cs/ww/en/view/77363773
How to Implement Robust Ring Networks using RSTP and eRSTP?	https://support.industry.siemens.com/cs/ww/en/view/109738240
How to Change the Log Level?	https://support.industry.siemens.com/cs/ww/en/view/109744203
What is the Difference Between RSTP (Rapid Spanning Tree Protocol) and eRSTP (enhanced Rapid Spanning Tree Protocol 4) PBDU (Bridge Protocol Data Unit)?	https://support.industry.siemens.com/cs/ww/en/view/109476379
How to Regenerate Keys and Certificates?	https://support.industry.siemens.com/cs/ww/en/view/109738241
Using BGP Route Reflection with VPNv4 Clients	https://support.industry.siemens.com/cs/ww/en/view/109757209
Building a Linux-Based Virtual Machine Image	https://support.industry.siemens.com/cs/ww/en/view/109482423
How to Control Bidirectional Traffic when Using Port Mirroring?	https://support.industry.siemens.com/cs/ww/en/view/109759351
How to determine the firmware upgrade path for a RUGGEDCOM ROX II device?	https://support.industry.siemens.com/cs/us/en/view/109806037
How to configure a SCEP server?	https://support.industry.siemens.com/cs/us/en/view/109811508

White Papers

Document Title	Link
Performance of the Rapid Spanning Tree Protocol in Ring Network Topology	https://assets.new.siemens.com/siemens/assets/api/uuid:d4af5d17-728c-493f-b00a-9c4db67b23ed/RSTP-whitepaper-EN-09-2020.pdf

Installation Manuals

Document Title	Link
RUGGEDCOM RX1400 Installation Manual	https://support.industry.siemens.com/cs/ww/en/view/109480955

SIMATIC NET Glossary

The SIMATIC NET Glossary describes special terms that may be used in this document.

The glossary is available online via Siemens Industry Online Support (SIOS) at:

https://support.industry.siemens.com/cs/ww/en/view/50305045

System Requirements

Each workstation used to connect to the RUGGEDCOM ROX II Rugged CLI interface must meet the following system requirements:

- Must have a working Ethernet interface compatible with at least one of the port types on the RUGGEDCOM RX1400
- The ability to configure an IP address and netmask on the computer's Ethernet interface
- A suitable Ethernet cable
- An SSH client application installed on a computer

Accessing Documentation

The latest user documentation for RUGGEDCOM ROX II v2.15 is available online at https://support.industry.siemens.com. To request or inquire about a user document, contact Siemens Customer Support.

License Conditions

RUGGEDCOM ROX II contains open source software. Read the license conditions for open source software carefully before using this product.

License conditions are detailed in a separate document accessible via RUGGEDCOM ROX II. To access the license conditions, log in to the RUGGEDCOM ROX II CLI and type the following command:

```
file show-license LicenseSummary.txt
```

Registered Trademarks

RUGGEDCOM ®, ROS®, RCDP®, and RUGGEDCOM Discovery Protocol® are registered trademarks of Siemens Canada Ltd.

Linux® is the registered trademark of Linus Torvalds in the United States and other countries.

The registered trademark Linux® is used pursuant to a sublicense from LMI, the exclusive licensee of Linus Torvalds, owner of the mark on a world-wide basis.

Other designations in this manual might be trademarks whose use by third parties for their own purposes would infringe the rights of the owner.

Warranty

Refer to the License Agreement for the applicable warranty terms and conditions, if any.

For warranty details, visit https://www.siemens.com or contact a Siemens customer service representative.

Training

Siemens offers a wide range of educational services ranging from in-house training of standard courses on networking, Ethernet switches and routers, to on-site customized courses tailored to the customer's needs, experience and application.

Siemens' Educational Services team thrives on providing our customers with the essential practical skills to make sure users have the right knowledge and expertise to understand the various technologies associated with critical communications network infrastructure technologies.

Siemens' unique mix of IT/Telecommunications expertise combined with domain knowledge in the utility, transportation and industrial markets, allows Siemens to provide training specific to the customer's application.

For more information about training services and course availability, visit https://www.siemens.com or contact a Siemens Sales representative.

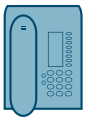
Customer Support

Customer support is available 24 hours, 7 days a week for all Siemens customers. For technical support or general information, contact Siemens Customer Support through any of the following methods:



Online

Visit http://www.siemens.com/automation/support-request to submit a Support Request (SR) or check on the status of an existing SR.



Telephone

Call a local hotline center to submit a Support Request (SR). To locate a local hotline center, visit https://w3.siemens.com/aspa_app/?lang=en.



Mobile App

Install the Industry Online Support app by Siemens AG on any Android, Apple iOS or Windows mobile device and be able to:

- Access Siemens' extensive library of support documentation, including FAQs and manuals
- Submit SRs or check on the status of an existing SR
- Contact a local Siemens representative from Sales, Technical Support, Training, etc.
- Ask questions or share knowledge with fellow Siemens customers and the support community

Contacting Siemens

Address	Siemens Canada Ltd. Digital Industries Process Automation 300 Applewood Crescent Concord, Ontario Canada, L4K 5C7
Telephone	Toll-free: 1 888 264 0006 Tel: +1 905 856 5288 Fax: +1 905 856 1995
E-Mail	info.ruggedcom@siemens.com
Web	https://www.siemens.com

1 Introduction

Welcome to the **RUGGEDCOM ROX II (Rugged Operating System on Linux®) v2.15 Configuration Manual** . This document details how to configure the RX1400 via the RUGGEDCOM ROX II Command Line Interface (CLI). RUGGEDCOM ROX II also features a Web interface, which is described in a separate Configuration Manual.

⚠ NOTICE
This Configuration Manual describes all features of RUGGEDCOM ROX II, but some features can only be configured through the Web interface. This is indicated throughout the Configuration Manual where applicable.

This document is specific to the following device platforms:

- RUGGEDCOM RX1400

1.1 Features and Benefits

The following describes the many features available in RUGGEDCOM ROX II and their benefits:

- **Cyber Security**

  Cyber security is an urgent issue in many industries where advanced automation and communications networks play a crucial role in mission critical applications and where high reliability is of paramount importance. Key RUGGEDCOM ROX II features that address security issues at the local area network level include:

Passwords	Multi-level user passwords secures against unauthorized configuration
SSH/SSL	Extends capability of password protection to add encryption of passwords and data as they cross the network
Enable/Disable Ports	Capability to disable ports so that traffic cannot pass
IEEE 802.1Q VLAN	Provides the ability to logically segregate traffic between predefined ports on switches
SNMPv3	Encrypted authentication and access security
HTTPS	For secure access to the Web interface
Firewall	Integrated stateful firewall provides protected network zones
VPN/IPSEC	Allows creation of secure encrypted and authenticated tunnels
IEEE 802.1X	Offers network access control through port-based authentication and authorization
RADIUS/TACACS+	Provides UDP- or TLS-based user authentication via remote authentication servers
EAP-TLS via WPA-EAP	Provides IEEE 802.1x authentication for wireless access points

- **Virtual Machine Support**

  Utilize the built-in virtualization environment to run a guest Linux operating system and third-party applications on the device, enabling intelligence at the network edge.

- **CloudConnect**

  With Siemens CloudConnect, the RUGGEDCOM RX1400 can operate as an Industrial Internet of Things (IIoT) gateway. CloudConnect provides an all-in-one solution for plug-and-play connectivity to common cloud services, such as MindSphere, Amazon Web Services (AWS), Microsoft Azure and other solutions. It features a standalone Web-based user interface, optimized data traffic based on publish/subscribe mechanisms, and trigger management for event driven and cyclic communication.

  CloudConnect is installed as a Virtual Processing Engine (VPE) image. It can be pre-installed at the factory or installed in the field.

  Note
  Registration with one of the supported cloud services is required.

  Note
  When installed, CloudConnect changes the default IP address of the device. For more information, refer to "Default IP Address (Page 73)".

  For more information about CloudConnect for the RUGGEDCOM RX1400, including configuration steps and specific security recommendations, refer to Getting Started with CloudConnect [https://support.industry.siemens.com/cs/us/en/view/109763521].

- **RUGGEDCOM CROSSBOW ADM Agent**

  The RUGGEDCOM CROSSBOW Asset Discovery and Management (ADM) Agent is a security feature used to discover and monitor the activity of network connected devices. This information is collected and reported to the Secure Access Manager (SAM). Operators using CROSSBOW are then made aware of any devices added to the operational environment within minutes of activation through the CROSSBOW user interface and event logging system. Purposefully deployed devices can be identified and vetted for inclusion, while rogue devices can be quickly identified and isolated.

  RUGGEDCOM CROSSBOW ADM is installed as a Virtual Processing Engine (VPE) image. It can be pre-installed at the factory or installed in the field.

  Note
  The ADM must be reachable from the RUGGEDCOM CROSSBOW SAM server.

  Note
  When installed, RUGGEDCOM CROSSBOW ADM changes the default IP address of the device. For more information, refer to "Default IP Address (Page 73)".

For more information about RUGGEDCOM CROSSBOW ADM, including configuration steps and specific security recommendations, contact Siemens Customer Support.

- **Enhanced Rapid Spanning Tree Protocol (eRSTP)™**

  Siemens's eRSTP allows the creation of fault-tolerant ring and mesh Ethernet networks that incorporate redundant links that are *pruned* to prevent loops. eRSTP implements both STP and RSTP to promote interoperability with commercial switches, unlike other proprietary *ring* solutions. The fast root failover feature of eRSTP provides quick network convergence in case of an RSTP root bridge failure in a mesh topology.

- **Quality of Service (IEEE 802.1p)**

  Some networking applications such as real-time control or VoIP (Voice over IP) require predictable arrival times for Ethernet frames. Switches can introduce latency in times of heavy network traffic due to the internal queues that buffer frames and then transmit on a first come first serve basis. RUGGEDCOM ROX II supports *Class of Service*, which allows time critical traffic to jump to the front of the queue, thus minimizing latency and reducing *jitter* to allow such demanding applications to operate correctly. RUGGEDCOM ROX II allows priority classification by port, tags, MAC address, and IP Type of Service (ToS). A configurable *weighted fair queuing* algorithm controls how frames are emptied from the queues.

- **VLAN (IEEE 802.1Q)**

  Virtual Local Area Networks (VLAN) allow the segregation of a physical network into separate logical networks with independent broadcast domains. A measure of security is provided since hosts can only access other hosts on the same VLAN and traffic storms are isolated. RUGGEDCOM ROX II supports 802.1Q tagged Ethernet frames and VLAN trunks. Port based classification allows legacy devices to be assigned to the correct VLAN. GVRP support is also provided to simplify the configuration of the switches on the VLAN.

- **Remote Monitoring and Configuration with SINEC NMS**

  SINEC NMS is Siemens's Network Management System software for the discovery, monitoring and management of RUGGEDCOM products and other IP enabled devices on a network. This highly configurable, full-featured product records and reports on the availability and performance of network components and services. Device, network and service failures are quickly detected and reported to reduce downtime.

  SINEC NMS is especially suited for remotely monitoring and configuring Siemens routers, switches, serial servers and WiMAX wireless network equipment. For more information, contact a Siemens Sales representative.

- **Device Management with SINEC PNI**

  RUGGEDCOM ROX II devices are compatible with SINEC PNI (Primary Network Initialization), a tool for commissioning Siemens RUGGEDCOM routers and switches. Use SINEC PNI to quickly add one or more devices to a network.

  Some of the features offered by SINEC PNI include:

- Bulk device management
- Change, load, or download device configurations
- Upgrade or downgrade firmware
- IP address assignment

- **Simple Network Management Protocol (SNMP)**

  SNMP provides a standardized method, for network management stations, to interrogate devices from different vendors. Supported SNMP versions include v1, v2c and v3. SNMPv3 in particular provides security features (such as authentication, privacy, and access control) not present in earlier SNMP versions. Numerous standard MIBs (Management Information Base) allow for easy integration with any Network Management System (NMS). A feature of SNMP supported by RUGGEDCOM ROX II is the ability to generate *traps* upon system events. SINEC NMS, the Siemens management solution, can record traps from multiple devices providing a powerful network troubleshooting tool. It also provides a graphical visualization of the network and is fully integrated with all Siemens products.

- **NETCONF Configuration Interface**

  The NETCONF configuration interface allows administrators to set device parameters and receive device updates through the use of XML-based commands. This standard, supported by multiple vendors, makes it possible to greatly simplify the task of network management.

  For more information about how to use NETCONF to configure RUGGEDCOM ROX II, refer to the " RUGGEDCOM ROX II NETCONF Reference Guide [https://support.industry.siemens.com/cs/us/en/view/109737085] ".

- **NTP (Network Time Protocol)**

  NTP automatically synchronizes the internal clock of all RUGGEDCOM ROX II devices on the network. This allows for correlation of time stamped events for troubleshooting.

- **Port Rate Limiting**

  RUGGEDCOM ROX II supports configurable rate limiting per port to limit unicast and multicast traffic. This can be essential to managing precious network bandwidth for service providers. It also provides edge security for Denial of Service (DoS) attacks.

- **Broadcast Storm Filtering**

  Broadcast storms wreak havoc on a network and can cause attached devices to malfunction. This could be disastrous on a network with mission critical equipment. RUGGEDCOM ROX II limits this by filtering broadcast frames with a user-defined threshold.

- **Port Mirroring**

  RUGGEDCOM ROX II can be configured to duplicate all traffic on one port to a designated mirror port. When combined with a network analyzer, this can be a powerful troubleshooting tool.

- **Port Configuration and Status**

  RUGGEDCOM ROX II allows individual ports to be *hard* configured for speed, duplex, auto-negotiation, flow control and more. This allows proper connection with devices that do not negotiate or have unusual settings. Detailed status of ports with alarm and SNMP trap on link problems aid greatly in system troubleshooting.

- **Port Statistics and RMON (Remote Monitoring)**

  RUGGEDCOM ROX II provides continuously updating statistics per port that provide both ingress and egress packet and byte counters, as well as detailed error figures.

  Also provided is full support for RMON statistics. RMON allows for very sophisticated data collection, analysis and detection of traffic patterns.

- **Event Logging and Alarms**

  RUGGEDCOM ROX II records all significant events to a non-volatile system log allowing forensic troubleshooting. Events include link failure and recovery, unauthorized access, broadcast storm detection, and self-test diagnostics among others. Alarms provide a snapshot of recent events that have yet to be acknowledged by the network administrator. An external hardware relay is de-energized during the presence of critical alarms, allowing an external controller to react if desired.

- **HTML Web Browser User Interface**

  RUGGEDCOM ROX II provides a simple, intuitive user interface for configuration and monitoring via a standard graphical Web browser or via a standard telecom user interface. All system parameters include detailed online Help to facilitate setup and configuration. RUGGEDCOM ROX II presents a common look and feel and standardized configuration process, allowing easy migration to other RUGGEDCOM managed products.

- **Command Line Interface (CLI)**

  A command line interface used in conjunction with remote shell to automate data retrieval, configuration updates, and firmware upgrades. A powerful Telecom Standard style Command Line Interface (CLI) allows expert users the ability to selectively retrieve or manipulate any parameters the device has to offer.

- **Link Backup**

  Link backup provides an easily configured means of raising a backup link upon the failure of a designated main link. The main and backup links can be Ethernet or Cellular. The feature can back up to multiple remote locations, managing multiple main: backup link relationships. The feature can also back up a permanent high speed WAN link to a permanent low speed WAN link and can be used to migrate the default route from the main to the backup link.

- **OSPF (Open Shortest Path First)**

  OSPF is a routing protocol that determines the best path for routing IP traffic over a TCP/IP network based on link states between nodes and several quality

parameters. OSPF is an Interior Gateway Protocol (IGP), which is designed to work within an autonomous system. It is also a link state protocol, meaning the best route is determined by the type and speed of the inter-router links, not by how many router hops they are away from each other (as in distance-vector routing protocols such as RIP).

- **BGP (Border Gateway Protocol)**

  BGPv4 is a path-vector routing protocol where routing decisions are made based on the policies or rules laid out by the network administrator. It is typically used where networks are multi-homed between multiple Internet Service Providers, or in very large internal networks where internal gateway protocols do not scale sufficiently.

- **RIP (Routing Information Protocol)**

  RIP version 1 and version 2 are distance-vector routing protocols that limit the number of router hops to 15 when determining the best routing path. This protocol is typically used on small, self-contained networks, as any router beyond 15 hops is considered unreachable.

- **IS-IS (Intermediate System - Intermediate System)**

  IS-IS is one of a suite of routing protocols tasked with sharing routing information between routers. The job of the router is to enable the efficient movement of data over sometimes complex networks. Routing protocols are designed to share routing information across these networks and use sophisticated algorithms to decide the shortest route for the information to travel from point A to point B. One of the first link-state routing protocols was IS-IS developed in 1985 and adopted by the ISO in 1998 (ISO/IEC 10589:2002). It was later republished as an IETF standard (RFC 1142 [http://tools.ietf.org/html/rfc1142]).

- **Brute Force Attack Prevention**

  Protection against Brute Force Attacks (BFAs) is standard in RUGGEDCOM ROX II. If an external host fails to log in to the CLI, NETCONF or Web interfaces after a fixed number of attempts, the host's IP address will be blocked for a period of time. That period of time will increase if the host continues to fail on subsequent attempts.

- **MicroSD/MicroSDHC Support**

  Use a removable microSD or microSDHC Flash drive to manage important files and configure RUGGEDCOM ROX II.

  - Upgrade/Downgrade Firmware – Use the microSD or microSDHC Flash drive as a portable repository for new or legacy versions of the RUGGEDCOM ROX II firmware.
  - Backup Files – Configure RUGGEDCOM ROX II to backup important information to the microSD or microSDHC Flash drive, such as rollbacks, log files, feature keys and configuration files.
  - Share Files – Quickly configure or upgrade other RUGGEDCOM RX1400 devices by copying files using the same microSD/microSDHC Flash drive.

⚠ NOTICE
Do not remove the microSD or microSDHC Flash drive during a file transfer.

Note
Only one partition is supported on the microSD/microSDHC Flash drive.

- **Hot Swapping SFP Transceivers**

  SFP transceivers can be safely replaced with transceivers of exactly the same type while the device is running, with minimal disruption to the network. The device only needs to be restarted after swapping an SFP transceiver with a different type, such as a 1000Base-X transceiver with a 100Base-FX transceiver.

  Following a hot swap, the new SFP transceiver will be automatically configured to operate in the same operational state as the previous module.

  Note
  A reboot is required if an SFP transceiver is installed in a socket that was empty when the device was started.

- **Jumbo Frames**

  In an Ethernet data network, the term **jumbo frames** designates non-standard and oversize messages. The standard size is defined as 1518 bytes by the IEEE 802.3 standard. Messages that are longer than 1518 bytes are called jumbo frames.

  The RUGGEDCOM RX1400 supports Layer 2 frames up to 1632 bytes on a VLAN.

1.2 Feature Keys

Feature keys add features to an existing installation of RUGGEDCOM ROX II. They can be purchased and installed at any time.

The following feature keys are currently available:

- Layer 3 Standard Edition with Layer 3 Hardware (L3SEL3HW)
- Layer 3 Standard Edition with Layer 2 Hardware (L3SEL2HW)
- Layer 3 Security Edition with Layer 3 Hardware (L3SECL3HW)
- Layer 3 Security Edition with Layer 2 Hardware (L3SECL2HW)

By default, each new RUGGEDCOM RX1400 is ordered with a base feature key, which is permanently installed on the device. Additional feature keys can be installed on the microSD/microSDHC drive, which allows them to be moved to other devices when needed.

Note
Each feature key is signed with the serial number of the device it is intended to be used in. Feature keys can be used in other RUGGEDCOM ROX II devices, but a low-level alarm will be generated indicating a hardware mismatch.

Feature keys include the following features:

Feature	Feature Key				
	Layer 2 Standard Edition (L2SE)	L3SEL3HW	L3SEL2HW	L3SECL3HW	L3SECL2HW
VLANs (802.1Q)	✓	✓	✓	✓	✓
QoS (802.1p)	✓	✓	✓	✓	✓
MSTP (802.1Q-2005)	✓	✓	✓	✓	✓
RSTP	✓	✓	✓	✓	✓
eRSTP™	✓	✓	✓	✓	✓
NTP	✓	✓	✓	✓	✓
L2TPv2 and L2TPv3	✓	✓	✓	✓	✓
Port Rate Limiting	✓	✓	✓	✓	✓
Broadcast Storm Filtering	✓	✓	✓	✓	✓
Port Mirroring	✓	✓	✓	✓	✓
SNMP v1/v2/v3	✓	✓	✓	✓	✓
RMON	✓	✓	✓	✓	✓
CLI	✓	✓	✓	✓	✓
HTML User Interface	✓	✓	✓	✓	✓
MPLS		✓	✓	✓	✓
DHCP		✓	✓	✓	✓
VRRPv2 and VRRPv3		✓	✓	✓	✓
PIM-SM		✓	✓	✓	✓
Firewall		✓	✓	✓	✓
OSPF		✓	✓	✓	✓
BGP		✓	✓	✓	✓
RIP v1/v2		✓	✓	✓	✓
IS-IS		✓	✓	✓	✓
Traffic Prioritization		✓	✓	✓	✓
VPN				✓	✓
IPSec				✓	✓
Virtualization[a]	✓	✓	✓	✓	✓
Hardware Accelerated Layer 3 Switching		✓		✓	

[a] Requires an additional feature key. For more information, refer to "*Virtualization* (Page 915)".

For information about installing and viewing the contents of feature keys, refer to "Managing Feature Keys (Page 85)".

1.3 Security Recommendations

To prevent unauthorized access to the device, note the following security recommendations:

Authentication

⚠ NOTICE

Accessibility hazard – risk of data loss

Do not misplace the passwords for the device. If both the maintenance and boot passwords are misplaced, the device must be returned to Siemens Canada Ltd. for repair. This service is not covered under warranty. Depending on the action that must be taken to regain access to the device, data may be lost.

- Replace the default passwords for the admin and maintenance mode accounts before the device is deployed.
- Use strong passwords. Avoid weak passwords (e.g. *password1*, *123456789*, *abcdefgh*) or repeated characters (e.g. *abcabc*). For more information about creating strong passwords, refer to the password requirements in "Managing Passwords and Passphrases (Page 140)".

  This recommendation also applies to symmetric passwords/keys configured on the device.
- Make sure passwords are protected and not shared with unauthorized personnel.
- Do not re-use passwords across different user names and systems, or after they expire.
- Record passwords in a safe, secure, off-line location for future retrieval should they be misplaced.
- When RADIUS or TACACS+ are utilized for user authentication, make sure all communications are within the security perimeter or protected by a secure channel.
- TACACS+ uses the MD5 algorithm for key encryption. Make sure to follow the security recommendations outlined in this document and configure the environment according to *defense in depth* best practices.
- PAP (Password Authentication Protocol) is not considered a secure protocol and, where possible, should be used in a protected network environment.
- Use the L2TP protocol in conjunction with IPsec to secure the L2TP tunnel.
- It is recommended to use shared keys for authentication between routing neighbors to help prevent unauthenticated routing updates.
- Be aware of any link layer protocols that do not provide any inherent authentication between endpoints, such as ARP in IPv4, neighbor discovery/ DAD in IPv6, and Wi-Fi in wireless networks. A malicious entity could exploit weaknesses in these protocols to attack hosts, switches, and routers connected to the Layer 2 network, for example, by poisoning the ARP caches of systems

within the subnet and subsequently intercepting traffic. Appropriate safeguards against non-secure Layer 2 protocols, such as securing physical access to the local network and using secure higher layer protocols, should be taken to prevent unauthorized access to the network.

- Change passwords regularly and often.

Physical/Remote Access

- It is highly recommended to keep Brute Force Attack (BFA) protection enabled to prevent a third-party from obtaining unauthorized access to the device. For more information, refer to "Enabling/Disabling Brute Force Attack Protection (Page 152)".
- SSH and SSL keys are accessible to the root user. Make sure to take appropriate precautions when shipping the device beyond the boundaries of the trusted environment:
  - Replace the SSH and SSL keys with *throwaway* keys prior to shipping.
  - Take the existing SSH and SSL keys out of service. When the device returns, create and program new keys for the device.
- Replace all default and auto-generated SSL certificates with certificates and keys signed by a trusted Certificate Authority (CA). Default and auto-generated certificates are self-signed by RUGGEDCOM ROX II.
- Restrict physical access to the device to only trusted personnel. A malicious user in possession of the device's removable media could extract critical information, such as certificates, keys, etc. (user passwords are protected by hash codes), or reprogram the media.
- Passwords/passphrases for service mode and maintenance mode should only be known to a single trusted user. These modes should have restricted access to protect the confidentiality and integrity of the device.

  When commissioning a unit, make sure the maintenance mode password is changed from its default setting.
- Control access to the serial console to the same degree as any physical access to the device. Access to the serial console allows for potential access to BIST and service mode, which includes tools that may be used to gain complete access to the device.
- Mirror ports allow bidirectional traffic (i.e. the device will not block incoming traffic to the mirror port or ports). This can lead to traffic being forwarded to unintended ports. For increased security, configure ingress filtering to control traffic flow when port mirroring is enabled. For more information about enabling port mirroring, refer to "Configuring Port Mirroring (Page 855)". For more information about enabling ingress filtering, refer to "Enabling/Disabling Ingress Filtering (Page 361)".
- For increased security, enable ingress filtering on all ports by default. For more information about enabling ingress filtering, refer to "Enabling/Disabling Ingress Filtering (Page 361)".

- When using SNMP (Simple Network Management Protocol):
  - Limit the number of IP addresses that can connect to the device.
  - Configure SNMP to raise any available traps on the occurrence of a security event.
  - Make sure the default community strings are changed to unique values.
  - Ensure that when enabling SNMP, SNMPv1 and SNMPv2c are disabled if not required.
  - Consider using SNMPv3 for additional security.

  For more information about SNMP, refer to "Managing SNMP (Page 834)".
- When using RUGGEDCOM ROX II as a client to securely connect to a server (such as, in the case of a secure upgrade or a secure syslog transfer), make sure the server side is configured with strong ciphers and protocols.
- Limit the number of simultaneous Web Server, CLI, SFTP and NETCONF sessions allowed.
- If a firewall is required, configure and start the firewall before connecting the device to a public network. Make sure the firewall is configured to accept connections from a specific domain and deny all other traffic. For more information, refer to "Managing Firewalls (Page 217)".
- Serial protocols are deactivated by default in RUGGEDCOM ROX II. Some serial protocols lack the necessary protections to integrity and confidentiality inherently available to TCP/IP based protocols. Given the critical infrastructure of the systems that are often controlled by serial protocols it is imperative that these protocols be protected by any means available. Examples of protection measures include using MicroLok encapsulated with TCP/IP and encrypting with IPsec wherever possible. If IPsec is not available for a given network segment, make sure to configure the environment according to defense-in-depth best practices.
- To ensure the permanence of a device's audit trail, configure the device to forward all logs using TLS to a hardened remote syslog server. For more information, refer to "Managing Logs (Page 90)".
- Configuration files are provided in either NETCONF or CLI format for ease of use. Make sure configuration files are properly protected when they exist outside of the device. For instance, digitally sign and encrypt the files, store them in a secure place, and transfer configuration files via secure communication channels only.
- It is highly recommended that critical applications and access to management services be limited to private networks. Connecting a RUGGEDCOM ROX II device to the Internet is possible. However, the utmost care should be taken to protect the device and the network behind it using secure means such as firewall and IPsec. For more information about configuring firewalls and IPsec, refer to "Managing Firewalls (Page 217)" and "Managing IPsec Tunnels (Page 502)".
- The safekeeping and management of the certificates and keys is the responsibility of the device owner. Use RSA key sizes of 2048 bits in length to

employ standard cryptographic strength. Before returning the device to Siemens Canada Ltd. for repair, replace the current certificates and keys with temporary *throwaway* certificates and keys that can be destroyed upon the device's return.

- Be aware of any non-secure protocols enabled on the device. While some protocols, such as HTTPS, SSH and 802.1x, are secure, others, such as SNMPv1/v2c and RSTP were not designed for this purpose. Appropriate safeguards against non-secure protocols should be taken to prevent unauthorized access to the device/network.
- Make sure the device is fully decommissioned before taking the device out of service. For more information, refer to "Decommissioning the Device (Page 84)".
- Configure port security features on access ports to prevent an unauthorized third-party from physically connecting to the device. For more information, refer to "Configuring Port Security (Page 159)".
- Be aware of insecure WLAN protocols, such as Open and WEP. Only use secure protocols when using WLAN, such as Wi-Fi Protected Access 2 (WPA2) and WPA-EAP (EAP-TLS).

Virtualization

- The integrity of any operating system installed on a virtual machine must be verified by the user before use and all relevant security patches must be included. The operating system installed is the responsibility of the user and not that of Siemens Canada Ltd..
- Make sure any files included in a virtual machine image do not contain malicious content or code. Interfaces connecting the virtual machine to the Internet should be protected using security best practices.
- Use a VLAN or physical port – other than the RUGGEDCOM ROX II management port – to access a bridge interface on a virtual machine. The port used to access the virtual machine should be in a separate VLAN.

Hardware/Software

⚠ NOTICE

Configuration hazard – risk of data corruption

Maintenance mode is provided for troubleshooting purposes and should only be used by Siemens Canada Ltd. technicians. As such, this mode is not fully documented. Misuse of this maintenance mode commands can corrupt the operational state of the device and render it inaccessible.

- Make sure the latest firmware version is installed, including the latest security-related patches. For the latest information on security patches for Siemens products, visit the CERT Services website [https://new.siemens.com/global/en/products/services/cert.html]. Updates to Siemens Product Security Advisories can be obtained by subscribing to the RSS feed on the ProductCERT Security

Advisories website [https://new.siemens.com/global/en/products/services/cert.html#SecurityPublications], or by following @ProductCert on Twitter.

- Select services are enabled by default in RUGGEDCOM ROX II. It is recommended to only enable the minimum services that are required. For more information about available services, "Available Services by Port (Page 13)".
- Physical interfaces that are not being used should be disabled. Unused physical ports could potentially be used to gain access to the network behind the device.
- Use the latest Web browser version compatible with RUGGEDCOM ROX II to make sure the most secure ciphers available are employed. Additionally, 1/n-1 record splitting is enabled in the latest Web browser versions of Mozilla Firefox, Google Chrome and Microsoft Edge, and mitigates against attacks such as SSL/TLS Protocol Initialization Vector Implementation Information Disclosure Vulnerability (e.g. BEAST).
- For optimal security, use SNMPv3 whenever possible and apply strong passwords.
- Validate the integrity of the running firmware as often as required. This task can be automated by scheduling a job to repeat every day or week. Firmware integrity can also be checked automatically at start-up.

  If an unauthorized/unexpected modification is detected, inspect the syslog for messages related to firmware integrity to identify which programs and/or files may have been compromised. If remote system logging is configured, this task can also be automated using scripts to identify key log messages.

  For more information about checking the firmware integrity, refer to "Monitoring Firmware Integrity (Page 121)".

Policy

- Periodically audit the device to make sure it complies with these recommendations and/or any internal security policies.
- Review the user documentation for other Siemens products used in coordination with the device for further security recommendations.

1.4 Available Services by Port

The following table lists the services available by the device, including the following information:

- **Services**

  The service supported by the device
- **Port Number**

  The port number associated with the service
- **Port Default**

  The default state of the port (i.e. open or closed)

- **Authenticated Access**

  Denotes whether the ports/services require authentication for access

Note
All listed ports can be configured as open or closed in RUGGEDCOM ROX II.

Services	Port Number	Port Default	Authenticated Access
SSH	TCP/22	Open	Yes
SSH (Service Mode)	TCP/222	Closed	Yes
NETCONF	TCP/830	Open	Yes
SFTP	TCP/2222	Closed	Yes
HTTP	TCP/80	Open	N/A
NTP	UDP/123	Closed	No
SNMP	UDP/161	Closed	Yes
HTTPS	TCP/443	Open	Yes
TCP Modbus	TCP/502	Closed	No
IPSec IKE	UDP/500	Closed	Yes
IPSec NAT-T	UDP/4500	Closed	Yes
DNPv3	TCP/20000 and UDP/20000	Closed	No
RawSocket	UDP/TCP 1024-65535	Closed	No
DHCP Agent	UDP/67	Closed	No
DHCP Server	UDP/67 listening, 68 responding	Closed	No
RADIUS	UDP/1812 to send, opens random port to listen	Closed	Yes
TACACS+	TCP/49 to send, opens random port to listen	Closed	Yes
L2TP	Random Port	Closed	Yes
BGP	TCP/179	Closed	No
RIP	UDP/520	Closed	No
MPLS-Ping	UDP/3503	Closed	No
LDP	TCP/646 and UDP/646	Closed	No
L2TPv3	UDP/1701	Closed	No

1.5 User Permissions

The following table lists the operation, configuration, and action commands permitted to the administrator, operator, and guest users.

Types of user access:

- **Create (C)** – can create and remove optional parameters
- **Execute (E)** – can run an action or command
- **No** – no access
- **Read (R)** – read access

- **Update (U)** – can modify existing parameter

Commands/Paths Permitted	Access			Notes
	Administrator	Operator	Guest	
config private | exclusive | no-confirm	Allowed	Allowed	No	
/admin/software-upgrade	R/U	R	No	
/admin/rox-imaging	R/U	R	No	
/admin/authentication	R/U	No	No	
/admin/authentication/password-complexity	R/U	No	No	
/admin/logging	C/R/U	No	No	
/admin/alarms (status)	R	R	No	Administrator and operator can see status of active-alarms, acknowledge and clear alarms
/admin/alarms-config/	R/U	R/U	No	Administrator and operator cannot create or delete alarm-lists
/admin/users	C/R/U	No	No	
/admin/users/userid	R/U	R/U	No	Operator can only change own password and cannot create users.
/admin/cli	R/U	R/U	No	
/admin/snmp	C/R/U	No	No	
/admin/netconf	R/U	No	No	
/admin/dns	C/R/U	No	No	
/admin/webui	R/U	R/U	No	
/admin/scheduler	C/R/U	No	No	
/admin/contact	R/U	No	No	
/admin/hostname	R/U	No	No	
/admin/location	R/U	No	No	
/admin/session-limits	R/U	No	No	
/admin/session-security	R/U	No	No	
/admin/sftp	R/U	No	No	
/admin/time (status)	R	R	No	
/admin/switch-config (status)	R/U	R	No	
/admin/system	R/U	No	No	
/admin/sytem-name	R/U	No	No	
/admin/timezone	R/U	No	No	
/admin/clear-all-alarms (action)	E	C/R/U	No	
/admin/backup-files (action)	E/R/U	No	No	
/admin/delete-all-ssh-known-hosts (action)	E	No	No	
/admin/delete-autoload-configuration-from-removable (action)	E	No	No	
/admin/delete-logs (action)	E	No	No	
/admin/delete-ssh-known-host (action)	E	No	No	

Commands/Paths Permitted	Access			Notes
	Administrator	Operator	Guest	
/admin/full-configuration-load (action)	E/U	No	No	
/admin/full-configuration-save (action)	E/U	No	No	
/admin/install-files (action)	E/U	No	No	
/admin/reboot (action)	E	E	No	
/admin/restore-factory-defaults (action)	E/U	No	No	
/admin/save-configuration-to-removable (action)	E/U	No	No	
/admin/set-system-clock (action)	E/U	No	No	
/admin/shutdown (action)	E	E	No	
/apps	C/R/U	C/R/U	R	
/chassis/part-list	R/U	R	R	
/chassis/fixed-modules	C/R/U	No	R	
/chassis/line-module-list	R/U	R	R	
/chassis/line-modules/line-module	R/U	No	R	
/interfaces	R	R	R	
/interface	C/R/U	R/U	R	
/routing	C/R/U	C/R/U	R	
/routing/dynamic/ospf/interface	C/R/U	C/R/U	R	
/routing/dynamic/rip/interface	C/R/U	C/R/U	R	
/routing/multicast/dynamic/pim-sm/interface	C/R/U	C/R/U	R	
/routing/dynamic/isis/interface	C/R/U	C/R/U	R	
/security/firewall	C/R/U	C/R/U	R	
/security/crypto	C/R/U	R	R	
/security/crypto/private-key	C/R/U	No	No	
/services	C/R/U	C/R/U	R	
/services/time/ntp/key/	C/R/U	No	No	
/tunnel/ipsec	C/R/U	No	No	
/tunnel/l2tunneld	C/R/U	C/R/U	R	
/ip	C/R/U	C/R/U	R	
/mpls	C/R/U	C/R/U	R	
/mpls/interface-mpls	C/R/U	C/R/U	R	
/mpls/ldp/interface-ldp	C/R/U	C/R/U	R	
/switch	C/R/U	C/R/U	R	
/switch/vlans/all-vlans	C/R/U	C/R/U	R	
/switch/port-security	R/U	No	No	
/qos	C/R/U	C/R/U	R	
/global	C/R/U	No	No	
hints	E	E	E	

Commands/Paths Permitted	Access			Notes
	Administrator	Operator	Guest	
monitor	E	E	No	
mpls-ping	E	E	No	
mpls-traceroute	E	E	No	
ping	E	E	No	
ping6	E	E	No	
reportstats	E	E	No	
ssh	E	E	No	
tcpdump	E	E	No	
telnet	E	E	No	
traceroute	E	E	No	
traceroute6	E	E	No	
traceserial	E	E	No	
wizard	E	No	No	

1.6 Removable Memory

The RUGGEDCOM RX1400 features a user-accessible memory slot that supports a microSD or microSDHC Flash drive. The drive can be used to manage configuration, firmware and other files on the device or a fleet of devices.

- Upgrade/Downgrade Firmware – Use the microSD or microSDHC Flash drive as a portable repository for new or legacy versions of the RUGGEDCOM ROX II firmware.
- Backup Files – Configure RUGGEDCOM ROX II to backup important information to the microSD or microSDHC Flash drive, such as rollbacks, log files, feature keys and configuration files.
- Share Files – Quickly configure or upgrade other RUGGEDCOM RX1400 devices by copying files using the same microSD/microSDHC Flash drive.

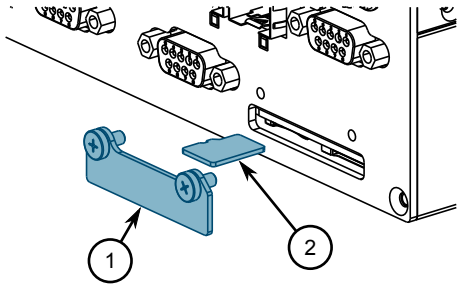
⚠ NOTICE

Do not remove the microSD or microSDHC Flash drive during a file transfer.

Note

Only one partition is supported on the microSD/microSDHC Flash drive.

Only the following file systems are supported on the microSD/microSDHC Flash drive: VFAT (recommended), ext2, ext3, ext4, FAT16 or FAT32. The advantage of using these file system types for the removable memory is that their contents can be modified on any general purpose computer that has a microSD/microSDHC interface.



① Access Panel
② microSD/microSDHC Flash drive

Figure 1.1 Memory Card Installation

For information about how to insert or remove the microSD/microSDHC Flash drive, refer to the "Installation Manual" for the RUGGEDCOM RX1400.

For CLI commands used to manage the microSD or microSDHC Flash drive, refer to "File Commands (Page 45)" and "Administration Commands (Page 54)".

1.7 Logged Events

RUGGEDCOM ROX II logs all events locally and forwards them automatically to a syslog server if remote logging is enabled. This section defines events and lists the built-in syslog messages generated when specific events occur.

Note
For information about enabling remote system logging, refer to "Configuring Secure Remote Syslog (Page 92)".

1.7.1 Structure of a Syslog Event

A syslog event is defined by the following elements:

Element	Description
Date	The date when the event was received/logged in the syslog server.
Time	The time when the event was received/logged in the System server.
Hostname	The name of the device that sent the event.
Facility[a]	The source of the event. Options include: • AUTH • AUTHPRIV • DAEMON • USER
Severity[a]	The severity level associated with the event. Options include: • INFO • NOTICE

Element	Description
	• AUTH • AUTHPRIV • ERR • CRITICAL • EMERGENCY
Message Text	Information about the event.

[a] Text defined in the SNMP Manager.

1.7.2 Syslog Event Types

Two types of syslog events are defined.

Event Type	Description
Event	Events are *authorized* activities that can be expected to occur during routine use.
Alarm	Alarms are activities that may indicate *unauthorized* activity.

Events of either type are stored locally on the device and transmitted automatically to the syslog server when they occur.

1.7.3 Logged Security Events

The following are security-related event messages that may be generated by RUGGEDCOM ROX II.

Category	Event Message	Facility	Severity	Event Type	Log
SE_LOCAL_SUCCESSFUL_LOGON	ruggedcom confd[{pid}]: audit user: {user}/{user id} assigned to groups: {role}	LOG_AUTHPRIV	Info	Event	Auth.log
	ruggedcom rmfmgr[{pid}]: username:{user name} usid:{user id} started {context} session from ip:127.0.0.1 source-port:{src port} through {local interface} protocol	LOG_AUTH	Notice	Event	Auth.log
SE_LOCAL_UNSUCCESSFUL_LOGON (Invalid Username)	audit user: {user name}1/0 no such local user	LOG_AUTHPRIV	Info	Event	Auth.log
	login failed, reason='No such local user', user='{username}',	LOG_AUTHPRIV	Error	Event	Auth.log

Category	Event Message	Facility	Severity	Event Type	Log
	context='{context}', proto='{local interface}', user ipaddr='127.0.0.1'				
SE_LOCAL_UNSUCCESSFUL_LOGON (Invalid Password)	audit user: {username}/0 Provided bad password	LOG_AUTHPRIV	Info	Event	Auth.log
	login failed, reason='Bad password', user='{username}', context='{context}', proto='{protocol}', user ipaddr='127.0.0.1"	LOG_AUTHPRIV	Error	Event	Auth.log
SE_NETWORK_SUCCESSFUL_LOGON	audit user: {username}/0 logged in over {protocol} from {source ip-address} with authmeth: {authentication-method}	LOG_AUTHPRIV	Info	Event	Auth.log
	audit user: admin/ {user id} assigned to groups: {role}	LOG_AUTHPRIV	Info	Event	Auth.log
	username:{username} usid:{user id} started {session-type} session from ip:{source ip-address} source-port: {source port} through {protocol} protocol	LOG_AUTH	Notice	Event	Auth.log
SE_NETWORK_UNSUCCESSFUL_LOGON (Invalid Username)	audit user: {user name}/0 no such local user	LOG_AUTHPRIV	Info	Event	Auth.log
	login failed, reason='No such local user', user='{username}', context='{session-type}', proto='{protocol}', user ipaddr='{source ip-address}'	LOG_AUTHPRIV	Error	Event	Auth.log
	audit user: {username}/0 Failed to login over {protocol}: No such local user	LOG_AUTHPRIV	Info	Event	Auth.log
SE_NETWORK_UNSUCCESSFUL_LOGON (Invalid Password)	audit user: {username}/0	LOG_AUTHPRIV	Info	Event	Auth.log

Category	Event Message	Facility	Severity	Event Type	Log
	Provided bad password				
	login failed, reason='Bad password', user='{username}', context='{session-type}', proto='{protocol}', user ipaddr='{source ip-address}'	LOG_AUTHPRIV	Error	Event	Auth.log
	audit user: {username}/0 Failed to login over {protocol}: Bad password	LOG_AUTHPRIV	Info	Event	Auth.log
SE_LOGOFF (Local)	username:{user name} usid:{user id} stopped {session-type} session from ip:127.0.0.1	LOG_AUTH	Notice	Event	Auth.log
SE_LOGOFF(Network)	username:{user name} usid:{user id} stopped {context} session from ip: {source ip-address}	LOG_AUTH	Notice	Event	Auth.log
	audit user: {user name}/0 Logged out {protocol} <local> user	LOG_AUTHPRIV	Info	Event	Auth.log
SE_ACCESS_PWD_ENABLED	Enabling Brute Force Attack Protection	LOG_USER	Error	Event	Syslog
SE_ACCESS_PWD_DISABLED	Brute Force Attack protection not enabled	LOG_USER	Error	Alarm	Syslog
SE_ACCESS_PWD_CHANGED	audit user: {User Group}/{User ID} WebUI action '/rmf_admin:admin/users/userid{"{Target User}"}/set-password'	LOG_DAEMON	Info	Event	Auth.log
SE_ACCESS_GRANTED	audit user: {Username}/0 logged in through Web UI from {IP Address}	LOG_DAEMON	Info	Event	Auth.log
	audit user: {Username}/{User ID} assigned to groups: {User Group}	LOG_DAEMON	Info	Event	Auth.log
	username: {Username} usid: {User ID} started	LOG_AUTH	Notice	Event	Auth.log

Category	Event Message	Facility	Severity	Event Type	Log
	{Context} session from ip:{IP Address} source-port:{Port} through {Protocol} protocol				
SE_ACCESS_DENIED	audit user: {Username}/0 Provided Invalid Password	LOG_DAEMON	Info	Alarm	Auth.log
	login failed, user:'{username}', reason='{reason}', user ipaddr='{IP Address}', context='{context}', proto='{protocol}'	LOG_AUTHPRIV	Error	Alarm	Auth.log
SE_ACCOUNT_LOCKED_TEMP	ALARM: BFA from IP {IP Address} is blocked -> {Event Time}	LOG_DAEMON	Emergency	Alarm	Syslog
	{Function}: detect BFA from {IP Address}, raise alarm	LOG_DAEMON	Verbose	Alarm	Syslog
	{Function}: alarm asserted id={Event ID}	LOG_DAEMON	Verbose	Alarm	Syslog
SE_ACCOUNT_LOCKED_TEMP (Freed)	{Function}: deassert BFA alarm ip={IP address}	LOG_DAEMON	Verbose	Event	Syslog
SE_AUDIT_LOG_CLEARED	Deleted logs by restore-factory-defaults issued by user {Username}	LOG_DAEMON	Emergency	Alarm	Syslog
SE_COMMUNICATION_DATA_INTEGRITY_ERROR	FAILURE. The firmware integrity check has failed. This may indicate that some operating system files have been modified or tampered with. For assistance, contact Siemens Customer Support.	LOG_DAEMON	Critical	Alarm	Syslog
SE_SESSION_CLOSED	username: {Username} usid: {User ID} stopped {Context} session from ip:{IP Address}	LOG_AUTH	Notice	Event	Auth.log
SE_SESSION_CLOSED (console)	username: {Username} usid: {User ID} started {Context} session from ip: 127.0.0.1	LOG_AUTH	Notice	Event	Auth.log

Category	Event Message	Facility	Severity	Event Type	Log
	source-port:0 through console protocol				
SE_PATCH_DEPLOYMENT_SUCCEEDED	The other partition was imaged successfully. A reboot is required to boot the other partition.	LOG_DAEMON	Notice	Event	Upgrade
SE_PATCH_DEPLOYMENT_FAILED (Failure during ROXFLASH)	A failure was encountered in the upgrade process.	LOG_DAEMON	Notice	Event	Upgrade
SE_PATCH_DEPLOYMENT_FAILED (During uninstall - ROXFLASH)	A failure was encountered in the uninstallation process.	LOG_DAEMON	Notice	Event	Upgrade
SE_PATCH_DEPLOYMENT_FAILED (Can not connect to upgrade server - ROXFLASH)	Failed to get upgrade details from server, please verify connection.	LOG_DAEMON	Notice	Event	Upgrade
SE_PATCH_DEPLOYMENT_FAILED (No differences - ROXFLASH)	No differences detected in target version. Nothing to upgrade	LOG_DAEMON	Notice	Event	Upgrade
SE_PATCH_DEPLOYMENT_FAILED (Failed to configure boot partition - ROXFLASH)	Failed to configure system to boot partition %s on next boot	LOG_DAEMON	Notice	Event	Upgrade
SE_PATCH_DEPLOYMENT_FAILED (Failed to upgrade target partition - upgrade)	Failed upgrading target partition	LOG_DAEMON	Notice	Event	Upgrade
SE_PATCH_DEPLOYMENT_FAILED (General) - upgrade	Failed running {Command} on target partition	LOG_DAEMON	Notice	Event	Upgrade

2 Using RUGGEDCOM ROX II

This chapter describes how to use the RUGGEDCOM ROX II interface.

2.1 Default User Names and Passwords

The following default passwords are pre-configured on the device for each access mode:

⚠ NOTICE

Security hazard – risk of unauthorized access and/or exploitation

To prevent unauthorized access to the device, change the default passwords before commissioning the device. For more information, refer to "Managing Passwords and Passphrases (Page 140)".

Note

Default passwords listed for Administrator and Operator access modes do not apply to WLAN-capable devices certified for use in the United States of America. In compliance with FCC regulations, the default passwords for these devices can only be obtained directly from Siemens. After initial use and before commissioning the device, these passwords can and should be changed to prevent unauthorized access.

For more information about obtaining the default passwords for a WLAN-capable device, contact Siemens Customer Support.

Mode	Username	Password
Service	root	admin
Maintenance	root	admin
Administrator	admin	admin
Operator	oper	oper
Guest	guest	guest

2.2 Logging In

To log in to RUGGEDCOM ROX II, do the following:

1. Connect to the device. For more information about the various methods of connecting to the device, refer "Connecting to RUGGEDCOM ROX II (Page 73)".

2. Once a connection is established with the device, press **Enter**. The login prompt appears.

Note
RUGGEDCOM ROX II features three default user accounts: admin, operator and guest. Additional user accounts can be added. For information about adding user accounts, refer to "Adding a User (Page 138)".

3. Type the user name and press **Enter**. The password prompt appears.

Note
If a unique password/passphrase has not been configured, use the factory default password. For more information, refer to "Default User Names and Passwords (Page 25)".

⚠ NOTICE

RUGGEDCOM ROX II features a Brute Force Attack (BFA) protection system to detect potentially malicious attempts to access the device. When enabled, the protection system will block an IP address after 15 failed login attempts over a 10 minute period. The IP address will be blocked for 720 seconds or 12 minutes the first time. If the same IP address fails again 15 times in a 10 minute period, it will be blocked again, but the waiting period will be 1.5 times longer than the previous wait period.

Siemens strongly recommends that BFA protection be enabled. For more information about enabling BFA protection, refer to "Enabling/Disabling Brute Force Attack Protection (Page 152)".

BFA protection is enabled by default for new installations of RUGGEDCOM ROX II.

4. Type the password associated with the username and press **Enter**.

```
login as: admin
admin@127.0.0.1's password:
Welcome to Rugged CLI
admin connected from 127.0.0.1 using console on ruggedcom
ruggedcom#
```

2.3 Logging Out

To log out of the device, type **`exit`** at the root level.

```
ruggedcom#  exit
```

2.4 Using Network Utilities

RUGGEDCOM ROX II features built-in troubleshooting tools for pinging hosts, tracing routes and analyzing packets.

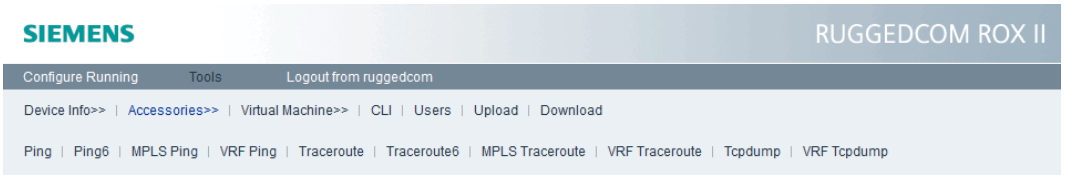


Figure 2.1 Accessories Menu

2.4.1 Pinging an IPv4 Address or Host

To ping an IPv4 address or host, do the following:

1. At the command prompt, type:

   ```
   ping { address }
   ```

   Where { address } is the target IPv4 address or host name.

   The results of the ping are displayed. For example:

   ```
   ruggedcom# ping 192.168.0.7
   PING 192.168.0.7 (192.168.0.7) 56(84) bytes of data.
   64 bytes from 192.168.0.7: icmp_seq=1 ttl=60 time=0.639 ms
   64 bytes from 192.168.0.7: icmp_seq=2 ttl=60 time=0.730 ms
   64 bytes from 192.168.0.7: icmp_seq=3 ttl=60 time=0.591 ms
   64 bytes from 192.168.0.7: icmp_seq=4 ttl=60 time=0.596 ms
   ```

2. Press **Ctrl-C** to stop the ping request.

2.4.2 Pinging an IPv6 Address or Host

To ping an IPv6 address or host, type:

- **For Hosts with IPv4 Addresses**

  ```
  ping { address } iface { interface } count
  { attempts } wait { seconds }
  ```

- **For Hosts with IPv6 Addresses**

  ```
  ping6 { address } iface { interface } count
  { attempts } wait { seconds }
  ```

Where:

- { address } is the IP address of the host
- { attempts } is the number of ping attempts

- { interface } is the interface to use
- { seconds } is the maximum number of seconds to for a response from the host

2.4.3 Pinging MPLS Endpoints

To ping an MPLS endpoint, type:

```
mpls-ping  { address }  { number }
```

Where:

- { address } is the IPv4 address and prefix of the MPLS endpoint
- { number } is the number of ping attempts

2.4.4 Pinging VRF Endpoints

To ping an VRF endpoint, type:

```
vrf-ping  address  { address }  count  { attempts }
vrfname  { name }
```

Where:

- { address } is the IPv4 address and prefix of the VRF endpoint
- { attempts } is the number of ping attempts
- { name } is the target VRF

2.4.5 Tracing a Route to an IPv4 Host

To trace a route to an IPv4 host, do the following:

```
traceroute  { host }
```

Where:

- `{ host }` is the name or IP address of the remote host

The results of the trace are displayed. For example:

```
ruggedcom# traceroute 192.168.0.7
traceroute to 192.168.0.7 (192.168.0.7), 30 hops max, 60 byte packets
 1  * * *
 2  * * *
 3  * * *
 4  * * *
 5  * * *
 .
 .
 .
```

2.4.6 Tracing a Route to an IPv6 Host

To trace a route to an IPv6 host, do the following:

```
traceroute6  { address }
```

Where { address } is the name or IP address of the remote host

The results of the trace are displayed. For example:

```
ruggedcom# traceroute6 2001:0db8:85a3:0000:0000:8a2e:0370:7334
traceroute to 2001:0db8:85a3:0000:0000:8a2e:0370:7334
 (2001:0db8:85a3:0000:0000:8a2e:0370:7334), 30 hops max, 60 byte packets
 1  * * *
 2  * * *
 3  * * *
 4  * * *
 5  * * *
 .
 .
 .
```

2.4.7 Tracing a Route to an MPLS Endpoint

To trace a route to an MPLS endpoint, do the following:

```
mpls-traceroute  { address }
```

Where { address } is the IPv4 address of the MPLS trace route

2.4.8 Tracing a Route to a VRF Endpoint

To trace a route to a VRF endpoint, do the following:

```
vrf-traceroute  vrfname   { name }
```

Where { name } is the VRF endpoint

2.4.9 Capturing Packets from a Network Interface

Tcpdump is a packet analyzer for TCP/IP and other packets. It can be used to capture packets at a specified network interface and dump them to a terminal or file.

To capture packets, type `tcpdump` and configure the following parameters:

Parameter	Description
`count`	The number of packets to capture
`host`	The host name to be ignored or allowed.
`interface`	The interface from the IP list to dump.
`port`	The ports to trace.

Parameter	Description
`verbosity`	The verbosity level. Type v, vv or vvv to set the level.
`address`	Displays the source IP for each packet.
`hex`	Converts the data to hexadecimal or ASCII characters.
`linkheader`	Displays the link level header.
`proto`	**Synopsis:** [t | u | i | a | v | g | o | e | h | p | s | n] The protocol or protocols to filter out. Options include: • **t** – Transmission Control Protocol (TCP) • **u** – User Datagram Protocol (UDP) • **i** – Internet Control Message Protocol (ICMP) • **a** – Address Resolution Protocol (ARP) • **v** – Virtual Redunancy Router Protocol (VRRP) • **g** – Internet Group Management Protocol (IGMP) • **o** – Open Shortest Path First (OSPF) • **e** – Encapsulating Security Payload (ESP) • **h** – Authentication Header (AH) • **p** – Protocol-Independent Multicast (PIM) • **s** – Spanning Tree Protocol (STP) • **n** – Ignores the protocols specified after To select more than one protocol, string the letters together. For example, **tui** will filter out TCP, UDP, and ICMP packets. To ignore a protocol, place **n** before the protocol or protocols that should be ingored. For example, **tui** filters TCP, UDP, and ICMP protocols, but **ntui** filters all protocols except TCP, UDP, and ICMP.

Sample Output

```
ruggedcom# tcpdump address y
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on switch, link-type EN10MB (Ethernet), capture size 262144 bytes
14:41:39.681559 IP 192.168.12.2 &amp;gt; 224.0.0.2: igmp v2 report 224.0.0.2
14:41:40.872170 IP 192.168.23.3 &amp;gt; 224.0.0.13: PIMv2, Hello, length 26
14:41:41.542195 IP 192.168.12.1 &amp;gt; 224.0.0.13: PIMv2, Hello, length 26
14:41:42.342000 IP 192.168.12.1 &amp;gt; 224.0.0.6: igmp v2 report 224.0.0.6
14:41:43.089546 IP 192.168.12.2 &amp;gt; 224.0.0.5: igmp v2 report 224.0.0.5
14:41:45.092975 IP 192.168.12.2 &amp;gt; 224.0.0.13: PIMv2, Hello, length 26
14:41:45.093216 IP 192.168.23.2 &amp;gt; 224.0.0.1: igmp query v2
14:41:45.693560 IP 192.168.23.2 &amp;gt; 224.0.0.13: igmp v2 report 224.0.0.13
14:41:45.808012 IP 192.168.23.3 &amp;gt; 224.0.0.6: igmp v2 report 224.0.0.6
14:41:47.065571 IP 192.168.23.2 &amp;gt; 224.0.0.5: igmp v2 report 224.0.0.5
10 packets captured
10 packets received by filter
0 packets dropped by kernel
```

2.4.10 Capturing Packets from a VRF Network Interface

VRF Tcpdump is a packet analyzer for TCP/IP and other packets. It can be used to capture packets at a specified VRF network interface and dump them to a terminal or file.

To capture packets, type `vrf-tcpdump` and configure the following parameters:

Parameter	Description
`vrfname`	Displays the source IP for each packet.
`address`	Displays the source IP for each packet.
`count`	The number of packets to capture
`hex`	Converts the data to hexadecimal or ASCII characters.
`host`	The host name to be ignored or allowed.
`interface`	The interface from the IP list to dump.
`linkheader`	Displays the link level header.
`port`	The ports to trace.
`proto`	**Synopsis:** [t | u | i | a | v | q | o | e | h] The protocol or protocols to filter out. Options include: • **t** – Transmission Control Protocol (TCP) • **u** – User Datagram Protocol (UDP) • **i** – Internet Control Message Protocol (ICMP) • **a** – Address Resolution Protocol (ARP) • **v** – Virtual Redunancy Router Protocol (VRRP) • **g** – Internet Group Management Protocol (IGMP) • **o** – Open Shortest Path First (OSPF) • **e** – Encapsulating Security Payload (ESP) • **h** – Authentication Header (AH) • **p** – Protocol-Independent Multicast (PIM) • **s** – Spanning Tree Protocol (STP) • **n** – Ignores the protocols specified after To select more than one protocol, string the letters together. For example, **tui** will filter out TCP, UDP, and ICMP packets. To ignore a protocol, place **n** before the protocol or protocols that should be ingored. For example, **tui** filters TCP, UDP, and ICMP protocols, but **ntui** filters all protocols except TCP, UDP, and ICMP.
`verbosity`	The verbosity level. Type v, vv or vvv to set the level.

2.5 Using the Command Line Interface

This section describes how to use Command Line Interface (CLI) for RUGGEDCOM ROX II. It covers common commands, conventions, and useful techniques.

2.5.1 Accessing Different CLI Modes

RUGGEDCOM ROX II provides commands for monitoring and configuring software, hardware and network connectivity. The Command Line Interface (CLI) supports the following modes:

Mode	Description
Operational Mode	Operational mode is the default mode after a user logs in to the device. It allows users to perform general device management actions and provides troubleshooting and maintenance utilities. It is used for viewing the system status, controlling the CLI environment, monitoring and troubleshooting network connectivity, and launching the Configuration mode.
Configuration Mode	Configuration mode is launched from the Operational Mode. It allows users to change the actual configuration of the device. All changes to the configuration are made on a copy of the active configuration, called the candidate configuration. Changes do not take effect until they are committed.

In both modes, the CLI prompt indicates the current mode. In Operational mode, the prompt is:

```
ruggedcom#
```

In Configuration mode, the prompt is:

```
ruggedcom(config)#
```

As a user navigates through the configuration data hierarchy, the prompt indicates the user's location in the configuration. For example, after navigating to ***interface » serial » serport » 1***, the CLI prompt will be:

```
ruggedcom(config-serial-serport/1)#
```

2.5.2 Using Command Line Completion

Commands and parameters do not need to be entered completely for the CLI to recognize them. By typing the first few letters of a command and pressing **Tab**, the CLI will display the possible completions. If the first few letters are unique to a specific command, the full command is automatically displayed. If the first few letters match more than one possible command, a lit of possible completions appears.

Note
Automatic completion is disabled inside quotation marks. If the name of a command or parameter contains a space, such as a filename, escape the space with a \ or enclose the string in quotation marks. For example:

```
who  file   foo\ bar
```

or

```
who  file   "foo bar"
```

Note
Auto-completion also applies to filenames and directories, but cannot be initiated using a space. Auto-completion using a space is disabled when typing a filename or directory name.

2.5.3 Displaying Available Commands

To display a list of available commands at any point in the CLI, type `?`.

For example, in Operational mode, typing `?` at the command prompt displays a list of all Operational mode commands:

```
ruggedcom# ?
Possible completions:
  admin               Configures the general device characteristics
  autowizard       Automatically query for mandatory elements
  clear                 Clear parameter
  commit             Confirm a pending commit
  .
  .
  .
  traceserial        Trace serial ports activities
  who                  Display currently logged on users
  write                 Write configuration
ruggedcom#
```

2.5.4 Editing Commands

The following commands can be used to edit command lines and move around the command history.

Moving the Cursor

Command	Description
Ctrl-B or **Left Arrow**	Moves the cursor back one character
Ctrl-F or **Right Arrow**	Moves the cursor forward one character
Esc-B or **Alt-B**	Moves the cursor back one word
Esc-F or **Alt-F**	Moves the cursor forward one word
Ctrl-A or **Home**	Moves the cursor to the beginning of the command line
Ctrl-E or **End**	Moves the cursor to the end of the command line

Deleting Characters

Command	Description
Ctrl-H, **Delete** or **Backspace**	Delete the character before the cursor
Ctrl-D	Delete the character after the cursor
Ctrl-K	Delete all characters from the cursor to the end of the line
Ctrl-U or **Ctrl-X**	Delete the whole line
Ctrl-W, **Esc-Backspace** or **Alt-Backspace**	Delete the whole before the cursor
Esc-D or **Alt-D**	Delete the whole after the cursor

Inserting Recently Deleted Text

Command	Description
Ctrl-Y	Inserts the most recently deleted text at the cursor's location

Displaying Previously Entered Commands

Command	Description
Ctrl-P or **Up Arrow**	Shows the previous command in the command history
Ctrl-N or **Down Arrow**	Shows the next command in the command history
Ctrl-R	Reverses the order of commands in the command history
`show history`	shows a list of previous commands

Capitalization

Command	Description
Esc-C	Capitalizes the first letter of the word at the cursor's location and sets all other characters to lowercase
Esc-L	Changes the entire word at the cursor's location to lowercase
Esc-U	Changes the entire word at the cursor's location to uppercase

Special Actions

Command	Description
Ctrl-C	Aborts a command or clears the command line
Ctrl-V or **Esc-Q**	Treats the next character(s) as character data, not a command
Ctrl-L	Redraws the screen
Ctrl-T	Transposes characters
Esc-M	Enters multi-line mode
Ctrl-D	Exits multi-line mode
Ctrl-Z	Exits configuration mode

Inserting Hard Returns

Command	Description
Esc-M	Inserts a hard return

2.5.5 Using Double Quotes

When the value for a parameter contains spaces, unless otherwise stated, wrap the value in double-quotes ("").

For example:

```
admin scheduler scheduled-jobs save-myconfig job-
command "show running-config | save myconfig"
```

2.5.6 Using Output Redirects

Information returned from a CLI term can be processed in various ways using an output redirect term. To specify an output redirect, type | after the CLI term and then type the redirect term. To display the available redirects, type | ? after a CLI term. For example:

```
 show admin | ?
Possible completions
  append        Append output text to a file
  begin         Begin with the line that matches
  best-effort   Display data even if data provider is unavailable or continue
                loading from file in presence of failures
  count         Count the number of lines in the output
  csv           Show table output in CSV format
  de-select     De-select columns
  display       Display options
  exclude       Exclude lines that match
  include       Include lines that match
  linnum        Enumerate lines in the output
  match-all     All selected filters must match
  match-any     At least one filter must match
  more          Paginate output
  nomore        Suppress pagination
  notab         Suppress table output
  repeat        Repeat show command with a given interval
  save          Save output text to a file
  select        Select additional columns
  sort-by       Select sorting indices
  tab           Enforce table output
  until         End with the line that matches
```

Command	Description
`append`	Appends the output text to a specified ASCII text file. For example, running these two terms appends the admin and chassis information to the specified file: `ruggedcom# show admin | append foo.txt`

Command	Description

	`ruggedcom# show interface | append foo.txt`
	
	The resulting file contains the results of `show interface` appended to the results of `show admin` (lines truncated with ... are shortened for illustrative purposes only):
	
	`ruggedcom# file show-config foo.txt`
	`admin`
	`time`
	`gmtime "Thu Oct 2 19:35:17 2014"`
	`localtime "Thu Oct 2 15:35:17 2014"`
	`rox-imaging`
	`roxflash-progress`
	`phase Inactive`
	`status message ""`
	`image flashing 0`
	`netconf`
	`statistics`
	`in bad hellos 0`
	`in sessions 0`
	`dropped sessions 0`
	`in rpcs 0`
	`in bad rpcs 0`
	`out rpc errors 0`
	`out notifications 0`
	`software-upgrade`
	`upgrade-progress`
	`software partition "Partition #1"`
	`current version "ROX 2.7.0-QA3.1 (2014-10-21 14:59)"`
	`upgrade state Inactive`
	`status message ""`
	`filesystem copy 0`
	`package download 0`
	`package installation 0`
	`last upgrade attempt "Thu Oct 2 09:57:46 EDT 2014"`
	`last upgrade result "Upgrade Successful"`

`begin`	Begins the output with the line containing the specified text. Regular expressions can be used with this redirect. For more information about regular expressions, refer to "Using Regular Expressions (Page 42)".
	
	For example, `show admin | begin netconf` returns all of the **admin** information following the `netconf` line:
	
	`ruggedcom# show admin | begin netconf`
	`netconf`
	`statistics`
	`in sessions 0 in xml parse errs 0 in bad hellos 0 in rpcs 0 in bad rpcs 0 in not...`

`best-effort`	Displays data even if the data provider is unavailable, or continues loading from file in presence of failures.

Command	Description
	For example, `show chassis line-modules line-module | best-effort` shows the line module status in the chassis, including slots with no line module detected. `show chassis line-modules line-module	best-effort`  `BYPASS OVERCURRENT` `SLOT DETECTED MODULE` `STATUS STATUS` `----------` `swport SM M88E6097F, 4FT 2GP -` `serport 2xRS232/422/485 -` `celport 1x Cell LTE NAM A/R/B/T -` `wlanport 1x WLAN 802.11 -`

`csv`	Shows table output in CSV (Comma-Separated-Values) format.
	
	For example, `show admin alarms | csv` shows the **alarms** information in CSV format.
	
	`show admin alarms | csv`
	`,ALARM,EVENT,,,,,`
	`SUBSYSTEM,ID,ID,SEVERITY,DESCRIPTION,DATE TIME,USER ACTIONS,ACTUATORS`
	`switch,1,1,notice,Link-up on port swport/1,Sat Mar 2 15:34:34 2019,clear-or-ack,none`

`de-select`	De-selects columns from table entries.
	
	For example, `show chassis line-modules line-module | de-select bypass` removes the BYPASS column from the display.
	
	`show chassis line-modules line-module`
	
	`BYPASS OVERCURRENT`
	`SLOT DETECTED MODULE`
	`STATUS STATUS`
	`----------`
	`swport SM M88E6097F, 4FT 2GP -`
	`serport 2xRS232/422/485 -`
	`celport 1x Cell LTE NAM A/R/B/T -`
	`wlanport 1x WLAN 802.11 -`
	
	`show chassis line-modules line-module | de-select bypass`
	`SLOT DETECTED MODULE`
	`----------`
	`swport SM M88E6097F, 4FT 2GP`

Command	Description

	`serport  2xRS232/422/485`
	`celport  1x Cell LTE NAM A/R/B/T`
	`wlanport  1x WLAN 802.11`

`display`	Provides displays options.
	For example, `show admin alarms | display xml` shows the **alarms** information in extensible markup language format.
	`& show admin alarms | display xml`
	`<config xmlns="http://tail-f.com/ns/config/1.0">`
	`<admin xmlns="http://ruggedcom.com/ns/rmf_admin">`
	`<alarms>`
	`<active-alarms>`
	`<subsystem>switch</subsystem>`
	`<alarm-id>1</alarm-id>`
	`<event-id>1</event-id>`
	`<severity>notice</severity>`
	`<description>Link-up on port swport/1</description>`
	`<date-time>Sat Mar 2 15:34:34 2019</date-time>`
	`<user-actions>clear-or-ack</user-actions>`
	`<actuators>none</actuators>`
	`</active-alarms>`
	`</alarms>`
	`</admin>`
	`</config>`

`exclude`	Excludes lines containing the specified text. Information that is a *child* of the excluded line is also excluded. Regular expressions can be used with this redirect. For more information about regular expressions, refer to "Using Regular Expressions (Page 42)".
	For example, `show admin | exclude netconf` shows the **admin** information, excluding the `netconf` lines.
	`ruggedcom# show admin | exclude netconf`
	`admin`
	`time`
	`gmtime "Tue Feb 15 08:25:27 2011\n"`
	`localtime "Tue Feb 15 03:25:27 2011\n"`

Command	Description
	software-upgrade upgrade-progress software partition "Partition #1" current version "ROX 2.1.0 (2010-12-03 17:38) ... statistics in sessions 0 in xml parse errs 0 in bad hellos 0 in rpcs 0 in bad rpcs 0 in not... supported rpcs 0 out rpc replies 0 out rpc errors 0 out notifications 0
`include`	Includes lines containing the specified text. Information that is a *child* of the included line is usually included, but may not be in some cases. Regular expressions can be used with this redirect. For more information about regular expressions, refer to "Using Regular Expressions (Page 42)". For example, `show admin | include time` shows the `time` lines from the **admin** information. `ruggedcom# show admin | include time` time gmtime "Tue Feb 15 08:34:55 2011\n" localtime "Tue Feb 15 03:34:55 2011\n" ruggedcom#
`linnum`	Numbers the lines in the output. For example: ruggedcom# show admin | linnum 1: admin 2: time 3: gmtime "Tue Feb 15 08:37:42 2011\n" localtime "Tue Feb 15 03:37:42 2011\n" 4: software-upgrade . . .
`match-all`	All selected filters must match. For example, `show running-config | include interface | match-all` adds a filter to show all available interfaces. show running-config | include interface | match-all partname "(MX)Rack Rear Mount, No interfaces/LEDs on Front Panel" partname "Rack Rear Mount, No interfaces/LEDs on Front Panel" interface interface-mpls cel-6-1 interface-mpls fe-cm-1 interface-ldp cel-6-1 interface-ldp fe-cm-1 interface cel-6-1 interface fe-cm-1

Command	Description

	`interface cel-6-1`
	`interface fe-cm-1`
	`interface cel-6-1`
	`interface fe-cm-1`
	`interface cel-6-1`
	`interface dummy0`
	`interface fe-cm-1`

`match-any`	At least one filter must match.
`more`	Paginates the output. When the output reaches the screen-length setting, the CLI prompts you to press a key for more. Press **Enter** to advance line-by-line; press **space** to advance page-by-page.
`nomore`	Suppresses pagination.

`notab`	Suppresses table output.
	For example, `show chassis | begin line-modules` shows the following table:
	`ruggedcom# show chassis | begin line-modules`
	` line-modules`
	`  line-module`
	`  BYPASS OVERCURRENT STATUS`
	`SLOT  DETECTED MODULE  STATUS`
	`---`
	`swport  SM M88E6097F, 4FT 2GP  -`
	`eth  none  -`
	`serport  2xRS232/422/485  -`
	`celport  1x Cell LTE EU  -`
	For example, `show chassis | begin line-modules | notab` suppresses the table formatting:
	`ruggedcom# show chassis | begin line-modules | notab`
	` line-modules`
	`  line-module swport`
	`  detected module "SM M88E6097F, 4FT 2GP"`
	`  line-module eth`
	`  detected module none`
	`  line-module serport`
	`  detected module 2xRS232/422/485`
	`  line-module celport`
	`  detected module "1x Cell LTE EU"`

`repeat`	Repeats the term at the specified interval. Specify an interval in seconds. The term repeats until you cancel it with **Ctrl-C**. For example, `show admin | repeat 10s` repeats the `show admin` term every 10 seconds.
`save`	Saves the output to the specified ASCII text file.

Command	Description
	For example, `show chassis | save foo.txt` saves the **chassis** information to the file `foo.txt`
`select`	Only the specified parameter is shown in in table entries. For example, `show chassis line-modules line-module | select detected-module` displays the DETECTED MODULE column. `show chassis line-modules line-module	select detected-module` `SLOT DETECTED MODULE` `---` `lm1 none` `lm2 none` `lm3 none` `lm4 1x Cell LTE NAM V/S` `lm5 none` `lm6 1x Cell LTE APAC`
`sort-by`	Sorts the output according to the specified parameter. For example, `show chassis line-modules line-module | sort-by detected-module` sorts the output per the DETECTED MODULE column. `show chassis line-modules line-module	sort-by detected-module` `BYPASS OVERCURRENT` `SLOT DETECTED MODULE` `STATUS STATUS` `---` `celport 1x Cell LTE NAM A/R/B/T -` `-` `wlanport 1x WLAN 802.11 -` `-` `serport 2xRS232/422/485 -` `-` `swport SM M88E6097F, 4FT 2GP -` `-`
`tab`	Enforces table layout for columnar data.

`until`	Includes output until a line containing the specified text appears. Regular expressions can be used with this redirect. For more information about regular expressions, refer to "Using Regular Expressions (Page 42)".
	For example, `show chassis | begin line-modules | until status` returns the **chassis** information beginning with `line-modules` and ending with `status`:
	`ruggedcom# show chassis | begin line-modules | until status`
	`line-modules`
	`line-module`

Command	Description
	BYPASS OVERCURRENT SLOT DETECTED MODULE STATUS STATUS --- swport SM M88E6097F, 4FT 2GP - - eth none - - serport 2xRS232/422/485 - - celport 1x Cell LTE EU - -

2.5.7 Using Regular Expressions

RUGGEDCOM ROX II command line regular expressions are a subset of the regular expressions found in egrep and in the AWK programming language. Regular expressions can be used along with several of the output redirects. For more information about using output redirects, refer to "Using Output Redirects (Page 35)".

Character	Description	Example
.	Matches any single character (e.g. .100, 100., .100.)	.100 100. .100.
*	Matches zero (0) or more occurrences of a pattern	100*
+	Matches 1 or more occurrences of a pattern	100+
?	Match 0 or 1 occurrences of a pattern	100?
^	Matches the beginning of the line	^100
$	Matches the end of the line	100$
()	Matches only the characters specified	(38a)
[]	Matches any character other than those specified	[^abc]
_ (underscore)	The underscore character has special meanings in an autonomous system path. It matches to: • Each space ( ) and comma (,) • Each AS set delimiter (e.g. *{* and *}*) • Each AS confederation delimiter (e.g. *(* and *)*) • The beginning and end of the line Therefore, the underscore can be used to match AS values.	_100,100_, _100_

For example, to show all the IP interfaces that are in the *up* state:

```
ruggedcom# show interfaces ip | include up
 admin state up
 state       up
 admin state up
 state       up
 admin state up
 state       up
 admin state up
```

```
 admin state up
 admin state up
 admin state up
 admin state up
```

2.5.8 Using CLI Utilities

The Operational mode provides a set of standard utility applications, similar to those on a typical Linux-based operating system.

Command	Description
`ssh host { address/name } { bind-address { address } | cipher-spec { cipher } | list-ciphers | login { name } | port { number } | sub-system { name } }`	Opens a secure shell on another host. Parameters include: • `host` is the name or IP address of the host. It is mandatory. • `bind-address` is the source address of the connection. Only useful on systems with more than one address. • `cipher-spec` is a comma-separated list of the ciphers to support for encrypting the session. To see the list of supported ciphers, use the `list-ciphers` option. • `list-ciphers` is the list of ciphers supported for SSH session encryption (e.g. aes256-ctr). • `login` is the users login name on the host. • `port` is the TCP port number to open an SSH session to. • `sub-system` invokes a subsystem on the remote system, such as NETCONF.
`telnet host { address/name }`	Opens a telnet session to another host. Parameters include: • `{ host }` is the name or IP address of the host

Further information about these well-known applications is publicly available on the Internet.

2.5.9 Specifying a Range

Some CLI commands accept a range of values, such as 3-6, to specify multiple targets. In the following example, a command is applied to ports 1, 2 and 3 on the swport slot:

```
ruggedcom(config)# interface switch swport 1-3
```

In this example, a command is issued to ports 1, 2 and 4 on the swport slot:

```
ruggedcom(config)# interface switch swport 1-2,4
```

When available, the `range` parameter can be included before the value range:

```
ruggedcom(config)# interface switch range swport 1-2,4
```

2.5.10 Common Commands

This section details common commands available in operational and configuration mode.

2.5.10.1 Basic CLI Commands

Use the following commands to perform basic CLI functions.

Command	Description
`exit [ level | configuration-mode | no-confirm ]`	**Default:** level Exits from the current mode. • `level` exits from the current mode. If performed at the top level, this command exits from the configuration mode. • `configuration-mode` exits from configuration mode regardless of mode. • `no-confirm` exits from configuration mode without prompting the user to commit any pending changes.
`help { command }`	Displays help text for the specified command.

`id`	Displays the current user's information. For example:
	`ruggedcom# id`
	`user = admin(0), gid=0, groups=admin, gids=`

`logout [ logout | sessionid ]`	Terminates the specified session. A session can be specified based on its user ID or session ID.
`quit`	Logs out of and ends the CLI session.

`send [ all | admin ] { message }`	Sends a message to all users of the specified type. For example:
	`ruggedcom# send all "Rebooting at midnight!"Message from admin@ruggedcom at 2011-02-15 08:42:49...`
	`Rebooting at midnight!`
	`EOF`

`show [ admin | chassis | interface | interfaces | netconf | routing | services ]`	Shows selected configuration information. Use auto completion to display the list of options available at each configuration level. For example: `ruggedcom# show chassis hardware slot-hardware`

Command	Description
	``` ORDER SERIAL SLOT FIELD DETECTED MODULE NUMBER --- swport SM0001 SM M88E6097F, 4FT 2GP serport SER0001 2xRS232/422/485 celport CELL0001 Cellular Modem ```
`show [ cli | history | jobs | log | { logfile } ]`	Shows selected system information. • `cli` shows the CLI environment settings. For example: ``` ruggedcom# show cli autowizard true complete-on-space true display-level 99999999 history 100 ignore-leading-space true output-file terminal paginate true screen-length 65 screen-width 237 service prompt config true show-defaults false terminal xterm ``` • `history` displays the CLI command history. • `jobs` displays currently running background jobs. For example: ``` ruggedcom# show jobs JOB COMMAND 2 monitor start /tmp/saved ``` • `log` and `logfile` display the selected log file. Use auto completion to view a list of available log files.
`show parser dump { command }`	Displays all possible commands starting with the specified command.
`show running-config { option }`	Displays the current configuration. If an `{ option }` parameter is not specified, the entire configuration will be displayed by default . Use auto completion to see a list of configuration options. Use | and one or more output redirects to restrict the information to be shown.

2.5.10.2 File Commands

Operational mode provides commands for managing log and configuration files on the device.

Note
Secure Copy Protocol (SCP) commands, such as `file scp-log-to-url` , require a user name, host name, or file path in the form of:

`{ user }@{ host }:{ path }`

Specific rules apply.

User Names

- May only contain alphabetic characters, numeric characters, underscores (_), and dashes (-)
- Must start and end with an alphabetic or numeric character

Host Names

- May be a valid host name or IP address
- Host names may only contain alphabetic characters, numeric characters, dashes (-), and periods (.)
- IP address must be valid IPv4 addresses of the format AAA.BBB.CCC.DDD

File Paths

- May only contain alphabetic characters, numeric characters, forward slashes (/), dashes (-), periods (.), underscores (_), astericks (*), plus signs (+), and tildes (~)

Command	Description

`file compare-config { filename1 } { filename2 }`	Compares the contents of two files. A **<** character indicates text that is present in the first selected file but not in the second file. A **>** character indicates text that is present in the second selected file but not in the first file. In the following example, the user information is present in the second file, but not in the first:
	`ruggedcom# file compare deleted_users all_users`
	`125,127d124`
	`< userid jsmith`
	`< password $1$N1YT8Azl $KcG1E6/r91EXc4mgEEsAW. role administrator`
	`< !`

`file copy-config { current-filename } { new-filename }`	Copies a configuration file. After typing the command, press **Tab** to view a list of available files. For example, the following command copies the **deleted_users** file to the **archive001** file: `ruggedcom# file copy-config deleted_users archive001`
`file copy-config-from-removable { path } [ { config-filename } | force | no-force ]`	Copies a config file from the removable drive to the **var/lib/config** directory. After typing the command, press **Tab** to view a list of available files. Options include: • `{ path }` is the path to the removable drive/configuration file.

Command	Description

	For example, the following command copies the **lnx2** file:
	`ruggedcom# file copy-config-from-removable sd://sd-1/lnx2`
	Additional options include:
	• `{ config-filename }` is the desired new filename of the configuration file to be copied. To use the current filename, specify the current filename or exclude this parameter from the command.
	For example, the following command copies and renames the **lnx2** file to **lnx3**:
	`ruggedcom# file copy-config-from-removable sd://sd-1/lnx2/lnx3`
	• `[ force | no force ]` allows the overwriting of a configuration with the same name that may exist in the **var/lib/config** directory. Excluding this parameter defaults to `no force`, meaning the existing file will not be overwritten.
	For example, the following command copies and overwrites the existing **lnx2** file in the **var/lib/config** directory:
	`ruggedcom# file copy-config-from-removable sd://sd-1/lnx2 force`

`file copy-config-to-removable { config-filename } { path } [ force | no-force ]`	Copies a config file from the **var/lib/config** directory to the removable drive. After typing the command, press **Tab** to view a list of available files. Options include: • `{ config-filename }` is name of the configuration file to be copied. • `{ path }` is the path to the removable drive. For example, the following command copies the **nextgen** file: `ruggedcom# file copy-config-to-removable nextgen sd://sd-1/nextgen` Redefining the path allows renaming the configuration file on the removable drive. For example, the following command copies the **nextgen** file from the **var/lib/config** directory and renames it **nextgen2** on the removable drive:

Command	Description

	`ruggedcom# file copy-config-to-removable nextgen sd://sd-1/nextgen2`
	
	Additional options include:
	• [force | no force] allows the overwriting of a configuration with the same name that may exist on the removable drive. Excluding this parameter defaults to no force , meaning the existing file will not be overwritten.
	
	For example, the following command copies and overwrites the existing **nextgen** file in the removeable drive:
	
	`ruggedcom# file copy-config-to-removable nextgen sd://sd-1/nextgen force`

`file copy-from-remote-to-removable { source-path } { removable-drive-path } [ force | no-force ]`	Copies a file from a remote host to the removable drive. After typing the command, press **Tab** to view a list of available files.
	
	Options include:
	• { source-path } is the path to the source file, either a remote PC or other host.
	• { removable-drive-path } is the path to the removable drive.
	
	For example, the following command copies the **nextgen** file:
	
	`ruggedcom# file copy-from-remote-to-removable ftp://172.30.142.230/nextgen sd://sd-1/nextgen`
	
	Redefining the path allows renaming the configuration file on the removable drive. For example, the following command copies the **nextgen** file from the remote host and renames it **nextgen2** on the removable drive:
	
	`ruggedcom# file copy-from-remote-to-removable ftp://172.30.142.230/nextgen sd://sd-1/nextgen2`
	
	Additional options include:
	• [force | no force] allows the overwriting of a configuration with the same name that may exist on the removable drive. Excluding this parameter defaults to no force , meaning the existing file will not be overwritten.
	
	For example, the following command copies and overwrites the existing **nextgen** file in the removable drive:

Command	Description
	`ruggedcom# file copy-from-remote-to-removable ftp://172.30.142.230/nextgen sd://sd-1/nextgen force`

`file copy-from-removable-to-remote { removable-drive-path } { target-path }`	**Note**
	Remote web servers must support *HTTP PUT* requests to accept files from the removable drive.
	
	Copies a file from the removable drive to a remote host. After typing the command, press **Tab** to view a list of available files.
	
	Options include:
	• `{ removable-drive-path }` is the path to the removable drive.
	• `{ target-path }` is the path to the target, either a remote PC or other host.
	
	For example, the following command copies the **nextgen** file:
	`ruggedcom# file copy-from-removable-to-remote sd://sd-1/nextgen ftp://username:password@172.30.142.230/nextgen`
	
	Redefining the path allows renaming the configuration file on the removable drive. For example, the following command copies the **nextgen** file from the remote host and renames it **nextgen2** on the removable drive:
	`ruggedcom# file copy-from-removable-to-remote sd://sd-1/nextgen ftp://username:password@172.30.142.230/nextgen2`

`file create-directory-on-removable { removable-drive-path }`	Creates a directory on the removable drive. Options include: • `{ removable-drive-path }` is the path/name of the new directory on the removable drive. For example, the following command creates the **lnx10** directory: `ruggedcom# file create-directory-on-removable sd://sd-1/lnx10`
`file delete-config { filename }`	Deletes a configuration file. After typing the command, press **Tab** to view a list of available files. For example, the following command deletes the **deleted_users** file:

Command	Description
	`ruggedcom# file delete-config deleted_users`

`file delete-from-removable { removable-drive-path } [ force | no-force ]`	Deletes a directory from the removable drive.
	Options include:
	• `{ removable-drive-path }` is the path/name of the directory to be deleted from the removable drive.
	For example, the following command deletes the **lnx6** directory:
	`ruggedcom# file delete-from-removable sd://sd-1/lnx6`
	Additional options include:
	• `[ force | no force ]` allows the deletion of a directory containing files. Excluding this parameter defaults to `no force`, meaning a directory containing files cannot be deleted.
	For example, the following command deletes the **lnx6** directory, containing files, from the removable drive:
	`ruggedcom# file delete-from-removable sd://sd-1/lnx6 force`

`file list-config`	Lists the configuration files. For example: `ruggedcom# file list-config --help 10.200.20.39 _tmp_confd_cmd.0 archive001 archive002 default_rx1000_config`
`file list-removable-directory { removable-drive-path } [ size | no-size ]`	Lists directory contents on the removable drive. Options include: • `{ removable-drive-path }` is the path/name of the directory to be listed. For example, the following command lists the contents of the **sd-1** directory: `ruggedcom# file list-removable-directory sd://sd-1/` **Note** The forward slash (/) is used to display the contents of the parent directory. To display the contents of a subdirectory, specify the full path. Additional options include: • `[ size | no size ]` allows the display of each file size in the listing. Excluding this

Command	Description
	parameter defaults to `size`, meaning file sizes will be displayed. For example, the following command lists files in the **sd-1** directory, including the size of each file: `ruggedcom# file list-removable-directory sd://sd-1/ size`
`file rename-config { current-filename } { new-filename }`	Renames a configuration file. For example, the following command renames the **test002** file to **production_config**: `ruggedcom# file rename-config test002 production_config`
`file rename-on-removable { current-name-path } { new-name-path }`	Renames a file or directory on the removable drive. For example, the following command renames the **test001.txt** file in the **sd-1** directory to **test002.txt**: `ruggedcom# file rename-on-removable sd://sd-1/test001.txt test002.txt`
`file scp-config-from-url { user }@{ host }:/{ path }/ { current-filename } { new-filename }`	Securely copies a configuration file from a remote computer to the device. The remote computer must have an SCP or SSH (secure shell) service or client installed and running. To use this command, the user credentials for the remote computer, the IP address or host name of the remote computer, the directory path to the configuration file on the remote computer, and the configuration file filename must all be known. Type the command in the following format: `file scp-config-from-url { user }@{ host }:/{ path }/ { current-filename } { new-filename }` Where: • `{ user }` is a user name with access rights to the remote computer. • `{ host }` is the host name or IP address of the remote computer. • `{ path }` path is the path to the configuration file on the remote computer. • `{ current-filename }` is the current filename of the configuration file. • `{ new-filename }` is the new filename for the configuration file. To use the current filename, specify the current filename or exclude this parameter from the command. When prompted, type the password to connect to the remote computer. For example:

Command	Description

	`ruggedcom# file scp-config-from-url jsmith@10.200.20.39:/c:/ruggedcom/standard_config standard_config`
	`jsmith@10.200.20.39's password:`
	`standard_config.txt 100% 7673 7.5KB/s 00:00`

`file scp-config-to-url { current-filename } { user }@{ host }:/{ path }/{ new-filename }`	Securely copies a configuration file from the device to a remote computer. The remote computer must have an SCP or SSH (secure shell) service or client installed and running.
	To use this command, the user credentials for the remote computer, the IP address or host name of the remote computer, the directory path to the configuration file on the remote computer, and the configuration file filename must all be known.
	Type the command in the following format:
	`file scp-config-to-url { current-filename } { user }@{ host }:/{ path }/{ new-filename }`
	Where:
	• `{ current-filename }` is the current filename of the configuration file.
	• `{ user }` is a user name with access rights to the remote computer.
	• `{ host }` is the host name or IP address of the remote computer.
	• `{ path }` path specifies where to save the configuration file on the remote computer.
	• `{ new-filename }` is the new filename for the configuration file. To use the current filename, specify the current filename or exclude this parameter from the command.
	When prompted, type the password to connect to the remote computer. For example:
	`ruggedcom# file scp-config-to-url default_config jsmith@10.200.20.39:/c:/ruggedcom/default_config`
	`jsmith@10.200.20.39's password:`
	`standard_config.txt 100% 7673 7.5KB/s 00:00`

`file scp-log-to-url { current-filename } { user }@{ host }:/{ path }/{ new-filename }`	Securely copies a log file to a remote computer from the device. The remote computer must have an SCP or SSH (secure shell) service or client installed and running. To use this command, the user credentials for the remote computer, the IP address or host name of the remote computer, the directory

Command	Description

	path to the log file on the remote computer, and the log file filename must all be known.
	Where:
	• `{ current-filename }` is the current filename of the log file.
	• `{ user }` is a user name with access rights to the remote computer.
	• `{ host }` is the host name or IP address of the remote computer.
	• `{ path }` path specifies where to save the log file on the remote computer.
	• `{ new-filename }` is the new filename for the log file. To use the current filename, specify the current filename or exclude this parameter from the command.
	When prompted, type the password to connect to the remote computer. For example:
	`ruggedcom# file scp-log-to-url syslog.1 jsmith@10.200.20.39:/c:/ruggedcom/syslog.1`
	`jsmith@10.200.20.39's password:`
	`syslog.1 100% 12KB 12.4KB/s 00:00`

`file show-config { filename }`	Displays the content of a specified file. Use auto completion to display a list of available files. For example:
	`ruggedcom# file show-config added_users.txt`
	`admin system-name "System Name" location Location contact Contact`
	`admin hostname name ruggedcom domain localdomain`
	`admin session-limits max-sessions 50`
	`.`
	`.`
	`.`

2.5.10.3 Interface and Services Commands

Operational mode provides commands for restarting and displaying information for various interfaces and services.

Command	Description
`interfaces cellmodem cel-1 lte [ at | reset ]`	Sends an AT or reset command to the specified modem. Use auto completion to display a list of available modems. • **at** – Sends an AT command to the selected modem. To send multiple AT commands, separate each command with a : colon. • **reset** – Resets the modem.

Command	Description
`interfaces serial restart-serserver`	Restarts the serial communication service.
`interfaces switch swport { port } clearportstats`	Clears statistics for the selected port.
`services dhcpserver show-active-leases`	Displays active DHCP leases.

2.5.10.4 Administration Commands

Operational mode provides commands for performing device administration tasks.

Command	Description
`admin acknowledge-all-alarms`	Acknowledges all system alarms.
`admin clear-all-alarms`	Clears all system alarms.
`admin delete-autoload-configuration-from-removable`	Deletes the automatic-loading file **autoload-config.cli** (if present) from the removable drive.
`admin restore-factory-defaults`	Restores the factory default configuration and settings, but does not erase any files you have saved on the device.
`admin reboot`	Reboots the device.
`admin save-configuration-to-removable allow-overwrite [ false | true ]`	Saves the current configuration to the removable drive as automatic-loading file **autoload-config.cli**. The allow-overwrite default option is `false` , meaning the action will fail if a file with the same name exists on the removable drive. The `true` options allows the existing **autoload-config.cli** file on the removable drive to be overwritten.
`admin save-configuration-to-removable { filename } allow-overwrite [ false | true ]`	Saves the specified file to the removable drive. The allow-overwrite default option is `false` , meaning the action will fail if a file with the same name exists on the removable drive. The `true` options allows the existing file with the same name on the removable drive to be overwritten.
`admin set-system-clock time { YYYY-MM-DD } { HH:MM:SS }`	Sets the date and time on the device. To specify just the date, type the date in the format `{ YYYY-MM-DD }` . To specify just the time, type the time in the format `{ HH:MM:SS }` . To specify both date and time, enclose the string in quotation marks and type the date and time in the format `{ "YYYY-MM-DD HH:MM:SS" }` . **Note** When setting the time, specifying seconds seconds (SS) is optional.
`admin shutdown`	Shuts down the device. For more information on shutting down the device, refer to "Shutting Down the Device (Page 83)"

Command	Description
`admin rox-imaging decline-upgrade`	Cancels (or declines) a recent software upgrade that is waiting for a reboot to the upgraded partition.
`admin rox-imaging software-upgrade`	Launches an upgrade in the alternate partition.
`admin rox-imaging rollback-reboot`	Boots to a previous software release on the alternate partition.
`key-tool-maint-mode`	A key tool to enter the maintenance mode key in hexadecimal format. The hexadecimal format key is available from Siemens Customer Support via telephone when email support is unavailable. The user must be an administrator.
`maint-login`	**⚠ NOTICE** **Configuration hazard – risk of data loss/ corruption** Maintenance mode is provided for troubleshooting purposes and should only be used by Siemens Canada Ltd. technicians. Maintenance mode is provided for troubleshooting purposes and all possible commands are not documented. Misuse of maintenance mode commands can corrupt the operational state of the device and render the device inaccessible. Logs in to the underlying operating system as the root user. The user must be an administrator and be able to provide the maint-login password.
`monitor start { filename }`	Starts displaying the specified system log or tracing the specified file. If necessary, the output can be redirected to a file. For information on how to redirect output, refer to "Using Output Redirects (Page 35)". Use auto completion to view a list of available logs and files.
`monitor stop { filename }`	Stops displaying the specified system log or tracing the specified file. Use auto completion to view a list of available logs and files.
`reportstats`	Displays an extensive collection of device-specific statistics. If necessary, the output can be redirected to a file. For information on how to redirect output, refer to "Using Output Redirects (Page 35)".
`config private`	Enters a configuration mode where users can make changes to the system. This is the primary mode for most users who want to make changes to the device/network configuration. It can be accessed by multiple Operator and Admin users. All changes made during a private configuration session are hidden from other users until they are committed. Each change must be committed before it is applied to the active system.

Command	Description
	If a user opens an exclusive configuration session during another user's private configuration session, the user in the private configuration session cannot commit their changes until the other user ends their session.
`config exclusive`	Enters a configuration mode where users can make changes to the system. This mode is similar to the private configuration mode, except all other users are blocked from committing their changes until the user using the exclusive configuration mode exits. Only one Operator or Admin user can use the exclusive configuration mode at a time per device. When committing changes in exclusive configuration mode, use the confirmed option to set a timeout period. Changes will be applied for the set period of time, after which the configuration will be reset to its previous settings. This allows users to test their configuration changes before fully applying them to the active system. For more information about the confirmed option, refer to "Configuration Mode General Commands (Page 56)". **⚠ NOTICE** Always log out of the exclusive configuration mode or exit the transaction. If the session is terminated before a user exits properly, other users logged in to the device will continue to be blocked from making changes until the session timeout period expires.

2.5.10.5 Configuration Mode General Commands

Configuration mode provides a set of general commands that allow users to work with configuration data.

Command	Description
`abort`	Exits the configuration session without saving changes. **Note** In an edit exclusive session, any pending unconfirmed commits will not be canceled until their timeout periods expire. A new edit exclusive session cannot be opened until the timeout period ends.
`clear`	Deletes all configuration changes.
`commit no-confirm`	Immediately commits the current set of configuration changes. This command will prompt

Command	Description
	the user to confirm the action. Use the `no-confirm` parameter to revert the configuration without requiring confirmation.
`commit abort`	In an edit exclusive session, this command aborts/ cancels all confirmed commits.
`commit and-quit`	Commits all confirmed and unconfirmed changes and exits the configuration mode.
`commit check`	Validates the current configuration.

`commit confirmed { timeout }`	Temporarily commits changes for a period of time, allowing users to test the configuration before fully committing the changes. The changes must be committed using a standard `commit` command before the timeout period ends. If changes are not committed before the timeout period ends, they are automatically discarded and the previous settings are restored.
	A timeout period can be specified at the end of the command. The default timeout period is 10 minutes. The minimum timeout period is 1 minute. For example:
	`ruggedcom(config-admin)# commit confirmed 2`
	To cancel a commit before the time elapses and discard the changes, type:
	`commit abort`
	To permanently commit the changes before the time elapses, type:
	`commit`

`commit comment { text }`	Immediately commits the current set of configuration changes along with a custom comment. The comment will appear next to the commit in a list of pending of commits.
`commit label { text }`	Immediately commits the current set of configuration changes along with a custom label. In a list of pending commits, the label will appear instead of the auto-generated commit ID.
`commit persist-id { text }`	Immediately commits the current set of configuration changes and assigns a user-specified ID or flag.
`commit save-running { file }`	Immediately commits the current set of configuration changes and saves them to the specified file. It does not save the complete running configuration.
`copy`	Copies a configured element to a new element. For example, the following command copies the userid *admin* to the new userid *wsmith*: `ruggedcom(config)# copy admin users userid admin smith`

Command	Description
	The new item has all of the attributes of the item from which it is copied. In this example, userid *wsmith* will have the same password and role attributes as the userid *admin*.

`details`	When used in combination with the `save` command, the `details` command includes default values in the saved configuration file. For example:
	`ruggedcom(config)# save {filename} | details`
	The details command can also be used to show default configuration values. For example:
	`ruggedcom(config)# show running-config admin session-limits | details`

`do`	Performs an Operational mode command. For example, the following command performs the Operational mode `ping` command in the Configuration mode session: `ruggedcom(config)# do ping 172.30.134.12`
`end`	Terminates the configuration session. The system prompts the user to commit uncommitted changes.
`exit`	Exits from the current mode. Unlike the `end` command, the system does not prompt the user to commit uncommitted changes.
`help command`	Displays help information for the specified command.
`load [ merge | override ] { filename }`	Loads a configuration from an ASCII CLI configuration file. Two parameters are available for the CLI load command: `override` and `merge` . • **Override:** this parameter is for users who have a full configuration file saved and want to load it back on to the device. The full configuration file can be previously created with the CLI **save** command executed from the top level in the configuration tree or with the `admin full-configuration-save` command. With the `override` parameter, the entire running configuration is overwritten by the contents of the configuration file. The override option has the following restrictions: • The configuration file must be a *complete* configuration for the device. A *complete* configuration is the entire configuration tree.

Command	Description
	• The `load` command must be invoked at the base of the configuration tree. • **Merge** – this parameter is for users who want to build a template configuration and load it to many devices. The template configuration file can be obtained by using the CLI save command. With the merge parameter, the contents of the configuration file will be merged with the running configuration. The remaining configurations, which are not included in the configuration file, will remain unchanged. After loading the configuration, use the `commit` command to commit the changes.
`move ip { interface } ipv4 address { address } [ after | before | first | last ] { address }`	Moves an existing IPv4 address to a new position in the list of addresses. The address can be moved to the first or last (default) position in the list, or before or after another address. For example, the following command moves 172.30.137.37/9 before 172.30.137.31/19: `ruggedcom(config)# move ip fe-3-1 ipv4 address 172.30.137.37/19 before 172.30.137.31/19`

`no`	Negates a command or sets it to its default setting. For example, the following command deletes the IP address 172.30.137.37/19:
	`ruggedcom(config)# no ip fe-3-1 ipv4 address 172.30.137.37/19`
	Note
	The `no` command affects only the parameter or setting of the node explicitly specified in the command. When using `no` to negate a parameter or setting that has dependencies, clearing the specific parameter does not clear the related dependencies.
	For example, the following command adds an IPv4 route with a gateway:
	`ruggedcom(config)# routing static ipv4 route 192.168.33.0/24 via 192.168.11.2`
	The following command deletes the gateway, but it does not delete the route:
	`ruggedcom(config)# no routing static ipv4 route 192.168.33.0/24 via 192.168.11.2`
	The `no` deletes only the explicitly specified parameter or object.

Command	Description

`pwd`	Displays the path to the current node. For example, after navigating to an IPv4 address, the following command displays the path through the command hierarchy to the current node:
	
	`ruggedcom(config-address-172.30.137.31/19)# pwd`
	` Current submode path:`
	` ip fe-3-1 \ ipv4 \ address`
	` 172.30.137.31/19`

`rename`	Changes the value of a parameter. For example, the following command changes the IPv4 address 172.30.137.36/19 to 172.30.137.40/19:
	
	`ruggedcom(config)# rename ip fe-3-1`
	` ipv4 address 172.30.137.36/19`
	` 172.30.137.40/19`

`resolved`	Issue this command when conflicts have been resolved. Conflicts are normally discovered when the commit operation is performed. Conflicts typically arise when multiple users edit the same parts of a configuration.
`revert no-confirm`	Copies the running configuration into the current configuration. This discards all changes to the current configuration. This command will prompt the user to confirm the action. Use the `no-confirm` parameter to revert the configuration without requiring confirmation.

`rollback configuration { number }`	Returns the configuration to a previously committed configuration. The system stores a limited number of old configurations. After reaching the maximum number of old configurations, storing a new configuration deletes the oldest configuration in the list. The most recently committed configuration (the running configuration) appears as item 0 in the list. Select a number from the list and press **Enter**.
	
	`ruggedcom(config)# rollback`
	` configuration`
	` Possible completions:`
	` 0 2012-01-08 13:51:46 by admin`
	` via cli`
	` 1 2012-01-08 13:50:58 by admin`
	` via cli`
	` 2 2012-01-08 12:05:46 by admin`
	` via cli`
	` 3 2012-01-08 10:47:42 by admin`
	` via cli`
	` 4 2012-01-08 07:49:38 by admin`
	` via cli`
	` 5 2012-01-08 07:46:14 by admin`
	` via cli`

Command	Description
	`ruggedcom(config)# rollback configuration` After rolling back the configuration, use the `commit` command to commit the changes.

`save { filename }`	Saves the current configuration, without default values, to an ASCII file. Specify a filename for the file.
	
	Current configuration means the configuration of the user's current level in the configuration data hierarchy. For example, if the user is at the top level, the `save` command will save the complete/full configuration of the device.
	
	`ruggedcom(config)# save {full-configuration-filename}`
	
	If the user is at a level other than the top level, such as the *firewall* level, the `save` command will save a partial configuration of the current level.
	
	`ruggedcom(config)#security firewall`
	`ruggedcom(config-firewall)# save {firewall-configuration-filename}`
	
	Use this command along with the `details` command to include default values in the saved configuration file. For example:
	
	`ruggedcom(config)# save {filename} | details`

`show`	Shows configuration, history or command line interface parser information. Type `show` and press **Tab** to navigate through the items available to display. This command can also be combined with the `details` command to display the default configuration values. For example: `ruggedcom# show running-config admin session-limits | details`
`top command`	Exits to the top level of the command hierarchy and, optionally, runs a command.
`validate`	Validates the current configuration.
`wizard [ rox_flash ]`	Runs the rox_flash wizard. For more information, refer to "Downgrading Software (Page 118)".
`wizard [ rox_upgrade ]`	Runs the rox_upgrade wizard. For more information, refer to either "Upgrading the Software and Retaining the Configuration (Page 113)" or "Upgrading the Software and Resetting the Configuration (Page 115)".

2.6 Configuring the CLI Interface

The following commands can be used to configure certain characteristics and customize the CLI interface.

Command	Description
`autowizard { true | false }`	When enabled, the CLI prompts for required settings when a new identifier is created.
`clear history`	Clears the CLI history.
`display-level`	Determines the depth of hierarchical information to display in command results.
`history { integer }`	Determines the number of items to record in the CLI history.
`output-file { { filename } | terminal }`	Directs CLI output to the specified ASCII text file, or to the terminal. Output is directed to the specified destination until another destination is set with a subsequent `output-file` command.
`paginate { true | false }`	Lengthy output is paginated by default. When the output reaches the screen-length setting, the CLI prompts the user to press a key for more output. Press **Enter** to advance line-by-line or press **Space** to advance page-by-page. When disabled, output is not paginated.
`screen-length { integer }`	Determines the number of lines in a terminal page.
`screen-width { integer }`	Determines the length of terminal lines.

`show-defaults { true | false }`	Determines if default values are shown when displaying the configuration. When enabled, default values appear as comments after the configured value. In the following example, the default value for the contact value is shown as a comment following the configured contact string of *wsmith@example.com*:
	`ruggedcom# show running-config admin`
	` contact`
	` admin`
	` contact "wsmith@example.com"  !`
	` Contact`
	` !`
	Default values only appear for parameters that have default values. If a parameter does not have a default value, no default appears when `show-defaults` is set to true.

`terminal { dumb | vt100 | xterm | linux | ansi }`	Determines the terminal type and controls how line editing is performed. Supported terminals are: dumb, vt100, xterm, linux, and ansi. Other terminals may also work but have no explicit support.

2.7 Accessing Different Modes

Aside from normal mode, there are three additional modes within RUGGEDCOM ROX II that offer various controls over the operating system.

2.7.1 Accessing BIST Mode

BIST (Built-In-Self-Test) mode is used by RUGGEDCOM ROX II to test and configure internal functions of the device. The method for accessing BIST is different if a new software image has been flashed onto the flash card.

⚠ NOTICE

Security hazard – risk of unauthorized access and/or exploitation

BIST mode is available to users with console access. As such, console access should be restricted to authorized personnel only.

⚠ NOTICE

Configuration hazard – risk of data corruption

BIST mode is provided for troubleshooting and advanced configuration purposes and should only be used by Siemens Canada Ltd. technicians. As such, this mode is not fully documented. Misuse of the commands available in this mode can corrupt the operational state of the device and render it inaccessible.

Note
BIST mode opens port TCP/222 and cannot be disabled. An IP address must be configured before users attempt to access the device via SSH.

To access BIST mode normally, do the following:

⚠ NOTICE

Do not connect the device to the network when it is in BIST mode. The device will generate excess multicast traffic in this mode.

1. Disconnect the device from the network.
2. Connect to the RUGGEDCOM RX1400 through the RS-232 console connection and a terminal application. For more information, refer to "Connecting Directly via Serial Console (Page 73)".
3. Reboot the device. For more information, refer to "Rebooting the Device (Page 83)".
4. If prompted, provide the boot password/passphrase for the device.
5. As soon as the device starts to boot up, press **ESC**. A list of possible boot modes for each partition appears.

```
****Boot Partition 4****
 [4-0]: Debian GNU/Linux, kernel 3.0.0-2-8360e
```

```
[4-1]: Debian GNU/Linux, kernel 3.0.0-2-8360e (BIST mode)
[4-2]: Debian GNU/Linux, kernel 3.0.0-2-8360e (single-user mode)
[4-3]: Debian GNU/Linux, kernel 3.0.0-2-8360e (service mode)

****Boot Partition 6****
[6-0]: Debian GNU/Linux, kernel 3.0.0-2-8360e
[6-1]: Debian GNU/Linux, kernel 3.0.0-2-8360e (BIST mode)
[6-2]: Debian GNU/Linux, kernel 3.0.0-2-8360e (single-user mode)
[6-3]: Debian GNU/Linux, kernel 3.0.0-2-8360e (service mode)

Auto booting [4-0], Hit [ESC] key to stop:  0
Welcome to the boot menu. Please select from the following options:

Enter [BootPartition-BootTarget] (e.g. '4.0') to boot.
'h' Show this help menu
'l' List the available boot targets
'c' Exit to the boot loader command line

Will reboot after 60 seconds of inactivity
:
```

Note
In the example above, the text `Auto booting [4-0]` indicates the active partition is Boot Partition 4.

6. Enter boot mode on the active partition by typing the associated target number. For example, if the active partition is Boot Partition 6, type `6-1` and press **Enter**. The self-test cycle begins.
7. Press **Ctrl+c** to stop the self-test cycle and halt the excess multicast traffic. A BIST prompt appears.

```
BIST:~#
```

To access BIST mode after flashing a new software image on to the flash card, do the following:

1. Connect to the RUGGEDCOM RX1400 through the RS-232 console connection and a terminal application. For more information, refer to "Connecting Directly via Serial Console (Page 73)".
2. Cycle power to the device.
3. If prompted, provide the boot password/passphrase for the device.
4. Press **Ctrl+c** to stop the self-test cycle and halt the excess multicast traffic. A BIST prompt appears.

```
BIST:~#
```

Once all configuration changes or tests are complete, it is important to change the boot mode by doing the following:

1. Set the next boot to normal by typing:

```
nextboot  normal
```

2. Reboot the device by typing:

   ```
   reboot
   ```

3. Connect the device to the network.

2.7.2 Accessing Service Mode

Service mode grants access to the Linux shell.

To access service mode, do the following:

⚠ NOTICE

Security hazard – risk of unauthorized access and/or exploitation

Service mode opens port TCP/222 and cannot be disabled. If the device is connected to the network, a user with remote access to the device and the root password could access the Linux shell. If required, protect the device by either:

- Disconnecting the device from the network
- Making sure a strong password is configured and the device is connected to a trusted network

⚠ NOTICE

Configuration hazard – risk of data corruption

Service mode is provided for troubleshooting and advanced configuration purposes and should only be used by Siemens technicians. As such, this mode is not fully documented. Misuse of the commands available in this mode can corrupt the operational state of the device and render it inaccessible.

⚠ NOTICE

Changes made to the configuration in this mode will override the current configuration settings (e.g. IP addresses, VLAN settings, etc.), but are discarded following a system reboot.

1. Connect to RUGGEDCOM ROX II through the RS-232 console connection and a terminal application. For more information, refer to "Connecting Directly via Serial Console (Page 73)".
2. Reboot the device. For more information, refer to "Rebooting the Device (Page 83)".
3. As soon as the device starts to boot up, press **ESC**. A list of possible boot modes for each partition appears.

```
****Boot Partition 4****
 [4-0]: Debian GNU/Linux, kernel 3.0.0-2-8360e
 [4-1]: Debian GNU/Linux, kernel 3.0.0-2-8360e (BIST mode)
 [4-2]: Debian GNU/Linux, kernel 3.0.0-2-8360e (single-user mode)
 [4-3]: Debian GNU/Linux, kernel 3.0.0-2-8360e (service mode)
```

```
****Boot Partition 6****
[6-0]: Debian GNU/Linux, kernel 3.0.0-2-8360e
[6-1]: Debian GNU/Linux, kernel 3.0.0-2-8360e (BIST mode)
[6-2]: Debian GNU/Linux, kernel 3.0.0-2-8360e (single-user mode)
[6-3]: Debian GNU/Linux, kernel 3.0.0-2-8360e (service mode)

Auto booting [4-0], Hit [ESC] key to stop:  0
Welcome to the boot menu. Please select from the following options:

Enter [BootPartition-BootTarget] (e.g. '4.0') to boot.
'h' Show this help menu
'l' List the available boot targets
'c' Exit to the boot loader command line

Will reboot after 60 seconds of inactivity
:
```

Note
In the example above, the text

```
Auto booting [4-0]
```

indicates the active partition is Boot Partition 4.

4. Enter service mode on the active partition by typing the associated target number. For example, if the active partition is Boot Partition 6, type `6-3`. A login prompt for service mode appears.
5. Type `root` and press **Enter**. A password prompt appears.

Note
If a unique password/passphrase has not been configured, use the factory default password. For more information, refer to "Default User Names and Passwords (Page 25)".

Note
The current service mode password/passphrase is the same as the password/passphrase for accessing maintenance mode.

6. Type the current service mode password/passphrase and press **Enter**.

```
ruggedcom login: root
 Password:
 Last login: Tue Oct 13 13:37:38 EDT 2020 on ttyS0
 Linux ruggedcom 3.0.0-2-8360e #1 Thu Jan 24 21:20:30 UTC 2013 ppc

 The programs included with the Debian GNU/Linux system are free software;
 the exact distribution terms for each program are described in the
 individual files in /usr/share/doc/*/copyright.

 Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
 permitted by applicable law.

 8t-eterminal size now 80x20

 Welcome to ruggedcom Partition1 (Rev ROX 2.4.0 (2013-01-24 18:20)) RX1510 SN
 12110102-0012-0030060017   13:42:07 up 7 min
 Temperature +38.5 C (+101.3 F)  Disk 24%  Memory 41%
```

```
root@ruggedcom:~#
```

2.7.3 Accessing Maintenance Mode

Maintenance mode grants access to the Linux shell.

To access maintenance mode, do the following:

⚠ NOTICE

Configuration hazard – risk of data corruption

Maintenance mode is provided for troubleshooting purposes and should only be used by Siemens Canada Ltd. technicians. As such, this mode is not fully documented. Misuse of the commands available in this mode can corrupt the operational state of the device and render it inaccessible.

⚠ NOTICE

Security hazard – risk of unauthorized access and/or exploitation

To avoid unauthorized users from accessing maintenance mode, make sure the default maintenance mode password has been replaced with a strong password. For information about creating strong passwords, refer to "Managing Passwords and Passphrases (Page 140)".

Note
A key is required to authorize maintenance mode access. To obtain an access key, contact Siemens Customer Support.

For information about installing the access key and enabling maintenance mode, refer to "Temporarily Enabling Maintenance Mode Authorization (Page 69)".

Note
Changes made to the configuration in this mode will override the current configuration settings (e.g. IP addresses, VLAN settings, etc.), but are discarded following a system reboot.

1. If the default password has been changed previously, proceed to step step 2. Otherwise, change the default maintenance mode password to a strong password. For information about setting the maintenance mode password, refer to "Setting the Maintenance Password/Passphrase (Page 143)".
2. Enable maintenance mode authorization. For more information, refer to "Temporarily Enabling Maintenance Mode Authorization (Page 69)".
3. In normal mode, type `maint-login` and press **Enter**. A password prompt appears.

Note
The current maintenance mode password/passphrase is the same as the password/passphrase for accessing service mode.

4. Type the current maintenance mode password/passphrase and press **Enter**.

   Example:

```
ruggedcom# maint-login
Password:

Welcome to ruggedcom Partition2 (Rev ROX 2.15.0 (2022-01-24 18:20)) RX1400 SN
 R15R-3410-PR061 22:29:20 up 1 day, 8:42
Temperature +41.0 C (+105.8 F) Disk 25% Memory 43%

root@ruggedcom:~#
```

5. [Optional] Enable SSH access. SSH is disabled by default. For more information, refer to "Enabling/Disabling SSH Access in Maintenance Mode (Page 68)".

2.7.4 Enabling/Disabling SSH Access in Maintenance Mode

SSH access to the device is disabled by default when the device is in maintenance mode. However, temporary access may be required.

⚠ NOTICE

Security hazard – risk of unauthorized access and/or exploitation

Before enabling SSH access, make sure a strong password is configured and the device is connected to a trusted network. Failure to protect the device could allow a user with remote access to the device and the root password to access the Linux shell

To temporarily enable SSH access on port 222 while the device is in maintenance mode, enter the following commands at the command prompt:

```
rm  /etc/ssh/sshd_not_to_be_run
systemctl  start  sshd.service
```

To again disable SSH access, enter the following commands:

```
systemctl  stop  sshd.service
touch  /etc/ssh/sshd_not_to_be_run
```

2.7.5 Managing Maintenance Mode Authorization

Maintenance mode grants access to the Linux shell. It is used primarily by Siemens Customer Support to access diagnostic information when needed as part of the troubleshooting process.

Misuse of the commands available in this mode can corrupt the operational state of the device and render it inaccessible. As such, a reusable access key specific to the device is required to authorize access to the maintenance mode command. To obtain an access key, contact Siemens Customer Support. Note that once the access key has been obtained, a maintenance mode password is still required to access maintenance mode.

Maintenence mode authorization is configurable to allow access either temporarily or permanently. When maintenance mode access is configured temporarily, access will remain active until either the device is rebooted or maintenance mode access is disabled manually. Upgrading the device requires a reboot that will disable maintenance mode access.

When maintenance mode access is configured permanently, access will remain active until either the device software is flashed, restored to factory default settings or disabled manually. Upgrading the device with permanent maintenance mode configured will retain the enabled maintenance mode setting.

⚠ NOTICE

Configuration hazard – risk of data corruption

To avoid accidental data corruption, Siemens recommends disabling maintenance mode access immediately when no longer required.

2.7.5.1 Temporarily Enabling Maintenance Mode Authorization

To enable maintenance mode authorization until the next device reboot, do the following:

Note
The access key contains several characters in multiple formats, and can be difficult to convey via telephone. As such, Siemens recommends providing the key via email. If email is unavailable, a hexadecimal format access key can be provided via telephone support.

To support this method the following CLI command is used:

```
key-tool-maint-mode
```

For more information about obtaining a hexadecimal format access key via telephone, contact Siemens Customer Support.

1. Contact Siemens Customer Support to obtain an access key.

   The MLFB (if provided) and serial number of the device will be required. To obtain this information, refer to "Displaying Device and Software Information (Page 77)" .

2. Type the following:

   ```
   admin authentication enable-maint-mode key { key }
   ```

Where:

- `{ key }` is the access key provided by Siemens Customer Support.

Maintenance mode authorization will be enabled until the next device reboot.

3. [Optional] To verify maintenence mode authorization status has been successfully enabled, refer to "Displaying Device and Software Information (Page 77)".
4. [Optional] Access maintenance mode with the maintenence mode password. For more information, refer to refer to "Accessing Maintenance Mode (Page 67)".

2.7.5.2 Permanently Enabling Maintenance Mode Authorization

Maintenance mode authorization can be enabled permanently, until either the device software is flashed/downgraded or the device is restored to factory default settings.

For more information about upgrading or downgrading software, refer to "Upgrading/Downgrading Software (Page 110)".

For more information restoring the factory default settings for the device, refer to "Restoring Factory Defaults (Page 83)".

⚠ NOTICE

Configuration hazard – risk of data corruption

Siemens recommends enabling permanent maintenance mode access only when absolutely necessary, and disabling maintenance mode access when no longer required.

To permanently enable maintenance mode authorization, do the following:

1. Enable maintenance mode. For more information, refer to "Temporarily Enabling Maintenance Mode Authorization (Page 69)".
2. Type the following:

   ```
   admin  authentication  permanent-maint-mode
   ```

   Maintenance mode authorization is enabled permanently until the device software is flashed/downgraded or the device is restored to factory default settings.

2.7.5.3 Disabling Maintenance Mode Authorization

To disable maintenance mode authorization, do the following:

- Type the following:

  ```
  admin  authentication  disable-maint-mode
  ```

Maintenance mode is disabled.

3 Getting Started

This section describes startup tasks to be performed during the initial commissioning of the device. Tasks include connecting to the device and accessing the RUGGEDCOM ROX II CLI, as well as configuring a basic network.

3.1 Connecting to RUGGEDCOM ROX II

The Web user interface and Command Line Interface (CLI) can be accessed via a direct connection between a workstation and a device or a remote connection over the network.

3.1.1 Default IP Address

The default IP address for the device is as follows:

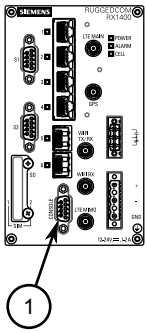
With CloudConnect or CROSSBOW ADM factory installed	192.168.0.3/24
Without CloudConnect or CROSSBOW ADM	192.168.0.2/24

3.1.2 Connecting Directly via Serial Console

The Command Line Interface (CLI) can be accessed directly using an appropriate cable connection between the device and a workstation.

To access the Command Line Interface (CLI) using a direct connection to the device, do the following:

1. Connect a workstation running terminal emulation software to the RS-232 console port on the device.



① RS-232 Console Port

Figure 3.1 RS-232 Console Port

2. Configure the terminal as follows:
   - 57600 bps
   - No parity
   - 8 bits
   - Set the terminal type to VT100
   - Disable hardware and software flow control
3. Establish a connection to the device and press any key. The login prompt appears.

```
{host name} login:
```

4. Log in to RUGGEDCOM ROX II. For more information, refer to "Logging In (Page 25)".

3.1.3 Connecting Remotely via SSH

The Command Line Interface (CLI) can be accessed securely and remotely using an SSH client.

To access the CLI, do the following:

1. Launch an SSH client and specify the following connection settings:
   - **Host Name:** The IP address of the device or the IP address prefixed with the desired user profile (e.g. admin@192.168.0.2)
   - **Port** – 22
2. Connect to the device.
3. If the device's SSH key has not been cached to the workstation's registry, a confirmation message will appear asking if the host is trusted. Click **Yes** to continue. The login prompt appears.

```
login as:
```

4. Log in to RUGGEDCOM ROX II. For more information, refer to "Logging In (Page 25)".

3.2 Configuring a Basic Network

RUGGEDCOM ROX II has the following Internet interfaces configured by default: *dummy0* and *switch.0001*. The default IP addresses for *switch.0001* is configured under the ***ip » switch.0001 » ipv4***. The default *switch.0001* interface is the VLAN interface and is only seen if there is one or more Ethernet line modules installed. It is created implicitly, as all switched ports have a default PVID of 1.

The following table lists the default IP addresses.

Interface	IP Address
switch.0001	192.168.0.2/24

3.2.1 Configuring a Basic IPv4 Network

To configure a basic IPv4 network, do the following:

1. Select two switched Ethernet ports and assign them each a unique VLAN. For more information about assigning VLANs to switched Ethernet ports, refer to "Configuring a Switched Ethernet Port (Page 314)".

   For the purposes of this procedure, the ports will be referred to as VLAN 1 and VLAN 2, respectively.
2. Configure an IPv4 address for the VLAN interface representing each port, making sure the VLAN 2 interface is in a different subnet. For more information, refer to "Adding an IPv4 Address (Page 251)".
3. Connect a computer to the VLAN 1 port.
4. Configure the computer to be on the same subnet as the VLAN 1 interface.
5. Configure the default gateway for the computer to be the same as the VLAN 1 interface's IPv4 address.
6. Connect a switch from an IPv4 capable network to the VLAN 2 port.
7. Configure all computers on the IPv4 network to be on the same subnet as the VLAN 2 interface.
8. Configure the default gateway for all computers on the IPv4 network to be the same as the VLAN 2 interface's IPv4 address.
9. Enable the Brute Force Attack (BFA) protection system on the device. For more information, refer to "Enabling/Disabling Brute Force Attack Protection (Page 152)".
10. Make sure all computers connected to the device can ping one another.

3.2.2 Configuring a Basic IPv6 Network

To configure a basic IPv6 network, do the following:

1. Select two switched Ethernet ports and assign them each a unique VLAN. For more information about assigning VLANs to switched Ethernet ports, refer to "Configuring a Switched Ethernet Port (Page 314)".

   For the purposes of this procedure, the ports will be referred to as VLAN 1 and VLAN 2, respectively.
2. Configure an IPv6 address for the VLAN interface representing each port, making sure the VLAN 2 interface is in a different subnet. For more information, refer to "Adding an IPv6 Address (Page 252)".
3. Connect a computer to the VLAN 1 port.
4. Configure the computer to be on the same subnet as the VLAN 1 interface.
5. Configure the default gateway for the computer to be the same as the VLAN 1 interface's IPv6 address.
6. Connect a switch from an IPv6 capable network to the VLAN 2 port.
7. Configure all computers on the IPv6 network to be on the same subnet as the VLAN 2 interface.
8. Configure the default gateway for all computers on the IPv6 network to be the same as the VLAN 2 interface's IPv6 address.
9. Enable the Brute Force Attack (BFA) protection system on the device. For more information, refer to "Enabling/Disabling Brute Force Attack Protection (Page 152)".
10. Enable IPv6 Neighbor Discovery. For more information, refer to "Configuring IPv6 Neighbor Discovery (Page 253)".
11. Make sure all computers connected to the device can ping one another.

4 Device Management

This chapter describes how to manage device hardware, including ports, files, logs, firmware, etc.

4.1 Displaying Device and Software Information

During troubleshooting or when ordering new devices/features, Siemens may request specific information about the device, such as the model, order code (MLFB) or system serial number.

To display general information about the device and its software, type:

```
show chassis chassis-status
```

A table or list similar to the following example appears:

```
ruggedcom# show chassis chassis-status
chassis-status
 model                       RX1400
 software license            "Layer 3 Security Edition"
 mlfb                        6GK60140AM2
 rox release                 "ROX 2.13.0-QA2.3 (2022-01-01 08:00)"
 system serial number        RUMED22080399
 last integrity check        "2022-01-01 09:00"
 last integrity check result Success
 BootLoader                  2014.04RR31
 maint mode status           Disabled
```

This list provides the following information:

Parameter	Description
`model`	**Synopsis:** A string The RuggedCom device model name.
`software-license`	**Synopsis:** A string The current software capability.
`mlfb`	**Synopsis:** A string 256 characters long MLFB(Machine-Readable Product Designation) or order code
`rox-release`	**Synopsis:** A string The release of ROX running on the chassis.
`system-serial-number`	**Synopsis:** A string 32 characters long The system serial number on the chassis label.

Parameter	Description
last-integrity-check	**Synopsis:** A string 32 characters long The last time the firmware integrity was checked.
last-integrity-check-result	**Synopsis:** A string The result of the last integrity check.
BootLoader	**Synopsis:** A string The version of the ROX bootloader software on the installed module.
maint-mode-status	**Synopsis:** A string The maintenance mode status (enabled or disabled).

4.2 Determining the GPS Location of the Device

With GPS enabled, the physical location of the device can be determined via RUGGEDCOM ROX II.

To determine the GPS location of the device, type:

```
interfaces cellmodem { port } lte gps-location
```

Where:

- { port } is the port number for the module

The GPS location of the device is displayed. For example:

```
ruggedcom# interfaces cellmodem cel-1 lte gps-location
gps_location_reply

UTC time:  2015-03-18 19:25:20 UTC
Localtime: 2015-03-18 15:25:20 EDT
Latitude: 43 deg. 48.4717 min. N
Longitude: 079 deg. 32.4272 min. W
Number of satellites in view: 8
```

4.3 Viewing Chassis Information and Status

This section describes how to view information about the device chassis, such as its configuration and operating status.

4.3.1 Viewing the Slot Hardware

To view a list of the hardware installed in each slot, type:

```
show chassis hardware slot-hardware
```

A table or list similar to the following example appears:

```
ruggedcom# show chassis hardware slot-hardware | tab
          ORDER                              SERIAL
SLOT      FIELD      DETECTED MODULE         NUMBER
-------------------------------------------------
swport    SM0001     SM M88E6097F, 4FT 2GP
serport   SER0001    2xRS232/422/485
celport   CELL0001   1x Cell LTE EU
```

4.3.2 Viewing Flash Card Storage Utilization

To view the Flash card storage utilization statistics for the Flash card installed in the device, type:

```
show  chassis  storage
```

A table or list similar to the following example appears:

```
ruggedcom# show chassis storage | tab
storage
 flash
  storage name                "Flash"
  total capacity              994896
  current partition           "Partition #1"
  current partition capacity  490496
  secondary partition capacity 490496
  current partition usage     67
```

This table or list provides the following information:

Parameter	Description
`storage-name`	**Synopsis:** A string between 0 and 32 characters long The type of storage.
`total-capacity`	**Synopsis:** An integer between 0 and 4294967295 The total capacity of the flash storage in KB.
`current-partition`	**Synopsis:** A string between 0 and 32 characters long The partition ROX is currently running on and booted from.
`current-partition-capacity`	**Synopsis:** An integer between 0 and 4294967295 The capacity of the current partition in KB.
`secondary-partition-capacity`	**Synopsis:** An integer between 0 and 4294967295 The capacity of the secondary partition in KB.
`current-partition-usage`	**Synopsis:** An integer between 0 and 100 The %usage of the current partition.

4.3.3 Viewing CPU/RAM Utilization

To view the CPU/RAM utilization statistics for each module installed in the device, type:

```
show chassis cpu slot-cpu
```

A table or list similar to the following example appears:

```
ruggedcom# show chassis cpu slot-cpu
                                                RAM
                                    CPU   RAM   AVAIL
SLOT  DETECTED MODULE               LOAD  AVAIL LOW
-----------------------------------------------------

cm    CM TI-AM5726 variant 0001  4     122   121
```

This table or list provides the following information:

Parameter	Description
`detected-module`	**Synopsis:** A string 60 characters long The installed module's type specifier.
`cpu-load`	**Synopsis:** An integer between 0 and 100 The CPU load, in percent, on the installed module.
`ram-avail`	**Synopsis:** An integer between 0 and 100 The proportion of memory (RAM) currently unused, in percent, on the installed module.
`ram-avail-low`	**Synopsis:** An integer between 0 and 100 The lowest proportion of unused memory (RAM), in percent, recorded for the installed module since start-up.

4.3.4 Viewing the Slot Status

To view the overall status of each slot, type:

```
show chassis status slot-status
```

A table or list similar to the following example appears:

```
ruggedcom# show chassis status slot-status | tab
                                        STATUS                                  START
SLOT  DETECTED MODULE            STATE  STRING  UPTIME            START DATE   TIME
-------------------------------------------------------------------------------------
cm    CM TI-AM5726 variant 0001  operating  Normal  0D 0hr 0min 0sec  2015-01-06Z  16:36:20Z
```

This table or list provides the following information:

Parameter	Description
`{ slot }`	**Synopsis:** [--- | pm1 | pm2 | main | sm | lm1 | lm2 | lm3 | lm4 | lm5 | lm6 | swport | eth | serport | celport | wlanport | cm | em | trnk] The slot name, as marked on the silkscreen across the top of the chassis.
`detected-module`	**Synopsis:** A string 60 characters long The installed module's type specifier.
`state`	**Synopsis:** [unknown | empty | disabled | resetting | operating | failed | disconnected] The current state of the installed module.
`status-string`	**Synopsis:** A string The runtime status of the installed module.
`uptime`	**Synopsis:** A string The total time elapsed since the start-up of the installed module.
`start-date`	**Synopsis:** A string The date on which the installed module was started up.
`start-time`	**Synopsis:** A string The time at which the installed module was started up.

4.3.5 Viewing the Slot Sensor Status

To view information about the slot sensors, type:.

```
show chassis sensors
```

A table or list similar to the following example appears:

```
show chassis sensors
sensors
SLOT  DETECTED MODULE                                    TEMPERATURE  CURRENT  VOLTAGE
-------------------------------------------------------------------------------------
cm    CM TI-AM5726 variant 0001                          38
wlanport 1x WLAN 802.11 US
```

This table or list provides the following information:

Parameter	Description
`{ slot }`	**Synopsis:** [--- | pm1 | pm2 | main | sm | lm1 | lm2 | lm3 | lm4 | lm5 | lm6 | swport | eth | serport | celport | wlanport | cm | em | trnk] The slot name, as marked on the silkscreen across the top of the chassis.
`detected-module`	**Synopsis:** A string 60 characters long The installed module's type specifier.

Parameter	Description
`temperature`	**Synopsis:** An integer between -55 and 125 The temperature, in degrees C, of the installed module. If multiple temperature sensors are present on the board, the maximum reading is reported.

4.4 Viewing the Parts List

To view a list of parts installed in the device, type:

```
show running-config chassis part-list
```

If jobs have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config chassis part-list | tab
MODEL   ORDERFIELD  PARTNUMBER                    PARTNAME
-------------------------------------------------------------------------------
RX1400  CELL0001    CELL-LTE-0.001  1x Cell LTE EU

                    DB-CELL-LTE-1.
                    001
RX1400  CELL0002    CELL-LTE-0.001  1x Cell LTE NAM A/R/B/T

                    DB-CELL-LTE-1.
                    002
RX1400  CELL0003    CELL-LTE-0.001  1x Cell LTE NAM V/S

                    DB-CELL-LTE-1.
                    003
RX1400  CELL0004    CELL-LTE-0.001  1x Cell LTE APAC

                    DB-CELL-LTE-1.
                    004
RX1400  CELL0005    CELL-LTE-0.001  1x Cell LTE Japan

                    DB-CELL-LTE-1.
                    005
RX1400  CM0001      BACKPLANE.001   CM TI-AM5726 variant 0001
RX1400  CM0001      CM-AM5726-0.00  CM TI-AM5726 variant 0001
                    1
RX1400  PM0001      PM-24VDC.001    12-24VDC Unmonitored PM
RX1400  PM0002      PM-48VDC.001    48VDC Unmonitored PM
RX1400  PM0003      PM-HI.001       HI AC-DC Unmonitored PM
RX1400  SER0001     SER-TP-0.001    2xRS232/422/485
                    DB-SER-TP-2.00
                    1
RX1400  SM0001      SM-L2-0.001     SM M88E6097F, 4FT 2GP
                    DB-ETH-FT-4.00
                    1
                    DB-ETH-GP-2.00
                    1
.
.
.
```

4.5 Shutting Down the Device

To shut down the device, type:

⚠ NOTICE

Security hazard – risk of unauthorized access and/or exploitation

Always shutdown the device before disconnecting power. Failure to shutdown the device first could result in data corruption.

Note
The device never enters a permanent shutdown state. When instructed to shutdown, the devices shuts down and provides a time-out period during which power can be disconnected from the device. The default time-out period is 300 seconds (five minutes). At the end of the time-out period, the device reboots and restarts.

Note
If wiring hinders the process of disconnecting power from the device, the power module(s) can be removed instead.

```
admin  shutdown
```

4.6 Rebooting the Device

To reboot the device, type:

```
admin  reboot
```

4.7 Restoring Factory Defaults

To restore the factory defaults for the device, use the following command:

```
admin  restore-factory-defaults
```

If necessary, include the following options:

Parameter	Description
`delete-logs { delete-logs }`	**Synopsis:** [true | false] **Default:** false Delete system logs as well as restoring default settings.
`default-both-partitions { default-both-partitions }`	**Synopsis:** [true | false] **Default:** false Perform the operation on both partitions.

Parameter	Description
`delete-saved-configurations { delete-saved-configurations }`	**Synopsis:** [true | false] **Default:** false Delete saved configuration files (works with default-both-partitions option).
`shutdown { shutdown }`	**Synopsis:** [true | false] **Default:** false Shutdown rather than reboot after restoring factory defaults.

4.8 Decommissioning the Device

Before taking the device out of service, either permanently or for maintenance by a third-party, make sure the device has been fully decommissioned. This includes removing any sensitive, proprietary information.

Note
For additional assistance in decommissioning the device or removable media, contact Siemens Customer Support.

To decommission the device, do the following:

1. Obtain a copy of the RUGGEDCOM ROX II firmware currently installed on the device. For more information, contact Siemens Customer Support.
2. Log in to maintenance mode. For more information, refer to "Accessing Maintenance Mode (Page 67)" .
3. Delete the current boot password/passphrase by typing:

   ```
   rox-delete-bootpwd  --force
   ```

4. Type `exit` and then press **Enter**.
5. Log in to RUGGEDCOM ROX II. For more information, refer to "Logging In (Page 25)".
6. Flash the RUGGEDCOM ROX II firmware obtained in step 1 to the inactive partition and reboot the device. For more information, refer to "Downgrading Software (Page 118)".
7. Repeat step 5 and step 6 to flash the RUGGEDCOM ROX II firmware obtained in step 1 to the other partition and reboot the device.
8. Shut down the device. For more information, refer to "Shutting Down the Device (Page 83)".

Additionally, if a VPE image is loaded on the device, the microSD/microSDHC drive should be decommissioned as well.

To decommission the microSD/microSDHC drive, do the following:

1. Connect the microSD/microSDHC drive containing the VPE image to an external PC that includes or can support data erasure tools.
2. From the PC, use standard erasure tools to erase data on the microSD/ microSDHC drive. For example, use standard Linux tools, such as dd, wipe, or shred, to wipe data from the drive.

⚠ NOTICE

Security hazard – risk of data exploitation

Regardless of the erasure tool or method employed, even following multiple rounds of flashing, erasure, or overwriting, residual data may still be present on Flash-based storage media. To guarantee the destruction of all sensitive data persisting on the unit, physical destruction of the storage media/platform may be required.

4.9 Viewing a List of Line Module Configurations

To view a list of line module configurations, type:

Note
Line module configurations are not configurable.

```
show  running-config  chassis  line-modules
```

If line modules have been configured, a table or list similar to the following example appears:

```
show running-config chassis line-modules | tab
chassis
 line-modules
  line-module
                                    ADMIN    ADMIN
SLOT      MODULE TYPE               ENABLED  BYPASS
-----------------------------------------------------
swport    SM M88E6097F, 4FT 2GP     X        -
serport   2xRS232/422/485           X        -
celport   1x Cell LTE NAM A/R/B/T   X        -
wlanport  1x WLAN 802.11 US         X        -

 !
!
```

4.10 Managing Feature Keys

RUGGEDCOM ROX II can be enhanced with additional features at any time by adding feature levels. Feature levels are encoded in feature keys that can be loaded on a device. At the time of ordering, a device feature key is encoded into the electronic signature of the device. Additional file-based feature keys can be added as needed.

Note
Some RUGGEDCOM ROX II features are only available through the purchase of feature levels. For more information about the available feature levels, refer to the product data sheet for the device available at https://www.siemens.com or contact a Siemens Sales representative.

When ordering feature levels, make sure to provide the *main* serial number for the device. An upgraded feature key file will be provided that is licensed to the device. For information on how to determine the *main* serial number, refer to "Displaying Device and Software Information (Page 77)".

4.10.1 Viewing the Contents of a Feature Key

To view the contents of a feature key saved on the device, do the following:

1. Make sure the CLI is in Operational mode.
2. At the command prompt, type:

   `file show-featurekey { filename }`

   Where:

   - `{ filename }` is the name of feature key file stored on the device

   For example:

   ```
   ruggedcom# file show-featurekey 1_cmRX1K-12-11-0015.key
   ```

3. Press **Enter**. The system displays the contents of the feature key file. For example:

   ```
   ruggedcom# file show-featurekey L3SE_cmRUMHD06096338.key
   GPG_FEATUREKEY_LEVEL=L3SE
   GPG_FEATUREKEY_CM_SERIALNUMBER=RUMHD06096338
   GPG_FEATUREKEY_SIGNATURE=iEYEABECAAYFAliGF4EACgkQP2pya
   +G5kdYj1ACfecKysp3DK3QBsP87I/gXgi92cwAAnjqrsgdqwaCczY4ghWrR0ELkr2TK
   ```

4.10.2 Installing Feature Keys

When installing a new feature key, RUGGEDCOM ROX II evaluates the new file-based feature key and the device feature key and enables the most capable feature level described by the keys.

Feature keys can be installed from a host computer or microSD/microSDHC drive.

Installing From a Host Computer

Note
Before installing a feature key from a host computer, the following information is required:

- The file name of the feature key
- The user name and password required to log into the host computer where the feature key is stored
- The host name or IP address of the computer where the feature key is stored

1. Make sure the CLI is in Operational mode.
2. Install the feature key by typing:

   ```
   file scp-featurekey-from-url { username }@{ host }:/
   { path }/{ current-filename } { new-filename }
   ```

   Where:

   - `{ username }` is the name of a user who can log into the computer where the feature key file is stored.
   - `{ host }` is the hostname or IP address of the computer where the feature key file is stored.
   - `{ path }` is the directory path to the feature key file in the host computer.
   - `{ current-filename }` is the current name of the feature key file.
   - `{ new-filename }` is the new name of the feature key file on the device. This parameter is optional. The current filename will be used if a new filename is not provided.

   For example:

   ```
   file scp-featurekey-from-url wsmith@10.200.10.39:/files/keys/
   L3SE_cmRUMHD06096338.key L3SE_cmRUMHD06096338.key
   ```

3. When prompted, type the user's password and then press **Enter**. The system uploads the feature key file:

   ```
    ruggedcom# file scp-featurekey-from-url wsmith@10.200.20.39:/files/keys/
   L3SE_cmRUMHD06096338.key L3SE_cmRUMHD06096338.key
   wsmith@10.200.20.39's password:
   L3SE_cmRUMHD06096338.key               100%  192     0.2KB/s   00:00
   ```

Installing From a MicroSD Card

For instructions on installing a feature key from a MicroSD Card, refer to "Installing Files (Page 88)".

4.11 Managing Files

RUGGEDCOM ROX II allows the transfer of select files to and from the device using the following methods:

- **Install**

  Allows users to upload files from a microSD/SDHC card or from a remote server using a file transfer protocol, such as FTP.

- **Backup**

  Allows users to download files to a microSD/SDHC card or to a remote server using a file transfer protocol, such as FTP.

4.11.1 Installing Files

To install a file on the device, such as a configuration file, feature key or virtual machine image, do the following:

⚠ NOTICE

A microSD/microSDHC card must be installed if the file type is a virtual machine image. Virtual machine images are saved to the microSD/microSDHC card when installed.

1. If the source of the file is a microSD/microSDHC card, insert the drive in the microSD/microSDHC port on the device. For more information, refer to the " RUGGEDCOM RX1400 Installation Manual".
2. Navigate to ***admin » install-files*** and configure the following parameter(s) as required:

Note
RUGGEDCOM ROX II supports implicit FTP over TLS (FTPS) URLs. Explicit FTP over TLS is not supported.

Note
For SFTP transfers, the SFTP server's public key must be added as a Known Host. For more information, refer to "Managing Known Hosts (Page 208)".

Parameter	Description
`file-type { file-type }`	**Synopsis:** [config | featurekey | vmfile] The file types to be copied.
`url { url }`	**Synopsis:** A string between 1 and 1024 characters long The URL of the ROX II file to copy. Supported URIs are HTTP, SCP, SFTP, FTPS and FTP. To install from a USB flash drive or microSD card (if applicable), the URL format is "usb://{ usb-device-name }/path-to-file-on-system" or "sd://sd-1//path-to-file-on-system". Run "show

Parameter	Description
	chassis" to determine the name of the USB device. Note that only one single partition is supported for either data medium. For all other protocols, the format is "protocol:// user:password@host:port/path-to-file". If "port" is not specified, the default port for the protocol is used.

3. If the VPE feature key (VIRTUALM) was installed, reboot the device to reveal the virtualization features. For more information, refer to "Rebooting the Device (Page 83)".

4.11.2 Backing Up Files

To backup files stored on the device, do the following:

1. If the file's destination is a microSD/microSDHC card, insert the drive in the microSD/microSDHC port on the device. For more information, refer to the " RUGGEDCOM RX1400 Installation Manual".
2. Make sure the CLI is in Configuration mode.
3. Navigate to ***admin » backup-files*** and configure the following parameter(s) as required:

Note
RUGGEDCOM ROX II supports implicit FTP over TLS (FTPS) URLs. Explicit FTP over TLS is not supported.

Note
For SFTP transfers, the SFTP server's public key must be added as a Known Host. For more information, refer to "Managing Known Hosts (Page 208)".

Parameter	Description
`file-type { file-type }`	**Synopsis:** [config | featurekey | logfiles | rollbacks | licenses | logarchive] The file types to copy.
`file { file }`	**Synopsis:** A string between 1 and 255 characters long The name of the logarchive or a list of file names to copy. For logarchive, only 1 file name is accepted to name the tar-archive that will be used to backup of the entire /var/log directory. The archive is created in /tmp directory and will be automatically deleted.
`timestamp { timestamp }`	**Synopsis:** [true | false] **Default:** false If enabled, a time stamp will be appended to the file name. This option is not applicable to file names that contain '*'.

Parameter	Description
`url { url }`	**Synopsis:** A string between 1 and 1024 characters long The URL of the ROX II file to copy. Supported URIs are HTTP, SCP, SFTP, FTPS and FTP. To save to a USB flash drive or microSD card (if applicable), the URL format is "usb://{ usb-device-name }/path-to-file" or "sd://sd-1//path-to-file". Run "show chassis" to determine the name of the USB device. Note that only one single partition is supported for either data medium. For all other protocols, the format is "protocol://user:password@host:port/path-to-file". If using a path only, close it with '/'. If "port" is not specified, the default port for the protocol is used.

4.12 Managing Logs

RUGGEDCOM ROX II maintains various logs to record information about important events. Each log falls into one of the following log types:

Security Event Logs	Information related to the following security events are logged by RUGGEDCOM ROX II: **Note** Passwords can be retried up to 3 times before the login attempt is considered a security event. • Successful and unsuccessful login attempts • Local and remote (RADIUS) authentication • Security-sensitive commands (whether successful or unsuccessful) • An optionally configurable SNMP Authentication Failure Trap (disabled by default) in accordance with SNMPv2-MIB All security event logs are recorded in **var/log/auth.log** and can be viewed in the Authlog Viewer. For more information about viewing logs, refer to "Viewing Logs (Page 91)".
Syslogs	Syslog allows users to configure local and remote syslog connections to record important, non-security event information. The remote Syslog protocol, defined in RFC 3164 [http://tools.ietf.org/html/rfc3164], is a UDP/IP-based transport that enables a device to send event notification messages across IP networks to event message collectors, also known as Syslog servers. The protocol is designed to simply transport these event messages from the generating device to the collector. All log files are organized in the log directory (**/var/log**) according to the facility and priority at which they have been logged. Remote Syslog sends the requested logs to the remote server(s) at whichever facility and priority they were initially logged, after filtering the logs based on the selectors configured for the server. The following log files are setup with the following default selectors: • **syslog** catches all logs except daemon.debug, auth or authpriv logs • **daemon.log** catches all *err* level (and above) logs written to the daemon facility • **messages** catches all *info*, *notice* and *warn* level logs for all facilities except auth, authpriv, cron, daemon, mail and news

	A selector setup using the following facilities at level *info* and up is recommended: • daemon • user • kern • syslog
Diagnostic Logs	Diagnostic logs record system information for the purposes of troubleshooting.

4.12.1 Viewing Logs

Select logs can be viewed directly within the CLI. Otherwise, these and other logs can be downloaded from the device and viewed in a text editor/viewer.

Note
For information about downloading log files from the device, refer to "Backing Up Files (Page 89)".

To view a log in the CLI, do the following:

```
show  log  { file }
```

Where:

- `{ file }` is the log file to view

For example, to view the auth.log, type:

```
show  log  auth.log
```

A result similar to the following is displayed:

```
ruggedcom# show log auth.log
Jan 29 09:25:00 ruggedcom confd[2068]: audit user: admin/0 failed to login using
 externalauth:  Local authentication
Jan 29 09:25:00 ruggedcom confd[2068]: audit user: admin/0 logged in through Web UI
 from 192.168.0.200
Jan 29 09:25:00 ruggedcom confd[2068]: audit user: admin/32 assigned to groups:
 admin
Jan 29 09:25:01 ruggedcom CRON[4599]: pam_unix(cron:session): session opened for
 user root by (uid=0)
.
.
.
```

4.12.2 Deleting Logs

To delete all logs stored on the device, type:

```
admin  delete-logs
```

4.12.3 Configuring Secure Remote Syslog

Secure remote syslog encrypts all system logs sent to syslog servers using an Secure Sockets Layer (SSL) certificate signed by a Certified Authority (CA).

⚠ NOTICE

The client (RUGGEDCOM ROX II) and server certificates must by signed by the same CA.

4.12.3.1 Enabling/Disabling Secure Remote Syslog

To configure a specific source IP address for all remote syslog messages, do the following:

1. Make sure the CLI is in Configuration mode.

   Note
   Once secure remote system logging is enabled and a remote syslog server is configured, TCP port 6514 is automatically opened.

2. Enable or disable secure remote syslog by typing either:

   Enabling

   ```
   admin  logging  secure-remote-syslog  enable
   ```

   Disabling

   ```
   no  admin  logging  secure-remote-syslog  enable
   ```

   ⚠ NOTICE

   All certificates must meet the following requirements:

   - X.509 v3 digital certificate format
   - PEM format
   - RSA key pair, 512 to 2048 bits in length

3. If secure remote syslog is enabled, specify a certificate to use for authentication with remote syslog server by typing:

   ```
   certificate  { certificate }
   ```

   Where:

   - { certificate } is the name of the certificate

   If the desired certificate is not listed, add it. For more information, refer to "Adding a Certificate (Page 207)".

4. [Optional] Define one or more match patterns or *permitted peers*. Permitted peers compare the server's host name to the common name defined in the

SSL certificate. For more information, refer to "Adding a Permitted Peer (Page 93)".

5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

4.12.3.2 Viewing a List of Permitted Peers

To view a list of permitted peers, type:

```
show running-config admin logging secure-remote-syslog permitted-peer
```

If peers have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config admin logging secure-remote-syslog permitted-peer

admin
 logging
  secure-remote-syslog permitted-peer *.example.com
  !
 !
!
```

If no permitted peers have been configured, add peers as needed. For more information, refer to "Adding a Permitted Peer (Page 93)".

4.12.3.3 Adding a Permitted Peer

To add a permitted peer for secure remote syslog, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the permitted peer by typing:

   ```
   admin logging secure-remote-syslog permitted-peer { pattern }
   ```

   Where:

   - { pattern } is the pattern used to match the common name defined in the SSL certificate received from the server

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

4.12.3.4 Deleting a Permitted Peer

To delete a permitted peer for secure remote syslog, do the following:

1. Make sure the CLI is in Configuration mode.

2. Delete the firewall by typing:

   ```
   no admin logging secure-remote-syslog permitted-peer { pattern }
   ```

   Where:

   - { pattern } is the pattern used to match the server's host name to the common name defined in the SSL certificate

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

4.12.3.5 Configuring a Source IP Address for Remote Syslog Messages

IP packets for remote syslog messages include a destination IP address and a source IP address. The source IP address is the interface from which the message is sent (e.g. switch.0001). However, that address may not be meaningful within the system log, or the address may conflict with a firewall rule or policy. In such cases, an alternative source IP address can be configured for all remote syslog messages.

To configure a specific source IP address for all remote syslog messages, do the following:

1. Make sure the CLI is in Configuration mode.
2. Make sure an IP address is first defined for the desired interface. For more information, refer to either "Adding an IPv4 Address (Page 251)" or "Adding an IPv6 Address (Page 252)".
3. Configure the source IP address by typing:

   ```
   admin logging source-ip { address }
   ```

   Where:

   - `{ address }` is the alternative source IP address

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

4.12.4 Managing Diagnostic Logs

Diagnostic logs are available for troubleshooting the device. Various device behavior is recorded in the following logs:

Log	Filename
Developer's Log	**/var/log/confd-dev.log**
SNMP Log	**/var/log/snmp-trace.log**
NETCONF Summary Log	**/var/log/netconf.log**
NETCONF Trace Log	**/var/log/netconf-trace.log**
XPATH Trace Log	**/var/log/xpath-trace.log**

Log	Filename
WebUI Trace Log	**/var/log/webui-trace.log**

⚠ NOTICE

Configuration hazard – risk of reduced performance

Enabling diagnostic logging will significantly affect the performance of RUGGEDCOM ROX II. Only enable diagnostic logging when directed by Siemens.

4.12.4.1 Enabling/Disabling the Developer's Log

The Developer's log records internal system transactions from the operational view.

⚠ NOTICE

Configuration hazard – risk of reduced performance

Enabling diagnostic logging will significantly affect the performance of RUGGEDCOM ROX II. Only enable diagnostic logging when directed by Siemens.

To enable or disable the Developer's log, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable or disable the Developer's log by typing the following commands:

   Enable

   ```
   admin logging diagnostics developer-log enabled
   ```

   Disable

   ```
   no admin logging diagnostics developer-log enabled
   ```

3. Configure the level of information provided by the Developer's log by typing:

Parameter	Description
`log-level { log-level }`	**Synopsis:** [error | info | trace] **Default:** info Sets the verbosity level for developer logging.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

4.12.4.2 Enabling/Disabling the SNMP Log

The SNMP log records all SNMP related events.

⚠ NOTICE

Configuration hazard – risk of reduced performance

Enabling diagnostic logging will significantly affect the performance of RUGGEDCOM ROX II. Only enable diagnostic logging when directed by Siemens.

To enable or disable the SNMP log, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable or disable the SNMP log by typing the following commands:

   Enable

   ```
   admin logging diagnostics snmp-log enabled
   ```

   Disable

   ```
   no admin logging diagnostics snmp-log enabled
   ```

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

4.12.4.3 Enabling/Disabling the NETCONF Summary Log

The NETCONF summary log briefly records NETCONF protocol transactions and, in particular, those which completed successfully. For example:

```
.
.
.
&amp;lt;INFO&amp;gt; 5-Apr-2012::04:26:33.877 ruggedcom confd[2098]: netconf id=9450
 new ssh session for user "admin" from 192.168.0.10
&amp;lt;INFO&amp;gt; 5-Apr-2012::04:27:03.574 ruggedcom confd[2098]: netconf id=9450
 got rpc: {urn:ietf:params:xml:ns:netconf:base:1.0}validate attrs: message-id="103"
&amp;lt;INFO&amp;gt; 5-Apr-2012::04:27:04.167 ruggedcom confd[2098]: netconf id=9450
 validate source=candidate attrs: message-id="103"
&amp;lt;INFO&amp;gt; 5-Apr-2012::04:27:06.691 ruggedcom confd[2098]: netconf id=9450
 sending rpc-reply, attrs: message-id="103"
.
.
.
```

⚠ NOTICE

Configuration hazard – risk of reduced performance

Enabling diagnostic logging will significantly affect the performance of RUGGEDCOM ROX II. Only enable diagnostic logging when directed by Siemens.

To enable or disable the NETCONF Summary log, do the following:

1. Make sure the CLI is in Configuration mode.

2. Enable or disable the NETCONF Summary log by typing the following commands:

   Enable

   ```
   admin logging diagnostics netconf-summary-log enabled
   ```

   Disable

   ```
   no admin logging diagnostics netconf-summary-log enabled
   ```

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

4.12.4.4 Enabling/Disabling the NETCONF Trace Log

The NETCONF trace log records the text of each NETCONF XML message received by and sent from the device. Each entry includes the NETCONF session identifier and the full text of the XML message. If the session identifier is followed by the word *read*, the XML message was received by the device. The word *write* indicates the XML message was sent by the device. For example:

```
.
.
.
**&amp;gt; sess:9450 read:
&amp;lt;rpc xmlns="urn:ietf:params:xml:ns:netconf:base:1.0" message-id="103"&amp;gt;
  &amp;lt;validate&amp;gt;
    &amp;lt;source&amp;gt;
      &amp;lt;running/&amp;gt;
    &amp;lt;/source&amp;gt;
  &amp;lt;/validate&amp;gt;
&amp;lt;/rpc&amp;gt;

**&amp;lt; sess:9450 write:
&amp;lt;rpc-reply message-id="103"
 xmlns="urn:ietf:params:xml:ns:netconf:base:1.0"&amp;gt;
  &amp;lt;ok/&amp;gt;
&amp;lt;/rpc-reply&amp;gt;
.
.
.
```

⚠ NOTICE

Configuration hazard – risk of reduced performance

Enabling diagnostic logging will significantly affect the performance of RUGGEDCOM ROX II. Only enable diagnostic logging when directed by Siemens.

To enable or disable the NETCONF Trace log, do the following:

1. Make sure the CLI is in Configuration mode.

2. Enable or disable the NETCONF Trace log by typing the following commands:

   Enable

   ```
   admin logging diagnostics netconf-trace-log enabled
   ```

   Disable

   ```
   no admin logging diagnostics netconf-trace-log
   enabled
   ```

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

4.12.4.5 Enabling/Disabling the XPATH Trace Log

The XPATH trace log records internal events related to XPATH routines that require interaction with an XPATH component.

> ⚠ **NOTICE**
>
> **Configuration hazard – risk of reduced performance**
>
> Enabling diagnostic logging will significantly affect the performance of RUGGEDCOM ROX II. Only enable diagnostic logging when directed by Siemens.

To enable or disable the XPATH Trace log, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable or disable the XPATH Trace log by typing the following commands:

   Enable

   ```
   admin logging diagnostics xpath-trace-log enabled
   ```

   Disable

   ```
   no admin logging diagnostics xpath-trace-log
   enabled
   ```

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

4.12.4.6 Enabling/Disabling the WebUI Trace Log

The WebUI trace log records all transactions related to the Web interface, such as configuration changes, error messages, etc.

⚠ NOTICE
Configuration hazard – risk of reduced performance
Enabling diagnostic logging will significantly affect the performance of RUGGEDCOM ROX II. Only enable diagnostic logging when directed by Siemens.

To enable or disable the WebUI Trace log, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable or disable the WebUI Trace log by typing the following commands:

   Enable

   ```
   admin logging diagnostics webui-trace-log enabled
   ```

   Disable

   ```
   no admin logging diagnostics webui-trace-log enabled
   ```

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

4.12.5 Managing Remote Syslog Servers

RUGGEDCOM ROX II can support up to 6 event message collectors, or remote Syslog servers. Remote Syslog provides the ability to configure:

- IP address(es) of collector(s)
- Event filtering for each collector based on the event severity level

4.12.5.1 Viewing a List of Remote Servers

To view a list of remote servers, type:

```
show running-config admin logging server
```

If remote servers have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config admin logging server
admin
 logging
  server 172.30.144.254
   enabled
   selector 1
    no negate
    facility-list [ all ]
   !
  !
 !
!
```

If no remote servers have been configured, add servers as needed. For more information, refer to "Adding a Remote Server (Page 100)".

4.12.5.2 Adding a Remote Server

To add a remote server, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the remote server by typing:

   ```
   admin logging server { address }
   ```

   Where { address } is the IP address of the remote server.
3. Configure the following parameter(s) as required:

Parameter	Description
`enabled`	Enables/disables the feed to the remote logging server.
`transport { transport }`	**Synopsis:** [udp | tcp] **Default:** udp TCP or UDP.
`monitor-interface { monitor-interface }`	**Synopsis:** A string The interface to monitor. If the IP address is changed on the interface, the logging daemon will restart.
`port { port }`	**Synopsis:** An integer between 1 and 65535 **Default:** 514 Port number.

4. Configure one or more selectors for the server. For more information, refer to "Adding a Remote Server Selector (Page 101)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

4.12.5.3 Deleting a Remote Server

To delete a remote server, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the remote server by typing:

   ```
   no admin logging server { address }
   ```

   Where:

   - `{ address }` is the IP address of the remote server.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

4.12.6 Managing Remote Server Selectors

Remote server selectors filter the information sent to specific servers.

4.12.6.1 Viewing a List of Remote Server Selectors

To view a list of remote server selectors, type:

```
show running-config admin logging server { address } selector
```

Where:

- `{ address }` is the IP address of the remote server.

If remote server selectors have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config admin logging server 172.30.144.254 selector
admin
 logging
  server 172.30.144.254
   selector 1
    no negate
    facility-list [ all ]
   !
  !
 !
!
```

If no remote server selectors have been configured, add selectors as needed. For more information, refer to "Adding a Remote Server Selector (Page 101)".

4.12.6.2 Adding a Remote Server Selector

To add a remote server selector, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the remote server selector by typing:

   ```
   admin logging server { address } selector { name }
   ```

   Where:

   - `{ address }` is the IP address of the remote server
   - `{ name }` is the name of the log selector identifier
3. Configure the following parameter(s) as required:

Parameter	Description
`negate`	Excludes messages defined in the **Remote Server Selector** fields from the log. Selecting this option acts as a logical NOT for the selector definition.

Parameter	Description
	For example: Selecting **same** , **debug** , and **mail** in the **Comparison** , **Level** , and **Facility-list** fields includes debug messages from the mail subsystem in the log. Selecting **Negate** **excludes** debug messages from the mail subsystem from the log.
`comparison { comparison }`	**Synopsis:** [same_or_higher | same] **Default:** same_or_higher The message severity levels to include in the log: • **same:** includes only messages of the severity level selected in the **Level** field. • **same_or_higher:** includes messages of the severity level selected in the **Level** field, and all messages of higher severity. For example: • Selecting **debug** in the **Level** field and **same** in the **Comparison** field includes only debug messages in the log. • Selecting **debug** in the **Level** field and **same_or_higher** in the **Comparison** field includes debug and all higher severity messages in the log.
`level { level }`	**Synopsis:** [emerg | alert | crit | err | warning | notice | info | debug | none | all] **Default:** all The base message severity level to include in the log. **all** includes all messages. **none** excludes all messages. Other levels are listed in order of increasing severity.
`facility-list { facility-list }`	**Synopsis:** [auth | authpriv | cron | daemon | ftp | kern | lpr | mail | news | security | syslog | user | uucp | local0 | local1 | local2 | local3 | local4 | local5 | local6 | local7 | all] The subsystems generating log messages. Messages from the selected subusystems are included in the log. At least one subsystem must be selected; up to 8 subsystems can be selected.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

4.12.6.3 Deleting a Remote Server Selector

To delete a remote server selector, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the remote server selector by typing:

   ```
   no admin logging server { address } selector { name }
   ```

   Where:

- `{ address }` is the IP address of the remote server
- `{ name }` is the name of the log selector identifier

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

4.13 Managing the Software Configuration

Configuration parameters for RUGGEDCOM ROX II can be saved on the device and loaded in the future.

4.13.1 Backing Up the Software Configuration

To recover from unexpected device failures quickly, it is important to backup the software configuration on a regular basis. This can be done manually by saving the configuration to a microSD/SDHC card or a remote server. It can also be done using the job scheduler, RUGGEDCOM NMS or SINEC NMS, or a separate utility, such as Ansible.

The following is an example of a job created through the CLI with RUGGEDCOM ROX II's job scheduler. This job backs up the software configuration locally and to a remote SFTP server every 24 hours.

```
admin
scheduler
  scheduled-jobs backup-config
   job-minute  13
   job-hour    14
   job-command "admin backup-files file-type config file test.cfg url sftp://
user:password@192.168.0.100/home/user/Documents/configs/"
  !
  scheduled-jobs save-config
   job-minute  12
   job-hour    14
   job-command "admin full-configuration-save format cli file-name test.cfg"
```

For information about using the job scheduler, refer to "Scheduling Jobs (Page 147)".

For information about backing up the software configuration manually, refer to "Saving the Configuration (Page 103)".

For all other methods, refer to the product's user documentation.

4.13.2 Saving the Configuration

The device configuration can be saved locally on the device (to be transferred later), to a microSD/microSDHC card, or to a remote server.

To save the configuration settings, do the following:

Saving the Configuration On the Device

```
admin full-configuration-save format cli file-name
{ filename }
```

Where:

- `{ filename }` is the name of the configuration file

Alternatively, to include only the default configuration parameter values in the saved configuration file, do the following:

1. Make sure the CLI is in Configuration mode.
2. Save the default values by typing:

   ```
   save { filename } | details
   ```

   Where:

   - `{ filename }` is the name of the configuration file

If required, once the configuration file has been saved, back it up to a microSD/microSDHC Flash card. For more information, refer to "Backing Up Files (Page 89)".

Saving the Configuration to a MicroSD/MicroSDHC Card

To save the configuration to a microSD/microSDHC card, type:

```
admin save-configuration-to-removable file-name { file
name } allow-overwrite [ true | false ]
```

Where:

- { file name } is the name of the file
- `allow-overwrite { true }` will overwrite any file on the card that has the same file name as the new file

Note
If a file name is not defined, the configuration will be saved as **autoload-config.cli**. This file name is recognized by RUGGEDCOM ROX II as a configuration that can be automatically loaded following a reboot, if the feature is enabled.

For more information about automatically loading a saved configuration, refer to "Managing Automatic Configuration Loading (Page 105)".

4.13.3 Loading a Configuration

To load a configuration file for RUGGEDCOM ROX II, do the following:

⚠ NOTICE

RUGGEDCOM ROX II only accepts configuration files from devices with the same hardware profile running the same software version. It is recommended to only load configuration files from the same device.

1. [Optional] Install the configuration file on the device. For more information, refer to "Installing Files (Page 88)".
2. Load the configuration file by typing:

   ```
   admin full-configuration-load format cli file-name
   { filename }
   ```

   Where:

   - `{ filename }` is the name of the configuration file
3. A confirmation message appears. Type **`yes`** to load the file or **`no`** to abort.

4.13.4 Managing Automatic Configuration Loading

RUGGEDCOM ROX II supports automatic loading of a configuration file via a microSD/microSDHC card, following a reboot of the device.

Configurations can be created and modified on a PC, or saved from one device onto a microSD/microSDHC card, then loaded onto another device or devices as needed. Saved configurations can also be loaded onto new devices to replace factory default settings.

4.13.4.1 Enabling/Disabling Automatic Configuration Loading

To enable or disable the automatic configuration loading feature, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable or disable the automatic configuration loading feature by typing:

   Enable

   ```
   admin automatic-config-load enabled
   ```

   Disable

   ```
   no admin automatic-config-load enabled
   ```
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

4.13.4.2 Automatically Loading a Configuration File from a Removable Drive

A configuration file can be saved to a microSD/microSDHC card and automatically loaded to an existing device. The loaded configuration will replace the existing configuration following a reboot.

Note
For more information about supported file systems in RUGGEDCOM ROX II, refer to "Removable Memory (Page 17)".

To automatically load a configuration file from a microSD/microSDHC card following a reboot, do the following:

1. Enable automatic configuration loading on the target device. For more information, refer to "Enabling/Disabling Automatic Configuration Loading (Page 105)".

   Note
   For detailed information about managing the Virtual Processing Engine (VPE), refer to "*Virtualization* (Page 915)".

2. If a VPE is being used, make sure the VPE feature key (VIRTUALM) is installed on the target device.
3. Create a configuration file from a PC or the desired source device. Name the file *autoload-config.cli*. For more information, refer to "Saving the Configuration (Page 103)".
4. If a VPE is being used, do the following on the configuration file to be loaded:
   a. Enable the virtualization service. For more information, refer to "Enabling/Disabling the Virtualization Service (Page 916)".
   b. Enable the virtual machine to be auto started. For more information, refer to "Configuring Global Settings (Page 917)".
   c. Make sure the uncompressed virtualization image files are loaded on the microSD/microSDHC card.
   d. Make sure the virtualization configuration maps to the virtualization image files.
5. Copy the configuration file to the removable drive. For more information, refer to "Backing Up Files (Page 89)".

   ⚠ NOTICE
   If the Automatic Configuration Load feature is not enabled, the loading of any Auto-Load Configuration File found on the removable drive will not occur, and the RUGGEDCOM ROX II device will continue with its normal startup.

6. Insert the microSD/microSDHC/microSD/microSDHCHC drive into the microSD/microSDHC/microSD/microSDHCHC drive slot on the target device. For more information, refer to the " RUGGEDCOM RX1400 Installation Manual".

7. Reboot the target device. For more information about rebooting, refer to "Rebooting the Device (Page 83)".

   The auto-loaded configuration file is loaded to the device. If the VPE service is configured to auto-start, the virtual machine starts.

4.13.4.3 Overriding Factory Settings Using a Removable Drive

A configuration file can be saved to a microSD/microSDHC card and automatically loaded to a new device. The loaded configuration will replace the factory default configuration following the initial boot.

Note
This procedure applies to the initial boot only. For information about loading the configuration from a microSD/microSDHC card after the initial boot, refer to "Automatically Loading a Configuration File from a Removable Drive (Page 106)".

Note
For more information about supported file systems in RUGGEDCOM ROX II, refer to "Removable Memory (Page 17)".

To automatically override factory settings using a removable drive, do the following:

1. If a VPE is required, make sure the VPE feature key (VIRTUALM) has been purchased. For more information about obtaining this feature key, contact a Siemens Sales representative or Customer Support.
2. Create a configuration file from a PC or the desired source device (i.e. another RUGGEDCOM ROX II device). Name the file *autoload-config.cli*. For more information, refer to "Saving the Configuration (Page 103)".
3. If a VPE is being used, do the following on the configuration file to be loaded:
   a. Enable the virtualization service. For more information, refer to "Enabling/Disabling the Virtualization Service (Page 916)".
   b. Enable the virtual machine to be auto started. For more information, refer to "Configuring Global Settings (Page 917)".
   c. Make sure the uncompressed virtualization image files are loaded on the microSD/microSDHC card.
   d. Make sure the virtualization configuration maps to the virtualization image files.
4. Copy the configuration file to the removable drive. For more information, refer to "Backing Up Files (Page 89)".
5. Insert the microSD/microSDHC/microSD/microSDHCHC drive into the microSD/microSDHC/microSD/microSDHCHC drive slot on the target device. For more information, refer to the " RUGGEDCOM RX1400 Installation Manual".
6. Start up and connect to the target device. For more information about connecting to the device, refer to "Connecting to RUGGEDCOM ROX II (Page 73)".

The auto-loaded configuration file is loaded to the device.

4.13.4.4 Deleting an Automatic Configuration File

To remove an **autoconfig.cli** from a microSD/microSDHC card, do the following:

1. Insert the microSD/microSDHC card into the device. For more information, refer to the " RUGGEDCOM RX1400 Installation Manual".
2. Enter the following command:

   ```
   admin  delete-autoload-configuration-removable
   ```

   The file **autoload-config.cli** is removed from the card.

4.14 Managing Upgrade Servers

RUGGEDCOM ROX II can be configured to retrieve software/firmware packages from a centralized upgrade server.

4.14.1 Understanding Upgrade Servers

Upgrade servers must meet the following requirements:

- The server must act as a Web server or FTP server, and be accessible to the device.
- The server must have sufficient disk space for at least two full software releases. Each full software release is approximately 102 MB, although most upgrades are typically much smaller.
- The server must have sufficient bandwidth. The bandwidth requirements will be based on the number of devices, the size of the upgrade, and when the devices launch an upgrade. The bandwidth is also limited by default for each device to 500 kbps. A modest (e.g. 486 class machine) Web server should be able to serve files up to the limit of the network interface bandwidth.
- The server must be able to accept at least as many HTTP, HTTPS, FTP, FTPS, or SFTP connections as there are devices on the network.
- The server must contain and publish a directory specifically for RUGGEDCOM ROX II software releases. The name of this directory will be specified in the upgrade settings for each device.
- Communication between the server and the device must be on a secure channel, such as IPsec.
- For upgrades via HTTPS, the server's public key must be signed by a trusted Certificate Authority (CA). A list of recognized CA's is available under **/etc/ssl/certs/**

Note
It is recommended to configure each device to upgrade at different times to minimize impact on the network. A large upgrade (or a low bandwidth limiting value on each device) may cause all devices to upgrade at the same time.

4.14.2 Configuring the Upgrade Server

For RUGGEDCOM ROX II to properly retrieve files from an upgrade server, the following must be configured on the server:

- **MIME Types**

  The following MIME types must be defined for the chosen upgrade server (e.g. Microsoft IIS Manager, Apache HTTP Server, Lighttpd, etc.) for RUGGEDCOM ROX II to properly retrieve files from the server:

  - application/x-bzip2
  - text/plain

  RUGGEDCOM ROX II software and application upgrades/installations may fail if these MIME types or not configured.

- **Enable Double-Escaping**

  Only required for firmware versions lower than RUGGEDCOM ROX II v2.14.0.

  Double-escaping allows special double-encoded characters, such as +, % and &, in a URI. As some files in RUGGEDCOM ROX II upgrade/downgrade packages may contain a + sign in their file names, double-escaping must be enabled for the upgrade server. If double-escaping is not enabled, some files will be un-retrievable and the upgrade will fail.

  In the case of Microsoft's Internet Information Services (IIS) Manager, double-escaping is enabled by setting the **allowDoubleEscaping** attribute in **web.config** to **true**.

```
&amp;lt;system.webServer&amp;gt;
 &amp;lt;security&amp;gt;
  &amp;lt;requestFiltering allowDoubleEscaping="true" /&amp;gt;
 &amp;lt;/security&amp;gt;
&amp;lt;/system.webServer&amp;gt;
```

For more information about configuring MIME types and double-escaping for the upgrade server, consult the product's user documentation.

4.15 Managing Software Versions

RUGGEDCOM ROX II uses a dual partition system to upgrade or downgrade (rollback) the system software while allowing the device to continue operating on the network.

Software can be installed directly on the device using removable media or remotely over the network via an upgrade server.

Note
If upgrading from a previous release of RUGGEDCOM ROX II to v2.15, refer to the documentation for the release that is currently installed on the device. **The following instructions only describe how to upgade from RUGGEDCOM ROX II v2.15 to a newer version.**

⚠ NOTICE

Restrictions/Requirements

Restrictions/requirements may apply when upgrading/downgrading to a newer or older software version. Before installing a different version of RUGGEDCOM ROX II, check the **Firmware Download** announcement for the target software release.

For a list of **Firmware Download** announcements for RUGGEDCOM ROX II, visit https://support.industry.siemens.com/cs/search?search=rox&type=Download.

If an annoucement is not available for the target software version, contact Siemens Customer Support.

4.15.1 Understanding Upgrades/Downgrades

Software upgrades are managed between two partitions. The active (or primary) partition contains the software version currently used by the device. The inactive (or secondary) partition contains an inactive version of RUGGEDCOM ROX II.

When upgrading or downgrading to a different version of RUGGEDCOM ROX II, the target software is uploaded to the inactive partition. Any software package already installed on the inactive partition is automatically replaced by the target software package.

Following a successful reboot, which is part of the upgrade/downgrade process, the inactive partition is made the active partition. The previous version of RUGGEDCOM ROX II is on the inactive partition. This mechanism allows the device to remain operational on the network while the upgrade/downgrade process takes place. It also allows users to revert to the previous version if needed.

Note
In the case of a software upgrade, the configuration and feature keys from the active partition are also copied to the inactive partition.

4.15.2 Upgrading/Downgrading Software

When upgrading the software, alternative methods are available that either retain the current software configuration or reset it to factory defaults.

⚠ NOTICE

If upgrading to a software release that is multiple versions ahead of the one currently installed, consider that potential changes to the system architecture at key release points may require the installation of an intermediary release(s).

{ current release } ⇨ { intermediary release } ⇨ { newer release }

For information about recommended upgrade paths, refer to " How to determine the firmware upgrade path for a RUGGEDCOM ROX II device? [https://support.industry.siemens.com/cs/us/en/view/109806037] ".

Note

The software upgrade/downgrade process is backwards compatible with select upgrade commands from previous RUGGEDCOM ROX II releases. This allows users to continue using any custom scripts or third-party software they have used previously. If compatibility issues occur, contact Siemens Customer Support.

4.15.2.1 Determining the Current Software Partition and Version

To determine which software partition is active and which version of RUGGEDCOM ROX II is running, enter the following command:

```
show admin rox-imaging partition-information
```

For example:

```
localhost# show admin rox-imaging partition-information
rox-imaging partition-information
 software partition "Partition #2"
 current version    "ROX 2.15.0 (2022-01-21 14:17)
```

The following information is displayed:

Parameter	Description
`software-partition`	**Synopsis:** A string 31 characters long The active partition. ROXflash is always peformed on the other partition.
`current-version`	**Synopsis:** A string 31 characters long The operating software version on the current software partition.

4.15.2.2 Obtaining a Software Release

Valid software releases are available online via Siemens Industry Online Support (SIOS) [https://support.industry.siemens.com] or through Siemens Customer Support.

Obtaining a Newer or Older Software Package

For details on how to obtain a newer or older version of RUGGEDCOM ROX II, refer to Guide to Download RUGGEDCOM Software and Firmware [https://support.industry.siemens.com/cs/us/en/view/109739630].

Installing a Software Package

After obtaining a software package, do the following:

1. Download the software package as instructed.

   The software package is provided as a compressed ZIP file that includes:

   - The software image
   - A GPG (GNU Private Guard) signature file

   The name of the package will be in the form of **rrX.Y.Z-armfh.zip**, where *X* represents the major release number, *Y* represents the minor release number, and *Z* represents the patch release number.
2. Save the file to either:
   - A local upgrade server
   - A microSD/microSDHC drive
3. Extract the contents of the compressed file, making sure not to modify the resulting file/directory structure.
4. During the software upgrade process, target the SD drive or upgrade server.

4.15.2.3 Stopping/Declining a Software Upgrade

To stop/decline an active software upgrade and revert back to the previously installed version, do the following:

⚠ NOTICE

A software upgrade can only be declined before the device is rebooted. If a system reboot has occurred, the previous software version can only be restored with a rollback.

For more information about rolling back RUGGEDCOM ROX II to the previous software version, refer to "Rolling Back a Software Upgrade (Page 120)".

1. Make sure the CLI is in Configuration mode.
2. Rollback the software version by typing:

```
admin  rox-imaging  decline-upgrade
```

4.15.2.4 Upgrading the Software and Retaining the Configuration

To install a newer version of RUGGEDCOM ROX II and retain the current device configuration, do the following:

Note
The target version must be greater than the active version currently in use.

Note
If upgrading from a previous release of RUGGEDCOM ROX II to v2.15, refer to the documentation for the release that is currently installed on the device. **The following instructions only describe how to upgrade from RUGGEDCOM ROX II v2.15 to a newer version.**

Note
Before upgrading to a newer version of RUGGEDCOM ROX II, note the following:

- The **Firmware Download** announcement for the target version may detail special upgrade requirements/restrictions. Make sure to review these details before proceeding.

  For a list of **Firmware Download** announcements for RUGGEDCOM ROX II, visit https://support.industry.siemens.com/cs/search?search=rox&type=Download.

  If an announcement is not available for the target software version, contact Siemens Customer Support.
- A valid GPG (GNU Private Guard) signature file is required. This is included in the software package. Make sure the corresponding GPG signature resides in the same location as the software package before installation.
- Make sure the system time and date are current. For more information, refer to "Configuring the System Time and Date (Page 900)".

1. Obtain the software package for the target release. For more information, refer to "Obtaining a Software Release (Page 111)".
2. If the software will be installed from a removable microSD/microSDHC card, insert the drive into the microSD/microSDHC card slot.

   For more information, refer to the "Installation Manual" for the device.
3. Make sure all applications installed on the device are compatible with the target version of RUGGEDCOM ROX II.

   If an application is not compatible, the upgrade process will stop automatically and details will be recorded in the upgrade log.
4. Make sure the CLI is in Configuration mode.

   Note
   If a removable drive is used, do not remove the drive from the device until the upgrade process is complete.

Note
For upgrades via HTTPS (SSL), the server's root CA certificate and CRL must be added. For more information, refer to "Adding a CA Certificate and CRL (Page 200)".

Note
For upgrades via FTPS, if the URL includes the port value **990** or no port is specified, the connection to the remote FTPS server will use **Implicit FTPS** mode. If a port value other than **990** is used, the connection will use **Explicit FTPS** mode.

Note
URL strings may only contain numbers, lowercase and uppercase characters, spaces, and the following special characters: .-:_/%@

5. Start the software upgrade using one of the following commands:

Command	Description

`admin rox-imaging software-upgrade url { URL }`	{ URL } is the URL for the software package in the form of:
	`protocol://user:password@host:port/path-to-file`
	Supported protocols include: http, https, ftp, ftps, sd
	For example:
	`http://webserver.local.lan/rr2/imagerr2.15.0-armhf.tar.bz2`

`wizard rox_upgrade`	This method requires user input to complete the upgrade. Follow the online instructions.
	When the upgrade process begins, the wizard displays the status of the upgrade. For example:
	`ruggedcom(config)# wizard rox_upgrade`
	`This wizard will install a ROXII image to the inactive partition along with the current configuration. On your next boot, that partition will become active and you will boot into the installed ROXII version.`
	`If the configuration cannot be upgraded the installation will abort. The current configuration may require to be modified to allow the installation and upgrade to complete.`
	`Do you wish to continue?(y/n): y`
	`Enter the url of the ROXII image. The following protocols are supported for file transfer: http, https, ftp, ftps, usb and sd.`
	`The url should take the form of protocol://user:password@host:port/path-to-file.`
	`If the server does not require authentication, you may leave out 'user:password@'. You may omit ':port' when using protocol's default port.`
	`Enter url: http://webserver.local.lan/rr2/imagerr2.15.0-armhf.tar.bz2`

Command	Description
	Checking connectivity to server... apply failed: /rmf_admin:admin/rox-imaging: A roxflash is in progress. Configurations are locked until the next boot. To unlock, you must decline the upgrade after it completes. Performing validation of current config against image validation scripts ... Image ROX version is greater than the current ROX version. The image gpg signature is valid. Current configuration passed the validation scripts from the image. Preparing partition #2 to be flashed... Flashing image to partition#2. Please do not disconnect from image source. progress: 100% Image flashed in 6 minutes 52 seconds. rox version:ROX 2.15.0 (2022-01-01 00:01) rc:0 Flashed image detected to be version ROX 2.15.0 (2022-01-01 00:01) Copying configuration to the target software partition ... Copying user files to the target software partition ... Finishing upgrade settings on the target software partition. Completed the upgrade on the target software partition. The software upgrade was successful. A reboot is required to boot the other partition.

Note
Rebooting the device is the final stage of the upgrade process. After a successful reboot, the inactive (secondary) partition where the software package was installed is switched to the active (primary) partition.

For information on how to stop/decline the current upgrade, refer to "Stopping/Declining a Software Upgrade (Page 112)"

6. When the software upgrade is complete, reboot the device. For more information about rebooting the device, refer to "Rebooting the Device (Page 83)".

4.15.2.5 Upgrading the Software and Resetting the Configuration

To install a newer version of RUGGEDCOM ROX II and reset the device configuration to factory defaults, do the following:

Note
The target version must be greater than the active version currently in use.

Note
If upgrading from a previous release of RUGGEDCOM ROX II to v2.15, refer to the documentation for the release that is currently installed on the device. **The**

following instructions only describe how to upgrade from RUGGEDCOM ROX II v2.15 to a newer version.

Note
Before upgrading to a newer version of RUGGEDCOM ROX II, note the following:

- The **Firmware Download** announcement for the target version may detail special upgrade requirements/restrictions. Make sure to review these details before proceeding.

  For a list of **Firmware Download** announcements for RUGGEDCOM ROX II, visit https://support.industry.siemens.com/cs/search?search=rox&type=Download.

  If an announcement is not available for the target software version, contact Siemens Customer Support.
- A valid GPG (GNU Private Guard) signature file is required. This is included in the software package. Make sure the corresponding GPG signature resides in the same location as the software package before installation.
- Make sure the system time and date are current. For more information, refer to "Configuring the System Time and Date (Page 900)".

1. Obtain the software package for the target release. For more information, refer to "Obtaining a Software Release (Page 111)".
2. If the software will be installed from a removable microSD/microSDHC card, insert the drive into the microSD/microSDHC card slot.

   For more information, refer to the "Installation Manual" for the device.
3. Make sure all applications installed on the device are compatible with the target version of RUGGEDCOM ROX II.

   If an application is not compatible, the upgrade process will stop automatically and details will be recorded in the upgrade log.
4. Make sure the CLI is in Configuration mode.

   Note
   If a removable drive is used, do not remove the drive from the device until the upgrade process is complete.

   Note
   For upgrades via HTTPS (SSL), the server's root CA certificate and CRL must be added. For more information, refer to "Adding a CA Certificate and CRL (Page 200)".

   Note
   For upgrades via FTPS, if the URL includes the port value **990** or no port is specified, the connection to the remote FTPS server will use **Implicit FTPS** mode.

If a port value other than **990** is used, the connection will use **Explicit FTPS** mode.

Note
URL strings may only contain numbers, lowercase and uppercase characters, spaces, and the following special characters: .-:_/%@

5. Start the software upgrade using one of the following commands:

Command	Description

`admin rox-imaging roxflash url { URL }`	{ URL } is the URL for the software package in the form of:
	`protocol://user:password@host:port/path-to-file`
	Supported protocols include: http, https, ftp, ftps, sd
	For example:
	`http://webserver.local.lan/rr2/imagerr2.15.0-armhf.tar.bz2`

`wizard rox_flash`	This method requires user input to complete the upgrade. Follow the online instructions.
	When the upgrade process begins, the wizard displays the status of the upgrade. For example:
	`ruggedcom(config)# wizard rox_upgrade`
	`This wizard will flash a ROXII image to the inactive partition.. On your next boot, that partition will become active and you will boot into the flashed ROXII version. Your configuration will not be transferred.`
	`Do you wish to continue?(y/n): y`
	`Enter the url of the ROXII image. The following protocols are supported for file transfer: http, https, ftp, ftps, usb and sd.`
	`The url should take the form of protocol://user:password@host:port/path-to-file.`
	`If the server does not require authentication, you may leave out 'user:password@'. You may omit ':port' when using protocol's default port.`
	`Enter url: http://webserver.local.lan/rr2/imagerr2.15.0-armhf.tar.bz2`
	`Checking connectivity to server...`
	`apply failed: /rmf_admin:admin/rox-imaging: A roxflash is in progress. Configurations are locked until the next boot. To unlock, you must decline the upgrade after it completes.`
	`Performing validation of current config against image validation scripts ...`
	`Image ROX version is greater than the current ROX version.`
	`The image gpg signature is valid.`
	`Current configuration passed the validation scripts from the image.`
	`Preparing partition #2 to be flashed...`

Command	Description
	Flashing image to partition#2. Please do not disconnect from image source. progress: 100% Image flashed in 6 minutes 52 seconds. rox version:ROX 2.15.0 (2022-01-01 00:01) rc:0 Flashed image detected to be version ROX 2.15.0 (2022-01-01 00:01) Copying configuration to the target software partition ... Copying user files to the target software partition ... Finishing upgrade settings on the target software partition. Completed the upgrade on the target software partition. The software upgrade was successful. A reboot is required to boot the other partition.

Note
Rebooting the device is the final stage of the upgrade process. After a successful reboot, the inactive (secondary) partition where the software package was installed is switched to the active (primary) partition.

For information on how to stop/decline the current upgrade, refer to "Stopping/Declining a Software Upgrade (Page 112)"

6. When the software upgrade is complete, reboot the device. For more information about rebooting the device, refer to "Rebooting the Device (Page 83)".

4.15.2.6 Downgrading Software

To downgrade the RUGGEDCOM ROX II software to an earlier version, do the following:

Note
When downgrading to an older version, the software is installed on the inactive partition with factory default settings. The software configuration and feature keys on the active partition are not copied to the inactive partition.

1. Obtain a link to or a copy of the software packages. Software packages (new and old) are available by through Siemens Customer Support.

   For more information about obtaining a software release, refer to "Obtaining a Software Release (Page 111)".

2. If the software will be installed from a removable microSD/microSDHC card, insert the drive into the microSD/microSDHC card slot.

   For more information, refer to the "Installation Manual".

Note
For downgrades via HTTPS (SSL), the server's public key must be signed by a trusted Certificate Authority (CA).

Note
For downgrades via FTPS, if the URL includes the port value **990** or no port is specified, the connection to the remote FTPS server will use **Implicit FTPS** mode. If a port value other than **990** is used, the connection will use **Explicit FTPS** mode.

3. Launch the ROXflash wizard by typing:

   ```
   wizard  rox_flash
   ```

   The wizard will require user input to complete the upgrade. Follow the online instructions.

   When the downgrade process begins, the wizard displays the status of the downgrade. For example:

   ```
   ruggedcom(config)# wizard rox_flash
   This wizard will flash a ROXII image to the inactive partition. On your next
    boot, that partition
   will become active and you will boot into the flashed ROXII version. Your
    configurations will not be transferred.
   Do you wish to continue?(y/n): y


   Enter the url of the ROXII image. The following protocols are supported: http,
    https, ftp, ftps, usb and sd.
   The url should take the form of protocol://user:password@host/path-to-file.
   If the server does not require authentication, you may leave out
    'user:password@'.

   Enter url: ftp://user:12345@ftpserver.local.lan/debianppc/rr2/image/
   imagerr2.tar.bz2
   Starting download of ROXII image...

   ################################################################### 100.0%
   Download complete.
   Preparing partition #2 to be flashed...
   Flashing image to partition#2...
   progress: 100%
   Flashed image detected to be version ROX 2 (2011-03-29 03:04)

   The other partition was imaged successfully.
   A reboot is required to boot the other partition.
   ```

Note
Rebooting the device is the final stage of the upgrade process. After a successful reboot, the inactive partition where the software package was installed is switched to the active (primary) partition.

For information on how to stop/decline the current upgrade, refer to "Stopping/Declining a Software Upgrade (Page 112)"

4. When the software upgrade is complete, reboot the device.

   For more information about rebooting the device, refer to "Rebooting the Device (Page 83)".

4.15.2.7 Rolling Back a Software Upgrade

To activate a previous version of the RUGGEDCOM ROX II software stored on the inactive (secondary) partition, do the following:

1. Make sure the CLI is in Configuration mode.
2. Rollback the software version by typing:

   ```
   admin  rox-imaging  rollback-reboot
   ```

   The device will automatically reboot. Once the reboot is complete, the previously inactive partition containing the older software version is changed to an active state.

4.15.2.8 Monitoring Software Upgrades/Downgrades

To monitor the real-time progress of an active software upgrade or downgrade, enter the following command:

```
show  admin  rox-imaging  roxflash-progress
```

For example:

```
localhost# show admin rox-imaging roxflash-progress
rox-imaging roxflash-progress
 phase          Inactive
 status message ""
 image flashing 0
```

The following information is displayed:

Parameter	Description
`phase`	**Synopsis:** [Inactive | Downloading image | Imaging partition | Unknown state | Completed successfully | Failed | Validating database | Copying configuration | Declined | Imaging app] The current phase or state of the ROXflash operation. It is always one of the following: Inactive, Imaging partition, Unknown state, Completed successfully, or Failed. These phrases do not vary, and may be used programatically for ascertaining state.
`status-message`	**Synopsis:** A string 1024 characters long Detailed messages about ROXflash progress or errors.
`image-flashing`	**Synopsis:** An integer between 0 and 100 Indicates the imaging progress and the percentage that is complete.

4.16 Monitoring Firmware Integrity

RUGGEDCOM ROX II can perform an integrity check to verify the integrity of running programs and installed files. The integrity check can be invoked in the following ways:

- automatically at system start-up
- as a scheduled job
- on demand via the user interface

If an unauthorized/unexpected modification is detected during the integrity check, an alarm is triggered and each offending file or program is logged.

Note
RUGGEDCOM ROX II validates the authenticity and integrity of the firmware. Software upgrades are cryptographically signed at the factory by Siemens and cannot be falsified. The firmware upgrade package is validated cryptographically at the time of the upgrade. During operation, the integrity of the installed files is verified and all running programs are verified to be part of the validated installation.

⚠ NOTICE

Security hazard – risk of unauthorized access and/or exploitation

For the firmware integrity check to be meaningful, appropriate care must be taken to protect the device. Make sure physical access to the device is restricted to authorized personnel only and that administrator login credentials are kept secure.

Note
The firmware integrity check only analyzes RUGGEDCOM ROX II operating system files. It does not detect additional files that may have been placed by a malicious user, unless they are program binary files that are running at the time of the integrity check.

4.16.1 Enabling/Disabling the Boot Time Firmware Integrity

The boot time integrity check is disabled by default. When enabled though, the check occurs whenever the device is restarted or powered on.

To enable or disable this feature, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable or disable the boot time integrity check by typing:

   Enable

   ```
   admin  boot-time-firmware-integrity-check
   ```

   Disable

   ```
   no  admin   boot-time-firmware-integrity-check
   ```

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

4.16.2 Checking the Firmware Integrity

To check the firmware integrity manually, type:

```
admin  check-integrity
```

If the integrity check fails, the following message is displayed:

```
FAILURE. The firmware integrity check has failed. This may indiciate that some
 operating system files have been modified or tampered with. For assistance, contact
 Siemens Customer Support.
```

4.16.3 Scheduling a Recurring Firmware Integrity Check

Using the RUGGEDCOM ROX II scheduler, the firmware integrity check can be scheduled to run automatically at a specific time and date, either once or on a recurring schedule. For more information about scheduling the firmware integrity check, refer to "Scheduling Jobs (Page 147)".

4.16.4 Viewing the Status of the Firmware Integrity Check

To view the status of the last firmware integrity check, type:

```
show  chassis  chassis-status
```

For example:

```
ruggedcom# show chassis chassis-status
chassis-status
 model                      RX1501
 software license           "Layer 3 Security Edition"
 rox release                "ROX 2.12.0-QA1.9 (2018-01-26 12:58)"
 system serial number       RX1501R-0812-00664
 last integrity check       "2018-02-07 14:31"
 last integrity check result "FAILURE. The firmware integrity check has failed. This
 may indicate that some operating system files have been modified or tampered with.
 For assistance, contact Siemens Customer Support."
```

The following parameters detail the integrity check:

Parameter	Description
`last-integrity-check`	**Synopsis:** A string 32 characters long The last time the firmware integrity was checked.
`last-integrity-check-result`	**Synopsis:** A string The result of the last integrity check.

If the integrity check as successful, the following message is displayed:

```
Success
```

If the integrity check failed, the following message is displayed:

```
FAILURE. The firmware integrity check has failed. This may indicate that some
 operating system files have been modified or tampered with. For assistance, contact
 Siemens Customer Support.
```

4.17 Managing SFP Transceivers

RUGGEDCOM ROX II supports a wide variety of Small Form-factor Pluggable (SFP) transceivers to help expand the capabilities of the device. For a full list of Siemens-approved SFP transceivers, refer to the RUGGEDCOM SFP Transceivers Catalog [https://support.industry.siemens.com/cs/ww/en/view/109482309].

⚠ NOTICE

It is strongly recommended to use SFP transceiver models approved by Siemens only. Siemens performs extensive testing on these transceivers to make sure they can withstand harsh conditions. If a different SFP transceiver model is used, it is the user's responsibility to verify it meets environmental and usage requirements.

4.17.1 SFP Transceiver Support

RUGGEDCOM ROX II offers the following support for SFP transceivers.

Hot Swappable

All SFP transceivers are hot swappable, meaning they can be removed and inserted while the device is operating. Only a previously established link on that port is affected while the socket is empty.

Automatic Detection

RUGGEDCOM ROX II actively monitors each SFP transceiver port to determine when an SFP transceiver has been inserted or removed. Each event is logged in the syslog.

Smart SFP For Select Transceivers

Smart SFP mode is available for SFP transceivers installed in ports **5** and **6** . This mode is enabled by default.

Smart SFP enables RUGGEDCOM ROX II to automatically configure the speed and auto-negotiation settings for the socket to match the transceiver. Settings are based on the capabilities read from the SFP transceivers EEPROM.

⚠ NOTICE

All SFP transceivers approved by Siemens support Smart SFP mode. SFP transceivers that do not support Smart SFP mode may be disabled upon insertion and marked as *Unidentified*. If this occurs, attempt to disable Smart SFP and configure the speed and auto-negotiation settings for the port manually.

For information about disabling (or enabling) Smart SFP mode, refer to "Enabling/Disabling Smart SFP Mode (Page 125)".

4.17.2 Viewing SFP Information

To view information about a specific Small Form-Factor Pluggable (SFP) transceiver in a line module, type:

Note

Some SFPs may not make information about themselves available. In these cases, a message similar to the following will appear:

```
ID: Unknown FF
```

```
interfaces switch { slot } { port } sfp
```

Where:

- `{ slot }` is the name of the module location
- `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module

If an SFP transceiver exists in the selected port, details about the transceiver are displayed. For example:

```
ruggedcom# interfaces switch lm1 1 sfp
sfp-info-string
ID: SFP or SFP "Plus"
Extended ID: GBIC/SFP function is defined by serial ID only
Connector: LC
Transceiver:
      Ethernet Compliance: 100Base-FX
      10G Ethernet Compliance: Not specified
      Fibre Channel link length: Not specified
      Fibre Channel transmitter technology: Not specified
      SFP+ cable technology: Not specified
      Fibre Channel transmission media: Not specified
      Fibre Channel speed: Not specified
Baud Rate, nominal: 100 Mbps
Encoding type: 4B5B
Length(SMF): Not specified
Length(SMF): Not specified
Length(50um): 2000 m
Length(62.5um): 2000 m
Length(Copper): Not specified
Length(OM3): Not specified
Vendor: AVAGO
IEEE company ID: 8193
```

```
Part number:
Revision: O
Laser wavelength: 8224 nm
Options: Power Level (see SFF-8431) - level 2
         Linear Receiver Output implemented (see SFF-8431)
         Loss of Signal implemented, inverted (often called Signal Detect)
BRmax: 700 Mbps
BRmin: Not specified
Serial number:
Manufacturing date code: Y:AV M:AG D:O
Monitoring type: Digital diag monitoring - MUST be '1' but is '0'
                 Internally calibrated
                 Received power measurement type - OMA
Enhanced options: Soft TX_FAULT monitoring
SFF-8472 revision compliance: Unknown 20
```

4.17.3 Enabling/Disabling Smart SFP Mode

Smart SFP mode can be disabled for SFP transceivers that do not support Smart SFP. These transceivers are disabled automatically upon insertion and marked as *Unidentified*.

Note
Smart SFP mode is only available for SFP transceivers installed in ports 5 and 6.

Note
To determine if an SFP transcever has been marked as *Unidentified*, refer to the **media** parameter under ***interfaces » switch » swport » {port}***, where *{port}* is the port number of the switched Ethernet port. The parameter will display the following if the SFP transceiver is marked as *Unidentified*:

```
SFP - Unidentified
```

The SFP transceiver is not marked as *Unidentified*, the **media** displays information about the SFP transceiver. For example:

```
SFP 1000LX SM LC 10 km
```

Note
If an SFP transceiver remains marked as *Unidentified* after disabling Smart SFP mode, contact Siemens Customer Support.

To enable or disable Smart SFP mode for an SFP transceiver, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable or disable Smart SFP mode by typing:

   Enable

   ```
   interface switch swport { port } sfp smart-sfp-mode
   ```

   Disable

```
no interface switch swport { port } sfp smart-
sfp-mode
```

3. If Smart SFP mode is disabled, review the configuration for the SFP transceiver socket. Some settings may need to be adjusted manually to match the capabilities of the installed SFP transceiver. For more information, refer to "Configuring a Switched Ethernet Port (Page 314)".
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

5 System Administration

This chapter describes how to perform various administrative tasks related to device identification, user permissions, alarm configuration, certificates and keys, and more.

5.1 Configuring the System Name and Location

To configure the system name and location of the device, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***admin*** and configure the following parameter(s) as required:

Parameter	Description
`system-name { system-name }`	**Synopsis:** A string 255 characters long **Default:** System Name An administratively-assigned name for this managed node. By convention, this is the node's fully-qualified domain name. If the name is unknown, the value is the zero-length string.
`location { location }`	**Synopsis:** A string 255 characters long **Default:** Location The physical location of this node (e.g., 'telephone closet, 3rd floor'). If the location is unknown, the value is the zero-length string.
`contact { contact }`	**Synopsis:** A string 255 characters long **Default:** Contact The textual identification of the contact person for this managed node, together with information on how to contact this person. If no contact information is known, the value is the zero-length string.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

5.2 Configuring the Host Name

To configure the host name for the device, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***admin » hostname*** and configure the following parameter(s) as required:

⚠ NOTICE
Special characters (i.e. !@#$%^&*()_+-={}[];:',<.>/?|`~) are not permitted in host names.

Parameter	Description
`name { name }`	**Synopsis:** A string between 1 and 63 characters long **Default:** ruggedcom The host name for the device. This name appears in the command line prompt. The host name must not contain special characters (i.e.\!@#$%^&*()_+-={}[];:',<.>/?\\|`~).
`domain { domain }`	**Synopsis:** A string between 1 and 253 characters long **Default:** localdomain The domain name associated with the device. This name is appended to the end of unqualified names (e.g. ruggedcom.example.com).

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

5.3 Customizing the Welcome Screen

A custom welcome message for both the Web and CLI interfaces can be displayed at the login prompt.

To add a welcome message, type:

```
admin authentication banner { message }
```

Where:

- `{ message }` is the custom welcome message

5.4 Setting the Maximum Number of Sessions

To set the maximum number of sessions that can be open at one time, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***admin » session-limits*** and configure the following parameter(s) as required:

Parameter	Description
`max-sessions-total { max-sessions-total }`	**Synopsis:** An integer **Default:** 70 Puts a limit on the total number of concurrent sessions to ROX.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

5.5 Enabling and Configuring WWW Interface Sessions

To enable and configure WWW interface sessions, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***admin » webui*** and configure the following parameter(s) as required:

Parameter	Description
`enabled { enabled }`	**Synopsis:** [true | false] **Default:** true Provides the ability to configure WebUI features on the device.
`listen-ip { listen-ip }`	**Synopsis:** A string **Default:** 0.0.0.0 The IP Address the CLI will listen on for WebUI requests.
`port { port }`	**Synopsis:** An integer between 0 and 65535 **Default:** 443 The port on which the WebUI listens for WebUI requests.
`extra-ip-ports { extra-ip-ports }`	**Synopsis:** A string The WebUI will also listen on these IP Addresses. For port values, add ':#' to set non-default port value. (ie. xxx.xxx.xxx.xxx:19343 [::] [::]:16000). If using the default address, do not specify another listen address with the same port.
`max-sessions { max-sessions }`	**Synopsis:** An integer **Default:** 20 The maximum number of concurrent WebUI sessions
`idle-timeout { idle-timeout }`	**Synopsis:** A string **Default:** PT30M The maximum idle time before terminating a WebUI session. If the session is waiting for notifications, or has a pending confirmed commit, the idle timeout is not used. A value of 0 means no timeout. PT30M means 30 minutes.

Parameter	Description
`ssl-redirect-enabled { ssl-redirect-enabled }`	**Synopsis:** [true | false] **Default:** true Redirects traffic from port 80 to port 443. If disabled, port 80 will be closed.
`client-certificate-verification { client-certificate-verification }`	**Synopsis:** [none | peer | fail-if-no-peer-cert] **Default:** none Level of verification the server does on client certificates • none - It does not do any verification. • peer - The server will ask the client for a client-certificate but not fail if the client does not supply a client-certificate. • fail-if-no-peer-cert - The server requires the client to supply a client certificate.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

5.6 Enabling/Disabling Remote Access Through a VRF Interface

A VRF interface can be used to remotely access the CLI and Web interface, or as an interface for SNMP. This capability is available on a per-interface basis and is disabled by default.

⚠ NOTICE

This feature does not support some services. Note the following restrictions:

- DHCP is not supported. As such, the VRF interface must not derive its IP address from an DHCP server.
- HTTP redirects to HTTPS are not supported. As such, HTTPS must be entered explicitly when accessing the Web user interface via a browser (e.g. https://x.x.x.x).
- HTTP is not supported on SNMP connections.

To enable or disable this function on a VRF instance, do the following:

1. Make sure at least one VRF instance has been configured. For information about configuring a VRF instance, refer to "Configuring VRF (Page 671)".
2. Make sure the CLI is in Configuration mode.
3. Enable remote administration for the desired VRF definition by typing:

   ```
   global vrf definition { name } remote-administration enabled
   ```

   Where { name } is the name of the VRF definition
4. Configure the following parameters:

Note
The parameters **snmp-enabled** and **snmp-listen-port** are only available when SNMP sessions are enabled. For information about how to enable SNMP sessions, refer to "Enabling and Configuring SNMP Sessions (Page 835)".

Parameter	Description
`webui-enabled { webui-enabled }`	**Synopsis:** [true | false] **Default:** true Enables access to the Web user interface over the VRF interface.
`webui-listen-port { webui-listen-port }`	**Synopsis:** An integer between 1 and 65535 **Default:** 443 The port the Web user interface will listen on for incoming connections over a VRF interface.
`cli-enabled { cli-enabled }`	**Synopsis:** [true | false] **Default:** true Enables access to the CLI over the VRF interface.
`cli-listen-port { cli-listen-port }`	**Synopsis:** An integer between 1 and 65535 **Default:** 22 The port the CLI will listen on for incoming connections over a VRF interface.
`snmp-enabled { snmp-enabled }`	**Synopsis:** [true | false] **Default:** true Enables SNMP access over the VRF interface.
`snmp-listen-port { snmp-listen-port }`	**Synopsis:** An integer between 1 and 65535 **Default:** 161 The port SNMP will listen on for incoming connections over a VRF interface.

5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

Note
Remote access through a VRF interface relies on Network Address Translation (NAT) rules to send frames through the VRF interface to the intended service running in the global namespace. In the case of SNMP, NAT rules are unaware of any listen IP address. As such, the listen IP address for SNMP sessions must be set to **0.0.0.0** to allow the session to connect to services in the global namespace.

6. If the VRF instance is to be used as a listen IP address for SNMP, make sure the **listen-ip** parameter for SNMP sessions is set to **0.0.0.0**. For more information, refer to "Enabling and Configuring SNMP Sessions (Page 835)".

5.7 Managing Alarms

The alarm system in RUGGEDCOM ROX II notifies users when events of interest occur. The system is highly configurable, allowing users to:

- Enable/disable most alarms, with the exception of mandatory alarms
- Configure whether or not an alarm triggers the failsafe relay and illuminates the alarm indicator LED on the device
- Configure the severity of most alarms (i.e. emergency, alert, critical, error, etc.), with the exception of some where the severity is fixed

Each alarm is categorized by its type (or subsystem):

Alarm Type	Description
Admin	Admin alarms are for administrative aspects of the device, such as feature-key problems.
Chassis	Chassis alarms are for physical or electrical problems, or similar events of interest. This includes irregular voltages at the power supply or the insertion or removal of a module.
Switch	Switch alarms are for link up/down events on switch interfaces.
Eth	Eth alarms are for fe-cm port related events, such as link up/down events.
WAN	WAN alarms are for T1/E1 and DDS interface related events, such as link up/down events.
Cellmodem	Cellular alarms are for cellular interface related events, such as link up/down events.
Security	Security alarms are for security-related events, such as Brute Force Attacks (BFA), firmware integrity, and certificate expiry. This includes warnings 30 days before a certificate is set to expire and when an expired certificate is installed.
Services	Service alarms are for events related to RUGGEDCOM ROX II services, such as Dynamic Domain Name Server (DNS), IPsec connections, and GRE tunnels.

5.7.1 Pre-Configured Alarms

RUGGEDCOM ROX II is equipped with a series of pre-configured alarms designed to monitor and protect the device.

For a full list of alarms, including user-configurable alarms, refer to "List of Alarms (Page 137)".

Admin

Name	Severity	Description	Suggested Resolution
Featurekey mismatch	Alert	The featurekey does not match the serial numbers for the control module and backplane hardware.	Move the featurekey to the correct device with the matching hardware or request an updated key from Siemens Customer Support.

Chassis

Name	Severity	Description	Suggested Resolution
PM1 bad supply	Critical	Input power to the power module is outside nominal operating range.	Make sure the input power operating range meets the device requirements.
PM1 MOV protection bad	Critical	The Metal Oxide Varistor (MOV) protection component within the PM1 power module is damaged.	Contact Siemens Customer Support to return the power module.
Real-time clock battery low	Warning	The Real-Time Clock (RTC) battery in the control module is depleted.	Contact Siemens Customer Support to return the device for repair.

Switch

Name	Severity	Description	Suggested Resolution
Link Up	Notice		
Link Down	Alert		
Internal Configuration Error	Alert		

Ethernet (Eth)

Name	Severity	Description	Suggested Resolution
Link Up	Notice		
Link Down	Alert		
Internal Configuration Error	Alert		

WAN

Name	Severity	Description	Suggested Resolution
Link Up	Notice		
Link Down	Alert		
Internal Configuration Error	Alert		
DS1 Line Status Change	Alert		

Security

Name	Severity	Description	Suggested Resolution
Certificate Expiration	Notice	The root certificate has expired.	Update the root certificate.
Brute Force Attack	Alert	A brute force attack has been attempted.	Review the **Auth.log** file to determine the IP address of the host attempting to access the device. For more information, refer to "Enabling/Disabling Brute Force Attack Protection (Page 152)".
Firmware Integrity	Security	The firmware has failed the binary integrity check, indicating that one or more operating system files have been modified or tampered with.	Contact Siemens Customer Support.

Services

Name	Severity	Description	Suggested Resolution
DDNS Bad Response	Warning		
IPsec Connection Up	Notice		
IPsec Connection Down	Warning		

5.7.2 Viewing a List of Active Alarms

To view a list of alarms for a specific alarm type, type:

```
show admin alarms
```

A table or list similar to the following example appears:

```
ruggedcom# show admin alarms | tab
           ALARM  EVENT
SUBSYSTEM  ID     ID     SEVERITY  DESCRIPTION               DATE TIME                USER ACTIONS
   ACTUATORS
-------------------------------------------------------------------------------------------------------------
switch     1      1      notice    Link-up on port swport/1    Thu Oct  2 09:28:25 2014  clear-or-ack
   none
switch     2      1      warning   Link-down on port swport/4  Thu Oct  2 09:28:23 2014  resolve-or-
ack  resolved
```

For information on how to clear or acknowledge an active alarm, refer to "Clearing and Acknowledging Alarms (Page 135)".

5.7.3 Clearing and Acknowledging Alarms

There are two types of alarms: conditional and non-conditional. Conditional alarms are generated when the condition is true and cleared when the condition is resolved and the incident is acknowledged by the user. Non-conditional alarms, however, are simply generated when the event occurs (a notification) and it is the responsibility of the user to clear the alarm.

An example of a conditional alarm is a *link down* alarm. When the condition is resolved (i.e. the link comes up), the LED and alarm relay are both disabled, if the `auto-clear` option is enabled.

Examples of non-conditional alarms are *link up* and internal configuration errors.

5.7.3.1 Clearing Alarms

Non-conditional alarms must be cleared by the user. Conditional alarms, when configured, are cleared automatically.

To clear all clear-able, non-conditional alarms, type:

```
admin clear-all-alarms
```

Alternatively, to clear an individual non-conditional alarm, type:

```
admin alarms active-alarms subsystem [ admin | cellmodem | chassis | eth | services | security | switch | wan ] { id } { event } clear
```

Where:

- `{ id }` is the ID for the chosen alarm
- `{ event }` is the ID for the chosen event

5.7.3.2 Acknowledging Alarms

To acknowledge all active alarms, type:

```
admin acknowledge-all-alarms
```

Alternatively, to acknowledge an individual alarm, type:

```
admin alarms active-alarms { type } { id } { event } acknowledge
```

Where:

- `{ type }` is the type of alarm. Options include **admin**, **cellmodem**, **chassis**, **eth**, **security**, **switch**, and **wan**.
- `{ id }` is the ID for the chosen alarm.
- `{ event }` is the ID for the chosen event.

5.7.4 Configuring an Alarm

While all alarms are pre-configured on the device, some alarms can be modified to suit the application. This includes changing the severity and enabling/disabling certain features.

Note
The `failrelay-enable` and `led-enable` parameters are non-configurable for *link up* alarms.

To configure an alarm, do the following:

1. Make sure the CLI is in Configuration mode.
2. Configure the alarm by typing:

   ```
   admin alarm-config subsystem [ admin | cellmodem | chassis | eth | services | security | switch | wan ] alarm-list { id }
   ```

   Where { id } is the ID for the chosen alarm.
3. Configure the following parameters as required:

   Note
   Depending on the alarm type, some parameters are not available.

   Note
   Alarm descriptions are not configurable.

Parameter	Description
`severity { severity }`	**Synopsis:** [emergency | alert | critical | error | warning | notice | info | debug] The severity level can be one of emergency, alert, critical, error, warning, notice, info, and debug. This cannot be changed for some alarms.
`admin-enable`	If disabled, the alarm is not reported in the active list and does not actuate LED/failrelay.
`failrelay-enable`	If enabled, this alarm will assert the failrelay.
`led-enable`	If enabled, the main 'Alarm' LED light will be red when this alarm is asserted. If disabled, the main 'Alarm' LED light is not affected by this alarm.
`auto-clear`	If enabled, the LED and failrelay will be cleared automatically when condition is met.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

5.7.5 List of Alarms

The following table lists alarms in RUGGEDCOM ROX II, including their default status and whether or not the alarm is user configurable.

For more information about configuring alarms, refer to "Configuring an Alarm (Page 136)".

Group	Name	Level	Failrelay Enable	LED Enable	User Configurable	Trap	Log
Admin	Featurekey mismatch	Alert	Enabled	Enabled	Yes	Yes	Yes
Admin	Featurekey partial match	Warning	Disabled	Enabled	Yes	Yes	Yes
Switch	Link Up	Notice	---	---	Yes	Yes	Yes
Switch	Link Down	Warning	Enabled	Enabled	Yes	Yes	Yes
Switch	Internal Configuration Error	Alert	Enabled	Enabled	No	No	Yes
Switch	RMON Threshold Rising Alert	Alert	Enabled	Enabled	Yes	Yes	Yes
Cellmodem	Link Up	Notice	---	---	Yes	Yes	Yes
Security	Certificate Expiration	Notice	Enabled	Enabled	Yes	Yes	Yes
Security	Brute Force Attack	Alert	Enabled	Enabled	Yes	No	Yes
Security	Firmware Integrity	emergency	Enabled	Enabled	Yes	No	Yes
Services	DDNS Bad Response: Bad host name bad authentication https error	Warning	Enabled	Enabled	Yes	No	Yes
Services	IPsec Connection Up	Notice	Disabled	Enabled	Yes	Yes	Yes
Services	IPsec Connection Down	Warning	Enabled	Enabled	Yes	Yes	Yes
Services	GRE Tunnel Up	Notice	Disabled	Disabled	Yes	Yes	Yes
Services	GRE Tunnel Down	Warning	Enabled	Enabled	Yes	Yes	Yes

5.8 Managing Users

RUGGEDCOM ROX II allows for up to three user profiles to be configured locally on the device. Each profile corresponds to one of the following access levels:

- Guest
- Operator
- Admin

The access levels provide or restrict the user's ability to change settings and execute various commands.

Rights	User Type		
	Guest	Operator	Admin
View Settings	✓	✓	✓
Clear Logs	✓	✓	✓

Rights	User Type		
	Guest	Operator	Admin
Reset Alarms	×	✓	✓
Clear Statistics	×	✓	✓
Change Basic Settings	×	✓	✓
Change Advanced Settings	×	×	✓
Run Commands	×	×	✓

⚠ NOTICE

Security hazard – risk of unauthorized access and/or exploitation

To prevent unauthorized access to the device, make sure to change the default passwords for all users before commissioning the device. For more information, refer to "Setting a User Password/Passphrase (Page 142)".

5.8.1 Viewing a List of Users

To view a list of user accounts, type:

```
show  running-config  admin  users
```

If users have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config admin users | tab
admin
 users
  userid
NAME   PASSWORD                                ROLE
-----------------------------------------------------------
admin  $1$LmRO$j7/q/wtlwjfUvbOVrbt4o.   administrator
guest  $1$uGztU0$6b7YS6gqwtrelTzA/2noQ. guest
oper   $1$eSsFfFMh$NEHgTHsU1T4RRz8sXNV2F1  operator
```

If no user accounts have been configured, add user accounts as needed. For more information, refer to "Adding a User (Page 138)".

5.8.2 Adding a User

To add a new user account, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the user account by typing:

   ```
   admin  users  userid  { name }  role  { role }
   ```

   Where:

   - `{ name }` is the name of the user account

- `{ role }` is the role of the user. The options are `administrator`, `operator`, and `guest`.

3. To set the user password, follow the instructions in "Setting a User Password/ Passphrase (Page 142)".
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.
5. [Optional] Assign a user authentication key to the user account, allowing the user to access the device via SSH without having to provide a password/ passphrase. For more information, refer to "Managing User Authentication Keys (Page 164)".

5.8.3 Deleting a User

To delete a user account, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the user account by typing:

   ```
   no admin users userid { name }
   ```

   Where:

   - `{ name }` is the name of the user account.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

5.8.4 Monitoring Users

Users currently logged in to the device are monitored by RUGGEDCOM ROX II and can be viewed through the CLI. RUGGEDCOM ROX II allows administrators to monitor users, log users out, and broadcast message to all users.

To view a list of users currently logged in to the device, type:

```
who
```

A table or list similar to the following appears:

```
ruggedcom# who
Session User  Context From          Proto Date     Mode
*147    admin cli     192.168.0.200 ssh   11:04:54 operational
 145    admin webui   192.168.0.200 https 10:51:05 operational
```

5.8.4.1 Kicking Users from the Network

To log a user out of the device, type:

Type:

```
logout [ [  session  |  { number }  ] [  user  |  { profile }
 ] ]
```

Where:

- `{ number }` is the session number
- `{ profile }` is the name of the user profile

5.8.4.2 Sending Messages to Users

To broadcast a message to all users or a specific user, type:

```
send [  { profile }  |  all  ]  { message }
```

Where:

- `{ profile }` is the name of the user profile
- `{ message }` is the message

5.9 Managing Passwords and Passphrases

RUGGEDCOM ROX II requires separate passwords or passphrases for logging into the various device modes, such as normal, boot, service and maintenance modes. Default passwords are configured for each user type initially. It is strongly recommended that these be changed before the device is commissioned.

Note
For a list of default passwords, refer to "Default User Names and Passwords (Page 25)".

The complexity of each password/passphrase can be chosen by the user or enforced through the device by an administrator. If a user's password/passphrase does not meet the password requirements, an alarm is generated. For example:

```
Error: Supplied password is shorter than the minimum password length: 12
```

In general, passwords/passphrases should consist of:

- One lower case character
- One upper case character
- One number
- One special character (i.e. !@#$%^&*()_+-={}[];:',<.>/?\|`~)

Note
User authentication can also be verified through a RADIUS or TACACS+ server. When enabled for authentication and authorization, the RADIUS or TACACS+ server will be used. For more information about configuring a RADIUS or TACACS+ server, refer to "Managing RADIUS Authentication (Page 167)" and "Configuring TACACS+ Authentication (Page 170)".

⚠ NOTICE

Security hazard – risk of unauthorized access and/or exploitation

To prevent unauthorized access to the device, change the default passwords before commissioning the device.

⚠ NOTICE

Accessibility hazard – risk of data loss

Do not forget the passwords for the device. If both the maintenance and boot passwords are forgotten, the device must be returned to Siemens Canada Ltd. for repair. This service is not covered under warranty. Depending on the action that must be taken to regain access to the device, data may be lost.

5.9.1 Configuring Password/Passphrase Complexity Rules

Special rules for password/passphrase complexity can be configured. These include setting the password/passphrase length and enabling requirements for special characters.

To configure the password/passphrase complexity rules for all passwords/passphrases, do the following:

Note
Password/passphrase complexity rules do not apply to passwords/passphrases previously configured on the device.

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***admin » authentication » password-complexity*** and configure the following parameter(s) as required:

Parameter	Description
`minimum-length { minimum-length }`	**Synopsis:** An integer between 1 and 128 **Default:** 12 Minimum password length.
`maximum-length { maximum-length }`	**Synopsis:** An integer between 1 and 128 **Default:** 128 Maximum password length.

Parameter	Description
`uppercase-required { uppercase-required }`	**Synopsis:** [true | false] **Default:** true Requires the password to have at least one uppercase letter.
`lowercase-required { lowercase-required }`	**Synopsis:** [true | false] **Default:** true Requires the password to have at least one lowercase letter.
`digits-required { digits-required }`	**Synopsis:** [true | false] **Default:** true Requires the password to have at least one numerical digit.
`special-characters-required { special-characters-required }`	**Synopsis:** [true | false] **Default:** true Requires the password to have at least one non-alphanumeric character. Allowed characters include "!@#$%^&*()_+-={}[];:',<.>/?|`~".

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

5.9.2 Setting a User Password/Passphrase

To set the password/passphrase for a user profile, do the following:

Note
RUGGEDCOM ROX II supports the following special characters in passwords/passphrases: !@#$%^&*()_+-={}[];:',<.>/?\|`~.

1. Type the following command and then press **Enter**:

   `admin users userid { profile } set-password new-password`

   Where `{ profile }` is the user profile (e.g. admin, oper or guest)

2. At the prompt, type the new password/passphrase and then press **Enter**.

```
Value for 'new-password' (&amp;lt;string, min: 1 chars, max: 128
 chars&amp;gt;):
```

3. At the next prompt, type the new password/passphrase again and then press **Enter**.

```
Value for 'new-password-repeat' (&amp;lt;string, min: 1 chars, max: 128
 chars&amp;gt;):
```

The password/passphrase is updated and the following message appears if the password/passphrase complies with the password complexity rules:

```
set-password-result success
```

5.9.3 Setting the Boot Password/Passphrase

The boot password/passphrase grants access to BIST mode and service mode, which are only accessible through the Command Line Interface (CLI). For more information about these modes, refer to "Accessing Different CLI Modes (Page 32)" .

⚠ NOTICE

Security hazard – risk of unauthorized access and/or exploitation

User authentication is not required to access BIST mode. Configure a boot password/passphrase to control initial access to the device.

To set the boot password/passphrase, do the following:

1. Issue the following command:

   ```
   admin authentication set-boot-password new-password
   ```

2. At the first prompt, type the new password/passphrase and then press **Enter**.
3. At the second prompt, type the new password/passphrase again and then press **Enter**.
4. At the third prompt, type the old password/passphrase and then press **Enter**. If this is the first time the boot password/passphrase is being set, only press **Enter**.

Example:

```
ruggedcom(config)# admin authentication set-boot-password new-password
Value for 'new-password' (&amp;lt;string, min: 0 chars, max: 128 chars&amp;gt;):
 ***************
Value for 'new-password-repeat' (&amp;lt;string, min: 0 chars, max: 128
 chars&amp;gt;): ***************
Value for 'old-password' (&amp;lt;string, min: 0 chars, max: 128 chars&amp;gt;):
 ***************
set-password-result success
```

5.9.4 Setting the Maintenance Password/Passphrase

The maintenance password/passphrase grants access to the maintenance mode, which is only accessible through the Command Line Interface (CLI). For more information about this mode, refer to "Accessing Different CLI Modes (Page 32)" .

⚠ NOTICE

Configuration hazard – risk of data corruption

Maintenance mode is provided for troubleshooting purposes and should only be used by Siemens technicians. As such, this mode is not fully documented. Misuse of

maintenance mode commands can corrupt the operational state of the device and render it inaccessible.

To set the maintenance password, do the following:

1. Set the maintenance password/passphrase by typing:

   ```
   admin authentication set-maint-password new-password
   ```

2. At the first prompt, type the new password/passphrase and then press **Enter**.
3. At the second prompt, type the new password/passphrase again and then press **Enter**.
4. At the third prompt, type the old password/passphrase and then press **Enter**. If this is the first time the boot password/passphrase is being set, only press **Enter**.

Example:

```
ruggedcom(config)# admin authentication set-maint-password new-password
Value for 'new-password' (&amp;lt;string, min: 0 chars, max: 128 chars&amp;gt;):
 ***************
Value for 'new-password-repeat' (&amp;lt;string, min: 0 chars, max: 128
 chars&amp;gt;): ***************
Value for 'old-password' (&amp;lt;string, min: 0 chars, max: 128 chars&amp;gt;):
 ***************
set-password-result success
```

5.9.5 Resetting the Admin Password/Passphrase

The admin password/passphrase provides access to the Web Interface and Command Line Interface (CLI). If this password is lost, access to these interfaces is impossible until the password/passphrase is reset directly on the device.

Note
The admin password/passphrase must be reset on both partitions.

To reset the admin password/passphrase, do the following:

1. Enter service mode. For more information, refer to "Accessing Service Mode (Page 65)".
2. Type `root` and press **Enter**. The password prompt appears.
3. Type the password/passphrase associated with the root profile and press **Enter**. The default password is *admin*.
4. Type `confd_cli` and press **Enter**.
5. Enable autowizard by typing:

   ```
   autowizard true
   ```

6. Type `config` and press **Enter**.

⚠ NOTICE

Passwords/passphrases that contain special characters, including spaces, must be wrapped in quotes (e.g. "password!2#").

7. Reset the admin password/passphrase by typing:

   ```
   admin users userid admin set-password new-password { new-password-passphrase } new-password-repeat { new-password-passphrase }
   ```

   If special characters are used, make sure to encapsulate the password in double-quotation marks (") as follows:

   Note
   RUGGEDCOM ROX II supports the following special characters in passwords/passphrases: !@#$%^&*()_+-={}[];:',<.>/?\|`~.

   ```
   admin users userid admin set-password new-password { new-password-passphrase } new-password-repeat { new-password-passphrase }
   ```

   Where:

   - `{ new-password-passphrase }` is the new password/passphrase. Make sure the password/passphrase complies with the password complexity rules configured for this device.

8. Reboot the device. For more information, refer to "Rebooting the Device (Page 83)".

9. As soon as the device starts to boot up, press **ESC**. A list of possible boot modes for each partition appears.

```
****Boot Partition 4****
 [4-0]: Debian GNU/Linux, kernel 3.0.0-2-8360e
 [4-1]: Debian GNU/Linux, kernel 3.0.0-2-8360e (BIST mode)
 [4-2]: Debian GNU/Linux, kernel 3.0.0-2-8360e (single-user mode)
 [4-3]: Debian GNU/Linux, kernel 3.0.0-2-8360e (service mode)

 ****Boot Partition 6****
 [6-0]: Debian GNU/Linux, kernel 3.0.0-2-8360e
 [6-1]: Debian GNU/Linux, kernel 3.0.0-2-8360e (BIST mode)
 [6-2]: Debian GNU/Linux, kernel 3.0.0-2-8360e (single-user mode)
 [6-3]: Debian GNU/Linux, kernel 3.0.0-2-8360e (service mode)

 Auto booting [4-0], Hit [ESC] key to stop:  0
 Welcome to the boot menu. Please select from the following options:

 Enter [BootPartition-BootTarget] (e.g. '4.0') to boot.
 'h' Show this help menu
 'l' List the available boot targets
 'c' Exit to the boot loader command line

 Will reboot after 60 seconds of inactivity
 :
```

Note
In the example above, the text `Auto booting [4-0]` indicates the active partition is Boot Partition 4.

10. Enter the inactive partition by typing the associated target number. For example, if the active partition is Boot Partition 4, type `6-0` and press **Enter** to enter Boot Partition 6.
11. Repeat step 1 and step 10 to reset the password/passphrase on the inactive partition and switch back to the original partition.

5.9.6 Resetting the Boot Password/Passphrase

The boot password/passphrase provides access to BIST mode (through the `maint-login` command) and service mode. If this password/passphrase is lost, access to these modes is impossible until the password/passphrase is reset directly on the device.

To reset the boot password/passphrase, do the following:

1. Log in to maintenance mode. For more information, refer to "Accessing Maintenance Mode (Page 67)".
2. Delete current boot password/passphrase by typing:

   ```
   rox-delete-bootpwd  --force
   ```

3. Type `exit` and press **Enter**.
4. Set a new boot password/passphrase. For more information, refer to "Setting the Boot Password/Passphrase (Page 143)".

5.9.7 Resetting the Maintenance Password/Passphrase

The maintenance password/passphrase grants access to the maintenance mode. If this password/passphrase is lost, access to this mode is impossible until the password/passphrase is reset directly on the device.

⚠ NOTICE

Configuration hazard – risk of data corruption

Maintenance mode is provided for troubleshooting purposes and should only be used by Siemens Canada Ltd. technicians. As such, this mode is not fully documented. Misuse of this maintenance mode commands can corrupt the operational state of the device and render it inaccessible.

Note
The maintenance password/passphrase must be reset on both partitions.

To reset the maintenance password/passphrase, do the following:

1. Make sure the CLI is in Configuration mode.
2. Reset the maintenance password by setting a new password. For more information, refer to "Setting the Maintenance Password/Passphrase (Page 143)".
3. Reboot the device. For more information, refer to "Rebooting the Device (Page 83)".
4. As soon as the device starts to boot up, press **ESC**. A list of possible boot modes for each partition appears.

```
****Boot Partition 4****
 [4-0]: Debian GNU/Linux, kernel 3.0.0-2-8360e
 [4-1]: Debian GNU/Linux, kernel 3.0.0-2-8360e (BIST mode)
 [4-2]: Debian GNU/Linux, kernel 3.0.0-2-8360e (single-user mode)
 [4-3]: Debian GNU/Linux, kernel 3.0.0-2-8360e (service mode)

 ****Boot Partition 6****
 [6-0]: Debian GNU/Linux, kernel 3.0.0-2-8360e
 [6-1]: Debian GNU/Linux, kernel 3.0.0-2-8360e (BIST mode)
 [6-2]: Debian GNU/Linux, kernel 3.0.0-2-8360e (single-user mode)
 [6-3]: Debian GNU/Linux, kernel 3.0.0-2-8360e (service mode)

 Auto booting [4-0], Hit [ESC] key to stop:  0
 Welcome to the boot menu. Please select from the following options:

 Enter [BootPartition-BootTarget] (e.g. '4.0') to boot.
 'h' Show this help menu
 'l' List the available boot targets
 'c' Exit to the boot loader command line

 Will reboot after 60 seconds of inactivity
 :
```

Note
In the example above, the text `Auto booting [4-0]` indicates the active partition is Boot Partition 4.

5. Enter the inactive partition by typing the associated target number. For example, if the active partition is Boot Partition 4, type `6-0` and press **Enter** to enter Boot Partition 6.
6. Log in to RUGGEDCOM ROX II. For more information about logging in to RUGGEDCOM ROX II, refer to "Logging In (Page 25)".
7. Repeat step 1 and step 5 to reset the password/passphrase on the inactive partition and switch back to the original partition.

5.10 Scheduling Jobs

The RUGGEDCOM ROX II scheduler allows users to create jobs that execute command line interface (CLI) commands at a specific date and time, or in response to specific configuration changes. Typical applications include scheduling the regular clearing of system logs, or performing periodic file transfers to remote servers.

There are two types of scheduled jobs:

- **Periodic jobs** are executed at a specified date and time.
- **Config change jobs** are executed only when a specific.

5.10.1 Viewing a List of Scheduled Jobs

To view a list of scheduled jobs, type:

```
show running-config admin scheduler
```

If jobs have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config admin scheduler | tab
admin
 scheduler
  scheduled-jobs
                                          JOB          JOB
SCHEDULER JOB               JOB     JOB   DAY    JOB   DAY
NAME              JOB TYPE  MINUTE  HOUR  MONTH  MONTH WEEK    JOB COMMAND
-------------------------------------------------------------------------------
Backup            periodic  1       -     -      -     Monday  backupconfig
Clear Message Log periodic  5       5:00  1      1     Monday  clearmessagelog
```

If no jobs have been configured, add jobs as needed. For more information, refer to "Adding a Scheduled Job (Page 148)".

5.10.2 Adding a Scheduled Job

To add a scheduled job, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***admin » scheduler***.
3. Configure the following parameter(s) as required:

Parameter	Description
`{ scheduler-job-name }`	**Synopsis:** A string 64 characters long The name of the scheduled job. The name can be up to 64 characters in length.
`job-type { job-type }`	**Synopsis:** [configchange | periodic] **Default:** periodic Determines when to launch the scheduled job: • periodic: The job launches at a set date and time. • configchange: The job launches when the configuration changes.
`job-minute { job-minute }`	**Synopsis:** A string 128 characters long **Default:** 0 For periodic jobs, sets the minutes portion of the job launch time. Valid values are in the range of 0 to 59. If no value is set,

Parameter	Description
	the scheduler uses the default value of 0 and launches the job every hour on the the hour. • To specify a single value, enter the value in the field. For example, to launch the job 10 minutes past the hour, enter 10. • To specify a list of values, enter the values as a comma-separated list. For example, to launch the job at 15, 30, and 45 minutes past the hour, enter 15,30,45. • To specify a range of values, enter the range as comma-separated values. For example, to launch the job every minute between 30 and 45 minutes past the hour, enter 30-45. This parameter is not required for configchange jobs.
`job-hour { job-hour }`	**Synopsis:** A string 64 characters long For periodic jobs, sets the hour portion of the job launch time, in the 24-hour clock format. Valid values are in the range of 0 to 23. If no value is set, the job launches every hour at the time set in the Minute field. • To specify a single value, enter the value in the field. For example, to launch the job at 5:00 pm, enter 17. • To specify a list of values, enter the values as a comma-separated list. For example, to launch the job at 9:00 am, 12:00 pm, and 5:00 pm, enter 9,12,17. • To specify a range of values, enter the range as comma-separated values. For example, to launch the job every hour between 9:00 am and 5:00 pm, enter 9-17. This parameter is not required for configchange jobs.
`job-day-month { job-day-month }`	**Synopsis:** A string 64 characters long For periodic jobs, sets the day of the month on which to run the scheduled job. Valid values are in the range of 1 to 31. If no value is set, the job launches every day. • To specify a single value, enter the value in the field. For example, to launch the job on the tenth day of the month, enter 10. • To specify a list of values, enter the values as a comma-separated list. For example, to launch the job on the first, fifteenth, and thirtieth days of the month, enter 10,15,30. • To specify a range of values, enter the range as comma-separated values. For example, to launch the job on days one through fifteen, enter 1-15. This parameter is not required for configchange jobs.
`job-month { job-month }`	**Synopsis:** A string 32 characters long For periodic jobs, sets the month in which to run the scheduled job. Valid values are in the rage of 1 to 12. If no value is set, the job launches every day. • To specify a single value, enter the value in the field. For example, to set the month to February, enter 2.

Parameter	Description
	• To specify a list of values, enter the values as a comma-separated list. For example, to set the months to January, June, and December, enter 1,6,12. • To specify a range of values, enter the range as comma-separated values. For example, to set the months to January through June, enter 1-6. This parameter is not required for configchange jobs.
`job-day-week { job-day-week }`	**Synopsis:** A string 16 characters long For periodic jobs, sets the day of the week on which to run the scheduled job. Valid entries are in the range of 0 to 6, where 0 represents Sunday, 1 represents Monday, and so on. If no value is set, the job launches every day. • To specify a single value, enter the value in the field. For example, to set the day to Monday, enter 1. • To specify a list of values, enter the values as a comma-separated list. For example, to set the days to Friday, Saturday, and Sunday, enter 5,6,0. • To specify a range of values, enter the range as comma-separated values. For example, to set the days to Monday through Friday, enter 1-5. This parameter is not required for configchange jobs.
`job-command { job-command }`	**Synopsis:** A string 1024 characters long One or more commands to execute at the scheduled time. For example, this command saves the running configuration to a file name 'myconfig': show running-config | save myconfig. Do not use interactive commands or commands that require a manual response or confirmation. When entered in the CLI, the command string must be enclosed in quotation marks. When entered in the WebUI, the command string must not be enclosed in quotation marks.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

5.10.3 Deleting a Scheduled Job

To delete a scheduled Job, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the scheduled job by typing:

   ```
   no admin scheduler schedule-jobs { name }
   ```

   Where:

   - `{ name }` is the name of the scheduled job
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6 Security

This chapter describes how to configure and manage the security-related features of RUGGEDCOM ROX II.

6.1 Enabling and Configuring CLI Sessions

To enable and configure CLI sessions, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***admin » cli*** and configure the following parameter(s) as required:

Parameter	Description
`enabled { enabled }`	**Synopsis:** [true | false] **Default:** true When enabled, a command line interface (CLI) may be used to configure the device. A secure shell (SSH) client or serial console may be used to access the CLI.
`listen-ip { listen-ip }`	**Synopsis:** A string **Default:** 0.0.0.0 The IPv4 or IPv6 address on which the CLI will listen for requests from the device. The default value (i.e. 0.0.0.0) enables the CLI to receive requests via any IP address with which it is associated.
`port { port }`	**Synopsis:** An integer between 0 and 65535 **Default:** 22 The default port on which the CLI will listen for requests from the device. The port corresponds with the IP address specified by the **Listen IP (listen-ip)** parameter.
`extra-ip-ports { extra-ip-ports }`	**Synopsis:** A string Additional IPv4 or IPv6 addresses and their associated ports on which the CLI will listen for requests from the device. IPv4 addresses and port numbers must be separated by a colon (e.g. 192.168.0.2: 19343). IPv6 addresses and port numbers must be separated by square brackets and a colon (e.g. [2001:db8:2728::2200]:[19343]). If the **Listen IP (listen-ip)** parameter is set to a value other than **0.0.0.0** , the port specified by the **Listen Port (port)** parameter must not be associated with any additional addresses.

Parameter	Description
`max-sessions { max-sessions }`	**Synopsis:** An integer **Default:** 10 The maximum number of concurrent CLI sessions.
`idle-timeout { idle-timeout }`	**Synopsis:** A string **Default:** PT30M The maximum period of time that a CLI session may remain idle. After this period of time, the session is terminated. Values are expressed in durations of years, months, weeks, days, hours, minutes, and/or seconds in ISO 8601 format (e.g. P1Y1M2W3DT2H3M30S corresponds with 1 year, 1 month, 2 weeks, 3 days, 2 hours, 3 minutes, and 30 seconds). A session is not considered idle if the CLI is waiting for notifications or if commits are pending. If the value of this parameter is changed during a session, the change will not take effect until the next session.
`greeting { greeting }`	**Synopsis:** A string between 1 and 8192 characters long A greeting message presented to users when they log in to the CLI. The message must be enclosed in quotation marks.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.2 Enabling/Disabling Brute Force Attack Protection

RUGGEDCOM ROX II features a Brute Force Attack (BFA) protection mechanism to prevent attacks via the CLI, Web interface and NETCONF. This mechanism analyzes the behavior of external hosts trying to access the SSH port, specifically the number of failed logins. After 15 failed login attempts, the IP address of the host will be blocked for 720 seconds or 12 minutes. The range of 15 failed login attempts exists to take into account various methods of accessing the device, notably when the same or different ports are used across a series of failed logins.

Note
The BFA protection system is not applicable to SNMP. Follow proper security practices for configuring SNMP. For example:

- Do not use SNMP over the Internet
- Use a firewall to limit access to SNMP
- Do not use SNMPv1

Note
Failed logins must happen within 10 minutes of each other to be considered malicious behavior.

Once the time has expired, the host will be allowed to access the device again. If the malicious behavior continues from the same IP address (e.g. another 15 failed login attempts), then the IP address will be blocked again, but the time blocked will increase by a factor of 1.5. This will continue as long as the host repeats the same behavior.

Note
Enabling, disabling or making a configuration change to the firewall will reset – but not disable – the BFA protection mechanism. Any hosts that were previously blocked will be allowed to log in again. If multiple hosts are actively attacking at the time, this could result in reduced system performance.

When BFA protection is started, the following Syslog entry is displayed:

```
Jun  5 09:36:34 ruggedcom firewallmgr[3644]: Enabling Brute Force Attack Protection
```

When a host fails to login, an entry is logged in **auth.log**. For example:

```
Jun  5 10:12:52 ruggedcom confd[3386]: audit user: admin/0 Provided bad password
Jun  5 10:12:52 ruggedcom rmfmgr[3512]: login failed, reason='Bad password', user
 ipaddr='172.11.150.1'
Jun  5 10:12:52 ruggedcom confd[3386]: audit user: admin/0 Failed to login over ssh:
 Bad password
```

Auth.log also details which IP addresses are currently being blocked:

```
Jun 5 14:43:04 ruggedrouter sshguard[24720]: Blocking 172.59.9.1:4 for
 &amp;gt;630secs: 60 danger in 5 attacks
over 70 seconds (all: 60d in 1 abuses over 70s).
```

Note
For information about how to view **auth.log**, refer to "Viewing Logs (Page 91)".

When the default alarm for brute force attacks is enabled, a host that exceeds the maximum number of failed login attempts will trigger an alarm. The alarm will be listed on the list of active alarms until the alarm is resolved and acknowledged.

```
ruggedcom# show admin alarms active-alarms | tab
           ALARM  EVENT
SUBSYSTEM  ID     ID     SEVERITY  DESCRIPTION
------------------------------------------------------------------------------
security   2      1      alert     BFA from IP 172.30.151.141 is blocked
```

To enable/disable the BFA protection mechanism, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable the BFA protection mechanism by typing:

   ```
   security  bruteforce  enabled
   ```

   Or disable the BFA protection mechanism by typing:

   ```
   no  security  bruteforce  enabled
   ```

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.
4. [Optional] Enable or disable the default alarm for brute force attacks. For more information, refer to "Configuring an Alarm (Page 136)".

6.3 Enabling/Disabling SYN Cookies

RUGGEDCOM ROX II can be configured to transmit SYN cookies when the SYN backlog queue of a socket begins to overflow. This is a technique used to resist SYN flood attacks.

To enable or disable the transmission of SYN cookies, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable SYN cookies by typing:

   ```
   admin  system  tcp-syn-cookies
   ```

   Disable SYN cookies by typing:

   ```
   no  admin  system  tcp-syn-cookies
   ```

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.4 Managing SFTP Sessions

RUGGEDCOM ROX II supports secure file transfers using the SSH File Transfer Protocol (SFTP). This section describes how to enable and configure SFTP server and client functionality.

6.4.1 Enabling and Configuring SFTP Sessions

To enable and configure SFTP server functionality, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***admin » sftp*** and configure the following parameter(s) as required:

Parameter	Description
`enabled { enabled }`	**Synopsis:** [true | false] **Default:** false When enabled, a Secure File Transfer Protocol (SFTP) server may be used to transfer files to and from the device.

Parameter	Description
`listen-ip { listen-ip }`	**Synopsis:** A string **Default:** 0.0.0.0 An IPv4 or IPv6 address on which the SFTP server will listen for requests from clients. The default value (i.e. 0.0.0.0) enables the SFTP server to listen for requests via any IP address associated with the server
`port { port }`	**Synopsis:** An integer between 0 and 65535 **Default:** 2222 A port on which the SFTP server will listen for requests from clients.
`extra-ip-ports { extra-ip-ports }`	**Synopsis:** A string Additional IPv4 or IPv6 addresses and their associated ports on which the SFTP server will listen for requests from clients. IPv4 addresses and port numbers must be separated by a colon (e.g. 192.168.0.2: 19343). IPv6 addresses and port numbers must be separated by square brackets and a colon (e.g. [2001:db8:2728::2200]:[19343]). If the **Listen IP (listen ip)** parameter is set to a value other than 0.0.0.0, the port specified by the **Listen Port (port)** parameter must not be associated with any additional addresses.
`max-sessions { max-sessions }`	**Synopsis:** An integer **Default:** 10

3. Add the private key from the SFTP server to the device. For more information, refer to "Adding a Private Key (Page 202)".
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.4.2 Adding an SFTP Server's Public Key

When RUGGEDCOM ROX II is the SFTP client, in order to authenticate the remote server, the public key presented by the server must be added to the device and listed as a known host.

Note
For more information about how SSH client services utilize the known hosts trust store, refer to "Managing Known Hosts (Page 208)".

To add an SFTP server's public SSH key, do the following:

1. Determine the server's public SSH key.
2. Take the server's public SSH key and add it to the device. For more information, refer to "Adding a Public Key (Page 204)".

3. Add a new known host to the configuration and associate it with the new public SSH key. For more information, refer to "Adding a Known Host (Page 209)".

6.5 Managing Port Security

Port security (or Port Access Control) provides the ability to authenticate access through individual ports, either through IEEE 802.1x authentication, static MAC address-based authorization, or both.

Using IEEE 802.1x authentication, RUGGEDCOM ROX II authenticates a source device against a remote RADIUS authentication server. Access is granted if the source device provides the proper credentials.

Using static MAC address-based authorization, RUGGEDCOM ROX II authenticates the source device based on its MAC address. Access is granted if the MAC address appears on the Static MAC Address table.

Note
RUGGEDCOM ROX II only supports the authentication of one host per port that has the port security mode set to **802.1x** or **802.1x/MAC-Auth**.

Note
RUGGEDCOM ROX II supports PEAP, EAP-TLS and EAP-MD5. PEAP and EAP-TLS are more secure and are recommended over EAP-MD5.

⚠ NOTICE

Do not apply port security on core switch connections. Port security is applied at the end of the network to restrict admission to specific devices.

6.5.1 Port Security Concepts

This section describes some of the concepts important to the implementation of port security in RUGGEDCOM ROX II.

6.5.1.1 Static MAC Address-Based Authentication

In this method, the device validates the source MAC addresses of received frames against the contents in the Static MAC Address Table. RUGGEDCOM ROX II also supports a highly flexible Port Security configuration that provides a convenient means for network administrators to use the feature in various network scenarios.

A Static MAC address can be configured without a port number being explicitly specified. In this case, the configured MAC address will be automatically authorized on the port where it is detected. This allows devices to be connected to any secure port on the switch without requiring any reconfiguration.

The device can also be programmed to learn (and, thus, authorize) a pre-configured number of the first source MAC addresses encountered on a secure port. This enables the capture of the appropriate secure addresses when first configuring MAC address-based authorization on a port. Those MAC addresses are automatically inserted into the Static MAC Address Table and remain there until explicitly removed by the user.

6.5.1.2 Static MAC Address-Based Authentication in an MRP Ring

When port security is configured on a Media Redundancy Client (MRC), the MAC address of the Media Redundancy Manager's (MRM's) ring ports must be configured in the **Static MAC Addresses** table for the ring to remain closed.

To allow communication (i.e. ping) between Media Redundancy Protocol (MRP) devices in a ring, each device with port security enabled on its MRP ports must contain the MAC addresses of all devices in the ring in its **Static MAC Addresses** table.

For information about configuring MRP, refer to "Managing the Media Redundancy Protocol (MRP) (Page 811)".

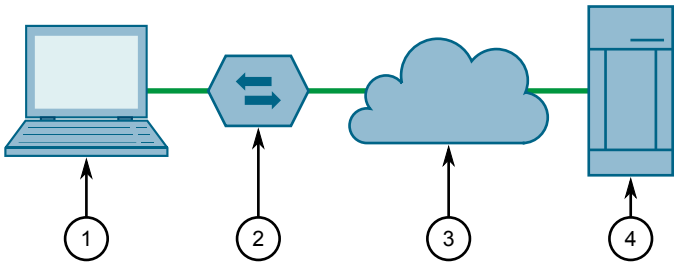
For information about configuring a static MAC address, refer to "Adding a Static MAC Address (Page 336)".

6.5.1.3 IEEE 802.1x Authentication

The IEEE 802.1x standard defines a mechanism for port-based network access control and provides a means of authenticating and authorizing devices attached to LAN ports.

Although IEEE 802.1x is mostly used in wireless networks, this method is also implemented in wired switches.

The IEEE 802.1x standard defines three major components of the authentication method: Supplicant, Authenticator and Authentication server. RUGGEDCOM ROX II supports the Authenticator component.



① Supplicant
② Authenticator Device
③ LAN

④ Authentication Server

Figure 6.1 IEEE 802.1x General Topology

⚠ NOTICE

RUGGEDCOM ROX II supports Protected Extensible Authentication Protocol (PEAP), EAP Transport Layer Security (EAP-TLS) and EAP-MD5. PEAP and EAP-TLS are more secure and are recommended if available in the supplicant.

IEEE 802.1x makes use of the Extensible Authentication Protocol (EAP), which is a generic PPP authentication protocol that supports various authentication methods. IEEE 802.1x defines a protocol for communication between the Supplicant and the Authenticator, referred to as EAP over LAN (EAPOL).

RUGGEDCOM ROX II communicates with the Authentication Server using EAP over RADIUS. For more information about configuring RADIUS authentication, refer to "Configuring RADIUS Authentication for Switched Ethernet Ports (Page 170)".

Note
The device supports authentication of one host per port.

Note
If the host's MAC address is configured in the Static MAC Address Table, it will be authorized, even if the host authentication is rejected by the authentication server.

6.5.1.4 IEEE 802.1X Authentication with MAC Address-Based Authentication

This method, also referred to as MAB (MAC-Authentication Bypass), is commonly used for devices, such as VoIP phones and Ethernet printers, that do not support the IEEE 802.1x protocol. This method allows such devices to be authenticated using the same database infrastructure as that used in IEEE 802.1x.

IEEE 802.1x with MAC-Authentication Bypass works as follows:

1. The device connects to a switch port.
2. The switch learns the device MAC address upon receiving the first frame from the device (the device usually sends out a DHCP request message when first connected).
3. The switch sends an EAP Request message to the device, attempting to start IEEE 802.1X authentication.
4. The switch times out while waiting for the EAP reply, because the device does not support IEEE 802.1x.
5. The switch sends an authentication message to the authentication server, using the device MAC address as the username and password.
6. The switch authenticates or rejects the device based on the reply from the authentication server.

6.5.1.5 Assigning VLANS with Tunnel Attributes

RUGGEDCOM ROX II supports assigning a VLAN to an authorized port using tunnel attributes, as defined in RFC 3580 [http://tools.ietf.org/html/rfc3580], when the Port Security mode is set to **802.1x** or **802.1x/MAC-Auth**.

In some cases, it may be desirable to allow a port to be placed into a particular VLAN, based on the authentication result. For example:

- To allow a particular device, based on its MAC address, to remain on the same VLAN as it moves within a network, configure the switches for 802.1X/MAC-Auth mode
- To allow a particular user, based on the user's login credentials, to remain on the same VLAN when the user logs in from different locations, configure the switches for 802.1X mode

If the RADIUS server wants to use this feature, it indicates the desired VLAN by including tunnel attributes in the Access-Accept message. The RADIUS server uses the following tunnel attributes for VLAN assignment:

- Tunnel-Type=VLAN (13)
- Tunnel-Medium-Type=802
- Tunnel-Private-Group-ID=VLANID

Note that VLANID is 12-bits and takes a value between 1 and 4094, inclusive. The Tunnel-Private-Group-ID is a string as defined in RFC 2868 [http://tools.ietf.org/html/rfc2868], so the VLANID integer value is encoded as a string.

If the tunnel attributes are not returned by the authentication server, the VLAN assigned to the switch port remains unchanged.

6.5.2 Configuring Port Security

To configure port security for a switched Ethernet port, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***interface » switch » swport » {port} » port-security***, where *{port}* is the switched Ethernet port.
3. Configure the port security settings by configuring the following parameter(s) as required:

Note
If **shutdown-enable** is enabled and **shutdown-time** is not defined, the port will remain disabled following a security violation until manually reset.

Note
The parameter **quarantine-vid** is only available when **security-mode** is set to either **dot1x** or **dot1x_max_auth**.

The parameter **guest-vid** is only available when **security-mode** is set to **dot1x**.

Parameter	Description
`security-mode { security-mode }`	**Synopsis:** [dot1x_mac_auth | dot1x | per_macaddress | off] **Default:** off The security mode for the port. Options include: • **dot1x_mac_auth** - IEEE 802.1X with MAC authentication protocols are applied to the port. Until the client is authenticated by an IEEE 802.1X server, only EAPoL packets or packets from other network control protocols are forwarded. If the client does not support IEEE 802.1X supplicant functionality, the router sends the client's MAC address to server as the username and password for authentication. • **dot1x** - IEEE 802.1X authentication protocols are applied to the port. Until the client is authenticated by an IEEE 802.1X server, only EAPoL packets or packets from other network control protocols are forwarded. • **per_macaddress** - Only packets from authorized MAC addresses are forwarded. Authorized MAC addresses are either preconfigured in the static MAC address table or learned dynamically. • **off** - Disables security on the port
`quarantine-vid { quarantine-vid }`	**Synopsis:** An integer between 1 and 4094 The VLAN identifier for the Quarantine VLAN. Only applicable when Security Mode has been set to dot1x or dot1x_mac_auth. The port will be placed in Quarantine VLAN mode if a client cannot be authenticated.
`guest-vid { guest-vid }`	**Synopsis:** An integer between 1 and 4094 The VLAN identifier for the Guest VLAN. Only applicable when Security Mode has been set to dot1x. The port will be placed in Guest VLAN mode if a client does not support the 802.1x standard.
`auto-learn { auto-learn }`	**Synopsis:** An integer between 0 and 16 **Default:** 0 The maximum number of MAC addresses that can be learned dynamically by the port. This includes static MAC addresses defined in the **Static MAC Address** table. Therefore, the actual number of learned MAC addresses is this number minus the number of addresses defined in the **Static MAC Address** table. **Security Mode** must be set to either **per_macaddress** or **dot1x_mac_auth**.
`shutdown-time { shutdown-time }`	**Synopsis:** An integer between 1 and 86400 The time in seconds (s) the port will be disabled if a security violation occurs. **Shutdown Enable** must be enabled.
`admin-shutdown`	When enabled, the port is automatically shut down if a security violation occurs. The port is enabled automatically after the period of time specified by **Shutdown Time** .

4. Configure the IEEE 802.1x settings by configuring the following parameter(s) as required:

Parameter	Description
`tx-period { tx-period }`	**Synopsis:** An integer between 1 and 65535 **Default:** 30 The maximum time in seconds (s) allowed for one full set of packets to be transferred between the port and its client.
`quiet-period { quiet-period }`	**Synopsis:** An integer between 0 and 65535 **Default:** 60 The time in seconds (s) to wait before retransmitting EAPoL packets to the client after a failed authentication session.
`reauth-enable`	When enabled, the port will attempt to reauthenticate the client periodically. The period of time between each reauthentication attempt is specified by **Reauthentication Period** . The port is considered unauthorized when the maximum number of reauthentication attempts (as defined by **Reauthentication Max Attempts**) is exceeded.
`reauth-period { reauth-period }`	**Synopsis:** An integer between 60 and 86400 **Default:** 3600 The period of time in seconds (s) the port will wait before attempting to reauthenticate the client. **Reauthentication** must be enabled.
`reauth-max { reauth-max }`	**Synopsis:** An integer between 1 and 10 **Default:** 2 The maximum number of unsuccessful reauthentication attempts allowed, after which the client is considered unauthorized. **Reauthentication** must be enabled.
`supp-timeout { supp-timeout }`	**Synopsis:** An integer between 1 and 300 **Default:** 30 The period of time in seconds (s) the port will wait to receive the client's response to the authentication server's request. If no response is received by the end of this period, the authentication session fails.
`server-timeout { server-timeout }`	**Synopsis:** An integer between 1 and 300 **Default:** 30 The period of time in seconds (s) the port will wait to receive the authentication server's response to the client's request. If no response is received by the end of this period, the authentication session fails.

Parameter	Description
`max-request { max-request }`	**Synopsis:** An integer between 1 and 10 **Default:** 2 The maximum number of times the port will attempt to forward the authentication server's request to the client. If none of these attempts are successful, the authentication session fails.

5. If IEEE 802.1x standard authentication or IEEE 802.1x with MAC authentication is selected, configure a primary and secondary RADIUS server. For more information, refer to "Configuring RADIUS Authentication for Switched Ethernet Ports (Page 170)".
6. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.5.3 Viewing the Security Status of Switched Ethernet Ports

To view the port security status of all switched Ethernet ports, type:

```
show interfaces switch swport port-security
```

For example:

```
show interfaces switch swport port-security
SLOT    PORT  STATUS
------------------------
swport  1     Unsecure
swport  2     Unsecure
swport  3     Unsecure
swport  4     Unsecure
swport  5     Unsecure
swport  6     Unsecure
```

To view the port security status of a specific switched Ethernet port, type:

```
show interfaces switch swport { port } port-security
```

Where:

- `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module

For example:

```
show interfaces switch swport 1 port-security
port-security
 status Unsecure
```

6.6 Managing User Authentication

This section describes the various methods for authenticating users.

6.6.1 Setting the User Authentication Mode

The user authentication mode controls whether user log in attempts are authenticated locally, by a RADIUS server, or by a TACACS+ server.

⚠ NOTICE
The RADIUS client uses only the Password Authentication Protocol (PAP) protocol to verify access. No other authentication protocol is supported.

To set the authentication mode, type:

```
admin authentication mode [ localonly | radius_local
| radius_only | radius_then_local | tacacsplus_local |
tacacsplus_only ]
```

Note
A RADIUS server is considered *unreachable* when:

- The server is unavailable at the specified IP address (wrong address configured in the server profile)
- The server is availabled, but not listening on the specified port (wrong port configured in the server profile)
- The server is reachable, but the RADIUS service is not running
- The server is reachable, but refuses to authenticate the user

- If **localonly** is selected, users will be authenticated locally, regardless of whether or not a RADIUS or TACACS+ server has been configured.
- If **radius_local** is selected, users will be authenticated against the configured RADIUS server. If the RADIUS server is unreachable, users will be authenticated locally.
- If **radius_only** is selected, users will be authenticated against the configured RADIUS server. If the primary RADIUS server is unreachable, the secondary Radius server is attempted. If the user still cannot be authenticated, authentication is considered failed and no further authentication is attempted. For console, if server(s) are unreachable, users will be authenticated locally.
- If **radius_then_local** is selected, users will be authenticated first against the configured RADIUS server. If the user cannot be authenticated, they will then be authenticated locally.
- If **tacacsplus_local** is selected, users will be authenticated against the configured TACACS+ server. If the user cannot be authenticated, they will then be authenticated locally.
- If **tacacsplus_only**is selected, users will be authenticated against the configured TACACS+ server. If the user cannot be authenticated, authentication is considered failed and no further authentication is attempted.

6.6.2 Managing User Authentication Keys

A user authentication key is the public key in an SSH key pair. When using a RUGGEDCOM ROX II user account associated with an authentication key, users can access the device via Secure Shell (SSH) without having to provide a password/ passphrase, as long as their workstation holds the matching private key.

⚠ NOTICE

RUGGEDCOM ROX II only accepts SSH2 RSA public keys. SSH1 or DSA keys are not supported.

6.6.2.1 Determining Which Keys are Associated to a User

To list the user authentication keys associated with a user account, type:

```
show runnging-config admin users userid { name }
authorized-keys
```

A list similar to the following appears:

```
ruggedcom# show running-config admin users userid admin authorized-keys
admin
 users
  userid admin
   authorized-keys keyid key1
    !
   !
  !
!
```

For information about associating keys with user accounts, refer to "Associating/ Disassociating a User Authentication Key (Page 166)".

6.6.2.2 Adding a User Authentication Key

To add a user authentication key to the device, do the following:

⚠ NOTICE

Security hazard – risk of unauthorized access and/or exploitation

Do not share the private key outside the organization or with untrusted personnel. The private key is used to decrypt all encrypted correspondences with the associated public key.

Note

It is strongly recommended to apply an encryption passphrase during the key creation process. The passphrase will be applied to the private key and prevent malicious users from accessing its contents.

Note
Only SSH-2 RSA keys are supported.

1. On the workstation that will access the device, create a pair of RSA-based public and private SSH keys by typing
2. Open the public key and copy its contents.
3. Log in to RUGGEDCOM ROX II. For more information, refer to "Logging In (Page 25)".
4. Make sure the CLI is in Configuration mode.
5. Define the new authentication key by typing:

   ```
   security crypto authorized-keys { key }
   ```

   Where { key } is a name assigned to the authentication key for easy identification.
6. Type `contents` and then press **Enter** to enter multi-line mode.
7. Insert the contents of the public key and then press **Ctrl-D**. For example:

   ```
   ruggedcom(config)# security crypto authorized-keys key1 contents
   (&amp;lt;string, min: 1 chars, max: 2048 chars&amp;gt;):
   [Multiline mode, exit with ctrl-D.]
   &amp;gt;{--contents--}
   ```
8. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.
9. Associate the new authentication key with one or more user accounts. For more information, refer to "Associating/Disassociating a User Authentication Key (Page 166)".

6.6.2.3 Deleting a User Authentication Key

To delete a user authentication key from the device, do the following::

1. Make sure the CLI is in Configuration mode.
2. Disassociate the chosen authentication key from the associated user account(s). For more information, refer to "Associating/Disassociating a User Authentication Key (Page 166)".
3. Delete the authentication key by typing:

   ```
   no security crypto authorized-keys { key }
   ```

   Where { key } is the name assigned to the authentication key for easy identification.
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.6.2.4 Associating/Disassociating a User Authentication Key

One or more user authentication keys can be associated with a single user account, allowing users to access the device from different workstations when needed.

⚠ NOTICE

The matching public key must reside on the user's workstation for them to log in to the device without a password/passphrase.

Associating an Authentication Key

To associate one of the authentication keys available on the device with a user account, do the following:

1. Log in to RUGGEDCOM ROX II. For more information, refer to "Logging In (Page 25)".
2. Make sure the CLI is in Configuration mode.
3. Associate an authentication key with the desired user profile by typing:

   ```
   admin users name { name } authorized-keys key-id { key }
   ```

   Where:

   - { name } is the name of the user account
   - { key } is the name assigned to the authentication key
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

Disassociating an Authentication Key

To disassociate one of the authentication keys from a user account, do the following:

1. Log in to RUGGEDCOM ROX II. For more information, refer to "Logging In (Page 25)".
2. Make sure the CLI is in Configuration mode.
3. Disassociate the desired authentication key from the desired user profile by typing:

   ```
   no admin users name { name } authorized-keys key-id { key }
   ```

   Where:

   - { name } is the name of the user account
   - { key } is the name assigned to the authentication key
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.6.3 Managing RADIUS Authentication

RADIUS is a UDP-based protocol used for carrying authentication, authorization and configuration information between a Network Access Server (NAS) that desires to authenticate its links and a shared authentication server. It provides centralized authentication and authorization for network access.

RADIUS is also widely used in conjunction with the IEEE 802.1x standard for port security using the Extensible Authentication Protocol (EAP).

Note
For more information about the RADIUS protocol, refer to RFC 2865 [http://tools.ietf.org/html/rfc2865].

For more information about the Extensible Authentication Protocol (EAP), refer to RFC 3748 [http://tools.ietf.org/html/rfc3748].

⚠ NOTICE

The user authentication mode must be set to **radius_local** for users to be authenticated against the RADIUS server. For more information about setting the authentication mode, refer to "Setting the User Authentication Mode (Page 163)".

⚠ NOTICE

RADIUS messages are sent as UDP messages. The switch and the RADIUS server must use the same authentication and encryption key.

In a RADIUS access request, the following attributes and values are typically sent by the RADIUS client to the RADIUS server:

Attribute	Value
User-Name	{ Guest, Operator, Admin }
User-Password	{ password }
Service-Type	1
Vendor-Specific	**Vendor-ID** – 15004 **Type** – 1 **Length** – 11 **String** – RuggedCom

A RADIUS server may also be used to authenticate access on ports with IEEE 802.1x security enabled. When this is required, the following attributes are sent by the RADIUS client to the RADIUS server:

Attribute	Value
User-Name	{ The user name as derived from the client's EAP identity response }
NAS-IP-Address	{ The Network Access Server IP address }
Service-Type	2
Frame-MTU	1500

Attribute	Value
EAP-Message[a]	{ A message(s) received from the authenticating peer }

[a] EAP-Message is an extension attribute for RADIUS, as defined by RFC 2869 [http://freeradius.org/rfc/rfc2869.html#EAP-Message].

Primary and secondary RADIUS servers, typically operating from a common database, can be configured for redundancy. If the first server does not respond to an authentication request, the request will be forwarded to the second server until a positive/negate acknowledgment is received.

Note
RADIUS authentication activity is logged to the authentication log file **var/log/auth.log**. Details of each authentication including the time of occurrence, source and result are included. For more information about the authentication log file, refer to "Viewing Logs (Page 91)".

RUGGEDCOM ROX II supports RADIUS authentication for the LOGIN and PPP services. Different RADIUS servers can be configured to authenticate both services separately or in combination.

The LOGIN services consist of the following access types:

- Local console logins via the serial port
- Remote shell logins via SSH and HTTPS
- Secure file transfers using HTTPS, SCP and SFTP (based on SSH)

Authentication requests for LOGIN services will attempt to use RADIUS first and any local authentication settings will be ignored. Only when there is no response (positive/negative) from any of the configured RADIUS servers will RUGGEDCOM ROX II authenticate users locally.

The PPP service represents incoming PPP connections via a modem. Authentication requests to the PPP service use RADIUS only. In the event that no response is received from any configured RADIUS server, RUGGEDCOM ROX II will not complete the authentication request.

6.6.3.1 Configuring RADIUS Authentication for LOGIN Services

To configure RADIUS authentication for LOGIN services, do the following:

⚠ NOTICE
Passwords are case-sensitive.

1. Make sure the CLI is in Configuration mode.
2. Type the following:

   ```
   admin  authentication  radius
   ```

3. [Optional] If port security is enabled on any ports, configuring the following parameter(s) to avoid conflicts with firewall rules/policies:

Parameter	Description
`nas-ip-address { nas-ip-address }`	**Synopsis:** A string between 7 and 15 characters long or A string between 6 and 40 characters long The NAS-IP-Address. Set this to the primary IP address of the unit.
`nas-identifier { nas-identifier }`	**Synopsis:** A string 64 characters long The NAS-Identifier. If not set, the hostname will be used as the NAS-Identifier.

4. Configure the primary or secondary RADIUS server by typing either `primary` or `secondary` and configuring the following parameter(s) as required:

Parameter	Description
`address { address }`	**Synopsis:** A string between 7 and 15 characters long or A string between 6 and 40 characters long The IP address of the server.
`port-udp { port-udp }`	**Synopsis:** An integer between 1 and 65535 **Default:** 1812 The network port of the server.
`password { password }`	**Synopsis:** A string The password of the RADIUS server.

5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.6.3.2 Configuring RADIUS Authentication for PPP Services

To configure RADIUS authentication for PPP services, do the following:

⚠ NOTICE

Passwords are case-sensitive.

1. Make sure the CLI is in Configuration mode.
2. Type the following:

```
global ppp radius
```

3. Configure the primary or secondary RADIUS server by typing either `primary` or `secondary` and configuring the following parameter(s) as required:

Parameter	Description
`address { address }`	**Synopsis:** A string between 7 and 15 characters long The IPv4 address of the server.

Parameter	Description
`port-udp { port-udp }`	**Synopsis:** An integer between 1 and 65535 **Default:** 1812
`password { password }`	**Synopsis:** A string

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.6.3.3 Configuring RADIUS Authentication for Switched Ethernet Ports

To configure RADIUS authentication for switched Ethernet ports, do the following:

⚠ NOTICE

Passwords are case-sensitive.

1. Make sure the CLI is in Configuration mode.
2. Type the following:

   ```
   switch  port-security  radius
   ```

3. Configure the primary or secondary RADIUS server by typing either `primary` or `secondary` and configuring the following parameter(s) as required:

Parameter	Description
`address { address }`	**Synopsis:** A string between 7 and 15 characters long The IPv4 address of the server.
`port-udp { port-udp }`	**Synopsis:** An integer between 1 and 65535 **Default:** 1812 The IPv4 port of the server.
`password { password }`	**Synopsis:** A string The password of the server

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.6.4 Configuring TACACS+ Authentication

TACACS+ (Terminal Access Controller Access-Control System Plus) is a TCP-based protocol which provides access control for routers, network access servers and other networked computing devices via one or more centralized servers. TACACS+ provides separate authentication, authorization and accounting services.

Primary and secondary TACACS+ servers, typically operating from a common database, can be configured for redundancy. If the first server does not respond to

an authentication request, the request will be forwarded to the second server until a positive/negate acknowledgment is received.

⚠ NOTICE

The user authentication mode must be set to **tacacsplus_local** or **tacacsplus_only** for users to be authenticated against the TACACS+ server. For more information about setting the authentication mode, refer to "Setting the User Authentication Mode (Page 163)".

To configure TACACS+ authentication, do the following:

⚠ NOTICE

Passwords are case-sensitive.

1. Make sure the CLI is in Configuration mode.
2. Type the following:

   ```
   admin authentication tacacsplus
   ```

3. Configure the following parameters as required:

Parameter	Description
`admin-priv { admin-priv }`	**Synopsis:** A string 5 characters long **Default:** 15 The privilege level(s) for administrator (admin) users. Options include any number between 0 and 15, or a range (e.g. 4-12).
`oper-priv { oper-priv }`	**Synopsis:** A string 5 characters long **Default:** 2-14 The privilege level(s) for operator (oper) users. Options include any number between 0 and 15, or a range (e.g. 4-12).
`guest-priv { guest-priv }`	**Synopsis:** A string 5 characters long **Default:** 1 The privilege level(s) for guest users. Options include any number between 0 and 15, or a range (e.g. 4-12).

4. Configure the primary or secondary Tacacsplus server by typing either `primary` or `secondary` and configuring the following parameter(s) as required:

Parameter	Description
`address { address }`	**Synopsis:** A string between 7 and 15 characters long or A string between 6 and 40 characters long The IP address of the TACACS+ server.
`port-tcp { port-tcp }`	**Synopsis:** An integer between 1 and 65535 **Default:** 49 The TCP port to use when connecting the TACACS+ server. The default port is 49.

Parameter	Description
`authentication-key { authentication-key }`	**Synopsis:** A string The authentication key to use for encrypting and decrypting TACACS+ traffic. Use only ASCII characters.

5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.7 Managing Certificates and Keys

RUGGEDCOM ROX II uses X.509v3 certificates and keys to establish secure connections for remote logins (SSH) and Web access (SSL).

To allow for initial configuration, all RUGGEDCOM ROX II devices are shipped from the factory with a pair of pre-installed default certificates and keys. Certificates and keys for TLS and SSH are also auto-generated during initial boot-up and can be replaced by user-defined certificates and keys. Auto-generated certificates are self-signed.

Siemens recommends that all certificates be replaced by ones signed by a trusted Certificate Authority (CA).

Note
Only admin users can read/write certificates and keys on the device.

6.7.1 Viewing the Local Host SSH/RSA Public Key

To view the local host SSH/RSA public key, type:

```
show security crypto local-host-ssh-rsa-public-key
```

For example:

```
show security crypto local-host-ssh-rsa-public-key
local-host-ssh-rsa-public-key
 contents "ssh-rsa AAAAB3NzaC1yc2EAAAADAQABAAABAQC0De8wvPyFpUGph9mwNXPcY3/
dwmQxIelGZe5Pt4laOZpeGOtuMSKqN15jcx29RcBasSdui5muLq8o
+iBfDwjJw2q5WBBqyweXHgGYQGC58e7PQ5eYWIvu2L/cgTpR3rCs4xTUh+URJYCTGEhh1V6jGOjuY8M3pO/
iLPrwtZ066uyCqNoJLoptYnLfRDJu8AdWNdxLfXQsSv4XOB8hzYKekyg8bqsE/
w6b5MyE60Xc51f413PMicZz6WhBcuaqvutHxoIqCR6oI7fkLGGyWaeCzWUO02FplVfiJe1vTwAaa5+JAoSdPNzTJKrHvF
```

6.7.2 Configuring Session Security

To provide secure SSH management access (TCP/22), SFTP server access (TCP/2222), and/or HTTPS access TCP/443, certificates and private keys must be selected.

To configure select certificates and private keys, do the following:

1. Make sure the CLI is in Configuration mode.

2. Navigate to ***admin » session-security*** and configure the following parameter(s) as required:

Note
Only SSH RSA private keys can be selected for SSH/SFTP server access.

Parameter	Description
`certificate { certificate }`	**Synopsis:** A string between 1 and 255 characters long The certificate name for SSL connections and associated private keys.
`certificate-private-key { certificate-private-key }`	**Synopsis:** A string between 1 and 255 characters long
`ssh-rsa-private-key { ssh-rsa-private-key }`	**Synopsis:** A string between 1 and 255 characters long The RSA key used for ssh security (SFTP)
`ssh-dsa-private-key { ssh-dsa-private-key }`	**Synopsis:** A string between 1 and 255 characters long The DSA key used for ssh security (CLI, NETCONF, SFTP)

For information about adding certificates, refer to "Adding a Certificate (Page 207)".

For information about adding private keys, refer to "Adding a Private Key (Page 202)".

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.7.3 Managing the Trusted Certificate Store

The Trusted Certificate Store includes an extensive collection of publically available X.509 v3 root certificates. Once enabled and associated with one or more Certified Authorities (CAs), these certificates are available for all HTTPS or FTPS operations.

For a list of root certificates included in the Trusted Certificate Store, refer to "List of Root Certificates in the Trusted Certificate Store (Page 174)".

Note
The Trusted Certificate Store is disabled by default.

Note
Custom certificates may be required for select features, such as IPsec tunnels. For more information about adding a custom certificate, refer to "Adding a Certificate (Page 207)".

6.7.3.1 Configuring the Trusted Certificate Store

To configure the Trusted Certificate Store, do the following:

1. Make sure the required CA certificates and CRLs are configured. For more information, refer to "Adding a CA Certificate and CRL (Page 200)".
2. Enable the Trusted Certificate Store. For more information, refer to "Enabling/Disabling the Trusted Certificate Store (Page 174)".
3. Add CA certificates to the Store to validate the authenticity of the root certificates. For more information, refer to "Adding a CA Certificate to the Trusted Certificate Store (Page 197)".

6.7.3.2 Enabling/Disabling the Trusted Certificate Store

⚠ NOTICE

Although the use of the Public CA Store is provided for convenience, it is not recommended for optimal security. Instead, it is recommended to configure the required CAs as system CAs to limit the size of the trust store used by RUGGEDCOM ROX II.

For more information about adding a certificate to the Trusted Certificate Store, refer to "Adding a CA Certificate to the Trusted Certificate Store (Page 197)".

The Trusted Certificate Store is disabled by default.

To enable or disable the Trusted Certificate Store, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable or disable the Trusted Certificate Store by typing:

   Enable

   ```
   admin  system-ca-certificates  use-public-ca-store
   ```

   Disable

   ```
   no  admin  system-ca-certificates  use-public-ca-store
   ```

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.7.3.3 List of Root Certificates in the Trusted Certificate Store

The Trusted Certificate Store adds the following X.509 v3 root certificates when enabled:

- **Entrust.net_Premium_2048_Secure_Server_CA.crt**

Subject Name:	O = Entrust.net, OU = www.entrust.net/CPS_2048 incorp. by ref. (limits liab.), OU = (c) 1999 Entrust.net Limited, CN = Entrust.net Certification Authority (2048)

Fingerprint:	6D:C4:71:72:E0:1C:BC:B0:BF:62:58:0D:89:5F:E2:B8:AC:9A:D4:F8:73:80:1E:0C:10:B9:C8:37:D2:1E:B1:77
Issued:	Dec 24 17:50:51 1999 GMT
Expires:	Jul 24 14:15:12 2029 GMT

- **Go_Daddy_Class_2_CA.crt**

Subject Name:	C = US, O = "The Go Daddy Group, Inc.", OU = Go Daddy Class 2 Certification Authority
Fingerprint:	C3:84:6B:F2:4B:9E:93:CA:64:27:4C:0E:C6:7C:1E:CC:5E:02:4F:FC:AC:D2:D7:40:19:35:0E:81:FE:54:6A:E4
Issued:	Jun 29 17:06:20 2004 GMT
Expires:	Jun 29 17:06:20 2034 GMT

- **Amazon_Root_CA_2.crt**

Subject Name:	C = US, O = Amazon, CN = Amazon Root CA 2
Fingerprint:	1B:A5:B2:AA:8C:65:40:1A:82:96:01:18:F8:0B:EC:4F:62:30:4D:83:CE:C4:71:3A:19:C3:9C:01:1E:A4:6D:B4
Issued:	May 26 00:00:00 2015 GMT
Expires:	May 26 00:00:00 2040 GMT

- **UCA_Global_G2_Root.crt**

Subject Name:	C = CN, O = UniTrust, CN = UCA Global G2 Root
Fingerprint:	9B:EA:11:C9:76:FE:01:47:64:C1:BE:56:A6:F9:14:B5:A5:60:31:7A:BD:99:88:39:33:82:E5:16:1A:A0:49:3C
Issued:	Mar 11 00:00:00 2016 GMT
Expires:	Dec 31 00:00:00 2040 GMT

- **TrustCor_RootCert_CA-1.crt**

Subject Name:	C = PA, ST = Panama, L = Panama City, O = TrustCor Systems S. de R.L., OU = TrustCor Certificate Authority, CN = TrustCor RootCert CA-1
Fingerprint:	D4:0E:9C:86:CD:8F:E4:68:C1:77:69:59:F4:9E:A7:74:FA:54:86:84:B6:C4:06:F3:90:92:61:F4:DC:E2:57:5C
Issued:	Feb 4 12:32:16 2016 GMT
Expires:	Dec 31 17:23:16 2029 GMT

- **SwissSign_Gold_CA_-_G2.crt**

Subject Name:	C = CH, O = SwissSign AG, CN = SwissSign Gold CA - G2
Fingerprint:	62:DD:0B:E9:B9:F5:0A:16:3E:A0:F8:E7:5C:05:3B:1E:CA:57:EA:55:C8:68:8F:64:7C:68:81:F2:C8:35:7B:95
Issued:	Oct 25 08:30:35 2006 GMT
Expires:	Oct 25 08:30:35 2036 GMT

- **Cybertrust_Global_Root.crt**

Subject Name:	O = "Cybertrust, Inc", CN = Cybertrust Global Root
Fingerprint:	96:0A:DF:00:63:E9:63:56:75:0C:29:65:DD:0A:08:67:DA:0B:9C:BD:6E:77:71:4A:EA:FB:23:49:AB:39:3D:A3
Issued:	Dec 15 08:00:00 2006 GMT

Expires:	Dec 15 08:00:00 2021 GMT

- **Chambers_of_Commerce_Root_-_2008.crt**

Subject Name:	C = EU, L = Madrid (see current address at www.camerfirma.com/address), serialNumber = A82743287, O = AC Camerfirma S.A., CN = Chambers of Commerce Root - 2008
Fingerprint:	06:3E:4A:FA:C4:91:DF:D3:32:F3:08:9B:85:42:E9:46:17:D8:93:D7:FE:94:4E:10:A7:93:7E:E2:9D:96:93:C0
Issued:	Aug 1 12:29:50 2008 GMT
Expires:	Jul 31 12:29:50 2038 GMT

- **emSign_ECC_Root_CA_-_G3.crt**

Subject Name:	C = IN, OU = emSign PKI, O = eMudhra Technologies Limited, CN = emSign ECC Root CA - G3
Fingerprint:	86:A1:EC:BA:08:9C:4A:8D:3B:BE:27:34:C6:12:BA:34:1D:81:3E:04:3C:F9:E8:A8:62:CD:5C:57:A3:6B:BE:6B
Issued:	Feb 18 18:30:00 2018 GMT
Expires:	Feb 18 18:30:00 2043 GMT

- **AffirmTrust_Premium_ECC.crt**

Subject Name:	C = US, O = AffirmTrust, CN = AffirmTrust Premium ECC
Fingerprint:	BD:71:FD:F6:DA:97:E4:CF:62:D1:64:7A:DD:25:81:B0:7D:79:AD:F8:39:7E:B4:EC:BA:9C:5E:84:88:82:14:23
Issued:	Jan 29 14:20:24 2010 GMT
Expires:	Dec 31 14:20:24 2040 GMT

- **Microsec_e-Szigno_Root_CA_2009.crt**

Subject Name:	C = HU, L = Budapest, O = Microsec Ltd., CN = Microsec e-Szigno Root CA 2009, emailAddress = info@e-szigno.hu
Fingerprint:	3C:5F:81:FE:A5:FA:B8:2C:64:BF:A2:EA:EC:AF:CD:E8:E0:77:FC:86:20:A7:CA:E5:37:16:3D:F3:6E:DB:F3:78
Issued:	Jun 16 11:30:18 2009 GMT
Expires:	Dec 30 11:30:18 2029 GMT

- **Network_Solutions_Certificate_Authority.crt**

Subject Name:	C = US, O = Network Solutions L.L.C., CN = Network Solutions Certificate Authority
Fingerprint:	15:F0:BA:00:A3:AC:7A:F3:AC:88:4C:07:2B:10:11:A0:77:BD:77:C0:97:F4:01:64:B2:F8:59:8A:BD:83:86:0C
Issued:	Dec 1 00:00:00 2006 GMT
Expires:	Dec 31 23:59:59 2029 GMT

- **D-TRUST_Root_Class_3_CA_2_EV_2009.crt**

Subject Name:	C = DE, O = D-Trust GmbH, CN = D-TRUST Root Class 3 CA 2 EV 2009
Fingerprint:	EE:C5:49:6B:98:8C:E9:86:25:B9:34:09:2E:EC:29:08:BE:D0:B0:F3:16:C2:D4:73:0C:84:EA:F1:F3:D3:48:81
Issued:	Nov 5 08:50:46 2009 GMT
Expires:	Nov 5 08:50:46 2029 GMT

- **COMODO_RSA_Certification_Authority.crt**

Subject Name:	C = GB, ST = Greater Manchester, L = Salford, O = COMODO CA Limited, CN = COMODO RSA Certification Authority
Fingerprint:	52:F0:E1:C4:E5:8E:C6:29:29:1B:60:31:7F:07:46:71:B8:5D:7E:A8:0D:5B:07:27:34:63:53:4B:32:B4:02:34
Issued:	Jan 19 00:00:00 2010 GMT
Expires:	Jan 18 23:59:59 2038 GMT

- **QuoVadis_Root_CA.crt**

Subject Name:	C = BM, O = QuoVadis Limited, OU = Root Certification Authority, CN = QuoVadis Root Certification Authority
Fingerprint:	A4:5E:DE:3B:BB:F0:9C:8A:E1:5C:72:EF:C0:72:68:D6:93:A2:1C:99:6F:D5:1E:67:CA:07:94:60:FD:6D:88:73
Issued:	Mar 19 18:33:33 2001 GMT
Expires:	Mar 17 18:33:33 2021 GMT

- **IdenTrust_Commercial_Root_CA_1.crt**

Subject Name:	C = US, O = IdenTrust, CN = IdenTrust Commercial Root CA 1
Fingerprint:	5D:56:49:9B:E4:D2:E0:8B:CF:CA:D0:8A:3E:38:72:3D:50:50:3B:DE:70:69:48:E4:2F:55:60:30:19:E5:28:AE
Issued:	Jan 16 18:12:23 2014 GMT
Expires:	Jan 16 18:12:23 2034 GMT

- **DigiCert_High_Assurance_EV_Root_CA.crt**

Subject Name:	C = US, O = DigiCert Inc, OU = www.digicert.com, CN = DigiCert High Assurance EV Root CA
Fingerprint:	74:31:E5:F4:C3:C1:CE:46:90:77:4F:0B:61:E0:54:40:88:3B:A9:A0:1E:D0:0B:A6:AB:D7:80:6E:D3:B1:18:CF
Issued:	Nov 10 00:00:00 2006 GMT
Expires:	Nov 10 00:00:00 2031 GMT

- **TrustCor_RootCert_CA-2.crt**

Subject Name:	C = PA, ST = Panama, L = Panama City, O = TrustCor Systems S. de R.L., OU = TrustCor Certificate Authority, CN = TrustCor RootCert CA-2
Fingerprint:	07:53:E9:40:37:8C:1B:D5:E3:83:6E:39:5D:AE:A5:CB:83:9E:50:46:F1:BD:0E:AE:19:51:CF:10:FE:C7:C9:65
Issued:	Feb 4 12:32:23 2016 GMT
Expires:	Dec 31 17:26:39 2034 GMT

- **USERTrust_RSA_Certification_Authority.crt**

Subject Name:	C = US, ST = New Jersey, L = Jersey City, O = The USERTRUST Network, CN = USERTrust RSA Certification Authority
Fingerprint:	E7:93:C9:B0:2F:D8:AA:13:E2:1C:31:22:8A:CC:B0:81:19:64:3B:74:9C:89:89:64:B1:74:6D:46:C3:D4:CB:D2
Issued:	Feb 1 00:00:00 2010 GMT
Expires:	Jan 18 23:59:59 2038 GMT

- **GlobalSign_Root_CA_-_R3.crt**

Subject Name:	OU = GlobalSign Root CA - R3, O = GlobalSign, CN = GlobalSign
Fingerprint:	CB:B5:22:D7:B7:F1:27:AD:6A:01:13:86:5B:DF:1C:D4:10:2E:7D:07:59:AF:63:5A:7C:F4:72:0D:C9:63:C5:3B
Issued:	Mar 18 10:00:00 2009 GMT
Expires:	Mar 18 10:00:00 2029 GMT

- **XRamp_Global_CA_Root.crt**

Subject Name:	C = US, OU = www.xrampsecurity.com, O = XRamp Security Services Inc, CN = XRamp Global Certification Authority
Fingerprint:	CE:CD:DC:90:50:99:D8:DA:DF:C5:B1:D2:09:B7:37:CB:E2:C1:8C:FB:2C:10:C0:FF:0B:CF:0D:32:86:FC:1A:A2
Issued:	Nov 1 17:14:04 2004 GMT
Expires:	Jan 1 05:37:19 2035 GMT

- **GlobalSign_Root_CA_-_R2.crt**

Subject Name:	OU = GlobalSign Root CA - R2, O = GlobalSign, CN = GlobalSign
Fingerprint:	CA:42:DD:41:74:5F:D0:B8:1E:B9:02:36:2C:F9:D8:BF:71:9D:A1:BD:1B:1E:FC:94:6F:5B:4C:99:F4:2C:1B:9E
Issued:	Dec 15 08:00:00 2006 GMT
Expires:	Dec 15 08:00:00 2021 GMT

- **E-Tugra_Certification_Authority.crt**

Subject Name:	C = TR, L = Ankara, O = E-Tu\C4\9Fra EBG Bili\C5\9Fim Teknolojileri ve Hizmetleri A.\C5\9E., OU = E-Tugra Sertifikasyon Merkezi, CN = E-Tugra Certification Authority
Fingerprint:	B0:BF:D5:2B:B0:D7:D9:BD:92:BF:5D:4D:C1:3D:A2:55:C0:2C:54:2F:37:83:65:EA:89:39:11:F5:5E:55:F2:3C
Issued:	Mar 5 12:09:48 2013 GMT
Expires:	Mar 3 12:09:48 2023 GMT

- **EE_Certification_Centre_Root_CA.crt**

Subject Name:	C = EE, O = AS Sertifitseerimiskeskus, CN = EE Certification Centre Root CA, emailAddress = pki@sk.ee
Fingerprint:	3E:84:BA:43:42:90:85:16:E7:75:73:C0:99:2F:09:79:CA:08:4E:46:85:68:1F:F1:95:CC:BA:8A:22:9B:8A:76
Issued:	Oct 30 10:10:30 2010 GMT
Expires:	Dec 17 23:59:59 2030 GMT

- **GeoTrust_Primary_Certification_Authority_-_G3.crt**

Subject Name:	C = US, O = GeoTrust Inc., OU = (c) 2008 GeoTrust Inc. - For authorized use only, CN = GeoTrust Primary Certification Authority - G3
Fingerprint:	B4:78:B8:12:25:0D:F8:78:63:5C:2A:A7:EC:7D:15:5E:AA:62:5E:E8:29:16:E2:CD:29:43:61:88:6C:D1:FB:D4
Issued:	Apr 2 00:00:00 2008 GMT
Expires:	Dec 1 23:59:59 2037 GMT

- **Staat_der_Nederlanden_Root_CA_-_G3.crt**

Subject Name:	C = NL, O = Staat der Nederlanden, CN = Staat der Nederlanden Root CA - G3
Fingerprint:	3C:4F:B0:B9:5A:B8:B3:00:32:F4:32:B8:6F:53:5F:E1:72:C1:85:D0:FD:39:86:58:37:CF:36:18:7F:A6:F4:28
Issued:	Nov 14 11:28:42 2013 GMT
Expires:	Nov 13 23:00:00 2028 GMT

- **SSL.com_EV_Root_Certification_Authority_ECC.crt**

Subject Name:	C = US, ST = Texas, L = Houston, O = SSL Corporation, CN = SSL.com EV Root Certification Authority ECC
Fingerprint:	22:A2:C1:F7:BD:ED:70:4C:C1:E7:01:B5:F4:08:C3:10:88:0F:E9:56:B5:DE:2A:4A:44:F9:9C:87:3A:25:A7:C8
Issued:	Feb 12 18:15:23 2016 GMT
Expires:	Feb 12 18:15:23 2041 GMT

- **Entrust_Root_Certification_Authority.crt**

Subject Name:	C = US, O = "Entrust, Inc.", OU = www.entrust.net/CPS is incorporated by reference, OU = "(c) 2006 Entrust, Inc.", CN = Entrust Root Certification Authority
Fingerprint:	73:C1:76:43:4F:1B:C6:D5:AD:F4:5B:0E:76:E7:27:28:7C:8D:E5:76:16:C1:E6:E6:14:1A:2B:2C:BC:7D:8E:4C
Issued:	Nov 27 20:23:42 2006 GMT
Expires:	Nov 27 20:53:42 2026 GMT

- **QuoVadis_Root_CA_1_G3.crt**

Subject Name:	C = BM, O = QuoVadis Limited, CN = QuoVadis Root CA 1 G3
Fingerprint:	8A:86:6F:D1:B2:76:B5:7E:57:8E:92:1C:65:82:8A:2B:ED:58:E9:F2:F2:88:05:41:34:B7:F1:F4:BF:C9:CC:74
Issued:	Jan 12 17:27:44 2012 GMT
Expires:	Jan 12 17:27:44 2042 GMT

- **Entrust_Root_Certification_Authority_-_EC1.crt**

Subject Name:	C = US, O = "Entrust, Inc.", OU = See www.entrust.net/legal-terms, OU = "(c) 2012 Entrust, Inc. - for authorized use only", CN = Entrust Root Certification Authority - EC1
Fingerprint:	02:ED:0E:B2:8C:14:DA:45:16:5C:56:67:91:70:0D:64:51:D7:FB:56:F0:B2:AB:1D:3B:8E:B0:70:E5:6E:DF:F5
Issued:	Dec 18 15:25:36 2012 GMT
Expires:	Dec 18 15:55:36 2037 GMT

- **GTS_Root_R4.crt**

Subject Name:	C = US, O = Google Trust Services LLC, CN = GTS Root R4
Fingerprint:	71:CC:A5:39:1F:9E:79:4B:04:80:25:30:B3:63:E1:21:DA:8A:30:43:BB:26:66:2F:EA:4D:CA:7F:C9:51:A4:BD
Issued:	Jun 22 00:00:00 2016 GMT
Expires:	Jun 22 00:00:00 2036 GMT

- **thawte_Primary_Root_CA_-_G2.crt**

Subject Name:	C = US, O = "thawte, Inc.", OU = "(c) 2007 thawte, Inc. - For authorized use only", CN = thawte Primary Root CA - G2
Fingerprint:	A4:31:0D:50:AF:18:A6:44:71:90:37:2A:86:AF:AF:8B:95:1F:FB:43:1D:83:7F:1E:56:88:B4:59:71:ED:15:57
Issued:	Nov 5 00:00:00 2007 GMT
Expires:	Jan 18 23:59:59 2038 GMT

- **GeoTrust_Universal_CA_2.crt**

Subject Name:	C = US, O = GeoTrust Inc., CN = GeoTrust Universal CA 2
Fingerprint:	A0:23:4F:3B:C8:52:7C:A5:62:8E:EC:81:AD:5D:69:89:5D:A5:68:0D:C9:1D:1C:B8:47:7F:33:F8:78:B9:5B:0B
Issued:	Mar 4 05:00:00 2004 GMT
Expires:	Mar 4 05:00:00 2029 GMT

- **Verisign_Class_3_Public_Primary_Certification_Authority_-_G3.crt**

Subject Name:	C = US, O = "VeriSign, Inc.", OU = VeriSign Trust Network, OU = "(c) 1999 VeriSign, Inc. - For authorized use only", CN = VeriSign Class 3 Public Primary Certification Authority - G3
Fingerprint:	EB:04:CF:5E:B1:F3:9A:FA:76:2F:2B:B1:20:F2:96:CB:A5:20:C1:B9:7D:B1:58:95:65:B8:1C:B9:A1:7B:72:44
Issued:	Oct 1 00:00:00 1999 GMT
Expires:	Jul 16 23:59:59 2036 GMT

- **GlobalSign_Root_CA_-_R6.crt**

Subject Name:	OU = GlobalSign Root CA - R6, O = GlobalSign, CN = GlobalSign
Fingerprint:	2C:AB:EA:FE:37:D0:6C:A2:2A:BA:73:91:C0:03:3D:25:98:29:52:C4:53:64:73:49:76:3A:3A:B5:AD:6C:CF:69
Issued:	Dec 10 00:00:00 2014 GMT
Expires:	Dec 10 00:00:00 2034 GMT

- **Buypass_Class_3_Root_CA.crt**

Subject Name:	C = NO, O = Buypass AS-983163327, CN = Buypass Class 3 Root CA
Fingerprint:	ED:F7:EB:BC:A2:7A:2A:38:4D:38:7B:7D:40:10:C6:66:E2:ED:B4:84:3E:4C:29:B4:AE:1D:5B:93:32:E6:B2:4D
Issued:	Oct 26 08:28:58 2010 GMT
Expires:	Oct 26 08:28:58 2040 GMT

- **GTS_Root_R3.crt**

Subject Name:	C = US, O = Google Trust Services LLC, CN = GTS Root R3
Fingerprint:	15:D5:B8:77:46:19:EA:7D:54:CE:1C:A6:D0:B0:C4:03:E0:37:A9:17:F1:31:E8:A0:4E:1E:6B:7A:71:BA:BC:E5
Issued:	Jun 22 00:00:00 2016 GMT
Expires:	Jun 22 00:00:00 2036 GMT

- **VeriSign_Universal_Root_Certification_Authority.crt**

Subject Name:	C = US, O = "VeriSign, Inc.", OU = VeriSign Trust Network, OU = "(c) 2008 VeriSign, Inc. - For authorized use only", CN = VeriSign Universal Root Certification Authority
Fingerprint:	23:99:56:11:27:A5:71:25:DE:8C:EF:EA:61:0D:DF:2F:A0:78:B5:C8:06:7F:4E:82:82:90:BF:B8:60:E8:4B:3C
Issued:	Apr 2 00:00:00 2008 GMT
Expires:	Dec 1 23:59:59 2037 GMT

- **Entrust_Root_Certification_Authority_-_G4.crt**

Subject Name:	C = US, O = "Entrust, Inc.", OU = See www.entrust.net/legal-terms, OU = "(c) 2015 Entrust, Inc. - for authorized use only", CN = Entrust Root Certification Authority - G4
Fingerprint:	DB:35:17:D1:F6:73:2A:2D:5A:B9:7C:53:3E:C7:07:79:EE:32:70:A6:2F:B4:AC:42:38:37:24:60:E6:F0:1E:88
Issued:	May 27 11:11:16 2015 GMT
Expires:	Dec 27 11:41:16 2037 GMT

- **GlobalSign_ECC_Root_CA_-_R5.crt**

Subject Name:	OU = GlobalSign ECC Root CA - R5, O = GlobalSign, CN = GlobalSign
Fingerprint:	17:9F:BC:14:8A:3D:D0:0F:D2:4E:A1:34:58:CC:43:BF:A7:F5:9C:81:82:D7:83:A5:13:F6:EB:EC:10:0C:89:24
Issued:	Nov 13 00:00:00 2012 GMT
Expires:	Jan 19 03:14:07 2038 GMT

- **VeriSign_Class_3_Public_Primary_Certification_Authority_-_G5.crt**

Subject Name:	C = US, O = "VeriSign, Inc.", OU = VeriSign Trust Network, OU = "(c) 2006 VeriSign, Inc. - For authorized use only", CN = VeriSign Class 3 Public Primary Certification Authority - G5
Fingerprint:	9A:CF:AB:7E:43:C8:D8:80:D0:6B:26:2A:94:DE:EE:E4:B4:65:99:89:C3:D0:CA:F1:9B:AF:64:05:E4:1A:B7:DF
Issued:	Nov 8 00:00:00 2006 GMT
Expires:	Jul 16 23:59:59 2036 GMT

- **NetLock_Arany_=Class_Gold=_Főtanúsítvány.crt**

Subject Name:	C = HU, L = Budapest, O = NetLock Kft., OU = Tan\C3\BAs\C3\ADtv \C3\A1nykiad\C3\B3k (Certification Services), CN = NetLock Arany (Class Gold) F\C5\91tan\C3\BAs\C3\ADtv\C3\A1ny
Fingerprint:	6C:61:DA:C3:A2:DE:F0:31:50:6B:E0:36:D2:A6:FE:40:19:94:FB:D1:3D:F9:C8:D4:66:59:92:74:C4:46:EC:98
Issued:	Dec 11 15:08:21 2008 GMT
Expires:	Dec 6 15:08:21 2028 GMT

- **SSL.com_Root_Certification_Authority_RSA.crt**

Subject Name:	C = US, ST = Texas, L = Houston, O = SSL Corporation, CN = SSL.com Root Certification Authority RSA
Fingerprint:	85:66:6A:56:2E:E0:BE:5C:E9:25:C1:D8:89:0A:6F:76:A8:7E:C1:6D:4D:7D:5F:29:EA:74:19:CF:20:12:3B:69

Issued:	Feb 12 17:39:39 2016 GMT
Expires:	Feb 12 17:39:39 2041 GMT

- **Amazon_Root_CA_1.crt**

Subject Name:	C = US, O = Amazon, CN = Amazon Root CA 1
Fingerprint:	8E:CD:E6:88:4F:3D:87:B1:12:5B:A3:1A:C3:FC:B1:3D:70:16:DE:7F:57:CC:90:4F:E1:CB:97:C6:AE:98:19:6E
Issued:	May 26 00:00:00 2015 GMT
Expires:	Jan 17 00:00:00 2038 GMT

- **thawte_Primary_Root_CA_-_G3.crt**

Subject Name:	C = US, O = "thawte, Inc.", OU = Certification Services Division, OU = "(c) 2008 thawte, Inc. - For authorized use only", CN = thawte Primary Root CA - G3
Fingerprint:	4B:03:F4:58:07:AD:70:F2:1B:FC:2C:AE:71:C9:FD:E4:60:4C:06:4C:F5:FF:B6:86:BA:E5:DB:AA:D7:FD:D3:4C
Issued:	Apr 2 00:00:00 2008 GMT
Expires:	Dec 1 23:59:59 2037 GMT

- **QuoVadis_Root_CA_2_G3.crt**

Subject Name:	C = BM, O = QuoVadis Limited, CN = QuoVadis Root CA 2 G3
Fingerprint:	8F:E4:FB:0A:F9:3A:4D:0D:67:DB:0B:EB:B2:3E:37:C7:1B:F3:25:DC:BC:DD:24:0E:A0:4D:AF:58:B4:7E:18:40
Issued:	Jan 12 18:59:32 2012 GMT
Expires:	Jan 12 18:59:32 2042 GMT

- **DigiCert_Global_Root_CA.crt**

Subject Name:	C = US, O = DigiCert Inc, OU = www.digicert.com, CN = DigiCert Global Root CA
Fingerprint:	43:48:A0:E9:44:4C:78:CB:26:5E:05:8D:5E:89:44:B4:D8:4F:96:62:BD:26:DB:25:7F:89:34:A4:43:C7:01:61
Issued:	Nov 10 00:00:00 2006 GMT
Expires:	Nov 10 00:00:00 2031 GMT

- **OISTE_WISeKey_Global_Root_GC_CA.crt**

Subject Name:	C = CH, O = WISeKey, OU = OISTE Foundation Endorsed, CN = OISTE WISeKey Global Root GC CA
Fingerprint:	85:60:F9:1C:36:24:DA:BA:95:70:B5:FE:A0:DB:E3:6F:F1:1A:83:23:BE:94:86:85:4F:B3:F3:4A:55:71:19:8D
Issued:	May 9 09:48:34 2017 GMT
Expires:	May 9 09:58:33 2042 GMT

- **Security_Communication_Root_CA.crt**

Subject Name:	C = JP, O = SECOM Trust.net, OU = Security Communication RootCA1
Fingerprint:	E7:5E:72:ED:9F:56:0E:EC:6E:B4:80:00:73:A4:3F:C3:AD:19:19:5A:39:22:82:01:78:95:97:4A:99:02:6B:6C
Issued:	Sep 30 04:20:49 2003 GMT
Expires:	Sep 30 04:20:49 2023 GMT

- **TeliaSonera_Root_CA_v1.crt**

Subject Name:	O = TeliaSonera, CN = TeliaSonera Root CA v1
Fingerprint:	DD:69:36:FE:21:F8:F0:77:C1:23:A1:A5:21:C1:22:24:F7:22:55:B7:3E:03:A7:26:06:93:E8:A2:4B:0F:A3:89
Issued:	Oct 18 12:00:50 2007 GMT
Expires:	Oct 18 12:00:50 2032 GMT

- **DigiCert_Global_Root_G2.crt**

Subject Name:	C = US, O = DigiCert Inc, OU = www.digicert.com, CN = DigiCert Global Root G2
Fingerprint:	CB:3C:CB:B7:60:31:E5:E0:13:8F:8D:D3:9A:23:F9:DE:47:FF:C3:5E:43:C1:14:4C:EA:27:D4:6A:5A:B1:CB:5F
Issued:	Aug 1 12:00:00 2013 GMT
Expires:	Jan 15 12:00:00 2038 GMT

- **AffirmTrust_Commercial.crt**

Subject Name:	C = US, O = AffirmTrust, CN = AffirmTrust Commercial
Fingerprint:	03:76:AB:1D:54:C5:F9:80:3C:E4:B2:E2:01:A0:EE:7E:EF:7B:57:B6:36:E8:A9:3C:9B:8D:48:60:C9:6F:5F:A7
Issued:	Jan 29 14:06:06 2010 GMT
Expires:	Dec 31 14:06:06 2030 GMT

- **GeoTrust_Universal_CA.crt**

Subject Name:	C = US, O = GeoTrust Inc., CN = GeoTrust Universal CA
Fingerprint:	A0:45:9B:9F:63:B2:25:59:F5:FA:5D:4C:6D:B3:F9:F7:2F:F1:93:42:03:35:78:F0:73:BF:1D:1B:46:CB:B9:12
Issued:	Mar 4 05:00:00 2004 GMT
Expires:	Mar 4 05:00:00 2029 GMT

- **Secure_Global_CA.crt**

Subject Name:	C = US, O = SecureTrust Corporation, CN = Secure Global CA
Fingerprint:	42:00:F5:04:3A:C8:59:0E:BB:52:7D:20:9E:D1:50:30:29:FB:CB:D4:1C:A1:B5:06:EC:27:F1:5A:DE:7D:AC:69
Issued:	Nov 7 19:42:28 2006 GMT
Expires:	Dec 31 19:52:06 2029 GMT

- **Sonera_Class_2_Root_CA.crt**

Subject Name:	C = FI, O = Sonera, CN = Sonera Class2 CA
Fingerprint:	79:08:B4:03:14:C1:38:10:0B:51:8D:07:35:80:7F:FB:FC:F8:51:8A:00:95:33:71:05:BA:38:6B:15:3D:D9:27
Issued:	Apr 6 07:29:40 2001 GMT
Expires:	Apr 6 07:29:40 2021 GMT

- **ACCVRAIZ1.crt**

Subject Name:	CN = ACCVRAIZ1, OU = PKIACCV, O = ACCV, C = ES
Fingerprint:	9A:6E:C0:12:E1:A7:DA:9D:BE:34:19:4D:47:8A:D7:C0:DB:18:22:FB:07:1D:F1:29:81:49:6E:D1:04:38:41:13

Issued:	May 5 09:37:37 2011 GMT
Expires:	Dec 31 09:37:37 2030 GMT

- **SecureTrust_CA.crt**

Subject Name:	C = US, O = SecureTrust Corporation, CN = SecureTrust CA
Fingerprint:	F1:C1:B5:0A:E5:A2:0D:D8:03:0E:C9:F6:BC:24:82:3D:D3:67:B5:25:57:59:B4:E7:1B:61:FC:E9:F7:37:5D:73
Issued:	Nov 7 19:31:18 2006 GMT
Expires:	Dec 31 19:40:55 2029 GMT

- **Actalis_Authentication_Root_CA.crt**

Subject Name:	C = IT, L = Milan, O = Actalis S.p.A./03358520967, CN = Actalis Authentication Root CA
Fingerprint:	55:92:60:84:EC:96:3A:64:B9:6E:2A:BE:01:CE:0B:A8:6A:64:FB:FE:BC:C7:AA:B5:AF:C1:55:B3:7F:D7:60:66
Issued:	Sep 22 11:22:02 2011 GMT
Expires:	Sep 22 11:22:02 2030 GMT

- **Amazon_Root_CA_4.crt**

Subject Name:	C = US, O = Amazon, CN = Amazon Root CA 4
Fingerprint:	E3:5D:28:41:9E:D0:20:25:CF:A6:90:38:CD:62:39:62:45:8D:A5:C6:95:FB:DE:A3:C2:2B:0B:FB:25:89:70:92
Issued:	May 26 00:00:00 2015 GMT
Expires:	May 26 00:00:00 2040 GMT

- **Certigna.crt**

Subject Name:	C = FR, O = Dhimyotis, CN = Certigna
Fingerprint:	E3:B6:A2:DB:2E:D7:CE:48:84:2F:7A:C5:32:41:C7:B7:1D:54:14:4B:FB:40:C1:1F:3F:1D:0B:42:F5:EE:A1:2D
Issued:	Jun 29 15:13:05 2007 GMT
Expires:	Jun 29 15:13:05 2027 GMT

- **Global_Chambersign_Root_-_2008.crt**

Subject Name:	C = EU, L = Madrid (see current address at www.camerfirma.com/address), serialNumber = A82743287, O = AC Camerfirma S.A., CN = Global Chambersign Root - 2008
Fingerprint:	13:63:35:43:93:34:A7:69:80:16:A0:D3:24:DE:72:28:4E:07:9D:7B:52:20:BB:8F:BD:74:78:16:EE:BE:BA:CA
Issued:	Aug 1 12:31:40 2008 GMT
Expires:	Jul 31 12:31:40 2038 GMT

- **COMODO_ECC_Certification_Authority.crt**

Subject Name:	C = GB, ST = Greater Manchester, L = Salford, O = COMODO CA Limited, CN = COMODO ECC Certification Authority
Fingerprint:	17:93:92:7A:06:14:54:97:89:AD:CE:2F:8F:34:F7:F0:B6:6D:0F:3A:E3:A3:B8:4D:21:EC:15:DB:BA:4F:AD:C7
Issued:	Mar 6 00:00:00 2008 GMT
Expires:	Jan 18 23:59:59 2038 GMT

- **Hellenic_Academic_and_Research_Institutions_RootCA_2011.crt**

Subject Name:	C = GR, O = Hellenic Academic and Research Institutions Cert. Authority, CN = Hellenic Academic and Research Institutions RootCA 2011
Fingerprint:	BC:10:4F:15:A4:8B:E7:09:DC:A5:42:A7:E1:D4:B9:DF:6F:05:45:27:E8:02:EA:A9:2D:59:54:44:25:8A:FE:71
Issued:	Dec 6 13:49:52 2011 GMT
Expires:	Dec 1 13:49:52 2031 GMT

- **Starfield_Root_Certificate_Authority_-_G2.crt**

Subject Name:	C = US, ST = Arizona, L = Scottsdale, O = "Starfield Technologies, Inc.", CN = Starfield Root Certificate Authority - G2
Fingerprint:	2C:E1:CB:0B:F9:D2:F9:E1:02:99:3F:BE:21:51:52:C3:B2:DD:0C:AB:DE:1C:68:E5:31:9B:83:91:54:DB:B7:F5
Issued:	Sep 1 00:00:00 2009 GMT
Expires:	Dec 31 23:59:59 2037 GMT

- **T-TeleSec_GlobalRoot_Class_2.crt**

Subject Name:	C = DE, O = T-Systems Enterprise Services GmbH, OU = T-Systems Trust Center, CN = T-TeleSec GlobalRoot Class 2
Fingerprint:	91:E2:F5:78:8D:58:10:EB:A7:BA:58:73:7D:E1:54:8A:8E:CA:CD:01:45:98:BC:0B:14:3E:04:1B:17:05:25:52
Issued:	Oct 1 10:40:14 2008 GMT
Expires:	Oct 1 23:59:59 2033 GMT

- **TrustCor_ECA-1.crt**

Subject Name:	C = PA, ST = Panama, L = Panama City, O = TrustCor Systems S. de R.L., OU = TrustCor Certificate Authority, CN = TrustCor ECA-1
Fingerprint:	5A:88:5D:B1:9C:01:D9:12:C5:75:93:88:93:8C:AF:BB:DF:03:1A:B2:D4:8E:91:EE:15:58:9B:42:97:1D:03:9C
Issued:	Feb 4 12:32:33 2016 GMT
Expires:	Dec 31 17:28:07 2029 GMT

- **ISRG_Root_X1.crt**

Subject Name:	C = US, O = Internet Security Research Group, CN = ISRG Root X1
Fingerprint:	96:BC:EC:06:26:49:76:F3:74:60:77:9A:CF:28:C5:A7:CF:E8:A3:C0:AA:E1:1A:8F:FC:EE:05:C0:BD:DF:08:C6
Issued:	Jun 4 11:04:38 2015 GMT
Expires:	Jun 4 11:04:38 2035 GMT

- **Comodo_AAA_Services_root.crt**

Subject Name:	C = GB, ST = Greater Manchester, L = Salford, O = Comodo CA Limited, CN = AAA Certificate Services
Fingerprint:	D7:A7:A0:FB:5D:7E:27:31:D7:71:E9:48:4E:BC:DE:F7:1D:5F:0C:3E:0A:29:48:78:2B:C8:3E:E0:EA:69:9E:F4
Issued:	Jan 1 00:00:00 2004 GMT
Expires:	Dec 31 23:59:59 2028 GMT

- **QuoVadis_Root_CA_2.crt**

Subject Name:	C = BM, O = QuoVadis Limited, CN = QuoVadis Root CA 2
Fingerprint:	85:A0:DD:7D:D7:20:AD:B7:FF:05:F8:3D:54:2B:20:9D:C7:FF:45:28:F7:D6:77:B1:83:89:FE:A5:E5:C4:9E:86
Issued:	Nov 24 18:27:00 2006 GMT
Expires:	Nov 24 18:23:33 2031 GMT

- **GeoTrust_Primary_Certification_Authority.crt**

Subject Name:	C = US, O = GeoTrust Inc., CN = GeoTrust Primary Certification Authority
Fingerprint:	37:D5:10:06:C5:12:EA:AB:62:64:21:F1:EC:8C:92:01:3F:C5:F8:2A:E9:8E:E5:33:EB:46:19:B8:DE:B4:D0:6C
Issued:	Nov 27 00:00:00 2006 GMT
Expires:	Jul 16 23:59:59 2036 GMT

- **QuoVadis_Root_CA_3.crt**

Subject Name:	C = BM, O = QuoVadis Limited, CN = QuoVadis Root CA 3
Fingerprint:	18:F1:FC:7F:20:5D:F8:AD:DD:EB:7F:E0:07:DD:57:E3:AF:37:5A:9C:4D:8D:73:54:6B:F4:F1:FE:D1:E1:8D:35
Issued:	Nov 24 19:11:23 2006 GMT
Expires:	Nov 24 19:06:44 2031 GMT

- **GlobalSign_ECC_Root_CA_-_R4.crt**

Subject Name:	OU = GlobalSign ECC Root CA - R4, O = GlobalSign, CN = GlobalSign
Fingerprint:	BE:C9:49:11:C2:95:56:76:DB:6C:0A:55:09:86:D7:6E:3B:A0:05:66:7C:44:2C:97:62:B4:FB:B7:73:DE:22:8C
Issued:	Nov 13 00:00:00 2012 GMT
Expires:	Jan 19 03:14:07 2038 GMT

- **COMODO_Certification_Authority.crt**

Subject Name:	C = GB, ST = Greater Manchester, L = Salford, O = COMODO CA Limited, CN = COMODO Certification Authority
Fingerprint:	0C:2C:D6:3D:F7:80:6F:A3:99:ED:E8:09:11:6B:57:5B:F8:79:89:F0:65:18:F9:80:8C:86:05:03:17:8B:AF:66
Issued:	Dec 1 00:00:00 2006 GMT
Expires:	Dec 31 23:59:59 2029 GMT

- **OISTE_WISeKey_Global_Root_GB_CA.crt**

Subject Name:	C = CH, O = WISeKey, OU = OISTE Foundation Endorsed, CN = OISTE WISeKey Global Root GB CA
Fingerprint:	6B:9C:08:E8:6E:B0:F7:67:CF:AD:65:CD:98:B6:21:49:E5:49:4A:67:F5:84:5E:7B:D1:ED:01:9F:27:B8:6B:D6
Issued:	Dec 1 15:00:32 2014 GMT
Expires:	Dec 1 15:10:31 2039 GMT

- **USERTrust_ECC_Certification_Authority.crt**

Subject Name:	C = US, ST = New Jersey, L = Jersey City, O = The USERTRUST Network, CN = USERTrust ECC Certification Authority

Fingerprint:	4F:F4:60:D5:4B:9C:86:DA:BF:BC:FC:57:12:E0:40:0D:2B:ED:3F:BC:4D:4F:BD:AA:86:E0:6A:DC:D2:A9:AD:7A
Issued:	Feb 1 00:00:00 2010 GMT
Expires:	Jan 18 23:59:59 2038 GMT

- **DigiCert_Assured_ID_Root_G3.crt**

Subject Name:	C = US, O = DigiCert Inc, OU = www.digicert.com, CN = DigiCert Assured ID Root G3
Fingerprint:	7E:37:CB:8B:4C:47:09:0C:AB:36:55:1B:A6:F4:5D:B8:40:68:0F:BA:16:6A:95:2D:B1:00:71:7F:43:05:3F:C2
Issued:	Aug 1 12:00:00 2013 GMT
Expires:	Jan 15 12:00:00 2038 GMT

- **GlobalSign_Root_CA.crt**

Subject Name:	C = BE, O = GlobalSign nv-sa, OU = Root CA, CN = GlobalSign Root CA
Fingerprint:	EB:D4:10:40:E4:BB:3E:C7:42:C9:E3:81:D3:1E:F2:A4:1A:48:B6:68:5C:96:E7:CE:F3:C1:DF:6C:D4:33:1C:99
Issued:	Sep 1 12:00:00 1998 GMT
Expires:	Jan 28 12:00:00 2028 GMT

- **Hongkong_Post_Root_CA_1.crt**

Subject Name:	C = HK, O = Hongkong Post, CN = Hongkong Post Root CA 1
Fingerprint:	F9:E6:7D:33:6C:51:00:2A:C0:54:C6:32:02:2D:66:DD:A2:E7:E3:FF:F1:0A:D0:61:ED:31:D8:BB:B4:10:CF:B2
Issued:	May 15 05:13:14 2003 GMT
Expires:	May 15 04:52:29 2023 GMT

- **Entrust_Root_Certification_Authority_-_G2.crt**

Subject Name:	C = US, O = "Entrust, Inc.", OU = See www.entrust.net/legal-terms, OU = "(c) 2009 Entrust, Inc. - for authorized use only", CN = Entrust Root Certification Authority - G2
Fingerprint:	43:DF:57:74:B0:3E:7F:EF:5F:E4:0D:93:1A:7B:ED:F1:BB:2E:6B:42:73:8C:4E:6D:38:41:10:3D:3A:A7:F3:39
Issued:	Jul 7 17:25:54 2009 GMT
Expires:	Dec 7 17:55:54 2030 GMT

- **T-TeleSec_GlobalRoot_Class_3.crt**

Subject Name:	C = DE, O = T-Systems Enterprise Services GmbH, OU = T-Systems Trust Center, CN = T-TeleSec GlobalRoot Class 3
Fingerprint:	FD:73:DA:D3:1C:64:4F:F1:B4:3B:EF:0C:CD:DA:96:71:0B:9C:D9:87:5E:CA:7E:31:70:7A:F3:E9:6D:52:2B:BD
Issued:	Oct 1 10:29:56 2008 GMT
Expires:	Oct 1 23:59:59 2033 GMT

- **SecureSign_RootCA11.crt**

Subject Name:	C = JP, O = "Japan Certification Services, Inc.", CN = SecureSign RootCA11

Fingerprint:	BF:0F:EE:FB:9E:3A:58:1A:D5:F9:E9:DB:75:89:98:57:43:D2:61:08:5C:4D:31:4F:6F:5D:72:59:AA:42:16:12
Issued:	Apr 8 04:56:47 2009 GMT
Expires:	Apr 8 04:56:47 2029 GMT

- **DigiCert_Trusted_Root_G4.crt**

Subject Name:	C = US, O = DigiCert Inc, OU = www.digicert.com, CN = DigiCert Trusted Root G4
Fingerprint:	55:2F:7B:DC:F1:A7:AF:9E:6C:E6:72:01:7F:4F:12:AB:F7:72:40:C7:8E:76:1A:C2:03:D1:D9:D2:0A:C8:99:88
Issued:	Aug 1 12:00:00 2013 GMT
Expires:	Jan 15 12:00:00 2038 GMT

- **LuxTrust_Global_Root_2.crt**

Subject Name:	C = LU, O = LuxTrust S.A., CN = LuxTrust Global Root 2
Fingerprint:	54:45:5F:71:29:C2:0B:14:47:C4:18:F9:97:16:8F:24:C5:8F:C5:02:3B:F5:DA:5B:E2:EB:6E:1D:D8:90:2E:D5
Issued:	Mar 5 13:21:57 2015 GMT
Expires:	Mar 5 13:21:57 2035 GMT

- **SwissSign_Silver_CA_-_G2.crt**

Subject Name:	C = CH, O = SwissSign AG, CN = SwissSign Silver CA - G2
Fingerprint:	BE:6C:4D:A2:BB:B9:BA:59:B6:F3:93:97:68:37:42:46:C3:C0:05:99:3F:A9:8F:02:0D:1D:ED:BE:D4:8A:81:D5
Issued:	Oct 25 08:32:46 2006 GMT
Expires:	Oct 25 08:32:46 2036 GMT

- **CFCA_EV_ROOT.crt**

Subject Name:	C = CN, O = China Financial Certification Authority, CN = CFCA EV ROOT
Fingerprint:	5C:C3:D7:8E:4E:1D:5E:45:54:7A:04:E6:87:3E:64:F9:0C:F9:53:6D:1C:CC:2E:F8:00:F3:55:C4:C5:FD:70:FD
Issued:	Aug 8 03:07:01 2012 GMT
Expires:	Dec 31 03:07:01 2029 GMT

- **certSIGN_ROOT_CA.crt**

Subject Name:	C = RO, O = certSIGN, OU = certSIGN ROOT CA
Fingerprint:	EA:A9:62:C4:FA:4A:6B:AF:EB:E4:15:19:6D:35:1C:CD:88:8D:4F:53:F3:FA:8A:E6:D7:C4:66:A9:4E:60:42:BB
Issued:	Jul 4 17:20:04 2006 GMT
Expires:	Jul 4 17:20:04 2031 GMT

- **Starfield_Services_Root_Certificate_Authority_-_G2.crt**

Subject Name:	C = US, ST = Arizona, L = Scottsdale, O = "Starfield Technologies, Inc.", CN = Starfield Services Root Certificate Authority - G2
Fingerprint:	56:8D:69:05:A2:C8:87:08:A4:B3:02:51:90:ED:CF:ED:B1:97:4A:60:6A:13:C6:E5:29:0F:CB:2A:E6:3E:DA:B5
Issued:	Sep 1 00:00:00 2009 GMT

Expires:	Dec 31 23:59:59 2037 GMT

- **emSign_Root_CA_-_C1.crt**

Subject Name:	C = US, OU = emSign PKI, O = eMudhra Inc, CN = emSign Root CA - C1
Fingerprint:	12:56:09:AA:30:1D:A0:A2:49:B9:7A:82:39:CB:6A:34:21:6F:44:DC:AC:9F:39:54:B1:42:92:F2:E8:C8:60:8F
Issued:	Feb 18 18:30:00 2018 GMT
Expires:	Feb 18 18:30:00 2043 GMT

- **AffirmTrust_Networking.crt**

Subject Name:	C = US, O = AffirmTrust, CN = AffirmTrust Networking
Fingerprint:	0A:81:EC:5A:92:97:77:F1:45:90:4A:F3:8D:5D:50:9F:66:B5:E2:C5:8F:CD:B5:31:05:8B:0E:17:F3:F0:B4:1B
Issued:	Jan 29 14:08:24 2010 GMT
Expires:	Dec 31 14:08:24 2030 GMT

- **DST_Root_CA_X3.crt**

Subject Name:	O = Digital Signature Trust Co., CN = DST Root CA X3
Fingerprint:	06:87:26:03:31:A7:24:03:D9:09:F1:05:E6:9B:CF:0D:32:E1:BD:24:93:FF:C6:D9:20:6D:11:BC:D6:77:07:39
Issued:	Sep 30 21:12:19 2000 GMT
Expires:	Sep 30 14:01:15 2021 GMT

- **SSL.com_EV_Root_Certification_Authority_RSA_R2.crt**

Subject Name:	C = US, ST = Texas, L = Houston, O = SSL Corporation, CN = SSL.com EV Root Certification Authority RSA R2
Fingerprint:	2E:7B:F1:6C:C2:24:85:A7:BB:E2:AA:86:96:75:07:61:B0:AE:39:BE:3B:2F:E9:D0:CC:6D:4E:F7:34:91:42:5C
Issued:	May 31 18:14:37 2017 GMT
Expires:	May 30 18:14:37 2042 GMT

- **UCA_Extended_Validation_Root.crt**

Subject Name:	C = CN, O = UniTrust, CN = UCA Extended Validation Root
Fingerprint:	D4:3A:F9:B3:54:73:75:5C:96:84:FC:06:D7:D8:CB:70:EE:5C:28:E7:73:FB:29:4E:B4:1E:E7:17:22:92:4D:24
Issued:	Mar 13 00:00:00 2015 GMT
Expires:	Dec 31 00:00:00 2038 GMT

- **emSign_ECC_Root_CA_-_C3.crt**

Subject Name:	C = US, OU = emSign PKI, O = eMudhra Inc, CN = emSign ECC Root CA - C3
Fingerprint:	BC:4D:80:9B:15:18:9D:78:DB:3E:1D:8C:F4:F9:72:6A:79:5D:A1:64:3C:A5:F1:35:8E:1D:DB:0E:DC:0D:7E:B3
Issued:	Feb 18 18:30:00 2018 GMT
Expires:	Feb 18 18:30:00 2043 GMT

- **D-TRUST_Root_Class_3_CA_2_2009.crt**

Subject Name:	C = DE, O = D-Trust GmbH, CN = D-TRUST Root Class 3 CA 2 2009
Fingerprint:	49:E7:A4:42:AC:F0:EA:62:87:05:00:54:B5:25:64:B6:50:E4:F4:9E:42:E3:48:D6:AA:38:E0:39:E9:57:B1:C1
Issued:	Nov 5 08:35:58 2009 GMT
Expires:	Nov 5 08:35:58 2029 GMT

- **AC_RAIZ_FNMT-RCM.crt**

Subject Name:	C = ES, O = FNMT-RCM, OU = AC RAIZ FNMT-RCM
Fingerprint:	EB:C5:57:0C:29:01:8C:4D:67:B1:AA:12:7B:AF:12:F7:03:B4:61:1E:BC:17:B7:DA:B5:57:38:94:17:9B:93:FA
Issued:	Oct 29 15:59:56 2008 GMT
Expires:	Jan 1 00:00:00 2030 GMT

- **SZAFIR_ROOT_CA2.crt**

Subject Name:	C = PL, O = Krajowa Izba Rozliczeniowa S.A., CN = SZAFIR ROOT CA2
Fingerprint:	A1:33:9D:33:28:1A:0B:56:E5:57:D3:D3:2B:1C:E7:F9:36:7E:B0:94:BD:5F:A7:2A:7E:50:04:C8:DE:D7:CA:FE
Issued:	Oct 19 07:43:30 2015 GMT
Expires:	Oct 19 07:43:30 2035 GMT

- **Taiwan_GRCA.crt**

Subject Name:	C = TW, O = Government Root Certification Authority
Fingerprint:	76:00:29:5E:EF:E8:5B:9E:1F:D6:24:DB:76:06:2A:AA:AE:59:81:8A:54:D2:77:4C:D4:C0:B2:C0:11:31:E1:B3
Issued:	Dec 5 13:23:33 2002 GMT
Expires:	Dec 5 13:23:33 2032 GMT

- **Izenpe.com.crt**

Subject Name:	C = ES, O = IZENPE S.A., CN = Izenpe.com
Fingerprint:	25:30:CC:8E:98:32:15:02:BA:D9:6F:9B:1F:BA:1B:09:9E:2D:29:9E:0F:45:48:BB:91:4F:36:3B:C0:D4:53:1F
Issued:	Dec 13 13:08:28 2007 GMT
Expires:	Dec 13 08:27:25 2037 GMT

- **Certum_Trusted_Network_CA_2.crt**

Subject Name:	C = PL, O = Unizeto Technologies S.A., OU = Certum Certification Authority, CN = Certum Trusted Network CA 2
Fingerprint:	B6:76:F2:ED:DA:E8:77:5C:D3:6C:B0:F6:3C:D1:D4:60:39:61:F4:9E:62:65:BA:01:3A:2F:03:07:B6:D0:B8:04
Issued:	Oct 6 08:39:56 2011 GMT
Expires:	Oct 6 08:39:56 2046 GMT

- **Staat_der_Nederlanden_Root_CA_-_G2.crt**

Subject Name:	C = NL, O = Staat der Nederlanden, CN = Staat der Nederlanden Root CA - G2

Fingerprint:	66:8C:83:94:7D:A6:3B:72:4B:EC:E1:74:3C:31:A0:E6:AE:D0:DB:8E:C5:B3:1B:E3:77:BB:78:4F:91:B6:71:6F
Issued:	Mar 26 11:18:17 2008 GMT
Expires:	Mar 25 11:03:10 2020 GMT

- **GTS_Root_R1.crt**

Subject Name:	C = US, O = Google Trust Services LLC, CN = GTS Root R1
Fingerprint:	2A:57:54:71:E3:13:40:BC:21:58:1C:BD:2C:F1:3E:15:84:63:20:3E:CE:94:BC:F9:D3:CC:19:6B:F0:9A:54:72
Issued:	Jun 22 00:00:00 2016 GMT
Expires:	Jun 22 00:00:00 2036 GMT

- **Hellenic_Academic_and_Research_Institutions_ECC_RootCA_2015.crt**

Subject Name:	C = GR, L = Athens, O = Hellenic Academic and Research Institutions Cert. Authority, CN = Hellenic Academic and Research Institutions ECC RootCA 2015
Fingerprint:	44:B5:45:AA:8A:25:E6:5A:73:CA:15:DC:27:FC:36:D2:4C:1C:B9:95:3A:06:65:39:B1:15:82:DC:48:7B:48:33
Issued:	Jul 7 10:37:12 2015 GMT
Expires:	Jun 30 10:37:12 2040 GMT

- **ePKI_Root_Certification_Authority.crt**

Subject Name:	C = TW, O = "Chunghwa Telecom Co., Ltd.", OU = ePKI Root Certification Authority
Fingerprint:	C0:A6:F4:DC:63:A2:4B:FD:CF:54:EF:2A:6A:08:2A:0A:72:DE:35:80:3E:2F:F5:FF:52:7A:E5:D8:72:06:DF:D5
Issued:	Dec 20 02:31:27 2004 GMT
Expires:	Dec 20 02:31:27 2034 GMT

- **GTS_Root_R2.crt**

Subject Name:	C = US, O = Google Trust Services LLC, CN = GTS Root R2
Fingerprint:	C4:5D:7B:B0:8E:6D:67:E6:2E:42:35:11:0B:56:4E:5F:78:FD:92:EF:05:8C:84:0A:EA:4E:64:55:D7:58:5C:60
Issued:	Jun 22 00:00:00 2016 GMT
Expires:	Jun 22 00:00:00 2036 GMT

- **VeriSign_Class_3_Public_Primary_Certification_Authority_-_G4.crt**

Subject Name:	C = US, O = "VeriSign, Inc.", OU = VeriSign Trust Network, OU = "(c) 2007 VeriSign, Inc. - For authorized use only", CN = VeriSign Class 3 Public Primary Certification Authority - G4
Fingerprint:	69:DD:D7:EA:90:BB:57:C9:3E:13:5D:C8:5E:A6:FC:D5:48:0B:60:32:39:BD:C4:54:FC:75:8B:2A:26:CF:7F:79
Issued:	Nov 5 00:00:00 2007 GMT
Expires:	Jan 18 23:59:59 2038 GMT

- **DigiCert_Global_Root_G3.crt**

Subject Name:	C = US, O = DigiCert Inc, OU = www.digicert.com, CN = DigiCert Global Root G3

Fingerprint:	31:AD:66:48:F8:10:41:38:C7:38:F3:9E:A4:32:01:33:39:3E:3A:18:CC:02:29:6E:F9:7C:2A:C9:EF:67:31:D0
Issued:	Aug 1 12:00:00 2013 GMT
Expires:	Jan 15 12:00:00 2038 GMT

- **Starfield_Class_2_CA.crt**

Subject Name:	C = US, O = "Starfield Technologies, Inc.", OU = Starfield Class 2 Certification Authority
Fingerprint:	14:65:FA:20:53:97:B8:76:FA:A6:F0:A9:95:8E:55:90:E4:0F:CC:7F:AA:4F:B7:C2:C8:67:75:21:FB:5F:B6:58
Issued:	Jun 29 17:39:16 2004 GMT
Expires:	Jun 29 17:39:16 2034 GMT

- **IdenTrust_Public_Sector_Root_CA_1.crt**

Subject Name:	C = US, O = IdenTrust, CN = IdenTrust Public Sector Root CA 1
Fingerprint:	30:D0:89:5A:9A:44:8A:26:20:91:63:55:22:D1:F5:20:10:B5:86:7A:CA:E1:2C:78:EF:95:8F:D4:F4:38:9F:2F
Issued:	Jan 16 17:53:32 2014 GMT
Expires:	Jan 16 17:53:32 2034 GMT

- **Baltimore_CyberTrust_Root.crt**

Subject Name:	C = IE, O = Baltimore, OU = CyberTrust, CN = Baltimore CyberTrust Root
Fingerprint:	16:AF:57:A9:F6:76:B0:AB:12:60:95:AA:5E:BA:DE:F2:2A:B3:11:19:D6:44:AC:95:CD:4B:93:DB:F3:F2:6A:EB
Issued:	May 12 18:46:00 2000 GMT
Expires:	May 12 23:59:00 2025 GMT

- **EC-ACC.crt**

Subject Name:	C = ES, O = Agencia Catalana de Certificacio (NIF Q-0801176-I), OU = Serveis Publics de Certificacio, OU = Vegeu https://www.catcert.net/verarrel (c)03, OU = Jerarquia Entitats de Certificacio Catalanes, CN = EC-ACC
Fingerprint:	88:49:7F:01:60:2F:31:54:24:6A:E2:8C:4D:5A:EF:10:F1:D8:7E:BB:76:62:6F:4A:E0:B7:F9:5B:A7:96:87:99
Issued:	Jan 7 23:00:00 2003 GMT
Expires:	Jan 7 22:59:59 2031 GMT

- **TWCA_Root_Certification_Authority.crt**

Subject Name:	C = TW, O = TAIWAN-CA, OU = Root CA, CN = TWCA Root Certification Authority
Fingerprint:	BF:D8:8F:E1:10:1C:41:AE:3E:80:1B:F8:BE:56:35:0E:E9:BA:D1:A6:B9:BD:51:5E:DC:5C:6D:5B:87:11:AC:44
Issued:	Aug 28 07:24:33 2008 GMT
Expires:	Dec 31 15:59:59 2030 GMT

- **DigiCert_Assured_ID_Root_G2.crt**

Subject Name:	C = US, O = DigiCert Inc, OU = www.digicert.com, CN = DigiCert Assured ID Root G2

Fingerprint:	7D:05:EB:B6:82:33:9F:8C:94:51:EE:09:4E:EB:FE:FA:79:53:A1:14:ED:B2:F4:49:49:45:2F:AB:7D:2F:C1:85
Issued:	Aug 1 12:00:00 2013 GMT
Expires:	Jan 15 12:00:00 2038 GMT

- **Staat_der_Nederlanden_EV_Root_CA.crt**

Subject Name:	C = NL, O = Staat der Nederlanden, CN = Staat der Nederlanden EV Root CA
Fingerprint:	4D:24:91:41:4C:FE:95:67:46:EC:4C:EF:A6:CF:6F:72:E2:8A:13:29:43:2F:9D:8A:90:7A:C4:CB:5D:AD:C1:5A
Issued:	Dec 8 11:19:29 2010 GMT
Expires:	Dec 8 11:10:28 2022 GMT

- **TWCA_Global_Root_CA.crt**

Subject Name:	C = TW, O = TAIWAN-CA, OU = Root CA, CN = TWCA Global Root CA
Fingerprint:	59:76:90:07:F7:68:5D:0F:CD:50:87:2F:9F:95:D5:75:5A:5B:2B:45:7D:81:F3:69:2B:61:0A:98:67:2F:0E:1B
Issued:	Jun 27 06:28:33 2012 GMT
Expires:	Dec 31 15:59:59 2030 GMT

- **Trustis_FPS_Root_CA.crt**

Subject Name:	C = GB, O = Trustis Limited, OU = Trustis FPS Root CA
Fingerprint:	C1:B4:82:99:AB:A5:20:8F:E9:63:0A:CE:55:CA:68:A0:3E:DA:5A:51:9C:88:02:A0:D3:A6:73:BE:8F:8E:55:7D
Issued:	Dec 23 12:14:06 2003 GMT
Expires:	Jan 21 11:36:54 2024 GMT

- **Certigna_Root_CA.crt**

Subject Name:	C = FR, O = Dhimyotis, OU = 0002 48146308100036, CN = Certigna Root CA
Fingerprint:	D4:8D:3D:23:EE:DB:50:A4:59:E5:51:97:60:1C:27:77:4B:9D:7B:18:C9:4D:5A:05:95:11:A1:02:50:B9:31:68
Issued:	Oct 1 08:32:27 2013 GMT
Expires:	Oct 1 08:32:27 2033 GMT

- **Hongkong_Post_Root_CA_3.crt**

Subject Name:	C = HK, ST = Hong Kong, L = Hong Kong, O = Hongkong Post, CN = Hongkong Post Root CA 3
Fingerprint:	5A:2F:C0:3F:0C:83:B0:90:BB:FA:40:60:4B:09:88:44:6C:76:36:18:3D:F9:84:6E:17:10:1A:44:7F:B8:EF:D6
Issued:	Jun 3 02:29:46 2017 GMT
Expires:	Jun 3 02:29:46 2042 GMT

- **GeoTrust_Primary_Certification_Authority_-_G2.crt**

Subject Name:	C = US, O = GeoTrust Inc., OU = (c) 2007 GeoTrust Inc. - For authorized use only, CN = GeoTrust Primary Certification Authority - G2
Fingerprint:	5E:DB:7A:C4:3B:82:A0:6A:87:61:E8:D7:BE:49:79:EB:F2:61:1F:7D:D7:9B:F9:1C:1C:6B:56:6A:21:9E:D7:66

Issued:	Nov 5 00:00:00 2007 GMT
Expires:	Jan 18 23:59:59 2038 GMT

- **TUBITAK_Kamu_SM_SSL_Kok_Sertifikasi_-_Surum_1.crt**

Subject Name:	C = TR, L = Gebze - Kocaeli, O = Turkiye Bilimsel ve Teknolojik Arastirma Kurumu - TUBITAK, OU = Kamu Sertifikasyon Merkezi - Kamu SM, CN = TUBITAK Kamu SM SSL Kok Sertifikasi - Surum 1
Fingerprint:	46:ED:C3:68:90:46:D5:3A:45:3F:B3:10:4A:B8:0D:CA:EC:65:8B:26:60:EA:16:29:DD:7E:86:79:90:64:87:16
Issued:	Nov 25 08:25:55 2013 GMT
Expires:	Oct 25 08:25:55 2043 GMT

- **GDCA_TrustAUTH_R5_ROOT.crt**

Subject Name:	C = CN, O = "GUANG DONG CERTIFICATE AUTHORITY CO.,LTD.", CN = GDCA TrustAUTH R5 ROOT
Fingerprint:	BF:FF:8F:D0:44:33:48:7D:6A:8A:A6:0C:1A:29:76:7A:9F:C2:BB:B0:5E:42:0F:71:3A:13:B9:92:89:1D:38:93
Issued:	Nov 26 05:13:15 2014 GMT
Expires:	Dec 31 15:59:59 2040 GMT

- **Atos_TrustedRoot_2011.crt**

Subject Name:	CN = Atos TrustedRoot 2011, O = Atos, C = DE
Fingerprint:	F3:56:BE:A2:44:B7:A9:1E:B3:5D:53:CA:9A:D7:86:4A:CE:01:8E:2D:35:D5:F8:F9:6D:DF:68:A6:F4:1A:A4:74
Issued:	Jul 7 14:58:30 2011 GMT
Expires:	Dec 31 23:59:59 2030 GMT

- **Hellenic_Academic_and_Research_Institutions_RootCA_2015.crt**

Subject Name:	C = GR, L = Athens, O = Hellenic Academic and Research Institutions Cert. Authority, CN = Hellenic Academic and Research Institutions RootCA 2015
Fingerprint:	A0:40:92:9A:02:CE:53:B4:AC:F4:F2:FF:C6:98:1C:E4:49:6F:75:5E:6D:45:FE:0B:2A:69:2B:CD:52:52:3F:36
Issued:	Jul 7 10:11:21 2015 GMT
Expires:	Jun 30 10:11:21 2040 GMT

- **Go_Daddy_Root_Certificate_Authority_-_G2.crt**

Subject Name:	C = US, ST = Arizona, L = Scottsdale, O = "GoDaddy.com, Inc.", CN = Go Daddy Root Certificate Authority - G2
Fingerprint:	45:14:0B:32:47:EB:9C:C8:C5:B4:F0:D7:B5:30:91:F7:32:92:08:9E:6E:5A:63:E2:74:9D:D3:AC:A9:19:8E:DA
Issued:	Sep 1 00:00:00 2009 GMT
Expires:	Dec 31 23:59:59 2037 GMT

- **OISTE_WISeKey_Global_Root_GA_CA.crt**

Subject Name:	C = CH, O = WISeKey, OU = Copyright (c) 2005, OU = OISTE Foundation Endorsed, CN = OISTE WISeKey Global Root GA CA

Fingerprint:	41:C9:23:86:6A:B4:CA:D6:B7:AD:57:80:81:58:2E:02:07:97:A6:CB:DF:4F:FF:78:CE:83:96:B3:89:37:D7:F5
Issued:	Dec 11 16:03:44 2005 GMT
Expires:	Dec 11 16:09:51 2037 GMT

- **SSL.com_Root_Certification_Authority_ECC.crt**

Subject Name:	C = US, ST = Texas, L = Houston, O = SSL Corporation, CN = SSL.com Root Certification Authority ECC
Fingerprint:	34:17:BB:06:CC:60:07:DA:1B:96:1C:92:0B:8A:B4:CE:3F:AD:82:0E:4A:A3:0B:9A:CB:C4:A7:4E:BD:CE:BC:65
Issued:	Feb 12 18:14:03 2016 GMT
Expires:	Feb 12 18:14:03 2041 GMT

- **GeoTrust_Global_CA.crt**

Subject Name:	C = US, O = GeoTrust Inc., CN = GeoTrust Global CA
Fingerprint:	FF:85:6A:2D:25:1D:CD:88:D3:66:56:F4:50:12:67:98:CF:AB:AA:DE:40:79:9C:72:2D:E4:D2:B5:DB:36:A7:3A
Issued:	May 21 04:00:00 2002 GMT
Expires:	May 21 04:00:00 2022 GMT

- **Buypass_Class_2_Root_CA.crt**

Subject Name:	C = NO, O = Buypass AS-983163327, CN = Buypass Class 2 Root CA
Fingerprint:	9A:11:40:25:19:7C:5B:B9:5D:94:E6:3D:55:CD:43:79:08:47:B6:46:B2:3C:DF:11:AD:A4:A0:0E:FF:15:FB:48
Issued:	Oct 26 08:38:03 2010 GMT
Expires:	Oct 26 08:38:03 2040 GMT

- **Autoridad_de_Certificacion_Firmaprofesional_CIF_A62634068.crt**

Subject Name:	C = ES, CN = Autoridad de Certificacion Firmaprofesional CIF A62634068
Fingerprint:	04:04:80:28:BF:1F:28:64:D4:8F:9A:D4:D8:32:94:36:6A:82:88:56:55:3F:3B:14:30:3F:90:14:7F:5D:40:EF
Issued:	May 20 08:38:15 2009 GMT
Expires:	Dec 31 08:38:15 2030 GMT

- **Amazon_Root_CA_3.crt**

Subject Name:	C = US, O = Amazon, CN = Amazon Root CA 3
Fingerprint:	18:CE:6C:FE:7B:F1:4E:60:B2:E3:47:B8:DF:E8:68:CB:31:D0:2E:BB:3A:DA:27:15:69:F5:03:43:B4:6D:B3:A4
Issued:	May 26 00:00:00 2015 GMT
Expires:	May 26 00:00:00 2040 GMT

- **CA_Disig_Root_R2.crt**

Subject Name:	C = SK, L = Bratislava, O = Disig a.s., CN = CA Disig Root R2
Fingerprint:	E2:3D:4A:03:6D:7B:70:E9:F5:95:B1:42:20:79:D2:B9:1E:DF:BB:1F:B6:51:A0:63:3E:AA:8A:9D:C5:F8:07:03
Issued:	Jul 19 09:15:30 2012 GMT
Expires:	Jul 19 09:15:30 2042 GMT

- **Security_Communication_RootCA2.crt**

Subject Name:	C = JP, O = "SECOM Trust Systems CO.,LTD.", OU = Security Communication RootCA2
Fingerprint:	51:3B:2C:EC:B8:10:D4:CD:E5:DD:85:39:1A:DF:C6:C2:DD:60:D8:7B:B7:36:D2:B5:21:48:4A:A4:7A:0E:BE:F6
Issued:	May 29 05:00:39 2009 GMT
Expires:	May 29 05:00:39 2029 GMT

- **DigiCert_Assured_ID_Root_CA.crt**

Subject Name:	C = US, O = DigiCert Inc, OU = www.digicert.com, CN = DigiCert Assured ID Root CA
Fingerprint:	3E:90:99:B5:01:5E:8F:48:6C:00:BC:EA:9D:11:1E:E7:21:FA:BA:35:5A:89:BC:F1:DF:69:56:1E:3D:C6:32:5C
Issued:	Nov 10 00:00:00 2006 GMT
Expires:	Nov 10 00:00:00 2031 GMT

- **QuoVadis_Root_CA_3_G3.crt**

Subject Name:	C = BM, O = QuoVadis Limited, CN = QuoVadis Root CA 3 G3
Fingerprint:	88:EF:81:DE:20:2E:B0:18:45:2E:43:F8:64:72:5C:EA:5F:BD:1F:C2:D9:D2:05:73:07:09:C5:D8:B8:69:0F:46
Issued:	Jan 12 20:26:32 2012 GMT
Expires:	Jan 12 20:26:32 2042 GMT

- **Certum_Trusted_Network_CA.crt**

Subject Name:	C = PL, O = Unizeto Technologies S.A., OU = Certum Certification Authority, CN = Certum Trusted Network CA
Fingerprint:	5C:58:46:8D:55:F5:8E:49:7E:74:39:82:D2:B5:00:10:B6:D1:65:37:4A:CF:83:A7:D4:A3:2D:B7:68:C4:40:8E
Issued:	Oct 22 12:07:37 2008 GMT
Expires:	Dec 31 12:07:37 2029 GMT

- **emSign_Root_CA_-_G1.crt**

Subject Name:	C = IN, OU = emSign PKI, O = eMudhra Technologies Limited, CN = emSign Root CA - G1
Fingerprint:	40:F6:AF:03:46:A9:9A:A1:CD:1D:55:5A:4E:9C:CE:62:C7:F9:63:46:03:EE:40:66:15:83:3D:C8:C8:D0:03:67
Issued:	Feb 18 18:30:00 2018 GMT
Expires:	Feb 18 18:30:00 2043 GMT

- **AffirmTrust_Premium.crt**

Subject Name:	C = US, O = AffirmTrust, CN = AffirmTrust Premium
Fingerprint:	70:A7:3F:7F:37:6B:60:07:42:48:90:45:34:B1:14:82:D5:BF:0E:69:8E:CC:49:8D:F5:25:77:EB:F2:E9:3B:9A
Issued:	Jan 29 14:10:36 2010 GMT
Expires:	Dec 31 14:10:36 2040 GMT

- **thawte_Primary_Root_CA.crt**

Subject Name:	C = US, O = "thawte, Inc.", OU = Certification Services Division, OU = "(c) 2006 thawte, Inc. - For authorized use only", CN = thawte Primary Root CA
Fingerprint:	8D:72:2F:81:A9:C1:13:C0:79:1D:F1:36:A2:96:6D:B2:6C:95:0A:97:1D:B4:6B:41:99:F4:EA:54:B7:8B:FB:9F
Issued:	Nov 17 00:00:00 2006 GMT
Expires:	Jul 16 23:59:59 2036 GMT

- **NetLock_Arany_=Class_Gold=_Fotanúsítvány.crt**

Subject Name:	C = HU, L = Budapest, O = NetLock Kft., OU = Tan\C3\BAs\C3\ADtv \C3\A1nykiad\C3\B3k (Certification Services), CN = NetLock Arany (Class Gold) F\C5\91tan\C3\BAs\C3\ADtv\C3\A1ny
Fingerprint:	6C:61:DA:C3:A2:DE:F0:31:50:6B:E0:36:D2:A6:FE:40:19:94:FB:D1:3D:F9:C8:D4:66:59:92:74:C4:46:EC:98
Issued:	Dec 11 15:08:21 2008 GMT
Expires:	Dec 6 15:08:21 2028 GMT

6.7.4 Managing CA Certificates for the Trusted Certificate Store

To establish trust between the device and an endpoint (e.g. server, portal, etc.), add the necessary CA certificates to the Trusted Certificate Store.

6.7.4.1 Viewing a List of CA Certificates Added to the Trusted Certificate Store

To view a list of CA certificates added to the Trusted Certificate Store, type:

```
show admin system-ca-certificates configured-cas
```

If CA certificates have been added to the Store, a table or list similar to the following example appears:

```
ruggedcom# show running-config admin system-ca-certificates configured-cas | tab
NAME
------
cert

!
```

If no CA certificates have been added to the Store, add certificates as needed. For more information, refer to "Adding a CA Certificate to the Trusted Certificate Store (Page 197)".

6.7.4.2 Adding a CA Certificate to the Trusted Certificate Store

To add a CA certificate to the Trusted Certificate Store, do the following:

1. Make sure the CLI is in Configuration mode.

2. Add the CA certificate by typing:

   ```
   admin system-ca-certificates configured-cas
   { certificate }
   ```

   Where { certificate } is the chosen CA certificate.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.7.4.3 Deleting a CA Certificate from the Trusted Certificate Store

To delete a CA certificate from the Trusted Certificate Store, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the CA certificate from the store by typing:

   ```
   no admin system-ca-certificates configured-cas
   { certificate }
   ```

   Where { certificate } is the chosen CA certificate.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.7.5 Managing CA Certificates and CRLs

This section describes how to view, add and delete Certified Authority (CA) certificates and Certificate Revocation Lists (CRLs) on the device.

6.7.5.1 Viewing a List of CA Certificates and CRLs

To view a list of certificates issued by a Certified Authority (CA) and the Certificate Revocation Lists (CRLs) associated with them, type:

```
show running-config security crypto ca
```

If certificates have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config security crypto ca security crypto ca ca-cert key-
cert-sign-certificate
```

If no certificates have been configured, add certificates as needed. For more information, refer to "Adding a CA Certificate and CRL (Page 200)".

6.7.5.2 Viewing the Status of a CA Certificate and CRL

To view the status of a CA certificate, type:

```
show security crypto ca { certificate } key-cert-sign-certificate-status
```

Where:

- `{ certificate }` is the name of the certificate

This table or list provides the following information:

Parameter	Description
`issuer`	**Synopsis:** A string
`subject`	**Synopsis:** A string
`not-before`	**Synopsis:** A string This certificate is not valid before this date.
`not-after`	**Synopsis:** A string This certificate is not valid after this date.

To view the status of a Certificate Revocation List (CRL) that was signed by a separate certificate, type:

```
show security crypto ca { certificate } crl-sign-certificate-status
```

Where:

- `{ certificate }` is the name of the certificate

This table or list provides the following information:

Parameter	Description
`issuer`	**Synopsis:** A string
`subject`	**Synopsis:** A string
`not-before`	**Synopsis:** A string This certificate is not valid before this date.
`not-after`	**Synopsis:** A string This certificate is not valid after this date.

To view the status of a Certificate Revocation List (CRL) that was not signed by a separate certificate, type:

```
show security crypto ca { certificate } crl-status
```

Where:

- `{ certificate }` is the name of the certificate

This table or list provides the following information:

Parameter	Description
`issuer`	**Synopsis:** A string
`this-update`	**Synopsis:** A string This CRL was updated at this date and time.
`next-update`	**Synopsis:** A string This CRL must be updated by this date and time.

6.7.5.3 Adding a CA Certificate and CRL

To add a certificate issued by a Certified Authority (CA) and its associated Certificate Revocation List (CRL), do the following:

Note
Only admin users can read/write certificates and keys on the device.

1. Enable auto-wizard by typing:

   ```
   autowizard  true
   ```

2. Make sure the CLI is in Configuration mode.

   Note
   Before inserting the contents of the certificate, enter multi-line mode by pressing **Esc+m**. Press **Ctrl+d** to exit multi-line mode after the certificate has been added.

3. Add the CA certificate by typing:

   ```
   security crypto ca { certificate } key-cert-sign-
   certificate { contents }
   ```

   Where:

   - `{ certificate }` is the name of the certificate
   - `{ contents }` is the contents of the certificate

4. Add the associated Certificate Revocation List (CRL).

   Note
   Large CRLs (bigger than 100KB) are not currently supported and may be difficult to add/view in the configuration.

   Note
   Before inserting the contents of the CRL, enter multi-line mode by pressing **Esc +m**. Press **Ctrl+d** to exit multi-line mode after the CRL has been added.

- If the CRL is signed by a separate certificate, type:

  ```
  security crypto ca { certificate } crl-sign-
  certificate { contents }
  ```

  Where:

  - `{ certificate }` is the name of the certificate
  - `{ contents }` is the contents of the signed CRL
- If the CRL is not signed, type:

  ```
  security crypto ca { certificate } crl
  { contents }
  ```

  Where:

  - `{ certificate }` is the name of the certificate
  - `{ contents }` is the contents of the CRL

5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.7.5.4 Deleting a CA Certificate and CRL

To delete a certificate issued by a Certified Authority (CA) and its associated Certificate Revocation List (CRL), do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the CA certificate and its associated Certificate Revocation List (CRL) by typing:

   ```
   no security crypto ca { certificate }
   ```

   Where:

   - `{ certificate }` is the name of the certificate
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.7.6 Managing Private Keys

This section describes how to view, add and delete private keys on the device.

Note
Private keys are automatically encrypted using an AES-CFB-128 cipher to protect them from being viewed by unauthorized users.

6.7.6.1 Viewing a List of Private Keys

To view a list of unsigned private keys, type:

```
show running-config security crypto private-key
```

If private keys have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config security crypto private-key
security
 crypto
  private-key key
   algorithm rsa
   contents
   "{--contents--}"
  !
 !
!
```

If no private keys have been configured, add keys as needed. For more information, refer to "Adding a Private Key (Page 202)".

6.7.6.2 Adding a Private Key

To add an unsigned private key, do the following:

Note
DSA keys are not supported on SSH, NETCONF or WebUI services.

Note
Private keys for SSH servers or HTTPS access must be in PEM format and **algorithm** is set to **rsa**.

1. Make sure the CLI is in Configuration mode.
2. Add the private key by typing:

   ```
   security crypto private-key { name }
   ```

   Where:

   - `{ name }` is the name of the private key
3. Configure the following parameter(s) as required:

   Note
   Before inserting the contents of the key, enter multi-line mode by pressing **Esc +m**. Press **Ctrl+d** to exit multi-line mode after the key has been added.

Parameter	Description
`algorithm { algorithm }`	**Synopsis:** [rsa | dsa | ssh-rsa] The type of key.

Parameter	Description
`contents { contents }`	**Synopsis:** A string between 1 and 8192 characters long The contents of the unsigned private key.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.7.6.3 Deleting a Private Key

To delete an unsigned private key, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the private key by typing:

   `no security crypto private-key { name }`

   Where { name } is the name of the private key
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.7.7 Managing Public Keys

This section describes how to manage public keys on the device.

6.7.7.1 Viewing a List of Public Keys

To view a list of unsigned public keys, type:

`show running-config security crypto public-key`

If public keys have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config security crypto public-key
security
crypto
  public-key ipsec-generated
   algorithm        rsa
   contents         "{--contents--}"
   private-key-name ipsec-generated
  !
!
!
```

If no public keys have been configured, add keys as needed. For more information, refer to "Adding a Public Key (Page 204)".

6.7.7.2 Adding a Public Key

To add an unsigned public key, do the following:

Note
Do not associate the public key with the private key if the public key belongs to another device.

1. Make sure the private key associated with the public key has been added. For more information, refer to "Adding a Private Key (Page 202)".
2. Enable auto-wizard by typing:

   ```
   autowizard  true
   ```

3. Make sure the CLI is in Configuration mode.
4. Add the public key by typing:

   ```
   security  crypto  public-key  { name }
   ```

   Where:

   - `{ name }` is the name of the public key

5. Configure the following parameter(s) as required:

   Note
   Before inserting the contents of the key, enter multi-line mode by pressing **Esc +m**. Press **Ctrl+d** to exit multi-line mode after the key has been added.

   Note
   For added security, consider adding an IPSec-formatted public key. For more information, refer to "Adding an IPSec-Formatted Public Key (Page 205)".

   Note
   When adding a public key for a known host when RUGGEDCOM ROX II is acting as an SSH client, make sure the key is in the OpenSSH public key format and the public key algorithm is set to *ssh-rsa*.

Parameter	Description
`algorithm { algorithm }`	**Synopsis:** [rsa | dsa | ssh-rsa] The algorithm of the key.
`contents { contents }`	**Synopsis:** A string between 1 and 8192 characters long The contents of the key.
`private-key-name { private-key-name }`	**Synopsis:** A string between 1 and 255 characters long The private key name associated with this public key.

6. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.7.7.3 Adding an IPSec-Formatted Public Key

IPSec-formatted public keys from systems that do not support the Privacy-Enhanced Mail (PEM) format, such as RUGGEDCOM ROX devices, can be imported into RUGGEDCOM ROX II and automatically converted.

Once added to the RUGGEDCOM ROX II database, the IPSec-formatted public key is visible via the **System Public Key** form under ***tunnel » ipsec » connection » {name} » {end}***, where *{name}* is the name of the connection and *{end}* is the either the left (local router) or right (remote router) connection end. **Type** must be set to **rsasig** to display the public key.

The public key can be copied from the **System Public Key** form and added to another RUGGEDCOM ROX II device, as described in the following procedure, or to a RUGGEDCOM ROX device.

To add an IPSec-formatted public key and have it converted into PEM format, do the following:

1. Make sure the desired public key has been added. For more information about adding a public key, refer to "Adding a Public Key (Page 204)".
2. Enable auto-wizard by typing:

   ```
   autowizard true
   ```

3. Make sure the CLI is in Configuration mode.
4. Type the following command:

   ```
   security crypto public-key { name } add-ipsec-formatted-public-key content
   ```

   Where:

   - `{ name }` is the name of the public key

   The CLI enters multi-line mode.
5. Enter the contents of the public key, pressing **Enter** for each new line. When finished, press **Ctrl-D**. The public keys is converted to PEM format and added to RUGGEDCOM ROX II.
6. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.7.7.4 Deleting a Public Key

To delete an unsigned public key, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the public key by typing:

   ```
   no security crypto public-key { name }
   ```

   Where { name } is the name of the public key

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.7.8 Managing Certificates

This section describes how to manage certificates on the device.

6.7.8.1 Viewing a List of Certificates

To view a list of certificates, type:

```
show running-config security crypto certificate
```

If certificates have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config security crypto certificate
security
 crypto
  certificate cert
   contents         "{--contents--}"
   private-key-name key
   ca-name          ca-cert
  !
 !
!
```

If no certificates have been configured, add certificates as needed. For more information, refer to "Adding a Certificate (Page 207)".

6.7.8.2 Viewing the Status of a Certificate

To view the status of a certificate, type:

```
show security crypto certificate { certificate } status
```

Where:

- `{ certificate }` is the name of the certificate

```
ruggedcom# show security crypto certificate ssl-cert status
status
 issuer     /C=CA/ST=Ontario/L=Concord/O=RuggedCom.com/OU=RC/
CN=localhost.localdomain
 subject    /C=CA/ST=Ontario/L=Concord/O=RuggedCom.com/OU=RC/
CN=localhost.localdomain
 not before 2017-01-06T18:45:49-00:00
 not after  2037-01-03T18:45:49-00:00
```

This table or list provides the following information:

Parameter	Description
`issuer`	**Synopsis:** A string
`subject`	**Synopsis:** A string
`not-before`	**Synopsis:** A string This certificate is not valid before this date.
`not-after`	**Synopsis:** A string This certificate is not valid after this date.

6.7.8.3 Adding a Certificate

To add a certificate, do the following:

Note
Only admin users can read/write certificates and keys on the device.

1. Make sure the required CA certificates and/or private keys have been added to the device.
   - For more information about adding CA Certificates, refer to "Adding a CA Certificate and CRL (Page 200)"
   - For more information about adding private keys, refer to "Adding a Private Key (Page 202)"
2. Make sure the CLI is in Configuration mode.
3. Add the certificate by typing:

   ```
   security crypto certificate { certificate }
   ```

   Where { certificate } is the name of the certificate.
4. Configure the following parameter(s) as required:

   Note
   Before inserting the contents of the certificate, enter multi-line mode by pressing **Esc+m**. Press **Ctrl+d** to exit multi-line mode after the certificate has been added.

Parameter	Description
`contents { contents }`	**Synopsis:** A string between 1 and 8192 characters long The contents of the certificate.
`private-key-name { private-key-name }`	**Synopsis:** A string between 1 and 255 characters long The private key associated with this certificate.
`ca-name { ca-name }`	**Synopsis:** A string between 1 and 255 characters long The optional CA certificate for this certificate.

5. [Optional] Select the certificate as the certificate to use for SSL/SSH connections. For more information, refer to "Configuring Session Security (Page 172)".
6. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.7.8.4 Deleting a Certificate

To delete a certificate, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the certificate by typing:

   ```
   no security crypto certificate { certificate }
   ```

   Where:

   - `{ certificate }` is the name of the certificate.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.7.9 Managing Known Hosts

RUGGEDCOM ROX II maintains a Known Hosts list for defining each SSH (SFTP) server the device pulls updates or files from. Servers are identified by their host name or IP address, and authenticated by the known hosts file stored on the device. Users can further define a specific port on the server designated for SSH communications and/or an SSH/RSA public key.

Note
Before any interactions with a remote SFTP server can take place (i.e. installing files, backing up files, or upgrading/downgrading the software), the server's public key must be pre-configured as a known host. This updates the trust store and allows RUGGEDCOM ROX II to securely connect to the remote SFTP server.

Other SSH-based client features, such as SCP file transfers and connecting via SSH from the device to another SSH server, will also reference known hosts, but with the following exception:

- RUGGEDCOM ROX II will still access an SCP server even if the server's public key is not pre-configured as a known host. In this case, the server's public key fingerprint is displayed for visual verification in the CLI before the connection is made. This can be removed by pre-configuring the SCP server's public key as a known host.

6.7.9.1 Viewing a List of Known Hosts

To view a list of servers defined in the Known Hosts list, type:

```
show running-config admin known-hosts
```

If servers have been defined, a table or list similar to the following example appears:

```
ruggedcom# show running-config admin known-hosts | tab
admin
 known-hosts
  server-identification
                                SERVER
                        SERVER  PUBLIC
NAME    SERVER ID       PORT    KEY     ENABLED
-------------------------------------------------
server  172.30.145.203  34      server  X

 !
!
```

If no servers have been configured, add servers as needed. For more information, refer to "Adding a Known Host (Page 209)".

6.7.9.2 Adding a Known Host

To add a server to the Known Hosts list, do the following:

1. Make sure the server's public key has been added to the device. For more information, refer to "Managing Public Keys (Page 203)".
2. Make sure the CLI is in Configuration mode.
3. Add the server by typing:

   ```
   admin known-hosts server-identification { name }
   server-id { id } server-port { port } server-
   public-key { key } enabled
   ```

   Where:

   - { name } is the unique name of the server.
   - { id } is the name to identify the server. The name may be host name or the server's IP address.
   - { port } is a specific port on the server configured for SSH communications. If no port is specified, RUGGEDCOM ROX II will access any port on the server that supports SSH.
   - { key } is the authorized SSH/RSA public key associated with the server.
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.7.9.3 Deleting a Known Host

To delete a server from the Known Hosts list, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the desired server by typing:

   ```
   no admin known-hosts server-identification { name }
   ```

   Where { name } is the unique name of the server.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.7.10 Managing SCEP

The Simple Certificate Enrollment Protocol (SCEP) is a scalable certificate management protocol for the automatic issuance and renewal of certificates in enterprise environments.

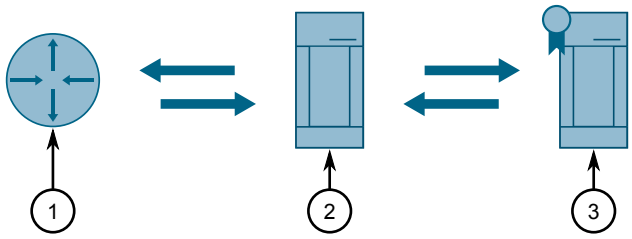
SCEP is used by network administrators to quickly and automatically issue Public Key Infrastructure (PKI) certificates to devices, as opposed to manually managing certificates for each individual device.

SCEP is an open-source protocol described in RFC 8894 [https://tools.ietf.org/html/rfc8894].

6.7.10.1 Understanding SCEP

In an SCEP environment, there are three entities:

- the SCEP client (or requester)
- the SCEP server
- and a Certificate Authority (CA)



① SCEP Client
② SCEP Server
③ Certificate Authority (CA)

Figure 6.2 SCEP Entities

RUGGEDCOM ROX II devices take the role of SCEP clients.

As an SCEP client, the device can retrieve CA certificates and SCEP certificates from an SCEP server. The server requests CA certificates from a root CA.

Every SCEP client requires a challenge password to authenticate itself with the SCEP server. This is a one-time password (OTP) provided out-of-band (OOB) by the server. When the client requests a new SCEP certificate, it provides the challenge password to the SCEP server, along with a self-generated private key and Certificate Signing Request (CSR). The CSR is derived from the client's configuration settings.

Once retrieved, the SCEP certificate can be used by IPsec.

When an SCEP certificate already exists on the device, the client can renew it automatically before it expires. The challenge password is not required when renewing an existing certificate.

⚠ NOTICE

Security hazard – risk of unauthorized access or exploitation

SCEP communications between the client and server must be protected within a secure network environment.

⚠ NOTICE

Security hazard – risk of unauthorized access or exploitation

The CA fingerprint must be obtained out-of-band (OOB) using a secure method. Receiving a fingerprint from a malicious entity could compromise authentication with the SCEP server.

Note
Certificate revocation is not available through SCEP. Contact the CA for alternative methods.

Note
SCEP certificates cannot be renewed once they have expired.

6.7.10.2 Configuring SCEP

To configure SCEP, do the following:

1. **Configure the SCEP server.**

   The FAQ "How to configure a SCEP server" [https://support.industry.siemens.com/cs/ww/en/view/109811508] provides guidance on how to configure a SCEP server using Windows Server and SICAM GridPass. For other SCEP servers, refer to the server's documentation for instructions.

2. **Obtain information from the SCEP server out-of-band.**

   This includes the following:

   - Server's URL
   - Challenge password (or shared secret)

- CA fingerprint algorithm
- Certificate hash
- Encryption algorithm
- Signature algorithm

⚠ NOTICE

Security hazard – risk of unauthorized access

Make sure the SCEP server is configured to issue only one challenge password per device and expire passwords after a short period of time. This protects the integrity of the secure network, reducing the risk of rogue devices entering the network.

3. **Configure the SCEP client.**

   This includes defining the URL of the SCEP server, CA certificate name and hash, and polling settings.

   For more information, refer to "Configuring the SCEP Client (Page 212)".

4. **Configure information that will be included in Certificate Signing Requests (CSRs).**

   This includes the subject alternative name, locality, organization, key size, and more.

   For more information, refer to "Configuring the SCEP Certificate Signing Requests (Page 213)".

5. **Retrieve a CA certificate from the SCEP server.**

   The CA certificate is required before an SCEP certificate can be request.

   For more information, refer to "Retrieving an SCEP CA Certificate (Page 215)".

6. **Retrieve the SCEP certificate from the server.**

   For more information, refer to "Retrieving an SCEP Certificate (Page 215)".

7. **Configure and enable automatic renewal of the SCEP certificate.**

   Once automatic renewal is enabled, the SCEP client will automatically renew SCEP certificate before it expires.

   For more information, refer to "Configuring Automatic Certificate Renewal (Page 216)".

8. **[Optional] Verify the CA certificate was added to the device.**

   For more information, refer to "Viewing the Status of a Certificate (Page 206)".

6.7.10.3 Configuring the SCEP Client

To configure the SCEP client, do the following:

1. Make sure the CLI is in Configuration mode.

2. Navigate to ***security » crypto » scep » scep-config*** and configure the following parameter(s) as required:

Note
The names of the SCEP CA certificate (**ca-certificate-name**) can only be changed if the certificate does not already exist on the device.

Parameter	Description
`server-url { server-url }`	**Synopsis:** A string between 1 and 1024 characters long The URL of the SCEP server.
`ca-certificate-name { ca-certificate-name }`	**Synopsis:** A string between 1 and 255 characters long **Default:** scep-ca The name of the SCEP CA certificate.
`ca-certificate-hash-value { ca-certificate-hash-value }`	**Synopsis:** A string between 1 and 256 characters long The hash value of the CA certificate obtained from the SCEP server for verification.
`ca-certificate-hash-type { ca-certificate-hash-type }`	**Synopsis:** [sha256 | sha1 | md5] **Default:** md5 The type of the hash value of the CA certificate obtained from the SCEP server.
`maximum-number-of-requests { maximum-number-of-requests }`	**Synopsis:** An integer between 1 and 256 **Default:** 60 The maximum number of SCEP certificate polling requests. Default is 60.
`max-polling-time { max-polling-time }`	**Synopsis:** An integer between 1 and 28800 **Default:** 3600 The maximum SCEP certificate polling time in seconds. Default is 3600.
`polling-interval { polling-interval }`	**Synopsis:** An integer between 1 and 3600 **Default:** 60 The interval in seconds between SCEP certificate polling attempts. Default is 60 seconds.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.7.10.4 Configuring the SCEP Certificate Signing Requests

To configure information that will be included in SCEP Certificate Signing Requests (CSRs), do the following:

1. Make sure the CLI is in Configuration mode.

2. Navigate to ***security » crypto » scep*** and configure the following parameter(s) as required:

Note
The names of the SCEP certificate (**certificate-name**) and private key (**private-key-name**) can only be changed if the associated file does not already exist on the device.

Parameter	Description
`subject-alternative-name { subject-alternative-name }`	**Synopsis:** A string between 1 and 128 characters long The subject alternative name associated with the SCEP certificate.
`subject-alternative-name-type { subject-alternative-name-type }`	**Synopsis:** [ip | email | dns] **Default:** dns The subject alternative name type associated with the SCEP certificate. Default is 'dns'.
`country { country }`	**Synopsis:** A string The country associated with the SCEP certificate.
`state-or-province { state-or-province }`	**Synopsis:** A string 128 characters long The state or province name associated with the SCEP certificate.
`locality { locality }`	**Synopsis:** A string 128 characters long The locality associated with the SCEP certificate.
`organization { organization }`	**Synopsis:** A string 64 characters long The organization associated with the SCEP certificate.
`organizational-unit { organizational-unit }`	**Synopsis:** A string 64 characters long The organizational unit associated with the SCEP certificate
`key-size { key-size }`	**Synopsis:** [4096 | 2048 | 1024] **Default:** 2048 The key size in bits, default is 2048
`certificate-name { certificate-name }`	**Synopsis:** A string between 1 and 255 characters long **Default:** scep-cert The name of the SCEP certificate.
`private-key-name { private-key-name }`	**Synopsis:** A string between 1 and 255 characters long **Default:** scep-rsa The name of the private key.
`encryption-algorithm { encryption-algorithm }`	**Synopsis:** [aes256 | aes192 | aes128 | 3des] **Default:** aes128 The encryption algorithm.

Parameter	Description
`signature-algorithm { signature-algorithm }`	**Synopsis:** [sha512 | sha384 | sha256 | sha224 | sha1] **Default:** sha256 The signature algorithm.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.7.10.5 Retrieving an SCEP CA Certificate

To retrieve an SCEP CA certificate from the SCEP server, do the following:

Note
A CA certificate is required as part of the Certificate Signing Request (CSR) sent when requesting an SCEP certificate. As such, the CA certificate must be obtained before the SCEP certificate is requested.

1. Make sure the CLI is in Configuration mode.
2. Request the SCEP certificate by entering the following command:

```
security crypto scep get-ca fingerprint-algorithm
[ sha1 | sha224 | sha256 | sha384 | sha512 ]
```

The device requests a CA certificate with the selected fingerprint algorithm from the SCEP server. Upon receipt, the certificate is added to the list of CA certificates.

6.7.10.6 Retrieving an SCEP Certificate

To retrieve an SCEP certificate, do the following:

1. Make sure the CLI is in Configuration mode.
2. Request the SCEP certificate by entering the following command:

```
security crypto scep get-certificate challenge-
password { password }
```

Where { password } is the challenge password (up to 128 characters long) provided by the SCEP server. The password is required to authenticate the device to the SCEP server if the SCEP certificate on the device has expired.

Upon entering the challenge password, the device generates a private key and Certificate Signing Request (CSR), which it then uses to request an SCEP certificate from the SCEP server. When the certificate is received, it is saved and added to the list of device certificates, along with the private key and CA certificate.

6.7.10.7 Configuring Automatic Certificate Renewal

To configure automatic certificate renewal, do the following:

Note
SCEP certificates cannot be renewed once they have expired.

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***security » crypto » scep*** and configure the following parameter(s) as required:

Parameter	Description
`enable { enable }`	**Synopsis:** [true | false] When enabled, the SCEP certificate will be automatically renewed at the configured time. Default is false.
`time-before-expiry { time-before-expiry }`	**Synopsis:** An integer between 1 and 365 **Default:** 14 The number of days or hours before expiry when the SCEP certificate will be automatically renewed. Default is 14.
`unit-of-time { unit-of-time }`	**Synopsis:** [hours | days] **Default:** days The unit of time in which the time before the SCEP certificate expiry is displayed. Default is 'days'.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.7.10.8 Renewing an Expired SCEP Certificate

SCEP certificates that have expired must be renewed by the user. Automatic renewal is only available for active certificates.

To renew an expired SCEP certificate, do the following:

1. Obtain a new challenge password (or shared secret) from the SCEP server.
2. Using the new challenge password, retrieve a new SCEP certificate from the SCEP server.

   For more information, refer to "Retrieving an SCEP Certificate (Page 215)".

6.7.10.9 Renewing an SCEP CA Certificate

SCEP CA certificates cannot be renewed automatically and, therefore, must be renewed by an administrator before or after they expire.

To renew an expired SCEP CA certificate, do the following:

1. Determine the fingerprint algorithm used by the SCEP server.

2. Retrieve a new SCEP CA certificate from the SCEP server, making sure to specify the correct fingerprint algorithm.

   For more information, refer to "Retrieving an SCEP CA Certificate (Page 215)".

6.8 Managing Firewalls

Firewalls are software systems designed to prevent unauthorized access to or from private networks. Firewalls are most often used to prevent unauthorized Internet users from accessing private networks (Intranets) connected to the Internet.

When the RUGGEDCOM ROX II firewall is enabled, the router serves as a gateway machine through which all messages entering or leaving the Intranet pass. The router examines each message and blocks those that do not meet the specified security criteria. The router also acts as a proxy, preventing direct communication between computers on the Internet and Intranet. Proxy servers can filter the kinds of communication that are allowed between two computers and perform address translation.

Note
In general, the RUGGEDCOM ROX II firewall implementation will maintain established connections. This applies when adding, deleting, or changing rules, and also when adding, deleting, or changing policies. When applying new, or modified, rules or policies, previous traffic seen by the router might still be considered as having valid connections by the connection tracking table. For instance:

1. A rule for the TCP and UDP protocols is applied.
2. The router sees both TCP and UDP traffic that qualifies for NAT.
3. The rule is then modified to allow only UDP.
4. The router will still see TCP packets (i.e. retransmission packets).

If required, reboot the router to flush all existing connection streams.

RUGGEDCOM ROX II employs a stateful firewall system known as netfilter, a subsystem of the Linux kernel that provides the ability to examine IP packets on a per-session basis.

For more information about firewalls, refer to "Firewall Concepts (Page 217)".

6.8.1 Firewall Concepts

This section describes some of the concepts important to the implementation of firewalls in RUGGEDCOM ROX II.

6.8.1.1 Stateless vs. Stateful Firewalls

There are two types of firewalls: stateless and stateful.

Stateless or static firewalls make decisions about traffic without regard to traffic history. They simply open a path for the traffic type based on a TCP or UDP port number. Stateless firewalls are relatively simple, easily handling Web and e-mail traffic. However, stateless firewalls have some disadvantages. All paths opened in the firewall are always open, and connections are not opened or closed based on outside criteria. Static IP filters offer no form of authentication.

Stateful or session-based firewalls add considerably more complexity to the firewalling process. They track the state of each connection, look at and test each packet (connection tracking), and recognize and manage as a whole traffic from a particular protocol that is on connected sets of TCP/UDP ports.

6.8.1.2 Linux netfilter

Netfilter, a subsystem of the Linux kernel, is a stateful firewall that provides the ability to examine IP packets on a per-session basis.

Netfilter uses rulesets, which are collections of packet classification rules that determine the outcome of the examination of a specific packet. The rules are defined by iptables, a generic table structure syntax and utility program for the configuration and control of netfilter.

RUGGEDCOM ROX II implements an IP firewall using a structured user interface to configure iptables rules and netfilter rulesets.

6.8.1.3 Network Address Translation

Network Address Translation (NAT) enables a LAN to use one set of IP addresses for internal traffic and a second set for external traffic. The netfilter NAT function makes all necessary IP address translations as traffic passes between the Intranet and the Internet. NAT is often referred to in Linux as IP Masquerading.

NAT itself provides a type of firewall by hiding internal IP addresses. More importantly, NAT enables a network to use more internal IP addresses. Since they are only used internally, there is no possibility of conflict with IP addresses used by other organizations. Typically, an internal network is configured to use one or more of the reserved address blocks described in RFC1918.

Table RFC1918 Reserved IP Address Blocks

IP Network/Mask	Address Range
10.0.0.0/8	10.0.0.0 – 10.255.255.255
172.16.0.0/12	172.16.0.0 – 172.31.255.255
192.168.0.0/16	192.168.0.0 – 192.168.255.255

When a packet from a host on the internal network reaches the NAT gateway, its source address and source TCP/UDP port number are recorded. The address and port number is translated to the public IP address and an unused port number on the public interface. When the Internet host replies to the internal host's packet, it is addressed to the NAT gateway's external IP address at the translation port number.

The NAT gateway searches its tables and makes the opposite changes it made to the outgoing packet. NAT then forwards the reply packet to the internal host.

Translation of ICMP packets happens in a similar fashion, but without the source port modification.

NAT can be used in static and dynamic modes. Static NAT (SNAT) masks the private IP addresses by translating each internal address to a unique external address. Dynamic NAT translates all internal addresses to one or more external addresses.

6.8.1.4 Port Forwarding

Port forwarding, also known as redirection, allows traffic coming from the Internet to be sent to a host behind the NAT gateway.

Previous examples have described the NAT process when connections are made from the Intranet to the Internet. In those examples, addresses and ports were unambiguous.

When connections are attempted from the Internet to the Intranet, the NAT gateway will have multiple hosts on the Intranet that could accept the connection. It needs additional information to identify the specific host to accept the connection.

Suppose that two hosts, 192.168.1.10 and 192.168.1.20 are located behind a NAT gateway having a public interface of 213.18.101.62. When a connection request for http port 80 arrives at 213.18.101.62, the NAT gateway could forward the request to either of the hosts (or could accept it itself). Port forwarding configuration could be used to redirect the requests to port 80 to the first host.

Port forwarding can also remap port numbers. The second host may also need to answer http requests. As connections to port 80 are directed to the first host, another port number (such as 8080) can be dedicated to the second host. As requests arrive at the gateway for port 8080, the gateway remaps the port number to 80 and forwards the request to the second host.

Port forwarding also takes the source address into account. Another way to solve the above problem could be to dedicate two hosts 200.0.0.1 and 200.0.0.2 and have the NAT gateway forward requests on port 80 from 200.0.0.1 to 192.168.1.10 and from 200.0.0.2 to 192.168.1.20.

6.8.1.5 Protecting Against a SYN Flood Attack

RUGGEDCOM ROX II responds to SYN packets according to the TCP standard by replying with a SYN-ACK packet for open ports and an RST packet for closed ports. If the device is flooded by a high frequency of SYN packets, the port being flooded may become unresponsive.

To prevent SYN flood attacks on closed ports, set the firewall to block all traffic to closed ports. This prevents SYN packets from reaching the kernel.

Siemens also recommends setting the listen ports to include IP addresses on separate interfaces. For example, set the device to listen to an IP address on switch.0001 and fe-cm-1. This will make sure that one port is accessible if the other is flooded.

6.8.1.6 Protecting Against IP Spoofing

IP spoofing is a technique where IP packets are created with a false source IP address, with the intent of concealing the identity of the sender or impersonating a trusted host. As a result, unauthorized users can gain access to a network.

In RUGGEDCOM ROX II, IP spoofing can be prevented by enabling the **routefilter** and **logmartians** for the firewall interface.

For information about enabling **routefilter** and **logmartians**, refer to "Adding an Interface (Page 228)".

6.8.1.7 Active and Working Firewall Configurations

To safely make changes to the firewall settings without first disabling the firewall or making changes live during operation, RUGGEDCOM ROX II supports an active and a working configuration. The active configuration is the configuration that will be used when the firewall is enabled. The working configuration is an alternate configuration that can be modified and validated without affecting the current firewall settings.

⚠ NOTICE

Configuration hazard – risk of authorized access

Only make changes to the working firewall configuration and make sure all changes are validated before enabling the working configuration as the new active configuration. Do not make changes to the current active configuration. The firewall will be disabled automatically if any validation errors are detected in the active configuration.

6.8.2 Viewing a List of Firewalls

To view a list of firewalls, type:

```
show running-config security firewall fwconfig
```

If firewalls have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config security firewall fwconfig
security
 firewall
  fwconfig firewall1
  !
  fwconfig firewall2
  !
 !
```

```
!
```

If no firewalls have been configured, add firewalls as needed. For more information, refer to "Adding a Firewall (Page 221)".

6.8.3 Adding a Firewall

To add a new firewall, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the firewall by typing:

   ```
   security firewall fwconfig { firewall }
   ```

   Where:

   - `{ firewall }` is the name of the firewall
3. Configure the following parameter(s) as required:

Parameter	Description
`description` `{ description }`	**Synopsis:** A string An optional description string.

4. Add interfaces associated with the firewall. For more information about adding interfaces, refer to "Adding an Interface (Page 228)".
5. Add network zones for the firewall. Make sure a zone with the type **firewall** exists. For more information about adding network zones, refer to "Adding a Zone (Page 226)".
6. Associate an interface with each zone. For more information about associating interfaces with zones, refer to "Associating an Interface with a Zone (Page 229)".
7. Set the default policies for traffic control between zones. Make sure the policies are as restrictive as possible. For more information about configuring policies, refer to "Managing Policies (Page 233)".
8. Configure the network address translation (NAT), masquerading or static network address translation (SNAT) settings. For more information about configuring NAT settings, refer to "Managing Network Address Translation Settings (Page 236)". For more information about configuring masquerading and/or SNAT settings, refer to "Managing Masquerade and SNAT Settings (Page 238)".
9. If hosts on the network must accept sessions from the Internet, configure the firewall to support Destination Network Address Translation (DNAT). For more information about configuring hosts, refer to "Managing Hosts (Page 230)".
10. If required, configure rules that override the default policies. For more information about configuring rules, refer to "Managing Rules (Page 240)".
11. If required, configure support for a VPN. For more information, refer to:

- "Configuring the Firewall for a VPN (Page 223)"
- "Configuring the Firewall for a VPN in a DMZ (Page 224)"

12. Validate the configuration. For more information about validating a firewall configuration, refer to "Validating a Firewall Configuration (Page 245)".
13. Enable the firewall. For more information, refer to "Enabling/Disabling a Firewall (Page 245)".
14. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.8.4 Deleting a Firewall

To delete a firewall, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the firewall by typing:

   ```
   no security firewall fwconfig { firewall }
   ```

   Where { firewall } is the name of the firewall.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.8.5 Working with Multiple Firewall Configurations

RUGGEDCOM ROX II allows users to create multiple firewall configurations and work with one configuration while another is active.

To set one configuration as the working configuration and another as the active configuration, do the following:

1. Make sure the CLI is in Configuration mode.
2. Specify the work configuration by typing:

   ```
   security firewall work-config { name }
   ```

   Where:

   - `{ name }` is the name of a firewall configuration
3. Specify the active configuration by typing:

   ```
   security firewall active-config { name }
   ```

   Where:

   - `{ name }` is the name of a firewall configuration
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.8.6 Configuring the Firewall for a VPN

To configure the firewall for a policy-based VPN, do the following:

1. Make sure a basic firewall has been configured. For more information about configuring a firewall, refer to "Adding a Firewall (Page 221)".
2. Make sure zones for local, network and VPN traffic have been configured. For more information about managing zones, refer to "Managing Zones (Page 225)".
3. Make sure a zone called *Any* exists and is of the type IPsec . For more information about managing zones, refer to "Managing Zones (Page 225)".
4. Configure the interface that carries the encrypted IPsec traffic. Make sure it is associated with the *Any* zone, as it will be carrying traffic for all zones. For more information about associating interfaces with zones, refer to "Associating an Interface with a Zone (Page 229)".
5. Configure a host for the interface that carries the unencrypted IPsec traffic. Make sure the VPN zone is associated with the interface. If VPN tunnels to multiple remote sites are required, make sure host entry exists for each or collapse them into a single subnet. For more information about configuring hosts, refer to "Managing Hosts (Page 230)".
6. Configure a second host for the interface that carries the encrypted IPsec traffic. Make sure the interface is associated with the network zone and specify a wider subnet mask, such as 0.0.0.0/0. For more information about configuring hosts, refer to "Managing Hosts (Page 230)".

Note
The VPN host must be specified before the network host so the more specific VPN zone subnet can be inspected first.

The following are examples of possible host configurations:

Host	Interface	Subnet	IPsec Zone
vpn	W1ppp	192.168.1.0/24	Yes
net	W1ppp	0.0.0.0/0	No

7. Configure rules with the following parameter settings for the UDP, Authentication Header (AH) and Encapsulation Security Payload (ESP) protocols:

Note
The IPsec protocol operates on UDP port 500, using protocols Authentication Header (AH) and Encapsulation Security Payload (ESP) protocols. The firewall must be configured to accept this traffic in order to allow the IPsec protocol.

Action	Source-Zone	Destination-Zone	Protocol	Dest-Port
Accept	net	fw	ah	—
Accept	net	fw	esp	—
Accept	net	fw	udp	500

For more information about configuring rules, refer to "Managing Rules (Page 240)".

8. Configure the following rule to allow traffic from Libreswan, the IPsec daemon, to enter the firewall:

Note
IPsec traffic arriving at the firewall is directed to Libreswan, the IPsec daemon. Libreswan decrypts the traffic and then forwards it back to the firewall on the same interface that originally received it. A rule is required to allow traffic to enter the firewall from this interface.

Action	Source-Zone	Destination-Zone	Protocol	Dest-Port
Accept	vpn	loc	—	—

For more information about configuring rules, refer to "Managing Rules (Page 240)".

6.8.7 Configuring the Firewall for a VPN in a DMZ

When the firewall needs to pass VPN traffic through to another device, such as a VPN device in a Demilitarized Zone (DMZ), then a DMZ zone and special rules are required.

To configure the firewall for a VPN in a DMZ, do the following:

1. Make sure a basic firewall has been configured. For more information about configuring a firewall, refer to "Adding a Firewall (Page 221)".
2. Make sure a zone called *dmz* exists. For more information about managing zones, refer to "Managing Zones (Page 225)".
3. Configure rules with the following parameter settings for the UDP, Authentication Header (AH) and Encapsulation Security Payload (ESP) protocols:

Note
The IPsec protocol operations on UDP port 500, using protocols Authentication Header (AH) and Encapsulation Security Payload (ESP) protocols. The firewall must be configured to accept this traffic in order to allow the IPsec protocol.

Action	Source-Zone	Destination-Zone	Protocol	Dest-Port
Accept	Net	dmz	Ah	—
Accept	Net	dmz	Esp	—
Accept	Net	dmz	UDP	500
Accept	dmz	Net	Ah	—
Accept	dmz	Net	Esp	—
Accept	dmz	Net	Udp	500

For more information about configuring rules, refer to "Managing Rules (Page 240)".

6.8.8 Configuring Netfilter

To configure Netfilter, do the following:

1. Make sure the CLI is in Configuration mode.
2. Set the time in seconds (s) a stale TCP connection can reside in the connection tracking table by typing:

   ```
   admin system tcp-est-conn-track-timeout { value }
   ```

   Where { value } is a number between 300 and 432000. The default value is 432000 s, or five days.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.8.9 Managing Zones

A network zone is a collection of interfaces for which forwarding decisions are made. Common zones include:

Zone	Description
Net	The Internet
Loc	The local network
DMZ	Demilitarized zone
Fw	The firewall itself
Vpn1	IPsec connections on w1ppp
Vpn2	IPsec connections on w2ppp

New zones may be defined as needed. For example, if each Ethernet interface is part of the local network zone, disabling traffic from the Internet zone to the local network zone would disable traffic to all Ethernet interfaces. If access to the Internet is required for some Ethernet interfaces, but not others, a new zone may be required for those interfaces.

6.8.9.1 Viewing a List of Zones

To view a list of zones, type:

```
show running-config security firewall fwconfig
{ firewall } fwzone
```

Where:

- `{ firewall }` is the name of the firewall

If zones have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config security firewall fwconfig fwzone
security
 firewall
  fwconfig firewall
   fwzone fw
    type        firewall
    description FirewallZone
   !
   fwzone man
    description IPv4Zone
   !
  !
 !
!
```

If no zones have been configured, add zones as needed. For more information, refer to "Adding a Zone (Page 226)".

6.8.9.2 Adding a Zone

To add a new zone for a firewall, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the zone by typing:

   `security firewall fwconfig { firewall } fwzone { zone }`

   Where:

   - `{ firewall }` is the name of the firewall
   - `{ zone }` is the name of the zone
3. Configure the following parameter(s) as required:

Parameter	Description
`iptype { iptype }`	**Synopsis:** [ipv4 | ipv6 | ipv4ipv6] **Default:** ipv4 Internet protocol type - use both when no addresses are used, otherwise define IPv4 and IPv6 rules for each type of addresses used.
`type { type }`	**Synopsis:** [ipv4 | ipsec | firewall] **Default:** ipv4 Zone types are plain IPv4, firewall, or IPSec
`description { description }`	**Synopsis:** A string (Optional) The description string for this zone

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.8.9.3 Deleting a Zone

To delete a zone, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the zone by typing:

   ```
   no security firewall fwconfig { firewall } fwzone { name }
   ```

   Where:

   - `{ firewall }` is the name of the firewall
   - `{ name }` is the name of the zone
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.8.10 Managing Interfaces

Firewall interfaces are the LAN and WAN interfaces available to the router. Each interface must be placed in a network zone. If an interface supports more than one zone, its zone must be marked as *undefined* and the interface must use the zone host's setup to define a zone for each subnet on the interface.

Example

Interface	Zone
Switch.0001	Loc
Switch.0002	Loc
Switch.0003	Any
Switch.0004	DMZ
W1ppp	net

6.8.10.1 Viewing a List of Interfaces

To view a list of interfaces, type:

```
show running-config security firewall fwconfig { firewall } fwinterface
```

Where { firewall } is the name of the firewall.

If interfaces have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config security firewall fwconfig fwinterface
security
 firewall
  fwconfig firewall
   fwinterface fe-cm-1
```

```
    zone man
    description Interface
   !
  !
 !
!
```

If no interfaces have been configured, add interfaces as needed. For more information, refer to "Adding an Interface (Page 228)".

6.8.10.2 Adding an Interface

To configure an interface for a firewall, do the following:

1. Display the list of available interfaces by typing:

   ```
   show running-config ip
   ```

2. Record the name of the chosen interface.
3. Enter Configuration mode by typing:

   ```
   config
   ```

4. Add the interface by typing:

   ```
   security firewall fwconfig { firewall } fwinterface
   { name }
   ```

   Where:

   - `{ firewall }` is the name of the firewall
   - `{ name }` is the name of the interface

5. Configure the interface settings by typing the following commands:

Parameter	Description
`iptype { iptype }`	**Synopsis:** [ipv4 | ipv6 | ipv4ipv6] **Default:** ipv4 Internet protocol type - use both when no addresses are used, otherwise define IPv4 and IPv6 rules for each type of addresses used.
`description { description }`	**Synopsis:** A string (Optional) The description string for this interface
`arp_filter`	IPv4 ONLY- See additional info. Responds only to ARP requests for configured IP addresses (This is permanently enabled system wide since ROX 2.3.0, and this option no longer has any effect).
`routeback`	IPv4 and IPv6 - Interface traffic routed back out that same interface.
`tcpflags`	IPv4 and IPv6. Illegal combinations of TCP flags dropped and logged at info level.

Parameter	Description
`dhcp`	IPv4 and IPv6 - Allows DHCP datagrams to enter and leave the interface.
`norfc1918`	Not currently implemented
`routefilter`	IPv4 and IPv6 - Enables /rpfilter/ spoofing protection
`proxyarp`	IPv4 ONLY - Enables proxy ARP.
`maclist`	Not currently implemented
`nosmurfs`	IPv4 ONLY - Packets with broadcast address as source dropped and logged at info level.
`logmartians`	IPv4 ONLY - Logging of packets with impossible source addresses.

6. Associate the interface with a pre-defined zone or mark the associated zone as undefined. For more information about associating the interface with a zone, refer to "Associating an Interface with a Zone (Page 229)".
7. Configure a broadcast address for the interface. For more information configuring a broadcast address, refer to "Configuring a Broadcast Address (Page 230)".
8. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.8.10.3 Associating an Interface with a Zone

To associate an interface with a predefined zone or mark the associated zone as undefined, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***security » firewall » fwconfig » {firewall} » fwinterface » {interface} » zone***, where *{firewall}* is the name of the firewall and *{interface}* is the name of the interface.
3. Configure one of the following options:

Parameter	Description
`predefined-zone { predefined-zone }`	**Synopsis:** A string between 0 and 5 characters long The interface is associated with the specified zone.
`undefined-zone`	The zone is marked as undefined.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.8.10.4 Configuring a Broadcast Address

To configure a broadcast address for an interface, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***security » firewall » fwconfig » {firewall} » fwinterface » {interface} » broadcast-addr***, where *{firewall}* is the name of the firewall and *{interface}* is the name of the interface.
3. Configure one of the following options:

Parameter	Description
`ipv4-address { ipv4-address }`	**Synopsis:** A string An IPv4 address for a broadcast address.
`detect`	The broadcast address(es) is detected automatically.
`none`	A broadcast address is not defined. This is the default option.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.8.10.5 Deleting an Interface

To delete an interface, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the interface by typing:

   ```
   no security firewall fwconfig { firewall } fwinterface { name }
   ```

   Where:

   - `{ firewall }` is the name of the firewall
   - `{ name }` is the name of the interface
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.8.11 Managing Hosts

Hosts are used to assign zones to individual hosts or subnets (if the interface supports multiple subnets). This allows the firewall to receive a packet and then redirect it to the same device that received it. This functionality is useful for VPN setups to handle the VPN traffic separately from the other traffic on the interface which carries the VPN traffic.

Example: Hosts for the Local and Guests Zones

Zone	Interface	IP Address or Network
Local	Switch.0003	10.0.0.0/8
Guests	Switch.0003	192.168.0.0/24

6.8.11.1 Viewing a List of Hosts

To view a list of hosts, type:

```
show running-config security firewall fwconfig
{ firewall } fwhost
```

Where:

- `{ firewall }` is the name of the firewall

If hosts have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config security firewall fwconfig firewall1 fwhost
security
 firewall
  fwconfig firewall1
   fwhost host1
    zone      man
    interface fe-cm-1
    no ipaddress
    no description
   !
  !
 !
!
```

If no hosts have been configured, add hosts as needed. For more information, refer to "Adding a Host (Page 231)".

6.8.11.2 Adding a Host

To add a new host for a firewall, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the host by typing:

   ```
   security firewall fwconfig { firewall } fwhost
   { name }
   ```

   Where:

   - { firewall } is the name of the firewall
   - { name } is the name of the host
3. Configure the host by typing the following commands:

Parameter	Description
`ipsec { ipsec }`	**Synopsis:** [true | false] **Default:** false
`iptype { iptype }`	**Synopsis:** [ipv4 | ipv6 | ipv4ipv6] **Default:** ipv4 Internet protocol type - use both when no addresses are used, otherwise define IPv4 and IPv6 rules for each type of addresses used.
`zone { zone }`	**Synopsis:** A string between 0 and 5 characters long A pre-defined zone
`interface { interface }`	**Synopsis:** A string between 1 and 15 characters long A pre-defined interface to which optional IPs and/or networks can be added.
`ipaddress { ipaddress }`	**Synopsis:** A string Additional IP addresses or networks - comma separated, or a range in the form of low.address-high.address
`description { description }`	**Synopsis:** A string (Optional) The description string for this host.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.8.11.3 Deleting a Host

To delete a host, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the host by typing:

   ```
   no security firewall fwconfig { firewall } fwhost { name }
   ```

   Where:

   - `{ firewall }` is the name of the firewall
   - `{ name }` is the name of the host
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.8.12 Managing Policies

Policies define the default actions for establishing a connection between different firewall zones. Each policy consists of a source zone, a destination zone and an action to be performed when a connection request is received.

The following example illustrates the policies for establishing connections between a local network and the Internet.

Policy	Source Zone	Destination Zone	Action
1	Loc	Net	ACCEPT
2	Net	All	DROP
3	All	All	REJECT

Each policy controls the connection between the source and destination zones. The first policy accepts all connection requests from the local network to the Internet. The second policy drops or ignores all connection requests from the Internet to any device on the network. The third policy rejects all other connection requests and sends a TCP RST or an ICMP destination-unreachable packet to the client.

The order of the policies is important. If the last policy in the example above were to be the first policy, the firewall would reject all connection requests.

Note
The source and destination zones must be configured before a policy can be created. For more information about zones, refer to "Managing Zones (Page 225)".

Note
Policies for specific hosts or types of traffic can be overridden by rules. For more information about rules, refer to "Managing Rules (Page 240)".

6.8.12.1 Viewing a List of Policies

To view a list of policies, type:

```
show running-config security firewall fwconfig
{ firewall } fwpolicy
```

Where:

- `{ firewall }` is the name of the firewall

If policies have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config security firewall fwconfig firewall1 fwpolicy
security
 firewall
  fwconfig firewall1
   fwpolicy p1
    description Policy
   !
  !
 !
```

```
!
```

If no policies have been configured, add policies as needed. For more information, refer to "Adding a Policy (Page 234)".

6.8.12.2 Adding a Policy

To configure a policy for the firewall, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the policy by typing:

   ```
   security firewall fwconfig { firewall } fwpolicy { policy }
   ```

   Where:

   - `{ firewall }` is the name of the firewall
   - `{ policy }` is the name of the policy
3. Configure the following parameter(s) as required:

Parameter	Description
`iptype { iptype }`	**Synopsis:** [ipv4 | ipv6 | ipv4ipv6] **Default:** ipv4 Internet protocol type - use both when no addresses are used, otherwise define IPv4 and IPv6 rules for each type of addresses used.
`policy { policy }`	**Synopsis:** [accept | drop | reject | continue] **Default:** reject A default action for connection establishment between different zones.
`log-level { log-level }`	**Synopsis:** [none | debug | info | notice | warning | error | critical | alert | emergency] **Default:** none (Optional) Determines whether or not logging will take place and at which logging level.
`description { description }`	**Synopsis:** A string (Optional) The description string for this policy.

4. Configure the source zone for the policy. For more information, refer to "Configuring the Source Zone (Page 235)".
5. Configure the destination zone for the policy. For more information, refer to "Configuring the Destination Zone (Page 235)".
6. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.8.12.3 Configuring the Source Zone

To configure the source zone for a firewall policy, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***security » firewall » fwconfig » {firewall} » fwpolicy » {policy} » source-zone***, where *{firewall}* is the name of the firewall and *{policy}* is the name of the policy.
3. Configure one of the following options:

Parameter	Description
`predefined-zone { predefined-zone }`	**Synopsis:** A string between 0 and 5 characters long The firewall policy applies to the specified zone.
`all`	The firewall policy applies to all zones.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.8.12.4 Configuring the Destination Zone

To configure the destination zone for a firewall policy, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***security » firewall » fwconfig » {firewall} » fwpolicy » {policy} » destination-zone***, where *{firewall}* is the name of the firewall and *{policy}* is the name of the policy. The **Destination Zone** form appears.
3. Configure one of the following options:

Parameter	Description
`predefined-zone { predefined-zone }`	**Synopsis:** A string between 0 and 5 characters long The firewall policy applies to the specified zone.
`all`	The firewall policy applies to all zones.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.8.12.5 Deleting a Policy

To delete a policy, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the policy by typing:

```
no security firewall fwconfig { firewall }
fwpolicy { policy }
```

Where:

- { firewall } is the name of the firewall
- { policy } is the name of the policy

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.8.13 Managing Network Address Translation Settings

Network address translation entries can be used to set up a one-to-one correspondence between an external address on the firewall and the RFC1918 address of a host behind the firewall. This is often set up to allow connections to an internal server from outside the network.

Note
Destination Network Address Translation (DNAT) can be setup by configuring the destination zone in a rule. For more information on rules, refer to "Managing Rules (Page 240)".

6.8.13.1 Viewing a List of NAT Settings

To view a list of NAT settings, type:

```
show running-config security firewall { firewall } fwnat
```

Where:

- `{ firewall }` is the name of the firewall

If NAT settings have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config security firewall fwconfig firewall1 fwnat
security
 firewall
  fwconfig firewall1
   fwnat n1
    external-addr 172.30.150.10
    interface     fe-cm-1
    internal-addr 192.168.1.100
    no description
   !
   fwnat fwmasq
    external-addr 172.30.159.5
    interface     fe-cm-1
    internal-addr 193.168.1.1
    no description
   !
  !
 !
!
```

If no NAT settings have been configured, add NAT settings as needed. For more information, refer to "Adding a NAT Setting (Page 237)".

6.8.13.2 Adding a NAT Setting

To configure a Network Address Translation (NAT) entry, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the entry by typing:

   ```
   security firewall fwconfig { firewall } fwnat
   { name }
   ```

   Where:

   - `{ firewall }` is the name of the firewall
   - `{ name }` is the name of the network address translation entry
3. Configure the following parameter(s) as required:

Parameter	Description
`external-addr { external-addr }`	**Synopsis:** A string The external IP Address. The address must not be a DNS name. External IP addresses must be manually added to the interface.
`interface { interface }`	**Synopsis:** A string between 1 and 15 characters long An interface that has an external IP address.
`ipalias`	Create IP Alias for NAT rule.
`internal-addr { internal-addr }`	**Synopsis:** A string The internal IP address. The address must not be a DNS Name.
`limit-interface`	Translation only effective from the defined interface.
`local`	Translation effective from the firewall system.
`description { description }`	**Synopsis:** A string (Optional) The description string for this NAT entry.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.8.13.3 Deleting a NAT Setting

To delete a network address translation entry, do the following:

1. Make sure the CLI is in Configuration mode.

2. Delete the entry by typing:

   ```
   no security firewall fwconfig { firewall } fwnat { name }
   ```

   Where:

   - `{ firewall }` is the name of the firewall
   - `{ name }` is the name of the network address translation entry

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.8.14 Managing Masquerade and SNAT Settings

Masquerading and Source Network Address Translation (SNAT) are forms of dynamic Network Address Translation (NAT). Both hide a subnetwork behind a single public IP address.

Masquerading is used when the ISP provides a dynamic IP address. SNAT is used when the ISP provides a static IP address.

6.8.14.1 Viewing a List of Masquerade and SNAT Settings

To view a list of masquerade and SNAT settings, type:

```
show running-config security firewall fwconfig { firewall } fwmasq
```

Where:

- `{ firewall }` is the name of the firewall

If masquerade and SNAT settings have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config security firewall fwconfig firewall2 fwmasq
security
 firewall
  fwconfig firewall2
   fwmasq SNAT
    out-interface fe-cm-1
    no out-interface-specifics
    source-hosts  192.168.1.0/24
    address       172.30.15.10
    no description
   !
   fwmasq Masq
    out-interface fe-cm-1
    no out-interface-specifics
    source-hosts  192.168.0.0/24
    no address
    no description
   !
  !
 !
```

```
!
```

If no masquerade or SNAT settings have been configured, add masquerade or SNAT settings as needed. For more information, refer to "Adding Masquerade or SNAT Settings (Page 239)".

6.8.14.2 Adding Masquerade or SNAT Settings

To add rules for masquerading or SNAT, do the following:

Note
Masquerading requires that the IP address being used to masquerade must belong to the router. When configuring the SNAT address under masquerading, the SNAT address must be one of the IP addresses on the outbound interface.

1. Make sure the CLI is in Configuration mode.
2. Add the masquerade or SNAT setting by typing:

   ```
   security firewall fwconfig { firewall } fwmasq { name }
   ```

   Where:

   - `{ firewall }` is the name of the firewall
   - `{ name }` is the name of the masquerade or SNAT setting
3. Configure the following parameter(s) as required:

Parameter	Description
`iptype { iptype }`	**Synopsis:** [ipv4 | ipv6 | ipv4ipv6] **Default:** ipv4 Internet protocol type - use both when no addresses are used, otherwise define IPv4 and IPv6 rules for each type of addresses used.
`out-interface { out-interface }`	**Synopsis:** A string An outgoing interface list - usually the internet interface.
`out-interface-specifics { out-interface-specifics }`	**Synopsis:** A string (Optional) An outgoing interface list - specific IP destinations for the out-interface.
`ipalias`	Create IP Alias for NAT rule.
`source-hosts { source-hosts }`	**Synopsis:** A string Subnet range or comma-separated list of hosts (IPs)
`address { address }`	**Synopsis:** A string (Optional) By specifying an address here, SNAT will be used and this will be the source address.

Parameter	Description
`description { description }`	**Synopsis:** A string (Optional) The description string for this masq entry.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.8.14.3 Deleting a Masquerade or SNAT Setting

To delete a masquerade or SNAT setting, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the masquerade or SNAT setting by typing:

   ```
   no security firewall fwconfig { firewall } fwmasq { name }
   ```

   Where:

   - `{ firewall }` is the name of the firewall
   - `{ name }` is the name of the masquerade or SNAT setting
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.8.15 Managing Rules

Rules establish exceptions to the default firewall policies for certain types of traffic, sources or destinations. Each rule defines specific criteria. If an incoming packet matches that criteria, the default policy is overridden and the action defined by the rule is applied.

6.8.15.1 Viewing a List of Rules

To view a list of rules, type:

```
show running-config security firewall fwconfig { firewall } fwrule
```

Where:

- `{ firewall }` is the name of the firewall

If rules have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config security firewall fwconfig firewall1 fwrule
security
 firewall
  fwconfig firewall1
   fwrule Rule1
```

```
    action accept
    source-zone man
    destination-zone man
    no description
   !
   fwrule Rule2
    action accept
    source-zone man
    destination-zone man
    no description
   !
  !
 !
!
```

If no rules have been configured, add rules as needed. For more information, refer to "Adding a Rule (Page 241)".

6.8.15.2 Adding a Rule

To configure a rule for a firewall, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the rule by typing:

   ```
   security firewall fwconfig { firewall } fwrule { rule }
   ```

   Where:

   - `{ firewall }` is the name of the firewall
   - `{ rule }` is the name of the rule
3. Configure the following parameter(s) as required:

Note
When applying new rules, previous traffic seen by the router might still be considered as having valid connections by the connection tracking table. For instance:

1. A rule for the TCP and UDP protocols is applied.
2. The router sees both TCP and UDP traffic that qualifies for NAT.
3. The rule is then modified to allow only UDP.
4. The router will still see TCP packets (i.e. retransmission packets).

If required, reboot the router to flush all existing connection streams.

Parameter	Description
`iptype { iptype }`	**Synopsis:** [ipv4 | ipv6 | ipv4ipv6] **Default:** ipv4 Internet protocol type - use both when no addresses are used, otherwise define IPv4 and IPv6 rules for each type of addresses used.
`action { action }`	**Synopsis:** [accept | drop | reject | continue | redirect | dnat- | dnat | copy-dnat] **Default:** reject The final action to take on incoming packets matching this rule. Options include: • accept: Allows the connection request to proceed. • continue: Passes the connection request past any other rules. • copy-dnat: Sends a copy to a second system using a DNAT rule. Protocol must be set to 'udp', and Original Destination must be defined. • dnat: Forwards the request to another system and (optionally) another port. • dnat-: Only generates the DNAT IPtables rule and not the companion ACCEPT rule. • drop: The connection request is ignored. No notification is sent. • redirect: Redirects the request to a local TCP port number on the local firewall. • reject: Rejects the connection with an RST (TCP) or ICMP destination-unreachable.
`source-zone-hosts { source-zone-hosts }`	**Synopsis:** A string (Optional) Add comma-separated host IPs to a predefined source-zone.
`destination-zone-hosts { destination-zone-hosts }`	**Synopsis:** A string (Optional) Add comma-separated host IPs to the destination-zone - may include :port for DNAT or REDIRECT.
`log-level { log-level }`	**Synopsis:** [none | debug | info | notice | warning | error | critical | alert | emergency] **Default:** none (Optional) Determines whether or not logging will take place and at which logging level.
`protocol { protocol }`	**Synopsis:** A string or [tcp | udp | icmp | all] **Default:** all The protocol to match for this rule - must be 'udp' for rules using copy-dnat actions.

Parameter	Description
`source-ports { source-ports }`	**Synopsis:** A string **Default:** none (Optional) The TCP/UDP port(s) the connection originated from. Default: all ports. Add a single port or a list of comma-separated ports
`destination-ports { destination-ports }`	**Synopsis:** A string **Default:** none (Optional) The TCP/UDP port(s) the connection is destined for. Default: all ports. Add a single port or a list of comma-separated ports
`original-destination { original-destination }`	**Synopsis:** A string or [None] **Default:** none (Optional) The destination IP address in the connection request as it was received by the firewall - (mandatory) for rules using copy-dnat actions.
`helper { helper }`	**Synopsis:** [none | ftp] **Default:** none The Netfilter Helper to associate with this rule.
`description { description }`	**Synopsis:** A string (Optional) The description string for this rule.

4. Configure the source zone for the rule. For more information, refer to "Configuring the Source Zone (Page 243)".
5. Configure the destination zone for the rule. For more information, refer to "Configuring the Destination Zone (Page 244)".
6. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.8.15.3 Configuring the Source Zone

A firewall rule can be applied to a single source zone, select source zones, or all source zones.

To configure the source zone(s) for a firewall rule, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***security » firewall » fwconfig » {firewall} » fwrule{rule} » source-zone***, where *{firewall}* is the name of the firewall and *{rule}* is the name of the rule.

⚠ NOTICE

It is recommended to select a specific zone, rather than all zones. Corresponding iptables rules between each active zone to all other zones will be

created for each rule whose source zone and destination zone are both set to **all**, which may affect system performance and configuration commit times.

3. Configure one of the following options:

Parameter	Description
`predefined-zone { predefined-zone }`	**Synopsis:** A string between 0 and 5 characters long The firewall policy applies to the specified zone.
`other { other }`	**Synopsis:** A string The firewall policy applies to select zones.
`all`	The firewall policy applies to all zones.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.8.15.4 Configuring the Destination Zone

A firewall rule can be applied to a single destination zone, select destination zones, or all destination zones.

To configure the destination zone for a firewall rule, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***security » firewall » fwconfig » {firewall} » fwrule{rule} » destination-zone***, where *{firewall}* is the name of the firewall and *{rule}* is the name of the rule. The **Destination Zone** form appears.

⚠ NOTICE

It is recommended to select a specific zone, rather than all zones.
Corresponding iptables rules between each active zone to all other zones will be created for each rule whose source zone and destination zone are both set to **all**, which may affect system performance and configuration commit times.

3. Configure one of the following options:

Parameter	Description
`predefined-zone { predefined-zone }`	**Synopsis:** A string between 0 and 5 characters long The firewall policy applies to the specified zone.
`other { other }`	**Synopsis:** A string The firewall policy applies to select zones.
`all`	The firewall policy applies to all zones.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.8.15.5 Deleting a Rule

To delete a rule, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the rule by typing:

   ```
   no security firewall fwconfig { firewall } fwrule { rule }
   ```

   Where:

   - `{ firewall }` is the name of the firewall
   - `{ rule }` is the name of the rule
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.8.16 Validating a Firewall Configuration

To validate a firewall configuration, do the following:

1. Make sure the CLI is in Configuration mode.
2. Set the firewall as the working configuration by typing:

   ```
   security firewall work-config { name }
   ```

   Where:

   - `{ name }` is the name of the firewall configuration
3. Type `commit` and press **Enter** to save the changes. The system validates the firewall configuration and displays the results.

6.8.17 Enabling/Disabling a Firewall

To enable or disable the firewall, do the following:

⚠ NOTICE

Enabling or disabling the firewall will reset – but not disable – the BFA protection mechanism, if previously enabled. Any hosts that were previously blocked will be allowed to log in again. If multiple hosts are actively attacking at the time, this could result in reduced system performance.

1. Make sure the CLI is in Configuration mode.
2. Enable the firewall by typing:

   ```
   security firewall enable
   ```

Or disable the firewall by using the *no* version of the command:

```
no security firewall enable
```

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

6.9 Restricting Management Access to Specific Interfaces

RUGGEDCOM ROX II can be configured to restrict CLI, WebUI, SNMP and NETCONF management access to specific VLANs and/or source IP addresses.

The following examples describe how to configure RUGGEDCOM ROX II to restrict management access via IP address and firewall configuration.

Specifying Listen IP Interfaces

In Layer 3 routing, RUGGEDCOM ROX II must have an IP address on each of the interfaces it is routing traffic between. However, administrative services do not need to be offered for each IP address.

In this configuration, a Listen IP address is configured for each of the available services, rather than being available on all configured interface addresses as per default.

⚠ NOTICE

Accessibility hazard – risk of access disruption

The following configuration can prevent administration of the device if the specified IP address becomes unreachable. Make sure serial console access is available during configuration.

Note

By default, ports are reachable over IPv6 addresses and their associated ports. To restrict access, make sure no extra IP port is configured for each service. For more information about configuring extra IP ports for available services, refer to "*Security* (Page 151)".

```
admin
 cli
  listen-ip      192.168.0.20
 !
 sftp
  listen-ip      192.168.0.20
 !
 webui
  listen-ip      192.168.0.20
  no ssl-redirect-enabled
 !
 netconf
  listen-ip      192.168.0.20
 !
 snmp
```

```
   listen-ip      192.168.0.20
  !
!
```

For more information about configuring the Listen IP for available services, refer to "*Security* (Page 151)".

Excluding the Management VLAN from the Network

In Layer 3 routing, each VLAN must have an IP address. However, VLANs handled by the device only as a Layer 2 switch do not need an IP address. As such, the device is not accessible through the network via IP address, and is therefore not exposed to directed IP-based traffic.

In this example, RUGGEDCOM ROX II exists on VLAN1 and VLAN3, and can route traffic between them, but does not exist on the VLAN2 network. It will only send Layer2 traffic between devices on VLAN2 switch ports. Administration is via the interface on VLAN3. The address on VLAN1 can be pinged, but no web or CLI interfaces exist on it.

```
ip switch.0001
 no bandwidth
 ipv4
  address 192.168.15.1/24
   no peer
  !
 !
!
ip switch.0002
 no bandwidth
!
ip switch.0003
 no bandwidth
 ipv4
  address 192.168.0.20/24
   no peer
  !
 !
!
```

For more information about configuring IP addresses, refer to "Adding an IPv4 Address (Page 251)" or "Adding an IPv6 Address (Page 252)".

Using a Firewall to Restrict Source IP Addresses

A firewall can be configured to restrict source IP addresses.

This configuration allows any source device to ping the RUGGEDCOM ROX II interfaces, but only devices with a specific IP address are granted admin access for a single administrator PC. All other connections are refused.

```
security
 firewall
  fwconfig asbestos
   fwzone fw
    type        firewall
    description "The DUT itself"
   !
```

```
    fwzone Loc
     description "The rest of the world"
    !
    fwinterface switch+
     zone Loc
     description "All traffic on all switch ports"
    !
    fwpolicy fwprotect
     source-zone all
     destination-zone fw
     description "Reject all input to DUT except as allowed in fwrules"
    !
    fwpolicy pass
     source-zone all
     destination-zone all
     policy      accept
     description "Allow all other traffic (passing or leaving DUT)"
    !
    fwrule pingme
     action            accept
     source-zone all
     destination-zone fw
     protocol          icmp
     destination-ports 8
     description       "Allow everyone to ping the DUT"
    !
    fwrule adm
     action            accept
     source-zone all
     source-zone-hosts 192.168.0.100
     destination-zone fw
     description       "Allow admin workstation to connect to DUT"
    !
   !
  !
!
```

For more information about configuring a firewall, refer to "Adding a Firewall (Page 221)".

7 IP Address Assignment

This chapter describes features related to the assignment of IP addresses, such as DHCP and DNS.

7.1 Managing IP Addresses for Routable Interfaces

This section describes how to manage IP address for routable interfaces.

7.1.1 Configuring Costing for Routable Interfaces

To configure the costing for a routable interface, do the following:

1. Make sure the CLI is in Configuration mode.
2. Set the costing by typing:

   ```
   ip { interface } bandwidth { cost }
   ```

   Where:

   - `{ interface }` is the name of the routable interface
   - `{ cost }` is the value used in auto-cost calculations for the routable logical interface in kbps
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.1.2 Viewing Statistics for Routable Interfaces

To view statistics for all routable interfaces, type:

```
show interfaces ip
```

A table or list similar to the following appears:

```
ruggedcom# show interfaces ip
interfaces ip dummy0
 admin state down
 state       down
 pointopoint false
 receive
  bytes   0
  packets 0
  errors  0
  dropped 0
```

```
 transmit
  bytes      0
  packets    0
  errors     0
  dropped    0
  collisions 0
interfaces ip fe-cm-1
.
.
.
```

This table or list displays the following information:

Parameter	Description
`admin-state`	**Synopsis:** [not set | up | down | testing | unknown | dormant | notPresent | lowerLayerDown] The port's administrative status.
`state`	**Synopsis:** [not set | up | down | testing | unknown | dormant | notPresent | lowerLayerDown] Shows whether the link is up or down.
`pointopoint`	**Synopsis:** [true | false] The point-to-point link.
`bytes`	**Synopsis:** An integer The number of bytes received.
`packets`	**Synopsis:** An integer The number of packets received.
`errors`	**Synopsis:** An integer The number of error packets received.
`dropped`	**Synopsis:** An integer The number of packets dropped by the receiving device.
`bytes`	**Synopsis:** An integer The number of bytes transmitted.
`packets`	**Synopsis:** An integer The number of packets transmitted.
`errors`	**Synopsis:** An integer The number of error packets transmitted.
`dropped`	**Synopsis:** An integer The number of packets dropped by the transmitting device.
`collisions`	**Synopsis:** An integer The number of collisions detected on the port.

7.1.3 Managing IPv4 Addresses

This section describes how to manage IPv4 addresses for a routable interface.

7.1.3.1 Viewing a List of IPv4 Addresses

To view a list of IPv4 address for a routable interface, type:

```
show running-config ip { interface } ipv4
```

Where:

- `{ interface }` is the name of the interface

If addresses have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config ip ipv4 | tab
IFNAME       IPADDRESS         PEER
-------------------------------------
dummy0
             1.1.1.1/32        -
fe-cm-1
             192.168.0.12/24   -
             172.30.150.12/19  -
switch.0001
switch.0011
             192.168.11.1/24   -
switch.0012
             192.168.12.1/24   -
switch.0014
             192.168.14.1/24   -
```

If no addresses have been configured, add addresses as needed. For more information, refer to "Adding an IPv4 Address (Page 251)".

7.1.3.2 Adding an IPv4 Address

To add an IPv4 address to a routable interface, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the address by typing:

   ```
   ip { interface } ipv4 address { address } peer { peer }
   ```

   Where:

   - { interface } is the name of the interface
   - { address } is the IPv4 address and prefix
   - { peer } is the peer IPv4 address
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.1.3.3 Deleting an IPv4 Address

To delete an IPv4 address for a routable interface, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the address by typing:

   ```
   no ip { interface } ipv4 address { address }
   ```

   Where:

   - `{ address }` is the IPv4 address
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.1.4 Managing IPv6 Addresses

This section describes how to manage IPv6 addresses for a routable interface.

7.1.4.1 Viewing a List of IPv6 Addresses

To view a list of IPv6 address for a routable interface, type:

```
show running-config ip { interface } ipv6 address
```

Where:

- `{ interface }` is the name of the interface

If addresses have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config ip dummy0 ipv6 address
ip dummy0
 ipv6
  address 2001:db8:a0b:12f0::1/24
  !
  address 2001:db9:a2C:25f0::2/24
  !
 !
!
```

If no addresses have been configured, add addresses as needed. For more information, refer to "Adding an IPv6 Address (Page 252)".

7.1.4.2 Adding an IPv6 Address

To add an IPv6 address to a routable interface, do the following:

1. Make sure the CLI is in Configuration mode.

2. Add the address by typing:

   ```
   ip { interface } ipv6 address { address }
   ```

   Where:

   - `{ interface }` is the name of the interface
   - `{ address }` is the IPv6 address

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.1.4.3 Deleting an IPv6 Address

To delete an IPv6 address for a routable interface, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the address by typing:

   ```
   no ip { interface } ipv6 address { address }
   ```

   Where:

   - `{ interface }` is the name of the interface
   - `{ address }` is the IPv6 address

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.1.5 Configuring IPv6 Neighbor Discovery

The Neighbor Discovery (ND) protocol in IPv6 is a replacement for IPv4 ARP messages. The protocol uses ICMPv6 messages with for various purposes including:

- Find a link-layer address of a neighbor
- Discover neighbor routers
- Determine any change in the link-layer address
- Determine when a neighbor is down
- Send network information from routers to hosts, which includes hop limit, MTU size, determining the network prefix used on a link, address auto configuration, and the default route information

The Neighbor Discovery protocol uses five types of ICMPv6 messages:

- **Router Solicitation (ICMPv6 type 133)**

  This message is sent by hosts to routers as a request to router advertisement message. It uses a destination multicast address (i.e. FF02:2).

- **Router Advertisement Messages (ICMPv6 type 134)**

This message is used by routers to announce its presence in a network. The message includes network information related to IPv6 prefixes, default route, MTU size, hop limit and auto configuration flag. It uses a destination multicast address (i.e. FF02:1).

- **Neighbor Solicitation Messages (ICMPv6 type 135)**

  This message is sent by hosts to determine the existence of another host on the same link. The goal is to find the link-layer of neighboring nodes.

- **Neighbor Advertisement Messages (ICMPv6 type 136)**

  This message is sent by hosts to indicate the existence of the host and it provides information about its own link-layer address.

- **Redirect Messages (ICMPv6 type 137)**

  This message is sent by a router to inform a host about a better router to reach a particular destination address.

Neighbor Discovery should be configured on all Ethernet interfaces enabled for IPv6.

To enable and configure settings for IPv6 Neighbor Discovery, do the following:

1. Make sure the CLI is in Configuration mode.
2. Type the following command:

   ```
   ip { interface } ipv6 nd
   ```

   Where:

   - `{ interface }` is the name of the interface
3. Configure neighbor discovery by configuring the following parameter(s) as required:

Parameter	Description
`enable-ra`	Enable to send router advertisement messages.
`adv-interval-option`	Includes an Advertisement Interval option which indicates to hosts the maximum time in milliseconds, between successive unsolicited router advertisements.
`home-agent-config-flag`	Sets/unsets the flag in IPv6 router advertisements which indicates to hosts that the router acts as a home agent and includes a home agent option.
`home-agent-lifetime { home-agent-lifetime }`	**Synopsis:** An integer between 0 and 65520 **Default:** 1800 The value to be placed in the home agent option, when the home agent configuration flag is set, which indicates the home agent lifetime to hosts. A value of 0 means to place a router lifetime value.

Parameter	Description
`home-agent-preference { home-agent-preference }`	**Synopsis:** An integer between 0 and 65535 **Default:** 0 The value to be placed in the home agent option, when the home agent configuration flag is set, which indicates the home agent preference to hosts.
`managed-config-flag`	The flag in IPv6 router advertisements, which indicates to hosts that they should use the managed (stateful) protocol for addresses autoconfiguraiton in addition to any addresses autoconfigured using stateless address autoconfiguration.
`other-config-flag`	The flag in IPv6 router advertisements, which indicates to hosts that they should use the administered (stateful) protocol to obtain autoconfiguration information other than addresses.
`ra-lifetime { ra-lifetime }`	**Synopsis:** An integer between 0 and 9000 **Default:** 1800 The value (in seconds) to be placed in the Router Lifetime field of router advertisements sent from the interface. Indicates the usefulness of the router as a default router on this interface. Setting the value to zero indicates that the router should not be considered a default router on this interface. It must be either zero or between the value specified with the IPv6 nd ra-interval (or default) and 9000 seconds.
`reachable-time-msec { reachable-time-msec }`	**Synopsis:** An integer between 0 and 3600000 **Default:** 0 The value (in milliseconds) to be placed in the Reachable Time field in the router advertisement messages sent by the router. The configured time enables the router to detect unavailable neightbors. The value zero means unspecified (by this router).

4. Configure the router advertisement interval by configuring the following parameter(s) as required:

Parameter	Description
`value { value }`	**Synopsis:** An integer between 3 and 1800 The interval value.
`unit { unit }`	**Synopsis:** [sec | msec] The interval unit.

5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.1.6 Managing IPv6 Network Prefixes

An IPv6-capable interface can use Neighbor Discovery to advertise IPv6 network prefixes to its neighbor on the same link.

7.1.6.1 Adding an IPv6 Network Prefix

To add a network prefix to the neighbor discovery configuration for an IPv6 address, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the network prefix by typing:

   ```
   ip { interface } ipv6 nd prefix { prefix }
   ```

   Where:

   - `{ interface }` is the name of the interface
   - `{ prefix }` is the IPv6 address and prefix
3. Configure the lifetime settings by configuring the following parameter(s):

Parameter	Description
`valid { valid }`	**Synopsis:** An integer between 0 and 4294967295 or [infinite] The length of time in seconds during which time the prefix is valid for the purpose of on-link determination.
`preferred { preferred }`	**Synopsis:** An integer between 0 and 4294967295 or [infinite] The length of time in seconds during which addresses generated from the prefix remain preferred.

4. Configure the prefix settings by configuring the following parameter(s):

Parameter	Description
`off-link`	Indicates that advertisement makes no statement about on-link or off-link properties of the prefix.
`no-autoconfig`	Indicates to hosts on the local link that the specified prefix cannot be used for IPv6 autoconfiguration.
`router-address`	Indicates to hosts on the local link that the specified prefix contains a complete IP address by setting the R flag.

5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.1.6.2 Deleting an IPv6 Network Prefix

To delete a network prefix to the neighbor discovery configuration for an IPv6 address, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the address by typing:

   ```
   no ip { interface } ipv6 address { address }
   ```

   Where:

   - `{ interface }` is the name of the interface

- `{ address }` is the IPv6 address

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.2 Managing the DHCP Relay Agent

A DHCP Relay Agent is a device that forwards DHCP packets between clients and servers when they are not on the same physical LAN segment or IP subnet. The feature is enabled if the DHCP server IP address and a set of access ports are configured.

DHCP Option 82 provides a mechanism for assigning an IP Address based on the location of the client device in the network. Information about the client's location can be sent along with the DHCP request to the server. Based on this information, the DHCP server makes a decision about an IP Address to be assigned.

DHCP Relay Agent takes the broadcast DHCP requests from clients received on the configured access port and inserts the relay agent information option (Option 82) into the packet. Option 82 contains the VLAN ID (2 bytes) and the port number of the access port (2 bytes: the circuit ID sub-option) and the switch's MAC address (the remote ID sub-option). This information uniquely defines the access port's position in the network. For example, in RUGGEDCOM ROX II, the Circuit ID for VLAN 2 on Line Module (LM) 4 Port 15 is `00:00:00:02:04:0F`.

The DHCP Server supporting DHCP Option 82 sends a unicast reply and echoes Option 82. The DHCP Relay Agent removes the Option 82 field and broadcasts the packet to the port from which the original request was received.

The DHCP Relay Agent communicates to the server on a management interface. The agent's IP address is the address configured for the management interface.

RUGGEDCOM ROX II can be configured to act as a DHCP Relay Agent that forwards DHCP and BOOTP requests from clients on one Layer 2 network to one or more configured DHCP servers on other networks. This allows the implementation of some measure of isolation between DHCP clients and servers.

The DHCP Relay Agent is configured to listen for DHCP and BOOTP requests on particular Ethernet and VLAN network interfaces, and to relay to a list of one or more DHCP servers. When a request is received from a client, RUGGEDCOM ROX II forwards the request to each of the configured DHCP servers. When a reply is received from a server, RUGGEDCOM ROX II forwards the reply back to the originating client.

Note
While DHCP Relay and DHCP Server may both be configured to run concurrently, they may not be configured to run on the same network interface.

7.2.1 Configuring the DHCP Relay Agent

To configure the DHCP relay agent, do the following:

1. Assign an IP address to the DHCP Server where DHCP queries are to be forwarded. For more information, refer to "Assigning a DHCP Server Address (Page 258)".

   Note
   If client ports do not reside on the same subnet, make sure to assign the client ports to different VLANs.

2. Add client ports. For more information, refer to "Adding a DHCP Client Port (Page 259)".
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.2.2 Assigning a DHCP Server Address

To assign a DHCP server address to the DHCP relay agent, do the following:

1. Make sure the CLI is in Configuration mode.
2. Configure the following parameter(s) as required:

Parameter	Description
`dhcp-server-address { dhcp-server-address }`	**Synopsis:** A string The IP address of the DHCP server to which DHCP queries will be forwarded from this relay agent.

3. Add client ports. For more information, refer to "Adding a DHCP Client Port (Page 259)".
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.2.3 Viewing a List of DHCP Client Ports

To view a list of DHCP relay agent client ports, type:

```
show running-config switch dhcp-relay-agent dhcp-client-ports
```

If client ports have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config switch dhcp-relay-agent dhcp-client-ports
switch dhcp-relay-agent
 dhcp-client-ports swport 1
 !
```

```
!
```

If no client ports have been configured, add client ports as needed. For more information, refer to "Adding a DHCP Client Port (Page 259)".

7.2.4 Adding a DHCP Client Port

To add a client port for the DHCP relay agent, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the client port by typing:

   ```
   switch dhcp-relay-agent dhcp-client-ports { slot }
   { port }
   ```

   Where:

   - `{ slot }` is the name of the module location.
   - `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.2.5 Deleting a DHCP Client Port

To delete a client port for the DHCP relay agent, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the client port by typing:

   ```
   no switch dhcp-relay-agent dhcp-client-ports
   { slot } { port }
   ```

   Where:

   - `{ slot }` is the name of the module location.
   - `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.2.6 Example: Configuring the Device as a Relay Agent

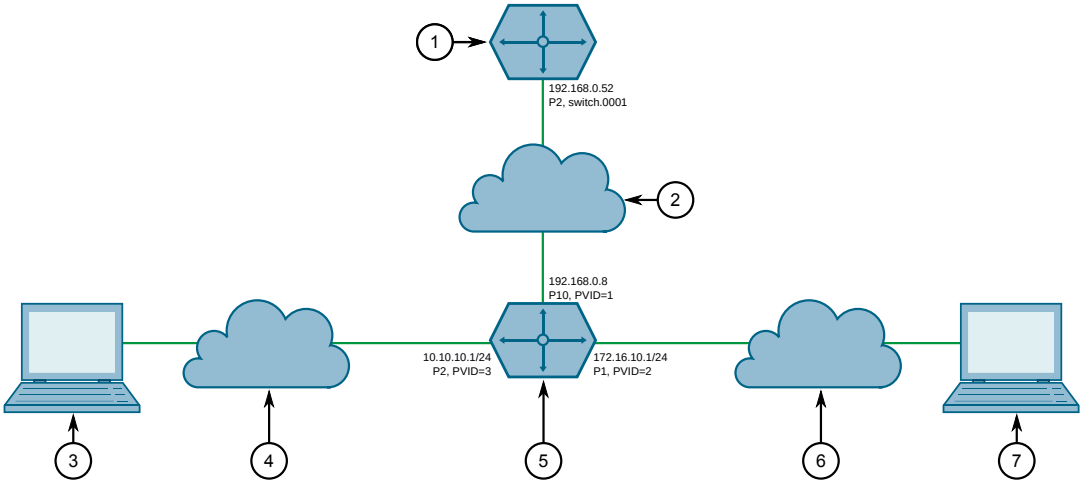
This example demonstrates how to configure the device as a DHCP relay agent.

The following topology depicts a scenario where two clients on separate LANs require IP addresses on different subnets from a DHCP server. Each client connects

to the DHCP relay agent using different VLANs. The DHCP relay agent manages the requests and responses between the clients and the DHCP server.

⚠ NOTICE

The values shown are specific to the provided topology. Actual values can vary based on the user's configuration.



① DHCP Server
② LAN A
③ Client 2
④ LAN B
⑤ DHCP Relay Agent (RUGGEDCOM ROX II Device)
⑥ LAN C
⑦ Client 1

Figure 7.1 Topology – Device as a Relay Agent

To configure the device as a DHCP relay agent per the topology, do the following:

1. Configure the device as a DHCP relay agent:
   a. Add VLAN 2 and VLAN 3. For more information, refer to "Adding a Static VLAN (Page 363)".
   b. Assign IP address *192.168.0.8* to VLAN 1. For more information, refer to "Adding an IPv4 Address (Page 251)" or "Adding an IPv6 Address (Page 252)".
   c. Change the PVID of port 1 to PVID 2, and change the PVID of port 2 to PVID 3. Refer to "Configuring a Switched Ethernet Port (Page 314)" for more information.
2. Configure a separate device as the DHCP Server. If the DHCP server being used is a RUGGEDCOM ROX II device, refer to "Example: Configuring the Device as a DHCP Server to Support a Relay Agent (Page 301)" for more information.

Final Configuration Example

The following configuration reflects the topology:

```
# show running-config switch dhcp-relay-agent
 dhcp-server-address 192.168.0.52
 dhcp-client-ports lm4 1
 !
 dhcp-client-ports lm4 2
 !
```

7.3 Managing the DHCP Server

Dynamic Host Configuration Protocol (DHCP) is a method for centrally and consistently managing IP addresses and settings for clients, offering a variety of assignment methods. IP addresses can be assigned based on the Ethernet MAC address of a client either sequentially or by using port identification provided by a DHCP relay agent device.

The information that is assigned to addresses in DHCP is organized to deal with clients at the interface, subnet, pool, shared network, host-group and host levels.

RUGGEDCOM ROX II supports both IPv4 and IPv6 address assignments.

7.3.1 Viewing a List of Active Leases

RUGGEDCOM ROX II can generate a list of active leases. The list includes the start and end times, hardware Ethernet address, and client host name for each lease.

To view a list of active leases, type:

- **For IPv4**

  ```
  services dhcpserver show-active-leases
  ```

- **For IPv6**

  ```
  services dhcpserver6 show-active-leases
  ```

If certificates have been configured, a table or list similar to the following example appears:

```
ruggedcom# services dhcpserver show-active-leases
dhcpActionResult
lease 192.168.0.9 {
  starts 2 2012/11/13 20:35:47;
  ends 2 2012/11/13 20:45:47;
  hardware Ethernet 00:01:c0:0c:8b:a4;
  client-hostname "ape2-PC";
}

lease 192.168.0.11 {
  starts 2 2012/11/13 20:38:37;
  ends 2 2012/11/13 20:48:37;
  hardware Ethernet 00:01:c0:0b:b7:70;
}
```

```
lease 192.168.0.8 {
  starts 2 2012/11/13 20:38:47;
  ends 2 2012/11/13 20:48:47;
  hardware Ethernet 00:01:c0:0c:8b:a3;
  client-hostname "ape2-PC";
}

lease 192.168.0.22 {
  starts 2 2012/11/13 20:36:14;
  ends 2 2012/11/13 20:46:14;
  hardware Ethernet 00:01:c0:0b:b7:71;
}
```

7.3.2 Configuring the DHCP Server

To configure the DHCP server, do the following:

Note
This procedure outlines the basic steps required to configure the device as a DHCP server. For a configuration example that includes a DHCP relay agent, refer to "Example: Configuring the Device as a DHCP Server to Support a Relay Agent (Page 301)".

1. [Optional] Configure a separate device as a DHCP relay agent. The relay agent may be a RUGGEDCOM ROX II device, a RUGGEDCOM ROS device, or a third party device with relay agent capabilities.

   If the relay agent being used is a RUGGEDCOM ROX II device, refer to "Example: Configuring the Device as a Relay Agent (Page 259)" for more information.
2. Enable the DHCP server. For more information, refer to "Enabling/Disabling the DHCP Server (Page 263)".
3. Add a DHCP listen interface. For more information, refer to "Adding a DHCP Listen Interface (Page 271)".
4. Assign an IP address to the listen interface. For more information, refer to "Adding a Subnet (Page 275)".
5. Create a shared network and enable Option82. For more information, refer to "Adding a Shared Network (Page 272)" and "Configuring Shared Network Options (Page 273)".
6. Create a subnet for each LAN that has DHCP clients. For more information about creating subnets, refer to "Adding a Subnet (Page 275)".
7. [Optional] If a dynamic IP address is needed for the relay agent, create a subnet for the DHCP relay agent. For more information about creating subnets, refer to "Adding a Subnet (Page 275)".
8. For each client subnet (excluding the subnet for the DHCP relay agent, if used), do the following:

   a. Create one or more IP address pools to define a range of IP addresses for each client.

For more information about IP address pools, refer to "Adding an Address Pool (IPv4) (Page 286)" or "Adding an Address Pool (IPv6) (Page 288)".

For more information about IP ranges, refer to "Adding an IP Range (IPv4) (Page 291)" or "Adding an IP Range (IPv6) (Page 293)".

b. [Optional] Configure the option82 class on the relay agent, if used. For more information, refer to "Adding an Option 82 Class to an Address Pool (Page 300)".

9. [Optional] Add and configure hosts and host-groups. For more information, refer to "Adding a Host (Page 283)".

7.3.3 Enabling/Disabling the DHCP Server

To enable or disable the DHCP server, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable or disable the DHCP server by typing:
   - **Enable for IPv4**

     ```
     services dhcpserver enabled
     ```

   - **Disable for IPv4**

     ```
     no services dhcpserver enabled
     ```

   - **Enable for IPv6**

     ```
     services dhcpserver6 enabled
     ```

   - **Disable for IPv6**

     ```
     no services dhcpserver6 enabled
     ```

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.4 Configuring DHCP Server Options

To configure options for the DHCP server, do the following:

Note
Options set at the subnet level override options set at the DHCP server level.

1. Make sure the CLI is in Configuration mode.
2. Navigate to:
   - **For IPv4**

     services » dhcpserver » options

- **For IPv6**

  services » dhcpserver6 » options

3. Configure the following parameter(s) as required:

⚠ NOTICE

For IPv4 only:

If DHCP relay (or Option 82) clients are used on the same subnet as the DHCP server, some clients will try to renew a lease immediately after receiving it by requesting a renewal directly from the DHCP server. Because the DHCP server is configured by default to only provide the lease through a relay agent configured with the current Option 82 fields, the server sends the client a NAK (negative acknowledgment or not acknowledged) message to disallow the lease. Enabling Option 82 disables the NAK message so the renewal request sent from the DHCP relay agent (which the DHCP server accepts, since it has the correct Option 82 fields added) is the only message for which the client receives a reply.

Option 82 support should only be enabled If the DHCP server and clients are on the same subnet.

The meaning of most Option 82 fields is determined by the DHCP relay client. To determine which values are required by the client for special options, refer to the client documentation.

DHCP relay support can also be enabled on individual subnets. For more information, refer to "Configuring Subnet Options (Page 276)".

Parameter	Description
`unknown-client { unknown-client }`	**Synopsis:** [allow | deny | ignore] The action to take for previously unregistered clients
`authorize-server`	Enables/disables the server's authorization on this client. If enabled, the server will send deny messages to the client that is trying to renew the lease, which the server knows the client shouldn't have.
`option82`	Enables/disables the NAK of option 82 clients for this subnet.

4. [Optional] Configure additional client configuration options. For more information, refer to "Configuring Standard DHCP Client Configuration Options (IPv4) (Page 265)" or "Configuring Standard DHCP Client Configuration Options (IPv6) (Page 266)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.5 Managing DHCP Client Configuration Options

Standard and custom options can be configured globally at the DHCP server level, or for specific shared networks, subnets, host groups or hosts. Options set at an individual level override options set at the global level.

7.3.5.1 Configuring Standard DHCP Client Configuration Options (IPv4)

Configuration options for DHCP clients can be configured globally or for an individual shared network, subnet, host group or host.

Note
Options set for individual shared networks, subnets, host groups or hosts override the options set at the global level.

To configure client options, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***services » dhcpserver » {path} » options***, where *path* is the path to and name of the desired shared network, subnet, host group or host. For example, to access the options for a shared network named *Shared*, navigate to:

   services » dhcpserver » shared-network » Shared » options

   To access the global options, navigate to:

   services » dhcpserver » options
3. Set the client options by configuring the following parameters as required:

Parameter	Description
`hostname { hostname }`	**Synopsis:** A string between 1 and 32 characters long The unique name to refer to the host within a DHCP configuration.
`subnetmask { subnetmask }`	**Synopsis:** A string between 7 and 15 characters long Subnet mask
`default-route { default-route }`	**Synopsis:** A string between 7 and 15 characters long The default route that the server offers to the client when it issues the lease to the client.
`broadcast { broadcast }`	**Synopsis:** A string between 7 and 15 characters long The broadcast address that the server offers to the client when it issues the lease to the client.
`domain { domain }`	**Synopsis:** A string between 1 and 253 characters long The domain name that the server offers to the client when it issues the lease to the client.
`dns-server { dns-server }`	**Synopsis:** A string between 7 and 31 characters long The domain name server that the server offers to the client when it issues the lease to the client.

Parameter	Description
`static-route { static-route }`	**Synopsis:** A string between 7 and 15 characters long The static route that the DHCP server offers to the client when it issues the lease to the client.

4. Define the NIS server settings by configuring the following parameters as required:

Parameter	Description
`server { server }`	**Synopsis:** A string between 7 and 15 characters long The NIS server address that the DHCP server offers to the client when it issues the lease to the client.
`domain { domain }`	**Synopsis:** A string between 1 and 253 characters long The NIS domain name that the DHCP server offers to the client when it issues the lease to the client.

5. Define the NetBios server settings by configuring the following parameters as required:

Parameter	Description
`scope { scope }`	**Synopsis:** A string between 1 and 256 characters long **Default:** netbios The NetBIOS scope that the DHCP server offers to the client when it issues the lease to the client.
`nameserver { nameserver }`	**Synopsis:** A string between 1 and 256 characters long **Default:** 127.0.0.1 The NetBIOS name server that the DHCP server offers to the client when it issues the lease to the client.

6. [Optional] Add custom options. For more information, refer to "Adding a Custom DHCP Client Configuration Option (Page 268)".
7. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.5.2 Configuring Standard DHCP Client Configuration Options (IPv6)

Configuration options for DHCP clients can be configured globally or for an individual shared network, subnet, host group or host.

Note
Options set for individual shared networks, subnets, host groups or hosts override the options set at the global level.

To configure client options, do the following:

1. Make sure the CLI is in Configuration mode.

2. Navigate to ***services » dhcpserver6 » {path} » {name} » options***, where *path* is the path to and name of the desired shared network, subnet6, host group or host and *name* is the user-added name.

   For example, to access the options for a shared network named *Shared*, navigate to:

   services » dhcpserver6 » shared-network » Shared » options

   To access the global options, navigate to:

   services » dhcpserver6 » options

3. Set the client options by configuring the following parameters as required:

Parameter	Description
`domain { domain }`	**Synopsis:** A string between 1 and 253 characters long The domain name that the server offers to the client when it issues the lease to the client.
`dns-server { dns-server }`	**Synopsis:** A string between 6 and 87 characters long The domain name server that the server offers to the client when it issues the lease to the client.
`domain-search { domain-search }`	**Synopsis:** A string 773 characters long The domain search list that the server offers to the client when it issues the lease to the client.

4. Define the NIS server settings by configuring the following parameters as required:

Parameter	Description
`server { server }`	**Synopsis:** A string between 6 and 40 characters long The NIS server address that the DHCPv6 server offers to the client when it issues the lease to the client.
`domain { domain }`	**Synopsis:** A string between 1 and 253 characters long The NIS domain name that the DHCPv6 server offers to the client when it issues the lease to the client.

5. [Optional] Add custom options. For more information, refer to "Adding a Custom DHCP Client Configuration Option (Page 268)".
6. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.5.3 Viewing a List of Custom DHCP Client Configuration Options

To view a list of custom DHCP client configuration options set at the global level or for a specific shared network, type:

- **For IPv4**

  ```
  show running-config services dhcpserver { path }
  options client custom
  ```

- **For IPv6**

  ```
  show running-config services dhcpserver6 options
  client custom
  ```

Where { path } is the path to and name of the desired shared network, subnet, host group or host.

If custom configurations have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services dhcpserver options client custom
services
 dhcpserver
  options
   client
    custom 120 500
    !
   !
  !
 !
!
```

If custom configurations have not been configured, add custom configurations as needed. For more information, refer to "Adding a Custom DHCP Client Configuration Option (Page 268)".

7.3.5.4 Adding a Custom DHCP Client Configuration Option

To add a custom client option, do the following:

Note
The number of the option (defined by the Internet Assigned Numbers Authority or IANA) and its allowed value must be known before a custom option can be configured. For more information about available DHCP options, refer to RFC 2132 [http://tools.ietf.org/html/rfc2132].

1. Make sure the CLI is in Configuration mode.
2. Navigate to:
   - **For IPv4**

     services » dhcpserver » {path} » options » client » custom
   - **For IPv6**

     services » dhcpserver6 » options » client » custom

   where *path* is the path to and name of the desired shared network, subnet, host group or host.

Note
Custom options at the **{path}** level are only available for IPv4.

For example, to access the custom IPv4 options for a shared network named *Shared*, navigate to:

services » dhcpserver » shared-network » Shared » options » client » custom

To access custom IPv4 options at the global level, navigate to:

services » dhcpserver » options » client » custom

3. Configure the following parameter(s) as required:

Parameter	Description
`number { number }`	**Synopsis:** An integer
`value { value }`	**Synopsis:** An integer The value of the custom option.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.5.5 Deleting a Custom DHCP Client Configuration Option

To delete a custom client option, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to:
   - **For IPv4**

     services » dhcpserver » {path} » options » client » custom
   - **For IPv6**

     services » dhcpserver6 » options » client » custom

   where *path* is the path to and name of the desired shared network, subnet, host group or host.

Note
Custom options at the **{path}** level are only available for IPv4.

For example, to access the custom IPv4 options for a shared network named *Shared*, navigate to:

services » dhcpserver » shared-network » Shared » options » client » custom

To access custom IPv4 options at the global level, navigate to:

services » dhcpserver » options » client » custom

3. Delete the custom option by typing:

- **For IPv4**

  ```
  no services dhcpserver { path } options client custom { number }
  ```

- **For IPv6**

  ```
  no services dhcpserver6 options client custom { number }
  ```

  Where:

  - { path } is the path to and name of the desired shared network, subnet, host group or host
  - { number } is the option number

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.6 Managing DHCP Listen Interfaces

DHCP listen interfaces specify the IP interface to which the client sends a request.

7.3.6.1 Viewing a List of DHCP Listen Interfaces

To view a list of DHCP listen interfaces, type:

- **For IPv4**

  ```
  show running-config services dhcpserver interface
  ```

- **For IPv6**

  ```
  show running-config services dhcpserver6 interface
  ```

If DHCP listen interfaces have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services dhcpserver interface | tab
NAME
-------------
switch.0001

 !
!
```

If no DHCP listen interfaces have been configured, add interfaces as needed. For more information, refer to "Adding a DHCP Listen Interface (Page 271)".

7.3.6.2 Adding a DHCP Listen Interface

To add a DHCP listen interface, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the interface by typing:
   - **For IPv4**

     ```
     services dhcpserver interface { name }
     ```

   - **For IPv6**

     ```
     services dhcpserver6 interface { name }
     ```

   Where:
   - `{ name }` is the name of the interface
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.6.3 Deleting a DHCP Listen Interface

To delete a DHCP listen interface, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the interface by typing:
   - **For IPv4**

     ```
     no services dhcpserver interface { name }
     ```

   - **For IPv6**

     ```
     no services dhcpserver6 interface { name }
     ```

   Where:
   - `{ name }` is the name of the interface
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.7 Managing Shared Networks

Shared networks are used when multiple subnets should be served by a single physical port. This applies both when using a DHCP relay agent connected to the port with additional subnets behind the relay agent, or when multiple virtual networks exist on one physical interface. Each subnet then gets its own subnet definition inside the shared network rather than at the top level. Shared networks contain subnets, groups and hosts.

7.3.7.1 Viewing a List of Shared Networks

To view a list of shared networks, type:

- **For IPv4**

  ```
  show running-config services dhcpserver shared-network
  ```

- **For IPv6**

  ```
  show running-config services dhcpserver6 shared-network
  ```

If shared networks have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services dhcpserver shared-network
services
 dhcpserver
  shared-network Shared
   options client
    no hostname
    no subnetmask
    no default-route
    no broadcast
    no domain
    no dns-server
    no static-route
    no nis server
    no nis domain
   !
  !
 !
!
```

If no shared networks have been configured, add shared networks as needed. For more information, refer to "Adding a Shared Network (Page 272)".

7.3.7.2 Adding a Shared Network

To add a shared network to the DHCP server, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the shared network by typing:
   - **For IPv4**

     ```
     services dhcpserver shared-network { name }
     ```

   - **For IPv6**

     ```
     services dhcpserver6 shared-network { name }
     ```

   Where:

   - `{ name }` is the name of the shared network

3. Configure options for the shared network. For more information, refer to "Configuring Shared Network Options (Page 273)".
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.7.3 Configuring Shared Network Options

To configure options for a shared network on the DHCP server, do the following:

Note
Options set at the shared network level override options set at the DHCP server level.

1. Make sure the CLI is in Configuration mode.
2. Navigate to:
   - **For IPv4**

     ```
     services dhcpserver shared-network{shared network} options
     ```

   - **For IPv6**

     ```
     services dhcpserver6 shared-network{shared network} options
     ```

3. Configure the leased time settings by configuring the following parameter(s) as required:

Parameter	Description
`default { default }`	**Synopsis:** An integer **Default:** 600 The minimum leased time in seconds that the server offers to the clients.
`maximum { maximum }`	**Synopsis:** An integer **Default:** 7200 The maximum leased time in seconds that the server offers to the clients.

4. Configure the client by configuring the following parameter(s) as required:

⚠ NOTICE

For IPv4 only:

If DHCP relay (or Option 82) clients are used on the same subnet as the DHCP server, some clients will try to renew a lease immediately after receiving it by requesting a renewal directly from the DHCP server. Because the DHCP server is configured by default to only provide the lease through a relay agent configured with the current Option 82 fields, the server sends the client a NAK (negative acknowledgment or not acknowledged) message to disallow the

lease. Enabling Option 82 disables the NAK message so the renewal request sent from the DHCP relay agent (which the DHCP server accepts, since it has the correct Option 82 fields added) is the only message for which the client receives a reply.

Option 82 support should only be enabled If the DHCP server and clients are on the same subnet.

The meaning of most Option 82 fields is determined by the DHCP relay client. To determine which values are required by the client for special options, refer to the client documentation.

DHCP relay support can also be enabled on individual subnets. For more information, refer to "Configuring Subnet Options (Page 276)".

Parameter	Description
`unknown-client { unknown-client }`	**Synopsis:** [allow | deny | ignore] The action to take for previously unregistered clients
`authorize-server`	Enables/disables the server's authorization on this client. If enabled, the server will send deny messages to the client that is trying to renew the lease, which the server knows the client shouldn't have.
`option82`	Enables/disables the NAK of option 82 clients for this subnet.

5. [Optional] Configure configuration options for DHCP clients at the shared network level. For more information, refer to refer to "Configuring Standard DHCP Client Configuration Options (IPv4) (Page 265)" or "Configuring Standard DHCP Client Configuration Options (IPv6) (Page 266)".
6. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.7.4 Deleting a Shared Network

To delete a shared network, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the shared network by typing:
   - **For IPv4**

     ```
     no services dhcpserver shared-network { name }
     ```

   - **For IPv6**

     ```
     no services dhcpserver6 shared-network { name }
     ```

   Where:

   - `{ name }` is the name of the shared network
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.8 Managing Subnets

Subnets control settings for each subnet that DHCP serves. A subnet can include a range of IP addresses to give clients. Subnets contain groups, pools and hosts. Only one subnet can contain dynamic IP address ranges without any access restrictions on any given physical port, since DHCP doesn't know which subnet a client should belong to when the request is received.

7.3.8.1 Viewing a List of Subnets

To view a list of subnets, type:

- **For IPv4**

  ```
  show running-config services dhcpserver subnet-name
  ```

- **For IPv6**

  ```
  show running-config services dhcpserver6 subnet6-name
  ```

If subnets have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services dhcpserver subnet-name network-ip | tab
NAME  NETWORK IP
----------------------
SUB1  192.168.0.0/27
SUB2  192.168.0.32/27

 !
!
```

If no subnets have been configured, add subnets as needed. For more information, refer to "Adding a Subnet (Page 275)".

7.3.8.2 Adding a Subnet

To add a subnet to the DHCP server, do the following:

Note
At least one shared network must be available if two or more subnets are configured for the same interface. For information about configuring a shared network, refer to "Adding a Shared Network (Page 272)".

1. Make sure the CLI is in Configuration mode.
2. Add the subnet by typing:
   - **For IPv4**

     ```
     services dhcpserver subnet-name { name }
     ```

- **For IPv6**

  ```
  services dhcpserver6 subnet6-name { name }
  ```

  Where:

  - `{ name }` is the name of the subnet

3. Configure the following parameter(s) as required:

Parameter	Description
`network-ip { network-ip }`	**Synopsis:** A string between 9 and 18 characters long The network IP address for this subnet.
`shared-network { shared-network }`	**Synopsis:** A string between 1 and 32 characters long The shared-network that this host belongs to.
`network-ip { network-ip }`	**Synopsis:** A string between 4 and 43 characters long The network IPv6 address for this subnet.
`shared-network { shared-network }`	**Synopsis:** A string between 1 and 32 characters long The shared-network that this host belongs to.

4. Configure the options for the subnet. For more information, refer to "Configuring Subnet Options (Page 276)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.8.3 Configuring Subnet Options

To configure options for a subnet, do the following:

Note
Options set at the subnet level override options set at the DHCP server level.

1. Make sure the CLI is in Configuration mode.
2. Navigate to:

   - **For IPv4**

     ```
     services dhcpserver subnet-name { name } options
     ```

   - **For IPv6**

     ```
     services dhcpserver6 subnet6-name { name }
     options
     ```

     Where:

     - `{ name }` is the name of the subnet

3. Configure the leased time settings by configuring the following parameter(s):

- **For IPv4:**

Parameter	Description
`default { default }`	**Synopsis:** An integer **Default:** 600 The minimum leased time in seconds that the server offers to the clients.
`maximum { maximum }`	**Synopsis:** An integer **Default:** 7200 The maximum leased time in seconds that the server offers to the clients.

- **For IPv6:**

Parameter	Description
`default { default }`	**Synopsis:** An integer **Default:** 600 The minimum leased time in seconds that the server offers to the clients.
`maximum { maximum }`	**Synopsis:** An integer **Default:** 7200 The maximum leased time in seconds that the server offers to the clients.

4. Configure the client settings by configuring the following parameter(s):

⚠ NOTICE

For IPv4 only:

If DHCP relay (or Option 82) clients are used on the same subnet as the DHCP server, some clients will try to renew a lease immediately after receiving it by requesting a renewal directly from the DHCP server. Because the DHCP server is configured by default to only provide the lease through a relay agent configured with the current Option 82 fields, the server sends the client a NAK (negative acknowledgment or not acknowledged) message to disallow the lease. Enabling Option 82 disables the NAK message so the renewal request sent from the DHCP relay agent (which the DHCP server accepts, since it has the correct Option 82 fields added) is the only message for which the client receives a reply.

Option 82 support should only be enabled If the DHCP server and clients are on the same subnet.

The meaning of most Option 82 fields is determined by the DHCP relay client. To determine which values are required by the client for special options, refer to the client documentation.

DHCP relay support can also be enabled on individual subnets.

- **For IPv4**

Parameter	Description
`unknown-client { unknown-client }`	**Synopsis:** [allow | deny | ignore] The action to take for previously unregistered clients
`option82`	Enables/disables the NAK of option 82 clients for this subnet.
`authorize-server`	Enables/disables the server's authorization on this client. If enabled, the server will send deny messages to the client that is trying to renew the lease, which the server knows the client shouldn't have.

- **For IPv6**

Parameter	Description
`unknown-client { unknown-client }`	**Synopsis:** [allow | deny | ignore] The action to take for previously unregistered clients
`authorize-server`	Enables/disables the server's authorization on this client. If enabled, the server will send deny messages to the client that is trying to renew the lease, which the server knows the client shouldn't have.

5. [Optional] Configure configuration options for DHCP clients at the subnet level. For more information, refer to refer to "Configuring Standard DHCP Client Configuration Options (IPv4) (Page 265)" or "Configuring Standard DHCP Client Configuration Options (IPv6) (Page 266)".
6. Configure one or more address pools to the subnet. For more information, refer to "Adding an Address Pool (IPv4) (Page 286)" or "Adding an Address Pool (IPv6) (Page 288)".
7. Configure one or more IP ranges to the subnet. For more information, refer to "Adding an IP Range (IPv4) (Page 291)" or "Adding an IP Range (IPv6) (Page 293)".
8. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.8.4 Deleting a Subnet

To delete a subnet, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the subnet by typing:
   - **For IPv4**

     ```
     no services dhcpserver subnet-name { name }
     ```

   - **For IPv6**

     ```
     no services dhcpserver6 subnet6-name { name }
     ```

Where:

- `{ name }` is the name of the subnet

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.9 Managing Host Groups

Host-groups allow identical settings to be created for a group of hosts, making it easier to manage changes to the settings for all the hosts contained within the group. Host-groups contain hosts.

7.3.9.1 Viewing a List of Host Groups

To view a list of host groups, type:

- **For IPv4**

  ```
  show running-config services dhcpserver host-groups
  ```

- **For IPv6**

  ```
  show running-config services dhcpserver6 host-groups
  ```

If host groups have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services dhcpserver host-groups
services
 dhcpserver
  host-groups "Local Group"
   options
    client
     no hostname
     no subnetmask
     no default-route
     no broadcast
     no domain
     no dns-server
     no static-route
     no nis server
     no nis domain
    !
   !
  !
 !
!
```

If no host groups have been configured, add host groups as needed. For more information, refer to "Adding a Host Group (Page 280)".

7.3.9.2 Adding a Host Group

To add a host group to the DHCP server, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to:
   - **For IPv4**

     ```
     services dhcpserver host-groups
     ```

   - **For IPv6**

     ```
     services dhcpserver6 host-groups
     ```

3. Configure the following parameter(s) as required:

Parameter	Description
`name { name }`	**Synopsis:** A string between 1 and 32 characters long The description of the host groups.

4. Configure the options for the host group. For more information, refer to "Configuring Host Group Options (Page 280)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.9.3 Configuring Host Group Options

To configure options for a host group on the DHCP server, do the following:

Note
Options set at the host group level override options set at the DHCP server level.

1. Make sure the CLI is in Configuration mode.
2. Change the mode to **Edit Private** or **Edit Exclusive**.
3. Navigate to:
   - **For IPv4**

     services » dhcpserver » host-groups » {host} » options

   - **For IPv6**

     services » dhcpserver6 » host-groups » {host} » options

   Where *{host}* is the name of the host group.
4. Configure the leased time settings by configuring the following parameter(s):

- **For IPv4:**

Parameter	Description
`default { default }`	**Synopsis:** An integer **Default:** 600 The minimum leased time in seconds that the server offers to the clients.
`maximum { maximum }`	**Synopsis:** An integer **Default:** 7200 The maximum leased time in seconds that the server offers to the clients.

- **For IPv6:**

Parameter	Description
`default { default }`	**Synopsis:** An integer **Default:** 600 The minimum leased time in seconds that the server offers to the clients.
`maximum { maximum }`	**Synopsis:** An integer **Default:** 7200 The maximum leased time in seconds that the server offers to the clients.

5. Configure the client settings by configuring the following parameter(s):

- **For IPv4**

Parameter	Description
`unknown-client { unknown-client }`	**Synopsis:** [allow | deny | ignore] The action to take for previously unregistered clients
`shared-network { shared-network }`	**Synopsis:** A string between 1 and 32 characters long The shared-network that this host belongs to.
`subnet { subnet }`	**Synopsis:** A string between 1 and 32 characters long The subnet that this host belongs to.

- **For IPv6**

Parameter	Description
`unknown-client { unknown-client }`	**Synopsis:** [allow | deny | ignore] The action to take for previously unregistered clients
`shared-network { shared-network }`	**Synopsis:** A string between 1 and 32 characters long The shared-network that this host belongs to.
`subnet6 { subnet6 }`	**Synopsis:** A string between 1 and 32 characters long The subnet that this host belongs to.

6. [Optional] Configure configuration options for DHCP clients at the host group level. For more information, refer to refer to "Configuring Standard DHCP Client Configuration Options (IPv4) (Page 265)" or "Configuring Standard DHCP Client Configuration Options (IPv6) (Page 266)".
7. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.9.4 Deleting a Host Group

To delete a host group, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the host group by typing:
   - **For IPv4**

     ```
     no services dhcpserver host-groups { name }
     ```

   - **For IPv6**

     ```
     no services dhcpserver6 host-groups { name }
     ```

   Where:

   - `{ name }` is the name of the host group
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.10 Managing DHCP Hosts

Host entries assign settings to a specific client based on its Ethernet MAC address.

7.3.10.1 Viewing a List of Hosts

To view a list of hosts on the DHCP server, type:

- **For IPv4**

  ```
  show running-config services dhcpserver host
  ```

- **For IPv6**

  ```
  show running-config services dhcpserver6 host
  ```

If hosts have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services dhcpserver host APE-INT
services
 dhcpserver
```

```
  host APE-INT
   options
    hardware mac 00:01:C0:0B:B7:71
    fixed-ip       192.168.0.60
    unknown-client allow
    subnet         SUB2
    client
     hostname APE-INT
     no subnetmask
     no default-route
     no broadcast
     no domain
     no dns-server
     no static-route
     no nis server
     no nis domain
    !
   !
  !
 !
!
```

If no hosts have been configured, add hosts as needed. For more information, refer to "Adding a Host (Page 283)".

7.3.10.2 Adding a Host

To add a host to the DHCP server, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the host by typing:
   - **For IPv4**

     `services dhcpserver host { name }`

   - **For IPv6**

     `services dhcpserver6 host { name }`

   Where:

   - `{ name }` is the name of the host
3. Configure options for the host. For more information, refer to "Configuring Host Options (Page 283)".
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.10.3 Configuring Host Options

To configure options for a host on the DHCP server, do the following:

Note
Options set at the host level override options set at the DHCP server level.

1. Make sure the CLI is in Configuration mode.
2. Navigate to:
   - **For IPv4**

     services » dhcpserver » hosts » {host} » options
   - **For IPv6**

     services » dhcpserver6 » hosts » {host} » options

   Where *{host}* is the name of the host.
3. Configure the hardware settings by configuring the following parameter(s):

Parameter	Description
`type { type }`	**Synopsis:** [fddi | token-ring | ethernet] **Default:** ethernet The type of network hardware used by the client, associated with the host entry.
`mac { mac }`	**Synopsis:** A string 17 characters long The physical network address of the client. Note that this corresponds to the hardware type; for example, the MAC address for the ethernet.

4. Configure the leased time settings by configuring the following parameter(s):

Parameter	Description
`default { default }`	**Synopsis:** An integer **Default:** 600 The minimum leased time in seconds that the server offers to the clients.
`maximum { maximum }`	**Synopsis:** An integer **Default:** 7200 The maximum leased time in seconds that the server offers to the clients.

5. Configure the client settings by configuring the following parameter(s):
   - **For IPv4**

Parameter	Description
`fixed-ip { fixed-ip }`	**Synopsis:** A string between 7 and 15 characters long The IP address that the server assigns to the matching client.
`unknown-client { unknown-client }`	**Synopsis:** [allow | deny | ignore] The action to take for previously unregistered clients
`shared-network { shared-network }`	**Synopsis:** A string between 1 and 32 characters long The shared-network that this host belongs to.
`subnet { subnet }`	**Synopsis:** A string between 1 and 32 characters long The subnet that this host belongs to.

Parameter	Description
`host-groups { host-groups }`	**Synopsis:** A string between 1 and 32 characters long The host groups that this host belongs to.

- **For IPv6**

Parameter	Description
`fixed-ip { fixed-ip }`	**Synopsis:** A string between 6 and 40 characters long The IPv6 address that the server assigns to the matching client.
`fixed-prefix6 { fixed-prefix6 }`	**Synopsis:** A string between 4 and 43 characters long The IPv6 prefix delegation that the server assigns to the matching client.
`unknown-client { unknown-client }`	**Synopsis:** [allow | deny | ignore] The action to take for previously unregistered clients
`shared-network { shared-network }`	**Synopsis:** A string between 1 and 32 characters long The shared-network that this host belongs to.
`subnet6 { subnet6 }`	**Synopsis:** A string between 1 and 32 characters long The subnet that this host belongs to.
`host-groups { host-groups }`	**Synopsis:** A string between 1 and 32 characters long The host groups that this host belongs to.

6. [Optional] Configure configuration options for DHCP clients at the host level. For more information, refer to refer to "Configuring Standard DHCP Client Configuration Options (IPv4) (Page 265)" or "Configuring Standard DHCP Client Configuration Options (IPv6) (Page 266)".
7. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.10.4 Deleting Hosts

To delete a host, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the host by typing:
   - **For IPv4**

     ```
     no services dhcpserver host { name }
     ```

   - **For IPv6**

     ```
     no services dhcpserver6 host { name }
     ```

   Where:

   - `{ name }` is the name of the host

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.11 Managing Address Pools (IPv4)

Address pools define a range of IP addresses that can be assigned to DHCP clients belonging to the same subnet.

7.3.11.1 Viewing a List of Address Pools (IPv4)

To view a list of address pools configured for a DHCP subnet, type:

```
show running-config services dhcpserver subnet-name
{ name } options ippool
```

Where:

- `{ name }` is the name of the subnet

If pools have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services dhcpserver subnet-name Local options ippool
services
 dhcpserver
  subnet Local
   options
    ippool pool1
     no unknown-client
     iprange 172.0.0.0
      end 172.0.0.1
     !
     option82 class1
      remote-id  00:00:00:01:03:01
      circuit-id 00:00:00:01:01:01
     !
    !
   !
  !
 !
!
```

If no IP pools have been configured, add pools as needed. For more information, refer to "Adding an Address Pool (IPv4) (Page 286)".

7.3.11.2 Adding an Address Pool (IPv4)

To add an address pool to a DHCP subnet, do the following:

1. Make sure the CLI is in Configuration mode.

2. Add the address pool by typing:

   ```
   services dhcpserver subnet-name { name } options
   ippool { description }
   ```

   Where:

   - `{ name }` is the name of the subnet
   - `{ description }` is the name of the IP pool

3. Configure the leased time settings by configuring the following parameter(s):

Parameter	Description
`default { default }`	**Synopsis:** An integer **Default:** 600 The minimum leased time in seconds that the server offers to the clients.
`maximum { maximum }`	**Synopsis:** An integer **Default:** 7200 The maximum leased time in seconds that the server offers to the clients.

4. Configure the client and failover settings by configuring the following parameter(s):

Parameter	Description
`unknown-client { unknown-client }`	**Synopsis:** [allow | deny | ignore] The action to take for previously unregistered clients
`failover-peer { failover-peer }`	**Synopsis:** A string between 7 and 15 characters long The IP address of a DHCP peer server if a failover pool is created.

5. Add one or more IP ranges to the pool. For more information, refer to "Adding an IP Range (IPv4) (Page 291)".
6. Add one or more Option82 classes to the pool. For more information, refer to "Adding an Option 82 Class to an Address Pool (Page 300)".
7. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.11.3 Deleting an Address Pool (IPv4)

To delete an address pool, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the address pool by typing:

   ```
   no services dhcpserver subnet-name { name }
   options ippool { description }
   ```

Where:

- `{ name }` is the name of the subnet
- `{ description }` is the name of the IP pool

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.12 Managing Address Pools (IPv6)

Address pools define a range of IP addresses that can be assigned to DHCP clients belonging to the same subnet.

7.3.12.1 Viewing a List of Address Pools (IPv6)

To view a list of address pools configured for a DHCP subnet, type:

```
show running-config services dhcpserver6 subnet6-name
{ name } options ippool6
```

Where:

- `{ name }` is the name of the subnet

If pools have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services dhcpserver6 subnet6-name options ippool6
services
 dhcpserver6
  subnet6-name Sub
   options
    ippool6 Pool1
     iprange6 2001:db8:2728::2221
      end 2001:db8:2728::2230
     !
    !
   !
  !
 !
!
!
```

If no IP pools have been configured, add pools as needed. For more information, refer to "Adding an Address Pool (IPv6) (Page 288)".

7.3.12.2 Adding an Address Pool (IPv6)

To add an address pool to a DHCP subnet, do the following:

1. Make sure the CLI is in Configuration mode.

2. Add the address pool by typing:

   ```
   services dhcpserver6 subnet6-name { name } options
   ippool6 { ippoolname }
   ```

   Where:

   - `{ name }` is the name of the subnet
   - `{ ippoolname }` is the name of the IPv6 pool

3. Configure the leased time settings by configuring the following parameter(s):

Parameter	Description
`default { default }`	**Synopsis:** An integer **Default:** 600 The minimum leased time in seconds that the server offers to the clients.
`maximum { maximum }`	**Synopsis:** An integer **Default:** 7200 The maximum leased time in seconds that the server offers to the clients.

4. Configure the client and failover settings by configuring the following parameter(s):

Parameter	Description
`unknown-client { unknown-client }`	**Synopsis:** [allow | deny | ignore] The action to take for previously unregistered clients

5. [Optional] Add one or more IP ranges to the pool. For more information, refer to "Adding an IP Range (IPv6) (Page 293)".
6. [Optional] Add one or more subnets to the pool. For more information, refer to "Adding a IPv6 Subnet (Page 298)".
7. [Optional] Add one or more temporary subnets to the pool. For more information, refer to "Adding a Temporary Subnet (Page 296)".
8. [Optional] Add one or more prefixes to the pool. For more information, refer to "Adding an IPv6 Prefix (Page 295)".
9. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.12.3 Deleting an Address Pool (IPv6)

To delete an address pool, do the following:

1. Make sure the CLI is in Configuration mode.

2. Delete the address pool by typing:

   ```
   no services dhcpserver subnet6-name { name }
   options ippool6 { ippoolname }
   ```

   Where:

   - `{ name }` is the name of the subnet
   - `{ ippoolname }` is the name of the IPv6 pool

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.13 Managing IP Ranges (IPv4)

An IP range represents the range of IP addresses the DHCP server can assign to clients. IP addresses outside the set range are reserved for statically addressed clients.

An IP range can be configured for a DHCP subnet and/or its associated address pool(s).

7.3.13.1 Viewing a List of IP Ranges (IPv4)

To view a list of IP ranges configured for a DHCP subnet, type:

- **For DHCP subnets**

  ```
  show running-config services dhcpserver subnet-name
  { name } options iprange
  ```

- **For an address pool**

  ```
  show running-config services dhcpserver subnet-name
  { name } options ippool { description } iprange
  ```

Where:

- { name } is the name of the subnet
- { description } (if applicable) is the name of the address pool

If ranges have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services dhcpserver subnet-name Local options iprange
services
 dhcpserver
  subnet Local
   options
    iprange 172.30.144.251
     end 172.30.144.254
    !
   !
  !
```

```
  !
!
```

If no IP ranges have been configured, add ranges as needed. For more information, refer to "Adding an IP Range (IPv4) (Page 291)" or "Adding an IP Range (IPv6) (Page 293)".

7.3.13.2 Adding an IP Range (IPv4)

To add an IP range to a DHCP subnet or one of its associated address pools, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the IP range by typing:
   - **For a DHCP subnet**

     ```
     services dhcpserver subnet-name { name } options
     iprange { start } end { end }
     ```

   - **For an address pool**

     ```
     services dhcpserver subnet-name { name } options
     ippool { description } iprange { start } end
     { end }
     ```

     Where:

     - { name } is the name of the subnet
     - { description } (if applicable) is the name of the address pool
     - { start } is the starting IP address pool the server uses to offer to the client
     - { end } is the ending IP address pool the server uses to offer to the client
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.13.3 Deleting an IP Range (IPv4)

To delete an IP range from a DHCP subnet or one of its associated address pools, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the IP range by typing:
   - **For a DHCP subnet**

     ```
     no dhcpserver subnet-name { name } options
     iprange { start } end { end }
     ```

- **For an address pool**

  ```
  no services dhcpserver subnet-name { name }
  options ippool { description } iprange { start }
  end { end }
  ```

  Where:

  - { name } is the name of the subnet
  - { description } (if applicable) is the name of the address pool
  - { start } is the starting IP address pool the server uses to offer to the client
  - { end } is the ending IP address pool the server uses to offer to the client

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.14 Managing IP Ranges (IPv6)

An IP range represents the range of IP addresses the DHCP server can assign to clients. IP addresses outside the set range are reserved for statically addressed clients.

An IP range can be configured for a DHCP subnet and/or its associated address pool(s).

7.3.14.1 Viewing a List of IP Ranges (IPv6)

To view a list of IP ranges configured for a DHCP subnet, type:

- **For DHCP IPv6 subnets**

  ```
  show running-config services dhcpserver6 subnet6-
  name { name } options iprange6
  ```

- **For an IPv6 address pool**

  ```
  show running-config services dhcpserver6 subnet6-
  name { name } options ippool6 { description }
  iprange6
  ```

  Where:

  - { name } is the name of the subnet
  - { description } (if applicable) is the name of the address pool

  If ranges have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services dhcpserver6 subnet6-name sub options
 iprange6
services
```

```
 dhcpserver6
  subnet6-name sub
   options
    iprange6 2001:db8:2728::2200
     end 2001:db8:2728::2220
    !
   !
  !
 !
!
!
```

If no IP ranges have been configured, add ranges as needed. For more information, refer to "Adding an IP Range (IPv6) (Page 293)".

7.3.14.2 Adding an IP Range (IPv6)

To add an IP range to a DHCP subnet or one of its associated address pools, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the IP range by typing:
   - **For a DHCP IPv6 subnet**

     ```
     services dhcpserver6 subnet6-name { name }
     options iprange6 { start } end { end }
     ```

   - **For an IPv6 address pool**

     ```
     services dhcpserver6 subnet6-name { name }
     options ippool6 { description } iprange6
     { start } end { end }
     ```

     Where:

     - { name } is the name of the subnet
     - { description } (if applicable) is the name of the address pool
     - { start } is the starting IP address pool the server uses to offer to the client
     - { end } is the ending IP address pool the server uses to offer to the client
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.14.3 Deleting an IP Range (IPv6)

To delete an IP range from a DHCP subnet or one of its associated address pools, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the IP range by typing:

- **For a DHCP IPv6 subnet**

  ```
  no dhcpserver6 subnet6-name { name } options iprange6 { start } end { end }
  ```

- **For an IPv6 address pool**

  ```
  no services dhcpserver6 subnet6-name { name } options ippool6 { description } iprange6 { start } end { end }
  ```

  Where:

  - { name } is the name of the subnet
  - { description } (if applicable) is the name of the address pool
  - { start } is the starting IP address pool the server uses to offer to the client
  - { end } is the ending IP address pool the server uses to offer to the client

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.15 Managing IPv6 Prefixes

One or more optional IPv6 prefix can be defined for the server to offer to the client.

A *prefix6* delegation includes the IPv6 subnetwork, along with the prefix length in bits. The subnetwork value used should be within the subnetwork value of the enclosing subnet6 declaration.

7.3.15.1 Viewing a List of IPv6 Prefixes

To view a list of IP ranges configured for a DHCP subnet, type:

For DHCP IPv6 subnets

```
show running-config services dhcpserver6 subnet6-name { name } options prefix6
```

Where:

- { name } is the name of the subnet

If prefixes have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services dhcpserver6 subnet6-name sub2 options
 prefix6
services
 dhcpserver6
  subnet6-name sub2
   options
    prefix6 2001:db8:28d2:f0::
     end  2001:db8:28d2:f0::
```

```
      bits 60
     !
    !
   !
  !
 !
!
```

If no prefixes have been configured, add ranges as needed. For more information, refer to "Adding an IPv6 Prefix (Page 295)".

7.3.15.2 Adding an IPv6 Prefix

To add a prefix, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the prefix by typing:

   ```
   services dhcpserver6 subnet6-name { name } options prefix6 { prefix }
   ```

   Where:

   - { name } is the name of the subnet
   - { prefix } is the starting IPv6 prefix delegation
3. Configure the IPv6 Range Configuration by configuring the following parameter(s) as required:

Parameter	Description
`end { end }`	**Synopsis:** A string between 6 and 40 characters long The ending IPv6 prefix delegation that the server uses to offer to the client.
`bits { bits }`	**Synopsis:** An integer between 1 and 64 Prefix delegations of bits length that are offered to the client.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.15.3 Deleting an IPv6 Prefix

To delete a prefix, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the prefix by typing:

   ```
   no services dhcpserver6 subnet6-name { name } options prefix6 { prefix }
   ```

   Where:

   - { name } is the name of the subnet

- { prefix } is the prefix

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.16 Managing Temporary Subnets

One or more optional IPv6 subnets with temporary addresses can be defined for the server to offer to the client.

7.3.16.1 Viewing a List of Temporary Subnets

To view a list of temporary subnets, type:

For DHCP IPv6 subnets

```
show running-config services dhcpserver6 subnet6-name
{ name } options temporarysubnet6
```

Where:

- { name } is the name of the subnet

If temporary subnets have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services dhcpserver6 subnet6-name sub2 options
 temporarysubnet6
services
 dhcpserver6
  subnet6-name sub2
   options
    temporarysubnet6 2001:db8:28d2::/112
    !
   !
  !
 !
!
!
```

If no prefixes have been configured, add ranges as needed. For more information, refer to "Adding an IPv6 Prefix (Page 295)".

7.3.16.2 Adding a Temporary Subnet

To add a temporary subnet, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the prefix by typing:

   ```
   services dhcpserver6 subnet6-name { name } options
   temporarysubnet6 { temporaryname }
   ```

Where:

- { name } is the name of the subnet
- { temporaryname } is the name of the temporary subnet

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.16.3 Deleting a Temporary Subnet

To delete a prefix, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the prefix by typing:

```
no services dhcpserver6 subnet6-name { name }
options temporarysubnet6 { temporaryname }
```

Where:

- { name } is the name of the subnet
- { temporaryname } is the temporary subnet

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.17 Managing IPv6 Subnets

One or more optional IPv6 subnets can be defined for the server to offer to the client.

7.3.17.1 Viewing a List of IPv6 Subnets

To view a list of IPv6 subnets, type:

```
show running-config services dhcpserver6 subnet6-name
{ name } options subnet6
```

Where:

- { name } is the name of the subnet

If IPv6 subnets have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services dhcpserver6 subnet6-name sub2 options
 subnet6
services
 dhcpserver6
  subnet6-name sub2
   options
    subnet6 2001:db8:28d2::/64
```

```
    !
   !
  !
 !
!
```

If no prefixes have been configured, add ranges as needed. For more information, refer to "Adding an IPv6 Prefix (Page 295)".

7.3.17.2 Adding a IPv6 Subnet

To add a IPv6 subnet, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the IPv6 subnet by typing:

   ```
   services dhcpserver6 subnet6-name { name } options subnet6 { subnet6name }
   ```

   Where:

   - { name } is the name of the subnet
   - { subnet6name } is the name of the IPv6 subnet
3. Configure the following parameter(s) as required:

Parameter	Description
`subnet-number { subnet-number }`	**Synopsis:** A string between 4 and 43 characters long The IPv6 subnet that the server uses to offer to the client.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.17.3 Deleting an IPv6 Subnet

To delete an IPv6 subnet, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the prefix by typing:

   ```
   no services dhcpserver6 subnet6-name { name } options subnet6 { subnet6name }
   ```

   Where:

   - { name } is the name of the subnet
   - { subnet6name } is the name of the IPv6 subnet
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.18 Managing Option 82 Classes for Address Pools

Option 82, or the DHCP relay agent information option, helps protect the DHCP server from IP address spoofing and DHCP IP starvation attacks by providing information about the network source of IP address requests. When a DHCP client issues an IP address request, a DHCP relay agent adds Option 82 information to the packet header for the request. The relay agent then forwards the request to the DHCP server for consideration. If the DHCP server determines the request came from an untrusted source, the request is rejected.

The DHCP server must be configured to accept Option 82 information if it is to determine the trustworthiness of the network interface used by a DHCP client. This can be done at the global level or for individual subnets.

Note
For more information about enabling the DHCP server to accept Option 82 information, refer to either "Configuring DHCP Server Options (Page 263)" or "Configuring Subnet Options (Page 276)".

Once Option 82 is enabled, sub-option components (or classes) must be defined for each address pool that includes DHCP clients that will send Option 82 information. This section describes how to manage the sub-option components for address pools.

7.3.18.1 Viewing a List of Option 82 Classes for Address Pools

To view a list of Option 82 classes configured for an address pool, type:

```
show running-config services dhcpserver subnet-name
{ name } options ippool { description } option82
```

Where:

- `{ name }` is the name of the subnet
- `{ description }` is the name of the address pool

If classes have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services dhcpserver subnet Local options ippool pool1
 option82
services
 dhcpserver
  subnet Local
   options
    ippool pool1
     option82 class1
      remote-id  00:00:00:01:03:01
      circuit-id 00:00:00:01:01:01
     !
    !
   !
  !
 !
!
```

If no Option 82 classes have been configured, add classes as needed. For more information, refer to "Adding an Option 82 Class to an Address Pool (Page 300)".

7.3.18.2 Adding an Option 82 Class to an Address Pool

To add an Option 82 class to an address pool, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the pool by typing:

   ```
   services dhcpserver subnet-name { name } options
   ippool { description } option82 { class }
   ```

   Where:

   - `{ name }` is the name of the subnet
   - `{ description }` is the name of the address pool
   - `{ class }` is the name of the Option82 class
3. Configure the following parameter(s) as required:

   Note
   The format for the `circuit-id` value is *00:00:00:{vlan}:{slot}:{port}*. If the remote host is connected to LM3/1 on VLAN 1, the ID would be 00:00:00:01:03:01. The Circuit ID uses hexadecimal values.

Parameter	Description
`remote-id { remote-id }`	**Synopsis:** A string 17 characters long Specifies the information relating to the remote host end of the circuit.
`circuit-id { circuit-id }`	**Synopsis:** A string 17 characters long Specifies the local information to which circuit the request came in on (ie. 00:02:03:02)

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.3.18.3 Deleting an Option 82 Class From an Address Pool

To delete an Option 82 class from an address pool, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the class by typing:

   ```
   no services dhcpserver subnet-name { name }
   options ippool { description } option82 { class }
   ```

   Where:

- `{ name }` is the name of the subnet
- `{ description }` is the name of the address pool
- `{ class }` is the name of the Option82 class

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

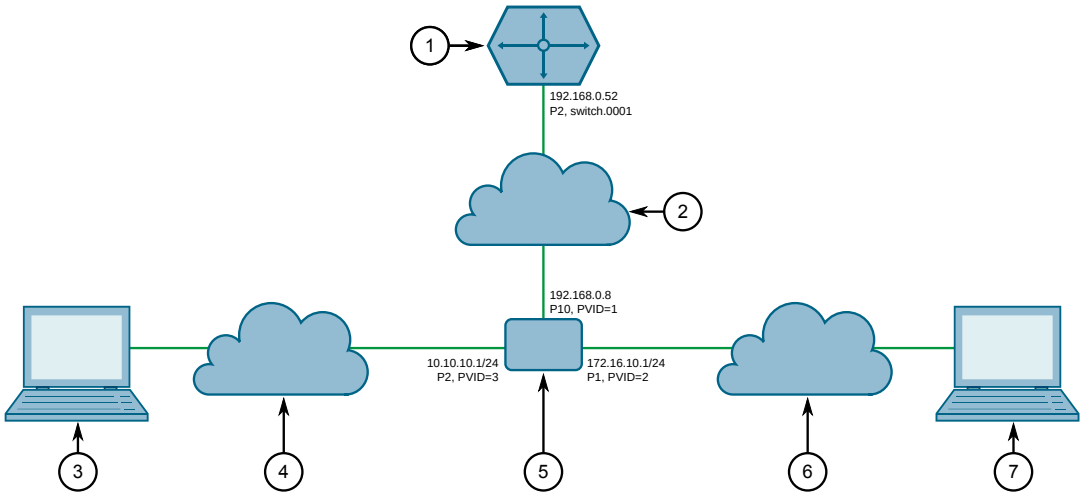
7.3.19 Example: Configuring the Device as a DHCP Server to Support a Relay Agent

This example demonstrates how to configure the device as a DHCP server, with a relay agent, without hosts or host groups.

The following topology depicts a scenario where two clients on separate LANs require IP addresses on different subnets from a DHCP server. Each client connects to the DHCP relay agent using different VLANs. The DHCP relay agent manages the requests and responses between the clients and the DHCP server.

⚠ NOTICE

The values shown are specific to the provided topology. Actual values can vary based on the user's configuration.



① DHCP Server (RUGGEDCOM ROX II Device)
② LAN A
③ Client 2
④ LAN B
⑤ DHCP Relay Agent
⑥ LAN C
⑦ Client 1

Figure 7.2 Topology – Device as a DHCP Server

To configure the device per the topology, do the following:

1. Configure a separate device as the DHCP relay agent:

   Note
   The relay agent may be a RUGGEDCOM ROX II device, a RUGGEDCOM ROS device, or a third party device with relay agent capabilities.

   a. Add and configure VLAN 2 and VLAN 3.
   b. Assign IP address *192.168.0.8* to VLAN 1.
   c. Change the PVID of port 1 to PVID 2.
   d. Change the PVID of port 2 to PVID 3.

   If the relay agent being used is a RUGGEDCOM ROX II device, refer to "Example: Configuring the Device as a Relay Agent (Page 259)" for more information.

2. Enable the DHCP server. For more information, refer to "Enabling/Disabling the DHCP Server (Page 263)".
3. Add the management interface (switch.0001) as a DHCP listen interface. For more information, refer to "Adding a DHCP Listen Interface (Page 271)".
4. Assign IP address *192.168.0.52* to switch.0001 on the DHCP server. For more information, refer to "Adding an IPv4 Address (Page 251)" or "Adding an IPv6 Address (Page 252)".
5. Create a shared network named *LAN.10-LAN.172* and enable Option82. For more information, refer to "Configuring Shared Network Options (Page 273)".
6. Under the subnet for the DHCP Client, create the following 3 subnets:

Name	Network IP	Shared Network
MainSub	192.168.0.0/24	LAN.10-LAN.172
LAN_A-172	172.16.10.0/24	LAN.10-LAN.172
LAN_B-10	10.10.10.0/24	LAN.10-LAN.172

   For more information about creating subnets, refer to "Adding a Subnet (Page 275)".

7. [Optional] For the LAN A-172 subnet, configure *172.16.10.1* as a default route for clients. For more information, refer to "Configuring Standard DHCP Client Configuration Options (IPv4) (Page 265)".
8. Create an address pool for the LAN A-172 subnet and configure the IP range for the address pool with the following parameters:

Pool Name	Starting Address	Ending Address
LAN-A_VLAN2	172.16.10.10	172.16.10.200

   For more information, refer to "Adding an Address Pool (IPv4) (Page 286)" or "Adding an Address Pool (IPv6) (Page 288)".

9. Configure the following option82 class for the LAN-A_VLAN2 pool:

Class Name	Remote ID	Circuit ID
LAN-A_Option	00:0a:dc:00:00:00	00:02:00:01

The Remote ID represents the MAC address of the DHCP relay agent. In the Circuit ID, *00:02* denotes the VLAN ID and *00:01* represents the line module (if applicable) and the port number of the DHCP relay agent where Client 1 is connected.

For more information, refer to "Adding an Option 82 Class to an Address Pool (Page 300)".

10. [Optional] For the LAN B-10 subnet, configure *10.10.10.1* as a default route for clients. For more information, refer to "Configuring Standard DHCP Client Configuration Options (IPv4) (Page 265)".
11. Create an address pool for the LAN B-10 subnet and configure the IP range for the address pool with the following parameters:

Pool Name	Starting Address	Ending Address
LAN-B_VLAN3	10.10.10.10	10.10.10.200

For more information, refer to "Adding an Address Pool (IPv4) (Page 286)" or "Adding an Address Pool (IPv6) (Page 288)".

12. Configure the following option82 class for LAN-B_VLAN3 pool:

Class Name	Remote ID	Circuit ID
LAN-B_Option	00:0a:dc:00:00:00	00:03:00:02

The Remote ID represents the MAC address of the DHCP relay agent, *00:03* denotes the VLAN ID and *00:02* represents the line module (if applicable) and the port number of the DHCP relay agent where Client 2 is connected.

For more information, refer to "Adding an Option 82 Class to an Address Pool (Page 300)".

Final Configuration Example

The following configuration reflects the topology:

```
#show running-config services dhcpserver
  enabled
  interface switch.0001
  !
  options
   client
    no hostname
    no subnetmask
 no default-route
    no broadcast
    no domain
    no dns-server
    no static-route
    no nis server
    no nis domain
   !
  !
```

```
  shared-network LAN.10-LAN.172
   options option82
   options client
    no hostname
    no subnetmask
    no default-route
    no broadcast
    no domain
    no dns-server
    no static-route
    no nis server
    no nis domain
   !
  !
  subnet-name "LAN A-172"
   network-ip     172.16.10.0/24
   shared-network LAN.10-LAN.172
   options
    no unknown-client
    ippool LAN-A_VLAN2
     no unknown-client
     iprange 172.16.10.10
      end 172.16.10.200
     !
     option82 LAN-A_Option
      remote-id  00:0a:dc:00:00:00
      circuit-id 00:02:00:01
     !
    !
    client
     no hostname`
     no subnetmask
     default-route 172.16.10.1
     no broadcast
no domain
     no dns-server
     no static-route
     no nis server
     no nis domain
    !
   !
  !
  subnet-name "LAN B-10"
   network-ip     10.10.10.0/24
   shared-network LAN.10-LAN.172
   options
    no unknown-client
    ippool LAN-B_VLAN3
     no unknown-client
     iprange 10.10.10.10
      end 10.10.10.200
     !
     option82 LAN-B_Option
      remote-id  00:0a:dc:00:00:00
      circuit-id 00:03:00:02
     !
    !
    client
     no hostname
     no subnetmask
     default-route 10.10.10.1
     no broadcast
     no domain
     no dns-server
     no static-route
     no nis server
     no nis domain
    !
```

```
   !
  !
  subnet-name mainSub
   network-ip     192.168.0.0/24
   shared-network LAN.10-LAN.172
   options
    no unknown-client
    client
     no hostname
no subnetmask
     no default-route
     no broadcast
     no domain
     no dns-server
     no static-route
     no nis server
     no nis domain
```

7.4 Managing Static DNS

This section describes how to reserve a static or fixed IP address for the device. While it is more common to obtain a random address from a *dynamic* DNS server, obtaining a fixed address from a static DNS server may be required to connect to Virtual Private Networks (VPNs) or other remote access services that only trust specific IP addresses.

7.4.1 Managing Domain Names

The DNS service can be configured to use one or more domain names when querying a domain name server. The list of domain names can include the domain in which the router is a member of, and other domains that may be used to search for an unqualified host name (i.e. as though it were local).

7.4.1.1 Viewing a List of Domain Names

To view a list of domain names, type:

```
show  running-config  dns  search
```

If domain names have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config admin dns search
admin
 dns
  search ruggedcom.com
  !
 !
!
```

If no domain names have been configured, add names as needed. For more information, refer to "Adding a Domain Name (Page 306)".

7.4.1.2 Adding a Domain Name

To add a domain name, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the domain name by typing:

   ```
   admin dns search { name }
   ```

   Where:

   - `{ name }` is the name of the domain
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.4.1.3 Deleting a Domain Name

To delete a domain name, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the domain name by typing:

   ```
   no admin dns search { name }
   ```

   Where:

   - `{ name }` is the name of the domain
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.4.2 Managing Domain Name Servers

A hierarchical list of domain name servers can be configured for the DNS service. RUGGEDCOM ROX II will contact each server in the order they are listed when domain names require resolution.

7.4.2.1 Viewing a List of Domain Name Servers

To view a list of domain name servers, type:

```
show running-config dns server
```

If domain name servers have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config admin dns server
admin
 dns
  server 10.1.1.1
  !
```

```
  !
!
```

If no domain name servers have been configured, add servers as needed. For more information, refer to "Adding a Domain Name Server (Page 307)".

7.4.2.2 Adding a Domain Name Server

To add a domain name server, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the domain name server by typing:

   ```
   admin dns server { address }
   ```

   Where:

   - `{ address }` is the IP address of the domain name server.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.4.2.3 Deleting a Domain Name Server

To delete a domain name server, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the domain name server by typing:

   ```
   no admin dns server { address }
   ```

   Where:

   - `{ address }` is the IP address of the domain name server.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.5 Managing Dynamic DNS

Enable the Dynamic Domain Name Server (DNS) service in RUGGEDCOM ROX II to allow remote hosts to connect with the device's default interface via a fixed host name. The Dynamic DNS service uses a DNS client to log into a DNS service provider and register the assigned host name(s) that can be used to access the device via the Internet.

An account is required with one of the supported dynamic DNS service providers:

- noip.com [http://www.noip.com]
- dyn.com [http://www.dyn.com]

Responses from each Dynamic DNS service provider are validated by the Dynamic DNS client. If a response is determined to be invalid, a *DDNS Bad Response* alarm is raised and the service is temporarily disabled. Service can only be restored once the alarm has been cleared. For information about how to configure this alarm, refer to "Configuring an Alarm (Page 136)".

7.5.1 Enabling and Configuring Dynamic DNS

To enable and configure dynamic DNS, do the following:

⚠ NOTICE

Update requests are sent to the selected service provider via HTTPS. Before enabling Dynamic DNS, the Public CA Store must be enabled, or a CA for DDNS must be added to the store.

Although the use of the Public CA Store is provided for convenience, it is not recommended for optimal security. Instead, it is recommended to configure the required CAs as system CAs to limit the size of the trust store used by RUGGEDCOM ROX II.

For more information about adding a certificate to the Trusted Certificate Store, refer to "Adding a CA Certificate to the Trusted Certificate Store (Page 197)".

For more information about enabling the Public CA Store, refer to "Enabling/Disabling the Trusted Certificate Store (Page 174)".

1. Make sure the CLI is in Configuration mode.
2. Enable the dynamic DNS client by typing:

   ```
   services ddns enabled true
   ```

3. Type `options` and then configure the following parameter(s) as required:

Parameter	Description
`ip-check-interval { ip-check-interval }`	**Synopsis:** An integer between 600 and 864000 **Default:** 1800 The time in seconds to wait before the IP address of the device is queried. If the address has changed, the new address is updated on the domain name service (DNS) server. The value of **IP Address Check Interval** should be less than the value of **Force Update Interval.**
`force-update-interval { force-update-interval }`	**Synopsis:** An integer between 600 and 2592000 **Default:** 86400 The time in seconds to wait before the IP address of the device is updated on the domain name service (DNS) server, even if the address has not changed. The value of **Force Update Interval** should be greater than the value of **IP Address Check Interval.**

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.5.2 Managing Dynamic DNS Servers

This section describes how to configure a connection with one or more of the supported dynamic DNS service providers.

7.5.2.1 Viewing a List of Dynamic DNS Servers

To view a list of WLAN aliases, type:

```
show running-config services ddns servers
```

```
ruggedcom# show running-config services ddns servers | tab
SERVER  ENABLED  USERNAME  PASSWORD                    HOSTNAME
-------------------------------------------------------------------
dyndns  true     admin     $4$wIo7Yd068FRwhYYI0d4IDw==
                                                      host1
noip    true     admin     $4$wIo7Yd068FRwhYYI0d4IDw==
                                                      host2

 !
!
```

If no dynamic DNS servers have been configured, add servers as needed. For more information, refer to "Adding a Dynamic DNS Server (Page 310)".

7.5.2.2 Viewing the Status of a Dynamic DNS Server

To view the status of a dynamic DNS server, type:

```
show services ddns servers [ noip | dyndns ] status
```

If the selected dynamic DNS server is enabled, a table or list similar to the following example appears:

```
ruggedcom# show services ddns servers dyndns status
status
 ddns state Enabled
 details
  ddns last success        "Wed Jan 25 11:18:39 2017"
  ddns last ip address     205.206.34.228
  ddns last failure        "Not available"
  ddns last failure reason "Not available"
```

The table/list provides the following information:

Parameter	Description
`ddns-state`	**Synopsis:** A string Displays DDNS state

Parameter	Description
`ddns-last-success`	**Synopsis:** A string Last successful update date and time
`ddns-last-ip-address`	**Synopsis:** A string Last successful update IP address
`ddns-last-failure`	**Synopsis:** A string Last failed update attempt date and time
`ddns-last-failure-reason`	**Synopsis:** A string Last failed update attempt reason

7.5.2.3 Adding a Dynamic DNS Server

To add a dynamic DNS server, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the dynamic DNS server by typing:

   ```
   services ddns servers [ dyndns | noip ]
   ```

3. Configure the following parameter(s) as required:

Parameter	Description
`enabled { enabled }`	**Synopsis:** [true | false] **Default:** false Enables / disables DDNS updates for the server
`username { username }`	**Synopsis:** A string between 2 and 24 characters long The username of the DDNS server
`password { password }`	**Synopsis:** A string The password of the DDNS server

4. Define one or more host names for the server. For more information, refer to "Adding a Host Name (Page 311)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.5.2.4 Deleting a Dynamic DNS Server

To delete a dynamic DNS server, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the dynamic DNS server by typing:

   ```
   no services ddns servers [ dyndns | noip ]
   ```

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.5.3 Managing Dynamic DNS Server Host Names

This section describes how to manage host names for the configured dynamic DNS servers.

⚠ NOTICE
At least one host name is required for each configured dynamic DNS server.

7.5.3.1 Viewing a List of Host Names

To view a list of WLAN aliases, type:

```
show running-config services ddns servers [ dyndns | noip ] hostnames
```

If host names have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services ddns servers noip hostnames
services
 ddns
  servers noip
   hostnames host1
   !
  !
 !
!
```

If no host names have been configured, add host names as needed. For more information, refer to "Adding a Host Name (Page 311)".

7.5.3.2 Adding a Host Name

To add a host name for a dynamic DNS server, do the following:

⚠ NOTICE
At least one host name is required for each configured dynamic DNS server.

1. Make sure the CLI is in Configuration mode.
2. Add the host name by typing:

   ```
   services ddns servers [ dyndns | noip ] hostnames { name }
   ```

   Where { name } is the host name to be updated by the dynamic DNS server.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7.5.3.3 Deleting a Host Name

To delete a host name, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the dynamic DNS server by typing:

   ```
   no services ddns servers [ dyndns | noip ] hostnames { name }
   ```

   Where { name } is the desired host name.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

8 Layer 2

This chapter describes the Layer 2, or Data Link Layer (DLL), features of RUGGEDCOM ROX II.

8.1 Managing Switched Ethernet Ports

This section describes how to configure and manage switched Ethernet ports.

8.1.1 Viewing a List of Switched Ethernet Ports

To view a list of switched Ethernet ports configured on the device, type:

```
show running-config interface switch
```

If switched Ethernet ports have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config interface switch
interface
 switch swport 1
  auton      on
  speed      auto
  duplex     auto
  switchport
  no flow-control
  no alias
  rate-limiting
   no ingress-limit
   no egress-limit
  !
  port-security
   no shutdown-time
   no admin-shutdown
   dot1x
    no reauth-enable
   !
  !
  lldp
   no notify
  !
  mcast-filtering
   no gmrp
  !
  cos
   no inspect-tos
  !
  vlan
   pvid 1
   no gvrp-mode
  !
```

```
  spanning-tree
   no restricted-role
   no restricted-tcn
  !
 !
.
.
.
```

8.1.2 Configuring a Switched Ethernet Port

To configure a switched Ethernet port, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***interface » switch » swport » {port}***, where *{port}* is the switched Ethernet port.
3. Configure the port settings by configuring the following parameter(s) as required:

⚠ NOTICE

Security hazard – risk of unauthorized access and/or exploitation

Switched Ethernet ports are enabled by default. It is recommended that ports that are not in use be disabled. Unused ports, if not configured properly, could potentially be used to gain access to the network behind the device.

⚠ NOTICE

Configuration hazard – risk of data corruption

Changing a switched Ethernet port from switchport mode to dedicated routing mode will automatically change any configuration elements that depended on it and potentially invalidate parts of the device configuration. For example, if a switched Ethernet port is a trunk port, changing it to dedicated routing mode will automatically remove it from the trunk and, therefore, make the trunk invalid. A trunk must consist of two trunk ports.

Note
Switched Ethernet ports in dedicated routing port mode cannot be trunk ports.

Note
The configuration for a switched Ethernet port in switchport mode can be restored when it is removed from a trunk. However, the configuration cannot be restored if the port is in dedicated routing mode.

Note
For information about configuring port rate limiting, refer to "Configuring Port Rate Limiting (Page 896)".

Note
For information about configuring RMON threshold alerts, refer to "Configuring RMON Threshold Alerts (Page 318)".

Parameter	Description
`enabled { enabled }`	**Synopsis:** [true | false] **Default:** true Provides the option to enable or disable this interface. When unchecked(i.e disabled), the interface will prevent all frames from being sent and received on that interface.
`auton { auton }`	**Synopsis:** [on | off] Enables or disables IEEE 802.3 auto-negotiation. Enabling auto-negotiation results in speed and duplex being negotiated upon link detection; both end devices must be auto-negotiation compliant for the best possible results.
`speed { speed }`	**Synopsis:** [auto | 1.5M | 2.4M | 10M | 100M | 1G | 10G | 1.776M | 3.072M | 7.2M | 1.2K | 2.4K | 9.6K | 19.2K | 38.4K | 57.6K | 115.2K | 230.4K | 4.8K | 76.8K] Speed (in megabits-per-second or gigabits-per-second). If auto-negotiation is enabled, this is the speed capability advertised by the auto-negotiation process. If auto-negotiation is disabled, the port is explicitly forced to this speed mode. AUTO means advertise all supported speed modes.
`duplex { duplex }`	**Synopsis:** [auto | half | full] If auto-negotiation is enabled, this is the duplex capability advertised by the auto-negotiation process. If auto-negotiation is disabled, the port is explicitly forced to this duplex mode. AUTO means advertise all supported duplex modes.
`link-alarms { link-alarms }`	**Synopsis:** [true | false] **Default:** true Disabling link-alarms will prevent alarms and LinkUp and LinkDown SNMP traps from being sent for that interface. Link alarms may also be controlled for the whole system under admin / alarm-cfg.
`switchport { switchport }`	**Synopsis:** [true | false] Sets the physical port into either switched mode or a dedicated routing mode.
`flow-control`	Flow control is useful for preventing frame loss during times of severe network traffic
`on-demand`	Bring up this interface on-demand only
`ip-address-src { ip-address-src }`	**Synopsis:** [static | dynamic] **Default:** static Whether the IP address is static or dynamically assigned via DHCP or BOOTP. Option DYNAMIC is a common case of a dynamically assigned IP address. It switches between BOOTP and DHCP until it gets the response from the relevant server. This must be static for non-management interfaces.

Parameter	Description
`ipv6-address-src { ipv6-address-src }`	**Synopsis:** [static | dynamic] **Default:** static Whether the IPv6 address is static or dynamically assigned via DHCPv6. Option DYNAMIC is a common case of a dynamically assigned IPv6 address. This must be static for non-management interfaces.
`proxyarp`	Enables/Disables whether the VLAN will respond to ARP requests for hosts other than itself
`mtu { mtu }`	**Synopsis:** An integer between 68 and 1500 **Default:** 1500 Maximum transmission unit (largest packet size allowed for this interface).
`alias { alias }`	**Synopsis:** A string 64 characters long The SNMP alias name of the interface

4. Configure the LLDP settings by configuring the following parameter(s) as required:

Parameter	Description
`admin-status { admin-status }`	**Synopsis:** [tx-only | rx-only | rx-tx | no-lldp] **Default:** rx-tx • no-lldp : The local LLDP agent can neither transmit nor receive LLDP frames. • rxTx : The local LLDP agent can both transmit and receive LLDP frames through the port. • txOnly : The local LLDP agent can only transmit LLDP frames. • rxOnly : The local LLDP agent can only receive LLDP frames.
`notify`	Disabling notifications will prevent sending notifications and generating alarms for a particular interface from the LLDP agent.

Note
Multicast filtering, CoS and VLAN parameters are only available when the port is in switchport mode.

5. Configure the Multicast filtering settings by configuring the following parameter(s) as required:

Parameter	Description
`gmrp { gmrp }`	**Synopsis:** [advertise_only | learn_advertise] GMRP (GARP Multicast Registration Protocol) operation on the port. There are several GMRP operation modes: • DISABLED : the port is not capable of any GMRP processing.

Parameter	Description
	• ADVERTISE ONLY : the port will declare all MCAST addresses existing in the switch (configured or learned) but will not learn any MCAST addresses. • ADVERTISE and LEARN : the port will declare all MCAST Addresses existing in the switch (configured or learned) and can dynamically learn MCAST addresses.

6. Configure the CoS settings by configuring the following parameter(s) as required:

Parameter	Description
`default-priority { default-priority }`	**Synopsis:** An integer between 0 and 7 **Default:** 0 The priority of frames received on this port that are not prioritized based on the frame's contents (e.g. the priority field in the VLAN tag, DiffServ field in the IP header, prioritized MAC address).
`inspect-tos`	Enables or disables parsing of the Type-of-Service (ToS) field in the IP header of the received frames to determine what Class of Service (CoS) they should be assigned. When ToS parsing is enabled the switch will use the differentiated services bits in the TOS field.

7. Configure the VLAN settings by configuring the following parameter(s) as required:

Parameter	Description
`pvid { pvid }`	**Synopsis:** An integer between 1 and 4094 The Port VLAN Identifier specifies the VLAN ID associated with untagged (and 802.1p priority tagged) frames received on this port. Frames tagged with a non-zero VLAN ID will always be associated with the VLAN ID retrieved from the frame tag.
`type { type }`	**Synopsis:** [edge | trunk | pvlanedge] **Default:** edge How the port determines its membership in VLANs. There are a few types of ports: • EDGE : the port is only a member of one VLAN (its native VLAN specified by the 'PVID' parameter). • PVLAN Edge : the port does not forward traffic to other PVLAN edge ports within the same VLAN. • TRUNK : the port is automatically a member of all configured VLANs. Frames transmitted out of the port on all VLANs except the port's native VLAN will be always tagged. It can also be configured to use GVRP for automatic VLAN configuration.

Parameter	Description
`format { format }`	**Synopsis:** [untagged | tagged] **Default:** untagged Whether frames transmitted out of the port on its native VLAN (specified by the 'PVID' parameter) will be tagged or untagged.
`gvrp-mode { gvrp-mode }`	**Synopsis:** [advertise_only | learn_advertise] GVRP (Generic VLAN Registration Protocol) operation on the port. There are several GVRP operation modes: • DISABLED : the port is not capable of any GVRP processing. • ADVERTISE ONLY : the port will declare all VLANs existing in the switch (configured or learned) but will not learn any VLANs. • ADVERTISE and LEARN : the port will declare all VLANs existing in the switch (configured or learned) and can dynamically learn VLANs.

Note
Once a VLAN ID has been assigned to a switched Ethernet port, a VLAN is created and can be configured in ***switch » vlans » all-vlans***.

8. If the port is in switchport mode, configure the VLAN for the port. For more information, refer to "Configuring VLANs for Switched Ethernet Ports (Page 362)".
9. Configure the port security settings. For more information, refer to "Configuring Port Security (Page 159)".
10. Configure the spanning tree settings. For more information, refer to "Configuring STP for Switched Ethernet Ports and Ethernet Trunk Interfaces (Page 797)".
11. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

8.1.3 Configuring RMON Threshold Alerts

RUGGEDCOM ROX II allows users to configure thresholds related to the performance and operation of physical Ethernet ports. When the rate of occurrence of a specified event is exceeded on the configured port, a log entry is recorded, an alarm is raised and an SNMP trap is generated.

An alarm and SNMP trap are only sent once when the threshold is crossed. If the current throughput value remains above the threshold value, additional alarms and traps are not sent at each interval. Once the current throughput value has dropped below the threshold value, its alarm state is reset and monitoring continues as normal. An alarm and trap are generated if the threshold is crossed again.

To configure RMON threshold alerts, do the following:

1. Make sure the CLI is in Configuration mode.

2. Navigate to ***interface » switch » swport » {port}***, where *{port}* is the Ethernet port.
3. Configure the RMON threshold alerts settings by configuring the following parameter(s) as required:

Note
RMON may generate false alarms or SNMP traps under the following conditions:

- **The interval is low and the traffic throughput is 95% (but below 100%)**

  In this scenario, do one of the following to eliminate the false alarms/traps:

  - Reset **interval** to its default value (60 seconds)
  - If **monitor-type** is set to absolute or delta, increase the value of **threshold-value** by 5%
  - If **monitor-type** is set to percentage, increase the value of **threshold-percentage** by 5%
- **CPU usage is high and the traffic throughput is 90% (but below 100%)**

  In this scenario, do one of the following to eliminate the false alarms/traps:

  - Reset **interval** to its default value (60 seconds)
  - If **monitor-type** is set to absolute or delta, increase the value of **threshold-value** by 10%
  - If **monitor-type** is set to percentage, increase the value of **threshold-percentage** by 10%

Parameter	Description
`enabled { enabled }`	**Synopsis:** [true | false] **Default:** false Enables/disables RMON threshold probing. When enabled, RMON probing will generate alarms and SNMP traps for that interface when threshold values are exceeded. RMON threshold alarms may also be controlled for the whole system under admin/alarm-cfg
`direction { direction }`	**Synopsis:** [ingress | egress | both] **Default:** both The direction of traffic to be monitored. Possible values include: • Ingress - Monitors only the received bytes. • Egress - Monitors only the transmitted bytes. • Both - Monitors both the received and transmitted bytes.
`monitoring-type { monitoring-type }`	**Synopsis:** [absolute | delta | percentage] **Default:** absolute The type of monitoring to perform on the threshold value. Possible values include: • Absolute - The current absolute value of the monitored value is compared with the threshold value.

Parameter	Description
	• Delta - The difference between the current value and the last recorded value (previous interval) of the monitored variable is compared with the threshold value. • Percentage - The percentage of the total port bandwidth being utilized.
`threshold-value { threshold-value }`	**Synopsis:** An integer between 1 and 18446744073709551615 **Default:** 1000 The value of data throughput (in bytes per interval period) to be compared.
`threshold-percentage { threshold-percentage }`	**Synopsis:** An integer between 1 and 100 **Default:** 80 The percentage of total data throughput to check for bandwidth threshold.
`interval { interval }`	**Synopsis:** An integer between 10 and 65535 **Default:** 60 The number of seconds over which the data is sampled and compared with the threshold

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

8.1.4 Viewing Switched Ethernet Port Statistics

To view statistics collected for a specific switched Ethernet port, type:

```
show interfaces switch swport { port } port-stats
```

Where:

- `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module

A table or list similar to the following example appears:

```
ruggedcom# show interfaces switch swport 1 port-stats
port-stats
 in octets  6820
 out octets 3086
 in pkts    33
 out pkts   18
 error pkts 0
```

This table or list provides the following information:

Parameter	Description
`in-octets`	**Synopsis:** An integer The number of octets in received good packets. (Unicast+Multicast +Broadcast) and dropped packets.

Parameter	Description
out-octets	**Synopsis:** An integer The number of octets in transmitted good packets.
in-pkts	**Synopsis:** An integer The number of received good packets (Unicast+Multicast +Broadcast) and dropped packets.
out-pkts	**Synopsis:** An integer The number of transmitted good packets.
error-pkts	**Synopsis:** An integer The number of any type of erroneous packets.

8.1.5 Viewing the Status of a Switched Ethernet Port

To view the current status of a switched Ethernet port, type:

```
show interfaces switch swport { port }
```

Where:

- `{ port }` is the port number for the switched Ethernet port

A table or list similar to the following example appears:

```
ruggedcom# show interfaces switch swport 1
 name   ge-1-1
 state  up
 media  1000T
 speed  100M
 duplex full
 mtu    1500
 mac    00:0a:dc:f6:c6:21
 .
 .
 .
```

This table or list provides the following information:

Parameter	Description
name	**Synopsis:** A string between 1 and 10 characters long A descriptive name that may be used to identify the device connected on that port.
state	**Synopsis:** [not set | up | down | testing | unknown | dormant | notPresent | lowerLayerDown] The port's link status.
media	**Synopsis:** A string 31 characters long The type of port media { 100TX, 10FL, 100FX, 1000X, 1000T, 802.11g, EoVDSL, 100TX }. It provides the user with a description of the installed media type on the port for modular products. Please note that fiber media may be either Single Mode(SM), Multi Mode(MM), and may be Short Distance, Long Distance or Very Long

Parameter	Description
	Distance with connectors like LC, SC, ST, MTRJ etc. For the modules with SFP/GBICs, the media description is displayed per the SFF-8472 specification, if the transceiver is plugged into the module. E.g. 10/100/1000TX RJ45, 100FX SM SC, 10FX MM ST,1000SX SFP LC S SL M5.
`speed`	**Synopsis:** [auto | 1.5M | 2.4M | 10M | 100M | 1G | 10G | 1.776M | 3.072M | 7.2M | 1.2K | 2.4K | 9.6K | 19.2K | 38.4K | 57.6K | 115.2K | 230.4K | 4.8K | 76.8K] Speed (in Megabits-per-second or Gigabits-per-second)
`duplex`	**Synopsis:** [auto | half | full] Duplex Setting: { Auto, Half, Full }
`mtu`	**Synopsis:** An integer The Maximum Transmission Unit of frame (in bytes) permitted on the interface.
`mac`	**Synopsis:** A string 17 characters long The MAC Address of this specific port.

8.1.6 Viewing RMON Port Statistics

To view Remote Network Monitoring (RMON) statistics collected for a specific switched Ethernet port, type:

```
show interfaces switch swport { port } rmon-stats
```

Where:

- `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module

A table or list similar to the following example appears:

```
ruggedcom# show interfaces switch swport 1 rmon-stats | tab
rmon-stats
 in octets              10107903
 in pkts                53903
 in bcast pkts          607
 in mcast pkts          42103
 total in octets        10107903
 total in pkts          53903
 out octets             4974162
 out pkts               14356
 drop events            0
 out bcast pkts         0
 out mcast pkts         405
 crc align errors       0
 undersize pkts         0
 oversize pkts          0
 fragments              0
 jabbers                0
 collisions             0
 late collisions        0
 pkts 64 octets         10978
 pkts 65to127 octets    24792
```

```
 pkts 128to255 octets   19970
 pkts 256to511 octets   2469
 pkts 512to1023 octets  8410
 pkts 1024to1518 octets 1640
```

This table or list provides the following information:

Parameter	Description
in-octets	**Synopsis:** An integer The number of octets in received good packets (Unicast+Multicast +Broadcast) and dropped packets.
in-pkts	**Synopsis:** An integer The number of received good packets (Unicast+Multicast +Broadcast) and dropped packets.
in-bcast-pkts	**Synopsis:** An integer The number of good broadcast packets received.
in-mcast-pkts	**Synopsis:** An integer The number of good multicast packets received.
total-in-octets	**Synopsis:** An integer The total number of octets of all received packets. This includes data octets of rejected and local packets which are not forwarded to the switching core for transmission. It should reflect all the data octets received on the line.
total-in-pkts	**Synopsis:** An integer The number of received packets. This includes rejected, dropped and local packets, as well as packets which are not forwarded to the switching core for transmission. It should reflect all packets received on the line.
out-octets	**Synopsis:** An integer The number of octets in transmitted good packets.
out-pkts	**Synopsis:** An integer The number of transmitted good packets.
drop-events	**Synopsis:** An integer The number of received packets that are dropped due to lack of receive buffers.
out-bcast-pkts	**Synopsis:** An integer The number of transmitted broadcast packets.
out-mcast-pkts	**Synopsis:** An integer The number of transmitted multicast packets. This does not include broadcast packets.
crc-align-errors	**Synopsis:** An integer The number of packets received which meet all the following conditions: 1. The packet data length is between 64 and 1536 octets inclusive. 2. The packet has invalid CRC. 3. A Collision Event has not been detected. 4. A Late Collision Event has not been detected.

Parameter	Description
undersize-pkts	**Synopsis:** An integer The number of received packets which meet all the following conditions: 1. The packet data length is less than 64 octets. 2. A Collision Event has not been detected. 3. A Late Collision Event has not been detected. 4. The packet has valid CRC.
oversize-pkts	**Synopsis:** An integer The number of packets received with data length greater than 1536 octets and valid CRC.
fragments	**Synopsis:** An integer The number of packets received which meet all the following conditions: 1. The packet data length is less than 64 octets, or it is a packet without SFD and is less than 64 octets in length. 2. A Collision Event has not been detected. 3. A Late Collision Event has not been detected. 4. The packet has invalid CRC.
jabbers	**Synopsis:** An integer The number of packets which meet all the following conditions: 1. The packet data length is greater that 1536 octets. 2. The packet has invalid CRC.
collisions	**Synopsis:** An integer The number of received packets for which a Collision Event has been detected.
late-collisions	**Synopsis:** An integer The number of received packets for which a Late Collision Event has been detected.
pkts-64-octets	**Synopsis:** An integer The number of received and transmitted packets with a size of 64 octets. This includes received and transmitted packets as well as dropped and local received packets. This does not include rejected received packets.
pkts-65to127-octets	**Synopsis:** An integer The number of received and transmitted packets with a size of 65 to 127 octets. This includes received and transmitted packets as well as dropped and local received packets. This does not include rejected received packets
pkts-128to255-octets	**Synopsis:** An integer The number of received and transmitted packets with a size of 128 to 257 octets. This includes received and transmitted packets as well as dropped and local received packets. This does not include rejected received packets
pkts-256to511-octets	**Synopsis:** An integer The number of received and transmitted packets with size of 256 to 511 octets. This includes received and transmitted packets as well as dropped and local received packets. This does not include rejected received packets.

Parameter	Description
pkts-512to1023-octets	**Synopsis:** An integer The number of received and transmitted packets with size of 512 to 1023 octets. This includes received and transmitted packets as well as dropped and local received packets. This does not include rejected received packets
pkts-1024to1518-octets	**Synopsis:** An integer The number of received and transmitted packets with a size of 1024 to 1536 octets. This includes received and transmitted packets as well as dropped and local received packets. This does not include rejected received packets.

8.1.7 Clearing Switched Ethernet Port Statistics

The following describes how to clear the statistics collected for switched ethernet ports. All of the statistics or only those for a specific switchport can be cleared.

Clearing All Switched Ethernet Port Statistics

To clear all statistics collected for switched Ethernet ports, type:

```
switch clear-all-switch-stats
```

Clearing Statistics for a Specific Switched Ethernet Port

To clear the statistics collected for a specific switched Ethernet port, type:

```
interfaces switch swport { port } clear-port-stats
```

Where:

- `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module

8.1.8 Resetting a Switched Ethernet Port

The following describes how to reset a specific Ethernet port, or all Ethernet ports.

Resetting All Switched Ethernet Ports

To reset all switched Ethernet ports, type:

```
switch reset-all-switch-ports
```

Resetting a Specific Switched Ethernet Port

To reset a specific switched Ethernet port, type:

```
interfaces switch swport { port } reset-port
```

Where:

- `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module

8.1.9 Testing Switched Ethernet Port Cables

Diagnostics can be performed on switched Ethernet port cables to assess their overall quality.

8.1.9.1 Running a Cable Diagnostic Test

To run a cable diagnostic test on a specific port, type:

⚠ NOTICE

When cable diagnostics are performed on a port, any established network link on the port will be dropped and normal network traffic will not be able to pass through either the Port Under Test (PUT) or the Partner Port. When the cable diagnostic test is done, the original network port settings for both the PUT and the Partner Port are restored along with any established link.

```
interfaces switch swport { port } diagnostics start-
cable-test run { runs } calibration { calibration }
```

Where:

- `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module
- `{ runs }` is the total number of times cable diagnostics should be performed on the selected port. When set to 0, cable diagnostics will be performed continuously on the selected port.
- `{ calibration }` is the value used to adjust or calibrate the estimated distance to fault. To calibrate the determine estimated distance to fault, do the following:
  1. Connect an Ethernet cable with a known length (e.g. 50m) to the port that requires calibration. Do not connect the other end of the cable to any link partner.
  2. Run a cable diagnostic test a few times on the port. An OPEN fault should be detected.
  3. Find the average distance to the OPEN fault recorded in the log and compare it to the known length of the cable. The difference can be used as the calibration value.

4. Enter the calibration value and run the cable diagnostic test a few more times. The distance to the OPEN fault should now be similar to the cable length. Use the distance value to determine the calibration value.

For information about how to view the test results, refer to "Viewing Cable Diagnostic Statistics (Page 327)".

8.1.9.2 Viewing Cable Diagnostic Statistics

To view the statistics collected for a switched Ethernet port after a cable diagnostic test, type:

```
show interfaces switch swport { port } diagnostics
cable-diagnostic-results
```

- `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module

A list similar to the following example appears:

```
ruggedcom# show interfaces switch swport 1 diagnostics cable-diagnostic-results
diagnostics cable-diagnostic-results
 running         false
 good            20
 open            0
 short           20
 imped           0
 pass fail total "   10/    0/   10  "
 run count       0
 pass count      0
 fail count      0
```

This list provides the following information:

Parameter	Description
`running`	**Synopsis:** [true | false] Whether or not a cable test is currently running on this port
`good`	**Synopsis:** An integer The number of times GOOD TERMINATION (no fault) is detected on the cable pairs of the selected port.
`open`	**Synopsis:** An integer The number of times OPEN is detected on the cable pairs of the selected port.
`short`	**Synopsis:** An integer The number of times SHORT is detected on the cable pairs of the selected port.
`imped`	**Synopsis:** An integer The number of times IMPEDANCE MISMATCH is detected on the cable pairs of the selected port.

Parameter	Description
`pass-fail-total`	**Synopsis:** A string between 1 and 19 characters long This field summarizes the results of the cable diagnostics performed so far. • Pass : the number of times cable diagnostics were successfully completed on the selected port. • Fail : the number of times cable diagnostics failed to complete on the selected port. • Total : the total number of times cable diagnostics have been attempted on the selected port.
`run-count`	**Synopsis:** An integer Run Count : The total number of iterations
`pass-count`	**Synopsis:** An integer Pass Count
`fail-count`	**Synopsis:** An integer Failure Count

8.1.9.3 Clearing Cable Diagnostic Statistics

The following describes how to clear the statistics collected when cable diagnostic tests are performed. All of the statistics or only those for a specific switchport can be cleared.

Clearing All Cable Diagnostic Statistics

To clear the statistics, type:

```
switch  clear-cable-stats-all
```

Clearing Cable Diagnostic Statistics for a Specific Switchport

To clear only the statistics for a specific switchport, type:

Where:

- `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module

8.2 Managing Ethernet Trunk Interfaces

This section describes how to configure and manage Ethernet trunk interfaces.

8.2.1 Viewing a List of Ethernet Trunk Interfaces

To view a list of Ethernet trunk interfaces, type:

```
show running-config interface trunk
```

If trunks have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config interface trunks
interface
 trunks 1
  switchport
  no alias
  no mcast-filtering gmrp
  no cos inspect-tos
  vlan pvid 1
  no vlan gvrp-mode
  trunk-ports swport 1
  !
  trunk-ports swport 2
  !
  no spanning-tree restricted-role
  no spanning-tree restricted-tcn
 !
!
```

If no Ethernet trunk interfaces have been configured, add trunks as needed. For more information, refer to "Adding an Ethernet Trunk Interface (Page 329)".

8.2.2 Adding an Ethernet Trunk Interface

To add an Ethernet trunk interface, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the interface by typing:

   ```
   interface trunks { id }
   ```

   Where:

   - `{ id }` is the ID given to the trunk
3. Configure the interface by typing the following commands:

Parameter	Description
`switchport { switchport }`	**Synopsis:** [true | false] The physical port into either Switched mode or a dedicated Routing mode.
`on-demand`	Bring up this interface on-demand only
`ip-address-src { ip-address-src }`	**Synopsis:** [static | dynamic] Whether the IP address is static or dynamically assigned via DHCP or BOOTP. Option DYNAMIC is a common case of a dynamically assigned IP address. It switches between BOOTP

Parameter	Description
	and DHCP until it gets the response from the relevant server. This must be static for non-management interfaces.
`ipv6-address-src { ipv6-address-src }`	**Synopsis:** [static | dynamic] **Default:** static Whether the IP address is static or dynamically assigned via DHCP. Option DYNAMIC is a common case of a dynamically assigned IP address. This must be static for non-management interfaces.
`proxyarp`	Enables/Disables whether the VLAN will respond to ARP requests for hosts other than itself
`mtu { mtu }`	**Synopsis:** An integer between 68 and 1500 **Default:** 1500 Maximum transmission unit (largest packet size allowed for this interface).
`alias { alias }`	**Synopsis:** A string 64 characters long The SNMP alias name of the interface

4. Configure the multicast filtering settings by typing the following commands:

Parameter	Description
`gmrp { gmrp }`	**Synopsis:** [advertise_only | learn_advertise] GMRP (GARP Multicast Registration Protocol) operation on the port. There are several GMRP operation modes: • DISABLED : the port is not capable of any GMRP processing. • ADVERTISE ONLY : the port will declare all MCAST addresses existing in the switch (configured or learned) but will not learn any MCAST addresses. • ADVERTISE and LEARN : the port will declare all MCAST Addresses existing in the switch (configured or learned) and can dynamically learn MCAST addresses.

5. Configure the CoS settings by typing the following commands:

Parameter	Description
`default-priority { default-priority }`	**Synopsis:** An integer between 0 and 7 **Default:** 0 The priority of frames received on this port that are not prioritized based on the frame's contents (e.g. priority field in the VLAN tag, DiffServ field in the IP header, prioritized MAC address).
`inspect-tos`	Enables or disables parsing of the Type-Of-Service (TOS) field in the IP header of the received frames to determine what Class of Service they should be assigned. When TOS parsing is enabled the switch will use the Differentiated Services bits in the TOS field.

6. Configure the VLAN settings by typing the following commands:

Parameter	Description
`pvid { pvid }`	**Synopsis:** An integer between 1 and 4094 The Port VLAN Identifier specifies the VLAN ID associated with untagged (and 802.1p priority tagged) frames received on this port. Frames tagged with a non-zero VLAN ID will always be associated with the VLAN ID retrieved from the frame tag.
`type { type }`	**Synopsis:** [edge | trunk | pvlanedge] **Default:** edge How the port determines its membership in VLANs. There are the following port types: • EDGE : the port is only a member of one VLAN (its native VLAN specified by the'PVID' parameter). • PVLAN Edge : the port does not forward traffic to other PVLAN edge ports within the same VLAN. • TRUNK : the port is automatically a member of all configured VLANs. Frames transmitted out of the port on all VLANs except the port's native VLAN will be always tagged. It can also be configured to use GVRP for automatic VLANconfiguration.
`format { format }`	**Synopsis:** [untagged | tagged] **Default:** untagged Whether frames transmitted out of the port on its native VLAN(specified by the 'PVID' parameter) will be tagged or untagged.
`gvrp-mode { gvrp-mode }`	**Synopsis:** [advertise_only | learn_advertise] GVRP (Generic VLAN Registration Protocol) operation on the port. There are several GVRP operation modes: • DISABLED : the port is not capable of any GVRP processing. • ADVERTISE ONLY : the port will declare all VLANs existing in the switch (configured or learned) but will not learn any VLANs. • ADVERTISE and LEARN : the port will declare all VLANs existing in the switch (configured or learned) and can dynamically learn VLANs.

7. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

8.2.3 Deleting an Ethernet Trunk Interface

To delete an Ethernet trunk interface, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the interface by typing:

```
no interface trunks { id }
```

Where:

- `{ id }` is the ID given to the trunk

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

8.2.4 Managing Ethernet Trunk Ports

This section describes how to manage Ethernet trunk port assignments.

8.2.4.1 Viewing a List of Ethernet Trunk Ports

To view a list of Ethernet trunk interfaces, type:

```
show running-config interface trunks { id } trunk-ports
```

Where:

- `{ id }` is the ID given to the interface

If trunk ports have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config interface trunks 1 trunk-ports
interface
 trunks 1
  trunk-ports swport 1
  !
  trunk-ports swport 2
  !
 !
!
```

If no Ethernet trunk ports have been configured, add ports as needed. For more information, refer to "Adding an Ethernet Trunk Port (Page 332)".

8.2.4.2 Adding an Ethernet Trunk Port

To add an Ethernet trunk port, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the port by typing:

   ```
   interface trunks { id } trunk-ports swport { port }
   ```

   Where:

   - `{ id }` is the ID given to the trunk

- `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

8.2.4.3 Deleting an Ethernet Trunk Port

To delete an Ethernet trunk port, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the port by typing:

   ```
   no interface trunks { id } trunk-ports swport { port }
   ```

   Where:

   - `{ id }` is the ID given to the trunk
   - `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

8.3 Managing MAC Addresses

As part of the Layer 2 functionality, RUGGEDCOM ROX II maintains a Media Access Control (MAC) address table, a list of unique MAC addresses for network interfaces that can communicate with the device at the data link layer. The MAC address table can be populated manually by defining specific MAC addresses and/or dynamically. When populated dynamically, RUGGEDCOM ROX II automatically adds the MAC addresses of network interfaces it detects on the network. It will also remove those addresses if the address ages out or there is a link failure.

8.3.1 Viewing a Dynamic List of MAC Addresses

To view a dynamic list of learned MAC addresses, type:

```
show switch mac-tables mac-table
```

A table or list similar to the following example appears:

```
ruggedcom# show switch mac-tables mac-table
MAC                VID  SLOT    PORT  TYPE     COS
-----------------------------------------------------
00:01:c0:0b:b6:58  4    swport  4     dynamic  N/A
00:04:5f:fb:62:36  4    swport  4     dynamic  N/A
00:04:5f:fb:63:8e  4    swport  4     dynamic  N/A
00:06:b5:64:92:75  4    swport  4     dynamic  N/A
```

```
00:0a:dc:02:4f:c0  4     swport  4     dynamic  N/A
00:0a:dc:2d:a6:e3  4     swport  4     dynamic  N/A
00:0a:dc:e5:86:ff  4     swport  4     dynamic  N/A
00:0a:dc:e5:a4:ff  4     swport  4     dynamic  N/A
```

This table or list provides the following information:

Parameter	Description
`slot`	**Synopsis:** [sm | lm1 | lm2 | lm3 | lm4 | lm5 | lm6 | swport | eth | serport | celport | wlanport] The slot containing the module including the port.
`port`	**Synopsis:** An integer between 1 and 16 The port on which the MAC address has been learned.
`type`	**Synopsis:** [static | dynamic] How the MAC address has been learned by the switch: • STATIC: The address has been learned as a result of static MAC address table configuration or some other management activity and cannot be automatically unlearned or relearned by the switch. • DYNAMIC: The address has been automatically learned by the switch and can be automatically unlearned.
`cos`	**Synopsis:** [N/A | normal | medium | high | crit] The Class Of Service (CoS) that is assigned to frames carrying this address as a source or destination address.

If a MAC address is not listed, do the following:

- Configure the MAC address learning options to dynamically detect the MAC addresses of other devices on the network. For more information, refer to "Configuring MAC Address Learning Options (Page 334)".
- Configure the address on the device as a static MAC address. For more information, refer to "Adding a Static MAC Address (Page 336)".

8.3.2 Purging the Dynamic MAC Address List

To purge the dynamic MAC address list of all entries, type:

```
switch  mac-tables  purge-mac-table
```

Once the table is purged, the following message appears:

```
purge-mac-table-string Success
```

8.3.3 Configuring MAC Address Learning Options

The MAC address learning options control how and when MAC addresses are removed automatically from the MAC address table. Individual addresses are

removed when the aging timer is exceeded. Addresses can also be removed when a link failure or topology change occurs.

To configure the MAC address learning options, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***switch » mac-tables*** and configure the following parameter(s) as required:

Parameter	Description
`mac-aging-time { mac-aging-time }`	**Synopsis:** An integer between 15 and 800 **Default:** 300 The time a learned MAC address is held before being aged out.
`mac-age-on-loss { mac-age-on-loss }`	**Synopsis:** [true | false] **Default:** true When link failure (and potentially a topology change) occurs, the switch may have some MAC addresses previously learned on the failed port. As long as those addresses are not aged-out, the switch will still be forwarding traffic to that port, thus preventing that traffic from reaching its destination via the new network topology. This parameter allows the aging-out of all MAC addresses learned on a failed port immediately upon link failure detection.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

8.3.4 Managing Static MAC Addresses

Static MAC addresses must be configured when destination devices are only able to receive frames, not transmit them. They may also need to be configured if port security (if supported) must be enforced.

Prioritized MAC addresses are configured when traffic to or from a specific device on a LAN segment is to be assigned a higher CoS priority than other devices on that LAN segment.

8.3.4.1 Viewing a List of Static MAC Addresses

To view a list of static MAC addresses configured on the device, type:

```
show running-config switch mac-tables static-mac-table
```

If static MAC addresses have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config switch mac-tables static-mac-table | tab
MAC               VID   LEARNED  SLOT    PORT  COS
-----------------------------------------------------------
00:0a:dc:f6:8b:ff  4085  -        swport  2     normal
```

```
00:10:94:00:24:01  4084  -        swport  1     normal
00:10:94:00:30:01  1     -        swport  2     normal
00:10:94:00:40:01  4086  -        swport  2     normal

!
```

If no static MAC addresses have been configured, add addreses as needed. For more information, refer to "Adding a Static MAC Address (Page 336)".

8.3.4.2 Adding a Static MAC Address

To add a static MAC address, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the static MAC address by typing:

   Note
   Letters in MAC addresses must be lowercase.

   ```
   switch mac-tables static-mac-table static-mac
   { address } { vlan }
   ```

   Where:

   - `{ address }` is the Unicast MAC address that is to be statically configured. It can have up to 6 '*' wildcard characters continuously applied from the right.
   - `{ vlan }` is the ID of the VLAN upon which the MAC address operates.
3. Configure the following parameter(s) as required:

Parameter	Description
`learned`	If set, the system will auto-learn the port upon which the device with this address is located.
`slot { slot }`	**Synopsis:** [sm | lm1 | lm2 | lm3 | lm4 | lm5 | lm6 | swport | eth | serport | celport | wlanport] The name of the module location provided on the silkscreen across the top of the device.
`port { port }`	**Synopsis:** An integer between 1 and 16 The selected ports on the module installed in the indicated slot.
`cos { cos }`	**Synopsis:** [N/A | normal | medium | high | crit] **Default:** normal The priority of traffic for a specified address.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

8.3.4.3 Deleting a Static MAC Address

To delete a static MAC address, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the static MAC address by the typing:

   ```
   no switch mac-tables static-mac-table static-mac
   { address } { vlan }
   ```

   Where:

   - `{ address }` is the Unicast MAC address that is to be statically configured. It can have up to 6 '*' wildcard characters continuously applied from the right.
   - `{ vlan }` is the ID of the VLAN upon which the MAC address operates.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

8.4 Managing Multicast Filtering

Multicast traffic can be filtered using either static multicast groups, IGMP (Internet Group Management Protocol) snooping, or GMRP (GARP Multicast Registration Protocol).

8.4.1 Multicast Filtering Concepts

This section describes some of the concepts important to the implementation of multicast filtering in RUGGEDCOM ROX II.

8.4.1.1 IGMP

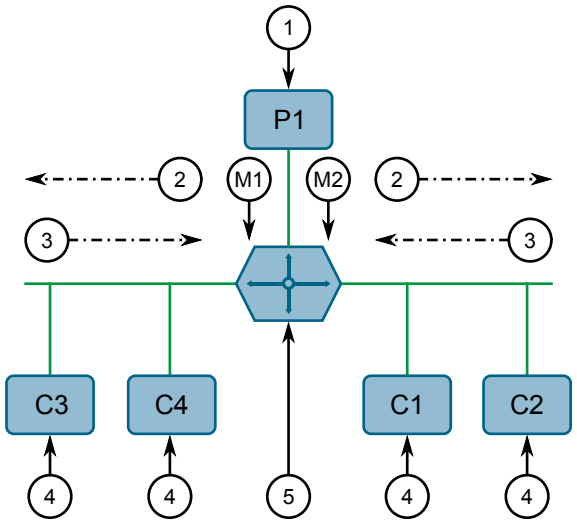
IGMP is used by IP hosts to report their host group memberships with multicast routers. As hosts join and leave specific multicast groups, streams of traffic are directed to or withheld from that host.

The IGMP protocol operates between multicast routers and IP hosts. When an unmanaged switch is placed between multicast routers and their hosts, the multicast streams will be distributed to all ports.This may introduce significant traffic onto ports that do not require it and receive no benefit from it.

IGMP Snooping, when enabled, will act on IGMP messages sent from the router and the host, restricting traffic streams to the appropriate LAN segments.

Example: IGMP In Operation

The following network diagram provides a simple example of the use of IGMP.



① Producer
② Membership Queries
③ Membership Reports
④ Host
⑤ Mulicast Router

Figure 8.1 Example – IGMP In Operation

One *producer* IP host (P1) is generating two IP multicast streams, M1 and M2. There are four potential *consumers* of these streams, C1 through C4. The multicast router discovers which host wishes to subscribe to which stream by sending general membership queries to each segment.

In this example, the general membership query sent to the C1-C2 segment is answered by a membership report (or *join*) indicating the desire to subscribe to stream M2. The router will forward the M2 stream to the C1-C2 segment. In a similar fashion, the router discovers that it must forward stream M1 to segment C3-C4.

A *consumer* may join any number of multicast groups, issuing a membership report for each group. When a host issues a membership report, other hosts on the same network segment that also require membership to the same group suppress their own requests, since they would be redundant. In this way, the IGMP protocol guarantees the segment will issue only one membership report for each group.

The router periodically queries each of its segments in order to determine whether at least one consumer still subscribes to a given stream. If it receives no responses within a given time period (usually two query intervals), the router will prune the multicast stream from the given segment.

A more common method of pruning occurs when consumers wishing to unsubscribe issue an IGMP *leave group* message. The router will immediately issue a group-specific membership query to determine whether there are any remaining subscribers of that group on the segment. After the last consumer of a group has unsubscribed, the router will prune the multicast stream from the given segment.

Switch IGMP Operation

The IGMP Snooping feature provides a means for switches to snoop (i.e. watch) the operation of routers, respond with joins/leaves on the behalf of consumer ports, and prune multicast streams accordingly. There are two modes of IGMP the switch can be configured to assume: active and passive.

- **Active Mode**

  IGMP supports a *routerless* mode of operation.

  When such a switch is used without a multicast router, it is able to function as if it is a multicast router sending IGMP general queries.

- **Passive Mode**

  When such a switch is used in a network with a multicast router, it can be configured to run Passive IGMP. This mode prevents the switch from sending the queries that can confuse the router causing it to stop issuing IGMP queries.

Note
A switch running in passive mode requires the presence of a multicast router or it will be unable to forward multicast streams at all if no multicast routers are present.

Note
Without a multicast router, at least one IGMP Snooping switch must be in active mode to make IGMP functional.

IGMP Snooping Rules

IGMP Snooping adheres to the following rules:

- When a multicast source starts multicasting, the traffic stream will be immediately blocked on segments from which joins have not been received.
- Unless configured otherwise, the switch will forward all multicast traffic to the ports where multicast routers are attached.
- Packets with a destination IP multicast address in the 224.0.0.X range that are not IGMP are always forwarded to all ports. This behavior is based on the fact that many systems do not send membership reports for IP multicast addresses in this range while still listening to such packets.
- The switch implements *proxy-reporting* (i.e. membership reports received from downstream are summarized and used by the switch to issue its own reports).
- The switch will only send IGMP membership reports out of those ports where multicast routers are attached, as sending membership reports to hosts could result in unintentionally preventing a host from joining a specific group.
- Multicast routers use IGMP to elect a master router known as the *querier*. The *querier* is the router with the lowest IP address. All other routers become non-queriers, participating only in forwarding multicast traffic. Switches running in active mode participate in the querier election the same as multicast routers.

- When the querier election process is complete, the switch simply relays IGMP queries received from the querier.
- When sending IGMP packets, the switch uses its own IP address, if it has one, for the VLAN on which packets are sent, or an address of 0.0.0.0, if it does not have an assigned IP address.

Note
IGMP Snooping switches perform multicast pruning using a multicast frame's destination MAC multicast address, which depends on the group IP multicast address. IP address W.X.Y.Z corresponds to MAC address 01-00-5E-XX-YY-ZZ where XX is the lower 7 bits of X, and YY and ZZ are simply Y and Z coded in hexadecimal.

One can note that IP multicast addresses, such as 224.1.1.1 and 225.1.1.1, will both map onto the same MAC address 01-00-5E-01-01-01. This is a problem for which the IETF Network Working Group currently has offered no solution. Users are advised to be aware of and avoid this problem.

IGMP and RSTP

An RSTP change of topology can render the routes selected to carry multicast traffic as incorrect. This results in lost multicast traffic.

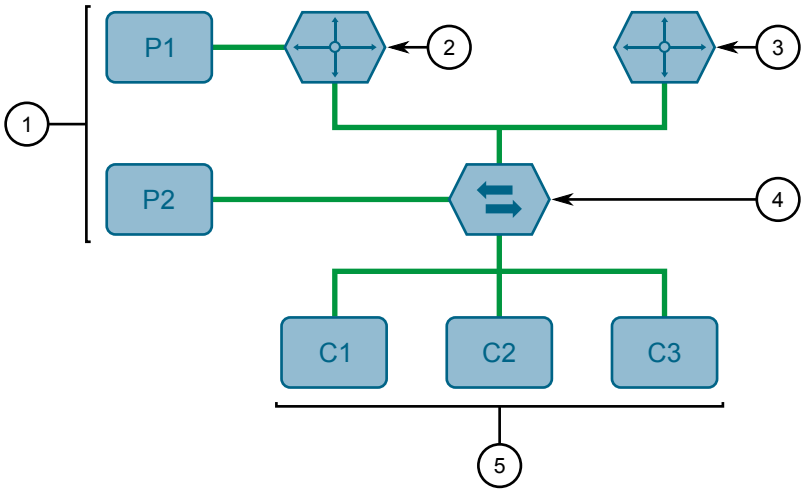
If RSTP detects a change in the network topology, IGMP will take some actions to avoid the loss of multicast connectivity and reduce network convergence time:

- The switch will immediately issue IGMP queries (if in IGMP Active mode) to obtain potential new group membership information.
- The switch can be configured to flood multicast streams temporarily out of all ports that are not RSTP Edge Ports.

Combined Router and Switch IGMP Operation

The following example illustrates the challenges faced with multiple routers, VLAN support and switching.

Producer P1 resides on VLAN 2 while P2 resides on VLAN 3. Consumer C1 resides on both VLANs whereas C2 and C3 reside on VLANs 3 and 2, respectively. Router 2 resides on VLAN 2, presumably to forward multicast traffic to a remote network or act as a source of multicast traffic itself.



① Producer
② Multicast Router 1
③ Multicast Router 2
④ Switch
⑤ Host

Figure 8.2 Example – Combined Router and Switch IGMP In Operation

In this example:

- P1, Router 1, Router 2 and C3 are on VLAN 2
- P2 and C2 are on VLAN 3
- C1 is on both VLAN 2 and 3

Assuming that router 1 is the querier for VLAN 2 and router 2 is simply a non-querier, the switch will periodically receive queries from router 1 and maintain the information concerning which port links to the multicast router. However, the switch port that links to router 2 must be manually configured as a *router port*. Otherwise, the switch will send neither multicast streams nor joins/leaves to router 2.

Note that VLAN 3 does not have an external multicast router. The switch should be configured to operate in its *routerless* mode and issue general membership queries as if it is the router.

- **Processing Joins**

  If host C1 wants to subscribe to the multicast streams for both P1 and P2, it will generate two membership reports. The membership report from C1 on VLAN 2 will cause the switch to immediately initiate its own membership report to multicast router 1 (and to issue its own membership report as a response to queries).

  The membership report from host C1 for VLAN 3 will cause the switch to immediately begin forwarding multicast traffic from producer P2 to host C2.

- **Processing Leaves**

  When host C1 decides to leave a multicast group, it will issue a leave request to the switch. The switch will poll the port to determine if host C1 is the last member of the group on that port. If host C1 is the last (or only) member, the group will immediately be pruned from the port.

  Should host C1 leave the multicast group without issuing a leave group message and then fail to respond to a general membership query, the switch will stop forwarding traffic after two queries.

  When the last port in a multicast group leaves the group (or is aged-out), the switch will issue an IGMP leave report to the router.

8.4.1.2 GMRP (GARP Multicast Registration Protocol)

The GARP Multicast Registration Protocol (GMRP) is an application of the Generic Attribute Registration Protocol (GARP) that provides a Layer 2 mechanism for managing multicast group memberships in a bridged Layer 2 network. It allows Ethernet switches and end stations to register and unregister membership in multicast groups with other switches on a LAN, and for that information to be disseminated to all switches in the LAN that support Extended Filtering Services.

GMRP is an industry-standard protocol first defined in IEEE 802.1D-1998 and extended in IEEE 802.1Q-2005. GARP was defined in IEEE 802.1D-1998 and updated in 802.1D-2004.

Note
GMRP provides similar functionality at Layer 2 to what IGMP provides at Layer 3.

Joining a Multicast Group

In order to join a multicast group, an end station transmits a GMRP *join* message. The switch that receives the *join* message adds the port through which the message was received to the multicast group specified in the message. It then propagates the *join* message to all other hosts in the VLAN, one of which is expected to be the multicast source.

When a switch transmits GMRP updates (from GMRP-enabled ports), all of the multicast groups known to the switch, whether configured manually or learned dynamically through GMRP, are advertised to the rest of network.

As long as one host on the Layer 2 network has registered for a given multicast group, traffic from the corresponding multicast source will be carried on the network. Traffic multicast by the source is only forwarded by each switch in the network to those ports from which it has received join messages for the multicast group.

Leaving a Multicast Group

Periodically, the switch sends GMRP queries in the form of a *leave all* message. If a host (either a switch or an end station) wishes to remain in a multicast group, it reasserts its group membership by responding with an appropriate *join* request. Otherwise, it can either respond with a *leave* message or simply not respond at all. If the switch receives a *leave* message or receives no response from the host for a timeout period, the switch removes the host from the multicast group.

Notes About GMRP

Since GMRP is an application of GARP, transactions take place using the GARP protocol. GMRP defines the following two Attribute Types:

- The Group Attribute Type, used to identify the values of group MAC addresses
- The Service Requirement Attribute Type, used to identify service requirements for the group

Service Requirement Attributes are used to change the receiving port's multicast filtering behavior to one of the following:

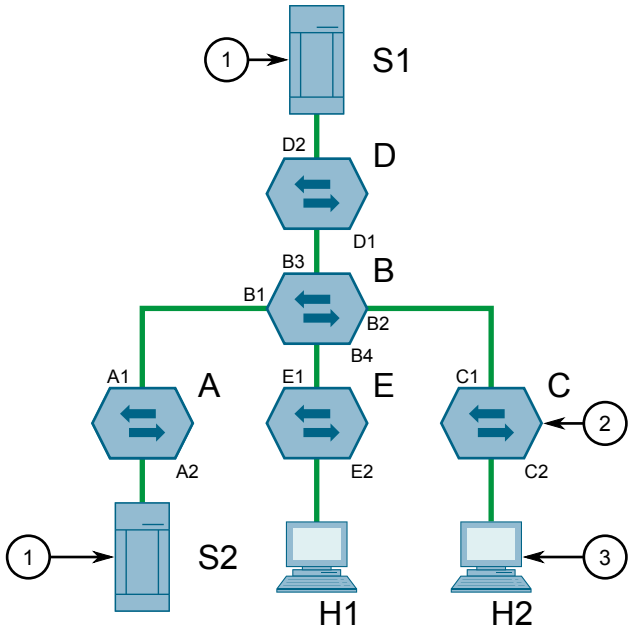
- Forward All Multicast group traffic in the VLAN, or
- Forward All Unknown Traffic (Multicast Groups) for which there are no members registered in the device in a VLAN

If GMRP is disabled on the RUGGEDCOM RX1400, GMRP packets received will be forwarded like any other traffic. Otherwise, GMRP packets will be processed by the RUGGEDCOM RX1400, and not forwarded.

Example: Establishing Membership with GMRP

The following example illustrates how a network of hosts and switches can dynamically join two multicast groups using GMRP.

In this scenario, there are two multicast sources, S1 and S2, multicasting to Multicast Groups 1 and 2, respectively. A network of five switches, including one core switch (B), connects the sources to two hosts, H1 and H2, which receive the multicast streams from S1 and S2, respectively.



① Multicast Source
② Switch
③ Multicast Host

Figure 8.3 Example – Establishing Membership with GMRP

The hosts and switches establish membership with the Multicast Group 1 and 2 as follows:

1. Host H1 is GMRP unaware, but needs to see traffic for Multicast Group 1. Therefore, Port E2 on Switch E is statically configured to forward traffic for Multicast Group 1.
2. Switch E advertises membership in Multicast Group 1 to the network through Port E1, making Port B4 on Switch B a member of Multicast Group 1.
3. Switch B propagates the *join* message, causing Ports A1, C1 and D1 to become members of Multicast Group 1.
4. Host H2 is GMRP-aware and sends a *join* request for Multicast Group 2 to Port C2, which thereby becomes a member of Multicast Group 2.
5. Switch C propagates the *join* message, causing Ports A1, B2, D1 and E1 to become members of Multicast Group 2.

Once GMRP-based registration has propagated through the network, multicast traffic from S1 and S2 can reach its destination as follows:

- Source S1 transmits multicast traffic to Port D2 which is forwarded via Port D1, which has previously become a member of Multicast Group 1.
- Switch B forwards the Group 1 multicast via Port B4 towards Switch E.
- Switch E forwards the Group 1 multicast via Port E2, which has been statically configured for membership in Multicast Group 1.

- Host H1, connected to Port E2, thus receives the Group 1 multicast.
- Source S2 transmits multicast traffic to Port A2, which is then forwarded via port A1, which has previously become a member of Multicast Group 2.
- Switch B forwards the Group 2 multicast via Port B2 towards Switch C.
- Switch C forwards the Group 2 multicast via Port C2, which has previously become a member of Group 2.
- Ultimately, Host H2, connected to Port C2, receives the Group 2 multicast.

8.4.2 Enabling and Configuring GMRP

To enable and configure GMRP (GARP Multicast Registration Protocol), do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***switch » mcast-filtering*** and configure the following parameter(s) as required:

Parameter	Description
`enabled { enabled }`	**Synopsis:** [true | false] **Default:** false GMRP Enable
`rstp-flooding`	Determines whether or not multicast streams will be flooded out of all Rapid Spanning Tree Protocol (RSTP) non-edge ports upon detection of a topology change. Such flooding is desirable, if multicast stream delivery must be guaranteed without interruption.
`leave-timer { leave-timer }`	**Synopsis:** An integer between 600 and 300000 **Default:** 4000 The time in milliseconds to wait after issuing Leave or LeaveAll before removing registered multicast groups. If Join messages for specific addresses are received before this timer expires, the addresses will be kept registered.

3. Enable GMRP on one or more switched Ethernet ports. For more information, refer to "Configuring a Switched Ethernet Port (Page 314)".
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

8.4.3 Managing IGMP Snooping

This sections describes how to configure IGMP snooping and manage ports monitored by the service.

8.4.3.1 Configuring IGMP Snooping

To configure IGMP snooping, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***switch » mcast-filtering » igmp-snooping*** and configure the following parameter(s) as required:

Parameter	Description
`igmp-mode { igmp-mode }`	**Synopsis:** [active | passive] **Default:** passive Specifies the IGMP mode: • PASSIVE : The switch passively snoops IGMP traffic and never sends IGMP queries. • ACTIVE : The switch generates IGMP queries, if no queries from a better candidate for the querier are detected for a while.
`igmp-query-interval { igmp-query-interval }`	**Synopsis:** An integer between 10 and 3600 **Default:** 60 The time interval between IGMP queries generated by the switch. NOTE: This parameter also affects the Group Membership Interval (i.e. the group subscriber aging time), therefore, it takes effect even in PASSIVE mode.
`igmp-version { igmp-version }`	**Synopsis:** [v2 | v3] **Default:** v2 The version of IGMP. Options include: • v2: IGMP version 2. • v3: IGMP version 3. Backwards compatible with v2.
`router-forwarding { router-forwarding }`	**Synopsis:** [true | false] **Default:** true Whether or not multicast streams will always be forwarded to multicast routers.
`rstp-flooding`	Whether or not multicast streams will be flooded out of all Rapid Spanning Tree Protocol (RSTP) non-edge ports upon detection of a topology change. Such flooding is desirable, if multicast stream delivery must be guaranteed without interruption.

3. Assign one or more ports for IGMP to use when sending Membership Reports. For more information, refer to "Adding a Router Port (Page 347)".
4. Enable IGMP snooping for the required static VLAN(s). For more information, refer to "Adding a Static VLAN (Page 363)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

8.4.3.2 Viewing a List of Router Ports

To view a list of router ports used for IGMP snooping, type:

```
show running-config switch mcast-filtering igmp-snooping router-ports
```

If router ports have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config switch mcast-filtering igmp-snooping router-ports |
 tab
SLOT  PORT
------------
swport   1

 !
!
```

If no router ports have been configured, add ports as needed. For more information, refer to "Adding a Router Port (Page 347)".

8.4.3.3 Adding a Router Port

To add a router port for IGMP snooping, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the router port by typing:

   ```
   switch mcast-filtering igmp-snooping router-ports swport { port }
   ```

   Where:

   - `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

8.4.3.4 Deleting a Router Port

To delete a router port for IGMP snooping, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the router port by typing:

   ```
   no switch mcast-filtering igmp-snooping router-ports swport { port }
   ```

   Where:

   - `{ slot }` is the name of the module location

- `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

8.4.4 Managing the Static Multicast Group Table

This section describes how to manage entries in the Static Multicast Group table.

8.4.4.1 Viewing a List of Static Multicast Group Entries

To view a list of entries for known static multicast groups on other devices, type:

```
show running-config switch mcast-filtering static-mcast-table
```

If entries have been established, a table or list similar to the following example appears:

```
ruggedcom# show running-config switch mcast-filtering static-mcast-table
switch mcast-filtering
 static-mcast-table 10 01:00:00:01:01:01
 !
!
```

If no entries have been configured, add entries as needed. For more information, refer to "Adding a Static Multicast Group Entry (Page 348)".

8.4.4.2 Adding a Static Multicast Group Entry

To list a static multicast group from another device in the Static Multicast Summary table, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the table entry by typing:

Note
Letters in MAC addresses must be lowercase.

```
switch mcast-filtering static-mcast-table { id } { address }
```

Where:

- `{ id }` is the ID for the VLAN upon which the static multicast group operates
- `{ address }` is the MAC address for the device in the form of 01:xx:xx:xx:xx:xx

3. Add one or more egress ports. For more information, refer to "Adding an Egress Port (Page 350)".
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

8.4.4.3 Deleting a Static Multicast Group Entry

To delete a static multicast group from the Static Multicast Summary table, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the table entry by typing:

   ```
   no switch mcast-filtering static-mcast-table { id } { address }
   ```

   Where:

   - `{ id }` is the ID for the VLAN upon which the static multicast group operates
   - `{ address }` is the MAC address for the device in the form of 01:xx:xx:xx:xx:xx
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

8.4.5 Managing Egress Ports for Multicast Groups

This section describes how to configure and manage egress ports for a multicast group.

8.4.5.1 Viewing a List of Egress Ports

To view a list of egress ports for a static multicast group defined in the Static Multicast Group Summary table, type:

```
show switch mcast-filtering static-mcast-table { id } { address } egress-ports
```

Where:

- `{ id }` is the ID for the VLAN upon which the static multicast group operates
- `{ address }` is the MAC address for the device in the form of 01:xx:xx:xx:xx:xx

If egress ports have been established, a table or list similar to the following example appears:

```
ruggedcom# show running-config switch mcast-filtering static-mcast-table 10
 01:00:00:01:01:01 egress-ports
switch mcast-filtering
 static-mcast-table 10 01:00:00:01:01:01
  egress-ports swport 1
  !
 !
!
```

If no egress ports have been configured, add egress ports as needed. For more information, refer to "Adding an Egress Port (Page 350)".

8.4.5.2 Adding an Egress Port

To add an egress port to a static multicast group defined in the Static Multicast Group Summary table, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the egress port by typing:

   ```
   switch mcast-filtering static-mcast-table { id }
   { address } egress-ports swport { port }
   ```

   Where:

   - `{ id }` is the ID for the VLAN upon which the static multicast group operates
   - `{ address }` is the MAC address for the device in the form of 01:xx:xx:xx:xx:xx
   - `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

8.4.5.3 Deleting an Egress Port

To delete an egress port for a static multicast group defined in the Static Multicast Group Summary table, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the table entry by typing:

   ```
   no switch mcast-filtering static-mcast-table { id }
   { address } egress-ports swport { port }
   ```

   Where:

   - `{ id }` is the ID for the VLAN upon which the static multicast group operates

- `{ address }` is the MAC address for the device in the form of 01:xx:xx:xx:xx:xx
- `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

8.4.6 Viewing a Summary of Multicast Groups

To view a summary of all multicast groups, type:

```
show switch mcast-filtering mcast-group-summary
```

If multicast groups have been configured, a table or list similar to the following example appears:

```
ruggedcom# show switch mcast-filtering mcast-group-summary
                        STATIC  STATIC  GMRP    GMRP
VID  MAC                SLOT    PORTS   SLOT    PORTS
-------------------------------------------------------
100  01:00:5e:00:01:01
                        swport  1
                                        swport  none
200  01:00:5e:00:01:02
                        swport  2
                                        swport  none
```

This table or list provides the following information:

Parameter	Description
`vid`	**Synopsis:** An integer The VLAN Identifier of the VLAN upon which the multicast group operates.
`mac`	**Synopsis:** A string 17 characters long The multicast group MAC address.
`{ slot }`	**Synopsis:** [sm | lm1 | lm2 | lm3 | lm4 | lm5 | lm6 | swport | eth | serport | celport | wlanport] The name of the module location provided on the silkscreen across the top of the device.
`ports`	**Synopsis:** A string 128 characters long The selected ports on the module installed in the indicated slot.
`{ slot }`	**Synopsis:** [sm | lm1 | lm2 | lm3 | lm4 | lm5 | lm6 | swport | eth | serport | celport | wlanport] The name of the module location provided on the silkscreen across the top of the device.
`ports`	**Synopsis:** A string 128 characters long The selected ports on the module installed in the indicated slot.

8.4.7 Viewing a List of IP Multicast Groups

To view a list of all multicast groups, type:

```
show switch mcast-filtering ip-mcast-groups
```

If IP multicast groups have been configured, a table or list similar to the following example appears:

```
ruggedcom# show switch mcast-filtering ip-mcast-groups
     IP                              JOINED     JOINED  ROUTER     ROUTER
VID  ADDRESS    MAC                  SLOT       PORTS   SLOT       PORTS
-------------------------------------------------------------------------
100  225.0.1.1  01:00:5e:00:01:01
                                     swport     3
                                                     swport     1
200  225.0.1.2  01:00:5e:00:01:02
                                     swport     4
                                                     swport     2
```

This table or list provides the following information:

Parameter	Description
`{ vid }`	**Synopsis:** An integer The VLAN Identifier of the VLAN upon which the multicast group operates.
`{ ip-address }`	**Synopsis:** A string The multicast group IP address.
`mac`	**Synopsis:** A string 17 characters long The multicast MAC address corresponding to the group multicast IP address.
`Joined Slot`	The name of the module location provided on the silkscreen across the top of the device.
`Joined Ports`	The selected ports on the module installed in the indicated slot.
`Router Slot`	The name of the module location provided on the silkscreen across the top of the device.
`Router Ports`	The selected ports on the module installed in the indicated slot.

8.5 Managing VLANs

A Virtual Local Area Network (VLAN) is a group of devices on one or more LAN segments that communicate as if they were attached to the same physical LAN segment. VLANs are extremely flexible because they are based on logical connections, rather than physical connections.

When VLANs are introduced, all traffic in the network must belong to one VLAN or another. Traffic on one VLAN cannot pass to another, except through an inter-network router or Layer 3 switch.

VLANs are created in three ways:

- **Explicitly**

  Static VLANs can be created in the switch. For more information about static VLANs, refer to "Managing Static VLANs (Page 363)".

- **Implicitly**

  When a VLAN ID (VID) is set for a Port VLAN (PVLAN), static MAC address or IP interface, an appropriate VLAN is automatically created if it does not yet exist.

- **Dynamically**

  VLANs can be learned through GVRP. For more information about GVRP, refer to "GARP VLAN Registration Protocol (GVRP) (Page 355)"

8.5.1 VLAN Concepts

This section describes some of the concepts important to the implementation of VLANs in RUGGEDCOM ROX II.

8.5.1.1 Tagged vs. Untagged Frames

VLAN tags identify frames as part of a VLAN network. When a switch receives a frame with a VLAN (or 802.1Q) tag, the VLAN identifier (VID) is extracted and the frame is forwarded to other ports on the same VLAN.

When a frame does not contain a VLAN tag, or contains an 802.1p (prioritization) tag that only has prioritization information and a VID of 0, it is considered an untagged frame.

8.5.1.2 Native VLAN

Each port is assigned a native VLAN number, the Port VLAN ID (PVID). When an untagged frame ingresses a port, it is associated with the port's native VLAN.

By default, when a switch transmits a frame on the native VLAN, it sends the frame untagged. The switch can be configured to transmit tagged frames on the native VLAN.

8.5.1.3 Edge and Trunk Port Types

Each port can be configured as an edge or trunk port.

An edge port attaches to a single end device, such as a PC or Intelligent Electronic Device (IED). An edge port carries traffic on the native VLAN.

Trunk ports are part of the network and carry traffic for all VLANs between switches. Trunk ports are automatically members of all VLANs configured in the switch.

The switch can 'pass through' traffic, forwarding frames received on one trunk port out of another trunk port. The trunk ports must be members of all VLANs that the 'pass through' traffic is part of, even if none of those VLANs are used on edge ports.

Frames transmitted out of the port on all VLANs other than the port's native VLAN are always sent tagged.

Note
It may be desirable to manually restrict the traffic on the trunk to a specific group of VLANs. For example, when the trunk connects to a device, such as a Layer 3 router, that supports a subset of the available LANs. To prevent the trunk port from being a member of the VLAN, include it in the VLAN's Forbidden Ports list.

For more information about the Forbidden Ports list, refer to "Forbidden Ports List (Page 354)".

Port Type	VLANs Supported	PVID Format	Usage
Edge	1 (Native) Configured	Untagged	*VLAN Unaware Networks*: All frames are sent and received without the need for VLAN tags.
		Tagged	*VLAN Aware Networks*: VLAN traffic domains are enforced on a single VLAN.
Trunk	All Configured	Tagged or Untagged	*switch-to-Switch Connections*: VLANs must be manually created and administered, or can be dynamically learned through GVRP. *Multiple-VLAN End Devices*: Implement connections to end devices that support multiple VLANs at the same time.

8.5.1.4 Ingress Filtering

Ingress filtering is a method of verifying that inbound packets arriving at a network originate from the source they are expected to be from, before entry (or ingress) is granted.

When ingress filtering is enabled, the switch verifies any tagged frame arriving at a port. When the port is not a member of the VLAN with which the frame is associated, the frame is dropped. When ingress filtering is disabled, frames from VLANs configured to the switch are not dropped. For more information about enabling or disabling ingress filtering, refer to "Enabling/Disabling Ingress Filtering (Page 361)".

8.5.1.5 Forbidden Ports List

Each VLAN can be configured to exclude ports from membership in the VLAN using the forbidden ports list. For more about configuring a list of forbidden ports, refer to "Managing Forbidden Ports (Page 364)".

8.5.1.6 VLAN-Aware Mode of Operation

The native operation mode for an IEEE 802.1Q compliant switch is VLAN-aware. Even if a specific network architecture does not use VLANs, RUGGEDCOM ROX II's default VLAN settings allow the switch to still operate in a VLAN-aware mode, while providing functionality required for almost any network application. However, the IEEE 802.1Q standard defines a set of rules that must be followed by all VLAN-aware switches:

- Valid VIDs are within the range of 1 to 4094. VIDs equal to 0 or 4095 are invalid.
- Each frame ingressing a VLAN-aware switch is associated with a valid VID.
- Each frame egressing a VLAN-aware switch is either untagged or tagged with a valid VID. Priority-tagged frames with an invalid VID will never sent out by a VLAN-aware switch.

Note
Some applications have requirements conflicting with IEEE 802.Q native mode of operation. For example, some applications explicitly require priority-tagged frames to be received by end devices.

8.5.1.7 GARP VLAN Registration Protocol (GVRP)

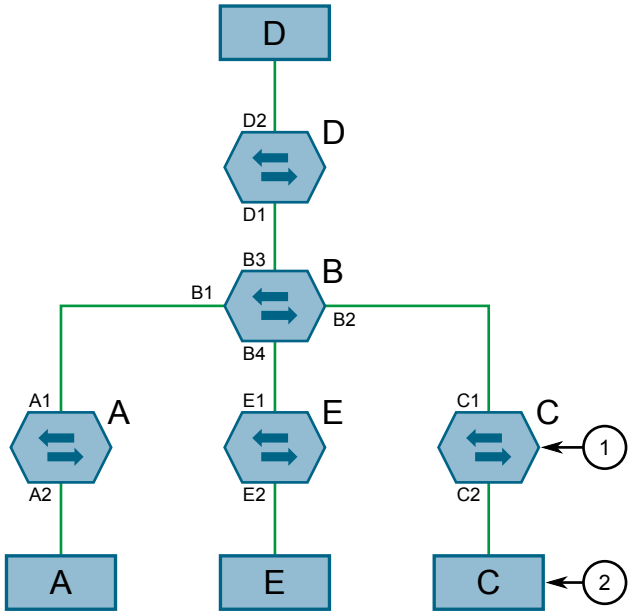
GARP VLAN Registration Protocol (GVRP) is a standard protocol built on GARP (Generic Attribute Registration Protocol) to automatically distribute VLAN configuration information in a network. Each switch in a network needs only to be configured with VLANs it requires locally. VLANs configured elsewhere in the network are learned through GVRP. A GVRP-aware end station (i.e. PC or Intelligent Electronic Device) configured for a particular VID can be connected to a trunk on a GVRP-aware switch and automatically become part of the desired VLAN.

When a switch sends GVRP bridge protocol data units (BPDUs) out of all GVRP-enabled ports, GVRP BPDUs advertise all the VLANs known to that switch (configured manually or learned dynamically through GVRP) to the rest of the network.

When a GVRP-enabled switch receives a GVRP BPDU advertising a set of VLANs, the receiving port becomes a member of those advertised VLANs and the switch begins advertising those VLANs through all the GVRP-enabled ports (other than the port on which the VLANs were learned).

To improve network security using VLANs, GVRP-enabled ports may be configured to prohibit the learning of any new dynamic VLANs but at the same time be allowed to advertise the VLANs configured on the switch.

The following is an example of how to use GVRP:



① Switch
② End Node

Figure 8.4 Using GVRP

- Switch B is the core switch, all others are edge switches
- Ports A1, B1 to B4, C1, D1, D2 and E1 are GVRP aware
- Ports B1 to B4, D1 and D2 are set to advertise and learn
- Ports A1, C1 and E1 are set to advertise only
- Ports A2, C2 and E2 are edge ports
- End node D is GVRP aware
- End nodes A, E and C are GVRP unaware
- Ports A2 and C2 are configured with PVID 7
- Port E2 is configured with PVID 20
- End node D is interested in VLAN 20, hence VLAN 20 is advertised by it towards switch D
- D2 becomes a member of VLAN 20
- Ports A1 and C1 advertise VID 7
- Ports B1 and B2 become members of VLAN 7
- Ports D1 and B1 advertise VID 20
- Ports B3, B4 and D1 become members of VLAN 20

8.5.1.8 PVLAN Edge

Protected VLAN (PVLAN) Edge refers to a feature of the switch that isolates multiple VLAN Edge ports from each other on a single device. All VLAN Edge ports in a switch that are configured as *protected* in this way are prohibited from sending frames to one another, but are still permitted to send frames to other, non-protected ports within the same VLAN. This protection extends to all traffic on the VLAN, including unicast, multicast and broadcast traffic.

Note
This feature is strictly local to the switch. PVLAN Edge ports are not prevented from communicating with ports outside of the switch, whether protected (remotely) or not.

Ports belonging to a specific PVID and a VLAN type of PVLAN Edge are part of one PVLAN Edge group. A PVLAN Edge group should include a minimum of two ports. There can be multiple PVLAN Edge groups on a switch.

8.5.1.9 Restricted VLANs

RUGGEDCOM ROX II allows users to configure 802.1X ports in **Guest VLAN** or **Quarantine VLAN** mode, to limit services to clients when IEEE 802.1x or 802.1x/MAC-Auth authentication fails. For example, an administrator may choose to restrict access to only printers, Internet, or specific downloads for unauthenticated users.

When a client fails to authenticate after a specified number of attempts, the configured port will switch automatically to either the Quarantine VLAN or the Guest VLAN, depending on the port security mode and the client's security setup:

- If a connected device supports 802.1x security but has failed authentication, the port will switch to the Quarantine VID.
- If a connected device is 802.1X incompatible and port security is set to 802.1X, the port will become a member of the Guest VLAN after the authentication times out.

When a port is a member of the Quarantine VLAN, RUGGEDCOM ROX II will attempt to re-authenticate the client at configured intervals. Clients who fail to authenticate remain in the Quarantine VLAN until successfully re-authenticated, or until the physical link goes down. If re-authentication fails, the port remains a member of the Quarantine VLAN.

There are no re-authentication attempts for clients in Guest VLANs. When an EAPOL Start frame is received from the client, the port will revert to the unauthenticated state, removing the client's access from the Guest VLAN to continue with the authentication process.

The following table outlines Quarantine vs Guest port placement behavior following authentication failure:

Port Security Mode	Client Security	Placement Following Authentication Failure
802.1x	802.1x Capable	Quarantine VLAN

Port Security Mode	Client Security	Placement Following Authentication Failure
	802.1x Not Capable	Guest VLAN
802.1x/MAC-Auth	802.1x Capable	Quarantine VLAN
	802.1x Not Capable	Quarantine VLAN

For more information about configuring a Guest/Quarantine VLAN, refer to "Configuring Port Security (Page 159)".

8.5.1.10 VLAN Advantages

The following are a few of the advantages offered by VLANs.

Traffic Domain Isolation

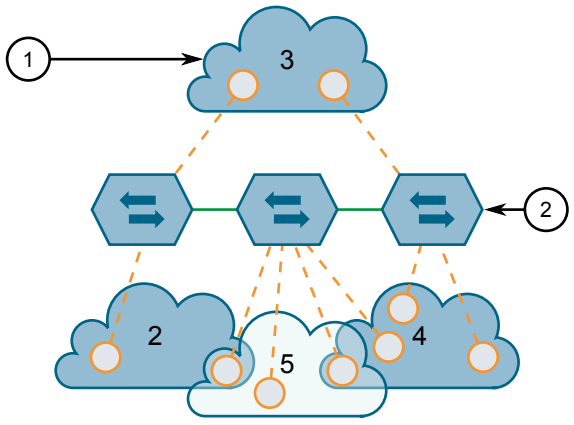
VLANs are most often used for their ability to restrict traffic flows between groups of devices.

Unnecessary broadcast traffic can be restricted to the VLAN that requires it. Broadcast storms in one VLAN need not affect users in other VLANs.

Hosts on one VLAN can be prevented from accidentally or deliberately assuming the IP address of a host on another VLAN.

The use of creative bridge filtering and multiple VLANs can carve seemingly unified IP subnets into multiple regions policed by different security/access policies.

Multi-VLAN hosts can assign different traffic types to different VLANs.



① VLAN
② Switch

Figure 8.5 Multiple Overlapping VLANs

Administrative Convenience

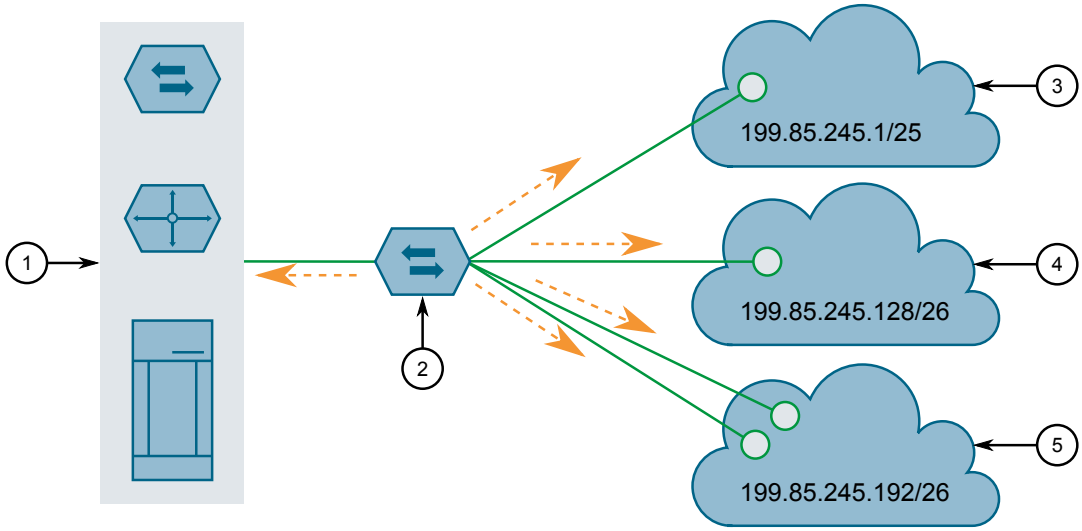
VLANs enable equipment moves to be handled by software reconfiguration instead of by physical cable management. When a host's physical location is changed, its connection point is often changed as well. With VLANs, the host's VLAN membership and priority are simply copied to the new port.

Reduced Hardware

Without VLANs, traffic domain isolation requires the use of separate bridges for separate networks. VLANs eliminate the need for separate bridges.

The number of network hosts may often be reduced. Often, a server is assigned to provide services for independent networks. These hosts may be replaced by a single, multi-horned host supporting each network on its own VLAN. This host can perform routing between VLANs.

Multi-VLAN hosts can assign different traffic types to different VLANs.



① Server, Router or Layer 3 Switch
② Switch
③ VLAN 2
④ VLAN 3
⑤ VLAN 4

Figure 8.6 Inter-VLAN Communications

8.5.2 Configuring the Internal VLAN Range

RUGGEDCOM ROX II creates and utilizes internal VLANs for internal functions. To provide RUGGEDCOM ROX II with a pool of VLAN IDs to pull from when creating internal VLANs, a range of VLAN IDs must be reserved.

⚠ NOTICE

Configuration hazard – risk of data loss

If the range-start or range-end values are changed in a way that invalidates any configured internal VLANs, the configurations defined for the affected VLANs will be lost upon repositioning.

Note
VLAN IDs reserved for internal VLANs should not be used by the network.

Note
Changing the `range-end` value repositions the matching serial VLAN. However, the matching serial VLAN is not affected when the `range-start` value is changed.

Note
If no internal VLANs are available when a switched Ethernet or trunk port is configured, the range is automatically extended so a unique value can be assigned.

Note
Routable Ethernet ports and trunks cannot be configured if internal VLANS are not enabled.

To configure the internal VLAN range, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***admin » switch-config » internal-vlans*** and configure the following parameter(s) as required:

   Note
   Internal VLAN ranges are enabled by default.

Parameter	Description
`enabled { enabled }`	**Synopsis:** [true | false] **Default:** false Enables/disables the Internal VLAN Range settings.
`range-start { range-start }`	**Synopsis:** An integer between 2 and 4094 **Default:** 4094 Defines the lower end of a range of VLANs used for the device only. VLAN ID 1 is not permitted.
`range-end { range-end }`	**Synopsis:** An integer between 2 and 4094 **Default:** 4094 Defines the higher end of a range of VLANs used for the device only.VLAN ID 1 is not permitted.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

8.5.3 Enabling/Disabling Ingress Filtering

When ingress filtering is enabled, any tagged packet arriving at a port, which is not a member of a VLAN with which that packet is associated, is dropped. When disabled, packets are not dropped.

To enable or disable ingress filtering, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable or disable ingress filtering by typing:

   Enabling Ingress Filtering

   ```
   switch vlans ingress-filtering enabled
   ```

   Disabling Ingress Filtering

   ```
   noswitch vlans ingress-filtering enabled
   ```

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

8.5.4 Managing VLANs for Switched Ethernet Ports

This section describes how to configure and manage VLANs assigned to switched Ethernet ports.

8.5.4.1 Viewing VLAN Assignments for Switched Ethernet Ports

To determine which VLANs are assigned to each switched Ethernet port, type:

```
show switch vlans vlan-summary
```

A table similar to the following example appears:

```
ruggedcom# show switch vlans vlan-summary | tab
      IGMP            UNTAGD  UNTAGD  TAGGED  TAGGED
VID   SNOOPING  MSTI  SLOT    PORTS   SLOT    PORTS   QOS  INGRESS  MARK
-------------------------------------------------------------------------
1     false     0
                      swport  1,5,6
                                      swport  none
                                                      0    0
                                                      1    0
                                                      2    0
                                                      3    0
                                                      4    0
                                                      5    0
                                                      6    0
                                                      7    0
```

```
.
.
.
```

The VLANs listed are based on the PVIDs assigned to the switched Ethernet ports. For more information about assigning PVIDs to switched Ethernet Ports, refer to "Configuring a Switched Ethernet Port (Page 314)".

8.5.4.2 Configuring VLANs for Switched Ethernet Ports

When a VLAN ID is assigned to a switched Ethernet port, the VLAN appears in the All-VLANs Table where it can be further configured.

To configure a VLAN for a switched Ethernet port, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***switch » vlans » all-vlans » {id}***, where *{id}* is the ID of the VLAN and configure the following parameter(s) as needed:

Parameter	Description
`ip-address-src { ip-address-src }`	**Synopsis:** [static | dynamic] Whether the IP address is static or dynamically assigned via Dynamic Host Configuration Protocol (DHCP) or Bootstrap Protocol (BOOTP). The DYNAMIC option is a common case of a dynamically assigned IP address. It switches between BOOTP and DHCP until it gets the response from the relevant server. This must be static for non-management interfaces.
`ipv6-address-src { ipv6-address-src }`	**Synopsis:** [static | dynamic] **Default:** static Whether the IPv6 address is static or dynamically assigned via Dynamic Host Configuration Protocol (DHCP). This must be static for non-management interfaces.
`proxyarp`	Enables/Disables whether the VLAN will respond to ARP requests for hosts other than itself.
`on-demand`	Brings up this interface on demand only.
`mtu { mtu }`	**Synopsis:** An integer between 68 and 1632 **Default:** 1500 Maximum transmission unit (largest packet size allowed for this interface). **Note** An MTU size over 1500 (jumbo frames) is only supported for Layer 2 traffic.

3. Add Quality of Service (QoS) maps to the VLAN. For more information, refer to "Adding a QoS Map (Page 877)".
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

8.5.5 Managing Static VLANs

This section describes how to configure and manage static VLANs.

8.5.5.1 Viewing a List of Static VLANs

To view a list of static VLANs, type:

```
show running-config switch vlans static-vlan
```

If static VLANs have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config switch vlans static-vlan | tab
     IGMP
VID  SNOOPING  MSTI  SLOT  PORT
---------------------------------
1    -         cst

!
```

If no static VLANs have been configured, add static VLANs as needed. For more information, refer to "Adding a Static VLAN (Page 363)".

8.5.5.2 Adding a Static VLAN

To add a static VLAN for either a routable Ethernet port or virtual switch, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the static VLAN by typing:

   ```
   switch vlans static-vlan { id }
   ```

   Where:

   - { id } is the VLAN identifier. The VLAN identifier is used to identify the VLAN in tagged Ethernet frames according to IEEE 802.1Q.
3. Configure the following parameter(s) as required:

Parameter	Description
`igmp-snooping`	Enables or disables IGMP Snooping on the VLAN.
`msti { msti }`	**Synopsis:** [cst] or An integer between 1 and 16 **Default:** cst Only valid for Multiple Spanning Tree Protocol (MSTP) and has no effect, if MSTP is not used. The parameter specifies the Multiple Spanning Tree Instance (MSTI) the VLAN should be mapped to.

4. If needed, configure a forbidden ports list. For more information, refer to "Adding a Forbidden Port (Page 365)".

5. Configure the VLAN for the port. For more information, refer to "Configuring VLANs for Switched Ethernet Ports (Page 362)".
6. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

8.5.5.3 Deleting a Static VLAN

To delete a static VLAN for either a routable Ethernet port or virtual switch, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the static VLAN by typing:

   ```
   no switch vlans static-vlan { id }
   ```

   Where:

   - `{ id }` is the ID of the VLAN
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

8.5.6 Managing Forbidden Ports

Static VLANs can be configured to exclude ports from membership in the VLAN using the forbidden ports list.

8.5.6.1 Viewing a List of Forbidden Ports

To view a list of forbidden ports, type:

```
show running-config switch vlans static-vlan forbidden-ports
```

If ports have been forbidden, a table or list similar to the following example appears:

```
ruggedcom# show running-config switch vlans static-vlan forbidden-ports | tab
VID  SLOT    PORT
-------------------
50
     swport  1
     swport  2
60
     swport  2
     swport  3
     swport  4
70
     swport  5

!
```

If no ports have been forbidden, add forbidden ports as needed. For more information, refer to "Adding a Forbidden Port (Page 365)".

8.5.6.2 Adding a Forbidden Port

To add a forbidden port, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the forbidden port by typing:

   ```
   switch vlans static-vlan { name } forbidden-ports swport { port }
   ```

   Where:

   - `{ name }` is the name of the static VLAN
   - `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

8.5.6.3 Deleting a Forbidden Port

To delete a forbidden port, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***switch » vlans » static-vlan » {name} » forbidden-ports***, where *{name}* is the name of the static VLAN.
3. Configure the following parameter(s) as required:

   ```
   no switch vlans static-vlan { name } forbidden-ports swport { port }
   ```

   Where:

   - `{ name }` is the name of the static VLAN
   - `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

8.5.7 Managing VLANs for Interfaces and Tunnels

The following sections describes how to view, add and delete tunnels for specific interfaces and tunnels.

- "Managing VLANs for Virtual Switches (Page 456)"

- "Managing VLANs for L2TPv3 Tunnels (Page 474)"

9 Serial Server

This chapter describes how to manage and configure the serial server, including serial ports, protocols, remote hosts and the Device Address Tables.

9.1 Managing Serial Ports

This section describes how to configure, monitor and manage serial ports on the device.

9.1.1 Viewing a List of Serial Ports

To view a list of serial ports configured on the device, type:

```
show running-config interface serial
```

A table or list similar to the following example appears:

```
ruggedcom# show running-config interface serial | tab
                                BAUD  DATA          STOP  FLOW     PORT
SLOT     PORT  ENABLED  ALIAS  RATE  BITS  PARITY  BITS  CONTROL  TYPE   PROTOCOL
-------------------------------------------------------------------------------
serport  1     true     -      9600  8     none    1     none     rs232
serport  2     true     -      9600  8     none    1     none     rs232

!
```

9.1.2 Viewing Serial Port Statistics

To view statistics collected for a specific serial port, type:

```
show interfaces serial port
```

A table or list similar to the following example appears:

```
ruggedcom# show interfaces serial port | tab
                              TX     TX       RX     RX       PACKET  PARITY  FRAMING  OVERRUN
IFNAME  MEDIA  SPEED  PROTOCOL  CHARS  PACKETS  CHARS  PACKETS  ERRORS  ERRORS  ERRORS   ERRORS
-------------------------------------------------------------------------------------------
ser-1   RS232  9.6K   none      0      0        0      0        0       0       0        0
ser-2   RS232  9.6K   none      0      0        0      0        0       0       0        0
```

This table or list provides the following information:

Parameter	Description
`{ ifname }`	**Synopsis:** A string between 1 and 10 characters long The name of the serial interface.
`media`	**Synopsis:** A string 31 characters long The type of port media { RS232 RS422 RS485 }.
`speed`	**Synopsis:** [auto | 1.5M | 2.4M | 10M | 100M | 1G | 10G | 1.776M | 3.072M | 7.2M | 1.2K | 2.4K | 9.6K | 19.2K | 38.4K | 57.6K | 115.2K | 230.4K | 4.8K | 76.8K] The speed (in Kilobits-per-second).
`protocol`	**Synopsis:** A string 31 characters long The serial protocol assigned to this port.
`tx-chars`	**Synopsis:** An integer The number of bytes transmitted over the serial port.
`tx-packets`	**Synopsis:** An integer The number of packets transmitted over the serial port.
`rx-chars`	**Synopsis:** An integer The number of bytes received by the serial port.
`rx-packets`	**Synopsis:** An integer The number of packets received by the serial port.
`packet-errors`	**Synopsis:** An integer The number of packet errors on this serial port.
`parity-errors`	**Synopsis:** An integer The number of parity errors on this serial port.
`framing-errors`	**Synopsis:** An integer The number of framing errors on this serial port.
`overrun-errors`	**Synopsis:** An integer The number of overrun errors on this serial port.

9.1.3 Viewing Transport Connection Statistics

To view the statistics collected for all transport connections, type:

```
show interfaces serial transport-connections
```

A table or list similar to the following appears:

```
ruggedcom# show interfaces serial transport-connections | tab
                     REMOTE  LOCAL             RX       TX       TARGET
INDEX  REMOTE IP     PORT    PORT   TRANSPORT  PACKETS  PACKETS  PORT      STATUS
-------------------------------------------------------------------------------
1      10.200.22.199 15836   20000  TCP        177      0        ser-1,  Active
```

To view the statistics collected for a specific transport connection, type:

```
show interfaces serial transport-connections { index }
```

A table or list similar to the following appears:

These tables or lists provide the following information:

Parameter	Description
`{ index }`	**Synopsis:** A string 32 characters long The transport connection index.
`remote-ip`	**Synopsis:** A string 32 characters long The IP address of the remote serial server.
`remote-port`	**Synopsis:** An integer The port of the remote serial server.
`local-port`	**Synopsis:** An integer The local port for the incoming connection.
`transport`	**Synopsis:** A string 8 characters long The transport protocol (UDP or TCP) for this serial port.
`rx-packets`	**Synopsis:** An integer The number of packets received from TCP/UDP.
`tx-packets`	**Synopsis:** An integer The number of packets transmitted to TCP/UDP.
`target-port`	**Synopsis:** A string 1024 characters long The target serial port.
`status`	**Synopsis:** A string 31 characters long The connection status of the serial port.

9.1.4 Viewing DNP Device Table Statistics

To view the statistics collected for DNP device tables, type:

```
show interfaces serial dnp-device-table
```

A table or list similar to the following appears:

```
ruggedcom# show interfaces serial dnp-device-table | tab
DEVICE                  SERIAL
ADDRESS  REMOTE IP      PORT
---------------------------------
10       -              ser-1
20       10.200.22.199  -
```

This table or list provides the following information:

Parameter	Description
`{ device-address }`	**Synopsis:** A string 32 characters long The DNP device address.
`remote-ip`	**Synopsis:** A string 32 characters long The IP address of the remote host that provides a connection to the this DNP device address.
`serial-port`	**Synopsis:** A string 128 characters long The target serial port.

9.1.5 Clearing Serial Port Statistics

To clear the statistics collected for a specific serial port, type:

```
interfaces serial port { name } clear-port-stats
```

Where:

- `{ name }` is the name assigned to the port

9.1.6 Configuring a Serial Port

To configure a serial port, do the following:

⚠ NOTICE

Do not enable flow control when Modbus TCP protocol is enabled.

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***interface » serial » {port}***, where *{port}* is the serial port.
3. Configure the following parameter(s) as required:

Parameter	Description
`enabled { enabled }`	**Synopsis:** [true | false] **Default:** true Provides the option to enable or disable this interface. When unchecked (i.e disabled), the interface will prevent all frames from being sent and received on that interface.
`alias { alias }`	**Synopsis:** A string 64 characters long The SNMP alias name of the interface.
`baud-rate { baud-rate }`	**Synopsis:** [1200 | 2400 | 4800 | 9600 | 19200 | 38400 | 57600 | 115200 | 230400 | 76800] **Default:** 9600 The baud rate selection of the serial port.

Parameter	Description
`data-bits { data-bits }`	**Synopsis:** An integer between 7 and 8 **Default:** 8 The number of data bits.
`parity { parity }`	**Synopsis:** [none | even | odd] **Default:** none The parity of the serial port.
`stop-bits { stop-bits }`	**Synopsis:** An integer between 1 and 2 **Default:** 1 The number of stop bits of the serial port.
`flow-control { flow-control }`	**Synopsis:** [none | xonxoff] **Default:** none The flow control of the serial port.
`port-type { port-type }`	**Synopsis:** [rs232 | rs422 | rs485] **Default:** rs232 The type of serial port.

4. Configure one or more serial protocols. For more information, refer to "Adding a Serial Port Protocol (Page 378)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

9.1.7 Restarting the Serial Server

To restart the serial server, type:

```
interfaces serial restart-serserver
```

9.1.8 Resetting a Serial Port

To reset a serial port, type:

```
interfaces serial port { name } reset
```

Where:

- `{ name }` is the name assigned to the port

9.2 Managing Serial Port Protocols

This section describes how to configure and manage serial protocols for serial ports.

9.2.1 Serial Port Protocol Concepts

This section describes some of the concepts important to the implementation of serial port protocols in RUGGEDCOM ROX II.

9.2.1.1 Raw Socket Applications

The raw socket protocol transports streams of characters from one serial port on the device to a specified remote IP address and port. The raw socket protocol supports TCP and UDP transport.

Broadcast RTU Polling

Broadcast polling allows a single host connected to the device to broadcast a polling stream to a number of remote RTUs.

The host connects through a serial port to the device. Up to 32 TCP remote RTUs may connect to the device's host-end via the network. For UDP transport, the device can send a polling stream to up to 64 remote hosts (RTUs).

Initially, the remote hosts place TCP connections to the device's host-end. The host-end in turn is configured to accept the required number of incoming TCP connections. The host connected to the device then sequentially polls each remote host. When a poll is received, the device forwards (i.e. broadcasts) it to all the remote hosts. All remote hosts will receive the request and the appropriate remote host will issue a reply. The reply is returned to the device, where it is forwarded to the host.

Host and Remote Roles

The raw socket protocol can either initiate or accept a TCP connection for serial encapsulation. It can establish a connection initiated from a remote host, vice versa, or bidirectionally.

Configure the device at the host-end to establish a connection with the remote host when:

- The host-end uses a port redirector that must make the connection
- The host-end is only occasionally activated and will make the connection when it becomes active
- A host-end firewall requires the connection to be made outbound

If the host-end wants to open multiple connections with the remote-ends in order to implement broadcast polling, configure the device to accept connections with the remote-ends.

Configure the device to connect from each side (host or remote) to the other if both sides support this functionality.

Message Packetization

The serial server buffers receive characters into packets in order to improve network efficiency and demarcate messages.

The serial server uses three methods to decide when to packetize and forward the buffered characters to the network:

- packetize on a specific character
- packetize on timeout
- packetize on a full packet

If configured to packetize on a specific character, the serial server will examine each received character, packetize and forward it upon receiving the specific character. The character is usually a <CR> or an <LF> character but may be any ASCII character.

If configured to packetize on a timeout, the serial server will wait for a configurable time after receiving a character before packetizing and forwarding it. If another character arrives during the waiting interval, the timer is restarted. This method allows characters transmitted as part of an entire message to be forwarded to the network in a single packet, when the timer expires after receiving the very last character of the message. This is usually the only packetizer selected when supporting Modbus TCP communications.

Finally, the serial server will always packetize and forward on a full packet, specifically when the number of characters fills its communications buffer (1024 bytes).

9.2.1.2 Modbus TCP Applications

The Modbus TCP Server application is used to transport Modbus requests and responses across IP networks. The source of the polls is a Modbus *master*, a host computer that issues the polls to a remote host (RTU) connected to the serial port of the device running the Modbus TCP Server application. The Modbus polls encapsulated in TCP packets received by the device will be forwarded to the remote host via the serial port based on the host's address defined in the RTU list. The responses from remote host are TCP encapsulated and returned to the *master* that originated the polls.

Port Numbers

The TCP port number dedicated to Modbus use is port 502. The Modbus TCP Server application can also be configured to accept a connection on a configurable port number. This auxiliary port can be used by masters that do not support port 502.

Retransmissions

The Server Gateway offers the ability to resend a request to a remote host should the remote host receive the request in error or the Server Gateway receives the remote host response in error.

The decision to use retransmissions, and the number to use, depends upon factors such as:

- The probability of a line failure.
- The number of remote hosts and the amount of traffic on the port.
- The cost of retransmitting the request from the server versus timing-out and retransmitting at the master. This cost is affected by the speed of the ports and of the network.

ModBus Exception Handling

If the Server Gateway receives a request for an un-configured remote host, it will respond to the originator with a special message called an exception (type 10). A type 11 exception is returned by the server if the remote host fails to respond to requests.

Native Modbus TCP polling packages will want to receive these messages. Immediate indication of a failure can accelerate recovery sequences and reduce the need for long timeouts.

9.2.1.3 DNP Applications

RUGGEDCOM ROX II supports Distributed Network Protocol (DNP) version 3.0, commonly used by utilities in process automation systems. DNP3 protocol messages specify source and destination addresses. A destination address specifies which device should process the data, and the source address specifies which device sent the message. Having both destination and source addresses satisfies at least one requirement for peer-to-peer communication since the receiver knows where to direct a response.

Each device supporting DNP must have a unique address within the collection of devices sending and receiving DNP messages.

Address Learning for DNP

RUGGEDCOM ROX II implements both local and remote address learning for DNP. A local Device Address Table is populated with DNP Addresses learned for local and remote DNP devices. Each DNP address is associated with either a local serial port or a remote IP address.

When a message with an unknown DNP source address is received on a local serial port, the DNP source address and serial port number are entered into the Device Address Table. When a message with an unknown DNP source address is received from the IP network, on the IP interface that is configured as the DNP learning

interface, the DNP source address and the IP address of the sender are entered into the Device Address Table.

When a message with an unknown DNP destination address is received on a local serial port, the message is sent in a UDP broadcast to the network interface configured as the DNP learning interface. When a message with an unknown DNP destination address is received from the IP network, it is sent to all local serial ports configured as DNP ports.

Note
Learned addresses are not recorded in the Device Address Table.

UDP transport is used during the DNP address learning phase.

An aging timer is maintained for each DNP address in the table, and is reset whenever a DNP message is sent to or received for the specified address.

This learning facility makes it possible to configure the DNP3 protocol with a minimum number of parameters: a TCP/UDP port number, a learning network interface and an aging timer.

DNP Broadcast Messages

DNP addresses 65521 through 65535 are reserved as DNP3 broadcast addresses. RUGGEDCOM ROX II supports DNP3 broadcast messages. DNP broadcast messages received on local serial ports are transmitted to all IP Addresses in the Device Address Table (whether learned or statically configured).

When a DNP broadcast message is received from the IP network, it is transmitted on all local serial ports configured as DNP ports.

9.2.1.4 MicroLok Applications

RUGGEDCOM ROX II supports both MicroLok II and MicroLok ATCS protocols, which specify source and destination addresses of MicroLok peer devices.

The destination address specifies which device should process the data, and the source address specifies which device sent the message. Each device supporting this protocol must have a unique address within the collection of devices sending and receiving messages to and from each other. Non-MicroLok packets or non-conforming data packets are discarded.

RUGGEDCOM ROX II supports the transport of MicroLok frames over both TCP and UDP.

MicroLok Address Format

Standard MicroLok II Peer Protocol addresses are 16-bits in length. The message format includes five main components, in the following order: message synchronization, message header, data field (optional depending on the message type), message security, and a message terminator.

MicroLok Message Components	
1. Message Synchronization/Format Character	
2. Message Header	Destination Address Field
	Source Address Field
	Send Sequence Number
	Receive Sequence Number
	Message Type (ID)
	Message Flag Field
	Timestamp (optional)
	Opinion Header Field
3. Data Field (optional, depending on message type)	
4. Message Security	
5. Message Terminator	

Framing Characters

Each message begins and ends with unique framing characters that must not appear elsewhere within the transmitted message. An escape character prevents these values from being transmitted as any of the other message bytes (i.e. header, data, or security). All framing characters are in the range $F0-$FF, with $F0 being the escape character.

Description	Value
Escape Character	$F0
Undefined	$F1-$F3
Header Format 1 - Normal two-byte addressing	$F4
Header Format 2 - ATCS addressing	$F5
Termination Character	$F6
Undefined	$F7-$FD
HMAC Header	$FE
Not Available	$FF

MicroLok II vs ATCS Message Formats

The destination and source addresses may be specified in either the MicroLok II address format or Advanced Train Control Systems (ATCS) address format. The destination and source address must be in the same format. Within a message, the destination address is always first, followed by the source address.

A MicroLok II address is a two-byte value, with the highest byte transmitted first.

- **MicroLok II message example:**

  F4 00 02 00 01 EF 57 03 00 2C 04 01 20 13 30 03 09 00 00 00 8F E1 9F 62 F6

A MicroLok ATCS address field consists of a size byte common to both addresses and two four-to-eight byte address fields.

- **ATCS message example:**

  F5 EE 78 A2 A1 A1 A1 AA A1 78 A2 A1 A1 A1 A1 A1 67 0F 03 00 2C 04 01 20 15 11 40 09 00 00 00 94 2B E3 1D F6

Determining Which Message Format to Use

When configuring the MicroLok address field in RUGGEDCOM ROX II, consider checking if the serial communication is MicroLok II or ATCS first to determine if the decimal (MicroLok II) or hexadecimal (ATCS) address notation should be used.

Use the following command:

```
traceserial protocol hex
```

In the output, if the message starts with F5 then the ATCS address notation schema is used. If the message starts with F4 then the Microlok II address notation is used.

MicroLok over IP

When the MICROLOK II Peer Protocol is transported over an Ethernet Link, it must be physically encapsulated in a TCP or UDP transport protocol. This encapsulation may be performed by the ASTS USA Network Interface Adapter (NIA) or by a compatible terminal server device.

In this scenario RUGGEDCOM ROX II acts as the NIA to communicate between the IP network and a MicroLok hub, or between the IP network and a MicroLok device.

When a RUGGEDCOM ROX II serial interface/port is configured with MicroLok, it listens for MicroLok frames at the configured interface/port. When a MicroLok frame is received, it is parsed and validated. Source and destination MicroLok addresses are extracted from the frame. These MicroLok addresses may correspond to a destination IP address in the device address table as configured by the user. The frame is then encapsulated in an IP packet and forwarded to the destination address or target MicroLok device using the configured transport protocol.

9.2.1.5 Incoming/Outgoing Serial Connections

The RUGGEDCOM RX1400 supports up to 32 TCP/UDP connections per serial port, up to a total of 64 TCP/UDP connections to the serial server.

9.2.2 Viewing a List of Serial Port Protocols

To view a list of serial port protocols configured on the device, type:

```
show interfaces serial port protocol
```

If protocols have been configured, a table or list similar to the following example appears:

```
ruggedcom# show interfaces serial port protocol
IFNAME  PROTOCOL
-----------------
ser-1   none
ser-2   none
```

If no serial port protocols have been configured, add protocols as needed. For more information, refer to "Adding a Serial Port Protocol (Page 378)".

9.2.3 Adding a Serial Port Protocol

To add a serial port protocol, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the protocol by typing:

   ```
   interface serial serport { port } protocols
   { protocol }
   ```

   Where:

   - `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module.
   - `{ protocol }` is the protocol type. Options include **dnp**, **tcpmodbus**, **rawsocket**, **vmserial** and **microlok**.
3. If **dnp**, **tcpmodbus**, **rawsocket** or **microlok** was selected, configure the protocol.
   - For information about configuring a DNP protocol, refer to "Configuring the DNP Protocol (Page 378)".
   - For information about configuring a Modbus TCP protocol, refer to "Configuring the Modbus TCP Protocol (Page 379)".
   - For information about configuring a raw socket protocol, refer to "Configuring the Raw Socket Protocol (Page 380)".
   - For information about configuring a MicroLok protocol, refer to "Configuring the MicroLok Protocol (Page 381)".
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

9.2.4 Configuring the DNP Protocol

To configure the DNP protocol for a serial port, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***interface » serial » {interface} » protocols » dnp » setdnp***, where *{interface}* is the serial port.

3. Configure the following parameter(s) as required:

Parameter	Description
`address-learning { address-learning }`	**Synopsis:** A string between 1 and 15 characters long The interface to learn the RTU address from.
`aging-timer { aging-timer }`	**Synopsis:** An integer between 60 and 10800 **Default:** 1000 The length of time a learned DNP device in the Device Address Table may go without any DNP communication before it is removed from the table.
`max-connection { max-connection }`	**Synopsis:** An integer between 1 and 32 **Default:** 1 The maximum number of incoming DNP connections.

4. Add a Device Address table. For more information about adding Device Address tables, refer to "Adding a DNP Device Address Table (Page 383)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

9.2.5 Configuring the Modbus TCP Protocol

To configure the modbus TCP protocol for a serial port, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***interface » serial » {interface} » protocols » tcpmodbus » settcpmodbus***, where *{interface}* is the serial port.
3. Configure the following parameter(s) as required:

Parameter	Description
`response-timer { response-timer }`	**Synopsis:** An integer between 50 and 10000 **Default:** 100 The maximum time from the last transmitted character of the outgoing poll until the first character of the response. If the RTU does not respond in this time, the poll will have been considered failed.
`pack-timer { pack-timer }`	**Synopsis:** An integer between 5 and 1000 **Default:** 1000 The maximum allowable time to wait for a response to a Modbus request to complete once it has started.
`turnaround { turnaround }`	**Synopsis:** An integer between 0 and 1000 **Default:** 0 The amount of delay (if any) to insert after the transmissions of Modbus broadcast messages out the serial port.

Parameter	Description
`retransmit { retransmit }`	**Synopsis:** An integer between 0 and 2 **Default:** 0 The number of times to retransmit the request to the RTU before giving up.
`max-connection { max-connection }`	**Synopsis:** An integer between 1 and 32 **Default:** 1 The maximum number of incoming connections.
`local-port { local-port }`	**Synopsis:** An integer **Default:** 502 The alternate local TCP port number. If this field is configured, a single connection (per serial port) may be made to this alternate port number. Note that Modbus TCP uses a default local port number of 502. There is no limit imposed on the number of connections to the default TCP port.
`rtu-list { rtu-list }`	**Synopsis:** A string The ID of the RTU(s) connected to the serial port. Specify multiple RTUs with a space (e.g. 1 2 3 4) or a comma and space (e.g. 1, 2, 3, 4). A strictly comma-separated list (e.g. 1,2,3,4) is not permitted.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

9.2.6 Configuring the Raw Socket Protocol

To configure the raw socket protocol for a serial port, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***interface » serial » {interface} » protocols » rawsocket***, where *{interface}* is the serial port.
3. Configure the following parameter(s) as required:

Parameter	Description
`pack-char { pack-char }`	**Synopsis:** [off] or An integer between 0 and 255 **Default:** off The numeric value of the ASCII character which will force forwarding of accumulated data to the network.
`pack-timer { pack-timer }`	**Synopsis:** An integer between 5 and 1000 **Default:** 1000 The delay from the last received character until when data is forwarded.

Parameter	Description
`pack-size { pack-size }`	**Synopsis:** [max] or An integer between 16 and 1400 **Default:** max The maximum number of bytes received from the serial port to be forwarded.
`turnaround { turnaround }`	**Synopsis:** An integer between 0 and 1000 **Default:** 0 The amount of delay (if any) to insert between the transmissions of individual messages out the serial port.
`call-direction { call-direction }`	**Synopsis:** [in | out | both] **Default:** out Whether to accept an incoming connection, place an outgoing connection or do both.
`max-connection { max-connection }`	**Synopsis:** An integer between 1 and 32 **Default:** 1 The maximum number of incoming connections to permit when the call direction is incoming.
`remote-ip { remote-ip }`	**Synopsis:** A string between 7 and 15 characters long or A string between 6 and 40 characters long The IP address used when placing an outgoing connection.
`remote-port { remote-port }`	**Synopsis:** An integer between 1024 and 65535 The TCP destination port used in outgoing connections.
`local-ip { local-ip }`	**Synopsis:** A string between 7 and 15 characters long or A string between 6 and 40 characters long The IP address used to establish a connection. Leaving it blank allows an incoming connection to any interface.
`local-port { local-port }`	**Synopsis:** An integer between 1024 and 65535 The local TCP/UDP port to use to accept incoming connections.
`transport { transport }`	**Synopsis:** [tcp | udp] **Default:** tcp The transport connection protocol (UDP or TCP).

4. If the transport connection protocol is set to UDP, configure one or more remote hosts for the port. For more information about adding a remote host, refer to "Adding a Remote Host (Page 397)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

9.2.7 Configuring the MicroLok Protocol

To configure the MicroLok protocol for a serial port, do the following:

1. Make sure the CLI is in Configuration mode.

2. Navigate to ***interface » serial » {interface} » protocols » microLok » setMicroLok***, where *{interface}* is the serial port.
3. Configure the following parameter(s) as required:

Parameter	Description
`transport { transport }`	**Synopsis:** [tcp | udp] **Default:** udp The network transport used to transport protocol data over an IP network.
`local-port { local-port }`	**Synopsis:** An integer between 1024 and 65535 **Default:** 60000 The local port number on which the Microlok protocol listens for UDP datagrams or TCP connections. The local port number must match the destination local and possible remote port numbers.
`dscp { dscp }`	**Synopsis:** An integer between 0 and 63 **Default:** 0 The DSCP value for Microlok traffic priority. Only egress traffic is supported.

4. Add a Device Address table. For more information about adding Device Address tables, refer to "Adding a MicroLok Device Address Table (Page 385)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

9.2.8 Deleting a Serial Port Protocol

To delete a serial port protocol, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the serial port protocol by typing:

   ```
   no interface serial serport { port } protocols { protocol }
   ```

   Where:

   - `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module
   - `{ protocol }` is the protocol type
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

9.3 Managing DNP Device Address Tables

This section describes how to manage DNP addresses in the local Device Address Table.

9.3.1 Viewing a List of DNP Device Address Tables

To view a list of Device Address tables configured for a serial port using the DNP protocol, type:

```
show running-config interface serial { slot/port } protocols dnp setdnp device-table
```

Where:

- `{ slot/port }` is the slot name and port number of the serial port

If Device Address tables have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config interface serial protocols dnp setdnp device-table
interface
 serial serport 1
  protocols dnp
   setdnp device-table 12
    remote-ip     172.30.130.2
    remote-device
   !
  !
 !
!
```

If no Device Address tables have been configured, add tables as needed. For more information, refer to "Adding a DNP Device Address Table (Page 383)".

9.3.2 Adding a DNP Device Address Table

To add a Device Address table for a serial port using the DNP protocol, do the following:

1. Make sure the CLI is in Configuration mode.
2. `interface serial serport { port } protocols dnp setdnp device-table { address }`

   Where:

   - `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module.
   - `{ address }` is the local or remote DNP device address. The address may be that of a DNP device connected to a local serial port or one available via the serial port of a remote IP host.
3. Configure the following parameter(s) as required:

Parameter	Description
`remote-ip { remote-ip }`	**Synopsis:** A string between 7 and 15 characters long or A string between 6 and 40 characters long The IP address of the remote host that provides a connection to the DNP device with the configured address. Leave this field empty to forward DNP messages that match the configured address to the local serial port.
`remote-device`	Enables forwarding of DNP messages that match the device address to the remote IP.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

9.3.3 Deleting a Device Address Table

To delete a Device Address table, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the Device Address Table by typing:

   ```
   no interface serial serport { port } protocols dnp setdnp device-table { address }
   ```

   Where:

   - `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module.
   - `{ address }` is the local or remote DNP device address. The address may be that of a DNP device connected to a local serial port or one available via the serial port of a remote IP host.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

9.4 Managing MicroLok Device Address Tables

This section describes how to manage MicroLok addresses in the local Device Address Table.

9.4.1 Viewing a List of MicroLok Device Address Tables

To view a list of Device Address tables configured for a serial port using the MicroLok protocol, type:

```
show running-config interface serial { slot/port } protocols microlok setmicrolok device-address-table
```

Where:

- `{ slot/port }` is the slot name and port number of the serial port

If Device Address tables have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config interface serial protocols microlok setmicrolok
 device-address-table
interface
 serial serport 1
  protocols microlok
   setmicrolok device-address-table 65535
  !
 !
!
```

If no Device Address tables have been configured, add tables as needed. For more information, refer to "Adding a MicroLok Device Address Table (Page 385)".

9.4.2 Adding a MicroLok Device Address Table

To add a Device Address table for a serial port using the MicroLok protocol, do the following:

1. Make sure the CLI is in Configuration mode.
2. `interface serial serport { port } protocols microlok setmicrolok device-address-table { address }`

   Where:

   - `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module.
   - `{ address }` is the local or remote MicroLok device address. The address may be that of a MicroLok device connected to a local serial port or one available via the serial port of a remote IP host.
3. Configure the following parameter(s) as required:

Parameter	Description
`device-name { device-name }`	**Synopsis:** A string between 1 and 16 characters long The addressed Microlok device name
`device-type { device-type }`	**Synopsis:** [local | remote] **Default:** local Specifies if this Microlok device is local to the current ROX device or remote. Default value is 'local'. 'Remote IP Address' must be configured when this is set to 'remote'.
`remote-ip { remote-ip }`	**Synopsis:** A string between 7 and 15 characters long The IP address of a remote host to which a device with a configured remote address is connected. This must be configured if 'Device Type' is set to 'remote'.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

9.4.3 Deleting a MicroLok Device Address Table

To delete a Device Address table, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the Device Address Table by typing:

   ```
   no interface serial serport { port } protocols microlok setmicrolok device-address-table { address }
   ```

   Where:

   - `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module.
   - `{ address }` is the local or remote DNP device address. The address may be that of a DNP device connected to a local serial port or one available via the serial port of a remote IP host.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

9.5 Managing Serial Multicast Streaming

RUGGEDCOM ROX II supports the ingress and egress of raw-socket UDP serial multicast streams.

This section describes how to configure and manage serial multicast streaming.

9.5.1 Understanding Serial Multicast Streaming

Serial multicast streaming allows the transport of serial data streams to individual or groups of remote hosts via the UDP protocol.

An Ethernet multicast stream consists of a multicast group IP address (e.g. 232.1.1.1), destination UDP port (e.g. 1 to 65535) and an interface.

A serial port can act as both:

- A *sink* for data coming from IP multicast streams
- A *source* of data to be transmitted to multiple IP multicast receivers

9.5.1.1 Sink vs. Source Ports

A serial port can act as either a *sink* and/or *source* port:

- **Sink Port**

  A sink port is a consumer of multicast packets. It registers itself to receive multicast traffic from a known multicast group IPv4 address and destination UDP port and then forwards the traffic along the serial link. The traffic is then received by a connected third-party serial device and processed.

- **Source Port**

  A source port is a producer of multicast packets. It receives serial traffic from a connected third-party serial device and packetizes it into multicast IPv4 packets. Each packet is assigned a specific multicast group IPv4 address, destination UDP port and source UDP port.

9.5.1.2 Multicast Streaming Examples

Serial multicast streaming can be deployed in multiple ways:

Serial Interfaces Configured as a Sink for Multicast Streams

In this configuration, the source of the multicast data comes from the Ethernet network interfaces and is transmitted to multiple sink serial devices. The advantage of this scenario is the ease of configuration on the Ethernet networking side. Instead of indicating which serial port to send to via unicast packets, the controller can send a single multicast stream to all or some connected serial devices.

Serial Interfaces Configured as a Source for Multicast Streams

In this configuration, the source of the multicast data comes from the serial port and device side and is transmitted to multiple Ethernet interfaces over one multicast stream. The advantage of this scenario is the ease of configuration of listening devices. There will be a lesser need to keep track of IP addresses of interfaces, and listeners can be easily substituted without concern over maintaining the same IP address.

Serial Interfaces Configured as a Source and Sink for Multicast Streams

In this configuration, the serial data is forwarded to other serial devices, with the ability to transmit to multiple Ethernet interfaces via a single multicast stream. This is an extension of the two previous examples. The advantage of this configuration is to allow one serial source device to send data to multiple receivers whether they are another serial port or a listener device over an Ethernet network.

9.5.2 Configuring Serial Multicast Streaming

To configure serial multicast streaming, do the following:

1. Add the rawsocket protocol. For more information, refer to "Adding a Serial Port Protocol (Page 378)".
2. Configure the Remote Host for the encapsulation of raw-socket serial over multicast with the destination Multicast IP, UDP port, and interface(s). For more information, refer to "Adding a Remote Host (Page 397)" and "Adding a Remote Host Interface (Page 401)".
3. Configure the Local Port, Local Host Multicast IP and Local Host interface(s) for the de-encapsulation of multicast stream(s) into raw-socket serial. For more information, refer to "Adding a Local Host (Page 399)" and "Adding a Local Host Interface (Page 403)".
4. Verify that multicast traffic can be seen on the incoming and outgoing interface(s) by typing:

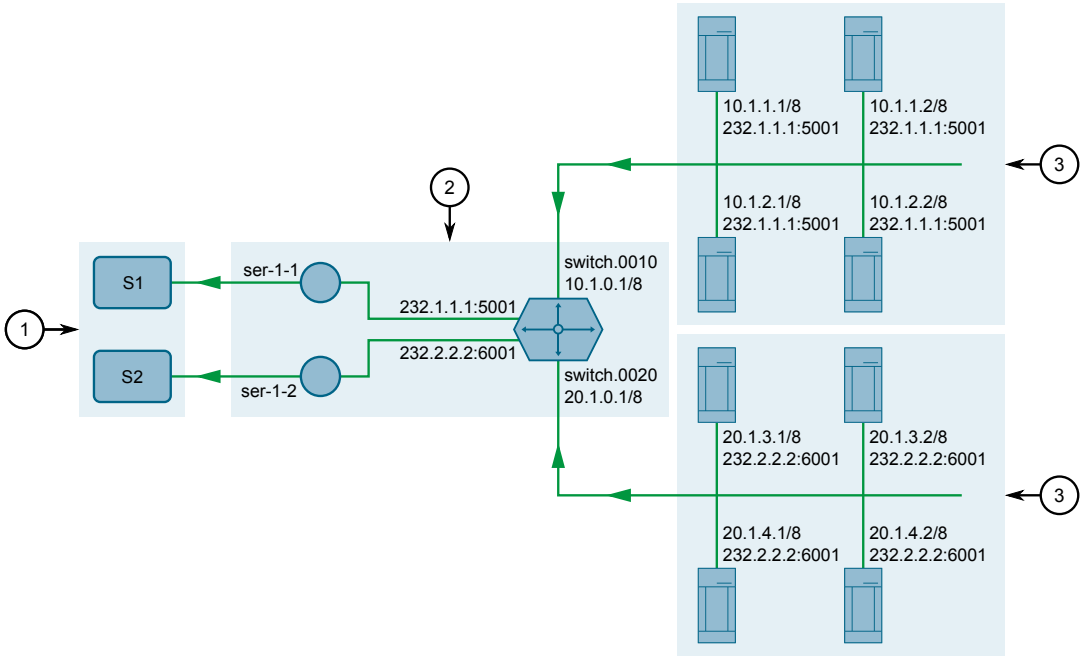
   ```
   traceserial
   ```

9.5.3 Example: Serial Interfaces Configured as a Sink for Multicast Streams

This configuration example shows multicast messages from group 232.1.1.1, directed to UDP port 5001, reaching ser-1-1 from the interface switch.0010 via raw socket connections. Ser-1-1, upon receiving these messages, passes on the data to serial device S1, to which it is directly connected.

⚠ NOTICE

The values shown are specific to the provided topology. Actual values can vary based on the user's configuration.



① Serial Devices
② Sink Device (RUGGEDCOM RX1400)
③ Ethernet Network Interfaces

Figure 9.1 Topology – Serial Interfaces Configured as a Sink for Multicast Streams

Step 1: Configure ser-1-1

1. Configure IP addresses for the interfaces (switch.0010 and switch.0020). For more information, refer to "Adding an IPv4 Address (Page 251)".
2. Create a rawsocket connection for ser-1-1:

   ```
   interface serial serport 1 protocols rawsocket
   ```

   For more information, refer to "Adding a Serial Port Protocol (Page 378)".
3. Set the rawsocket of the local port to 5001:

   ```
   setrawsocket local-port 5001
   ```

   For more information, refer to "Configuring the Raw Socket Protocol (Page 380)".
4. Set the transport method to *UDP*:

   ```
   setrawsocket transport udp
   ```

   For more information, refer to "Configuring the Raw Socket Protocol (Page 380)".

5. Set the multicast group for the local host to 232.1.1.1:

   ```
   setrawsocket local-host 232.1.1.1
   ```

   For more information, refer to "Adding a Local Host (Page 399)".
6. Set *switch.0010* as the interface for the local host:

   ```
   interface switch.0010
   ```

   For more information, refer to "Adding a Local Host Interface (Page 403)"
7. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

1. Create a raw socket connection for ser-1-2:

   ```
   interface serial serport 2 protocols rawsocket
   ```

   For more information, refer to "Adding a Serial Port Protocol (Page 378)".
2. Set the local port for raw socket to 6001:

   ```
   setrawsocket local-port 6001
   ```

   For more information, refer to "Configuring the Raw Socket Protocol (Page 380)".
3. Set the transport method for raw socket to *UDP*:

   ```
   setrawsocket transport udp
   ```

   For more information, refer to "Configuring the Raw Socket Protocol (Page 380)".
4. Set the multicast group for the local host to 232.2.2.2:

   ```
   setrawsocket local-host 232.2.2.2
   ```

   For more information, refer to "Adding a Local Host (Page 399)".
5. Set *switch.0020* as the interface for the local host:

   ```
   interface switch.0020
   ```

   For more information, refer to "Adding a Local Host Interface (Page 403)"
6. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.
7. Verify the configuration by typing the following:

   ```
   traceserial
   ```

Final Configuration Example

ser-1-1 Configuration

```
serial serport 1
  no alias
```

```
  protocols rawsocket
   setrawsocket local-port 5001
   setrawsocket transport udp
   setrawsocket local-host 232.1.1.1
    interface switch.0010
```

ser-1-2 Configuration

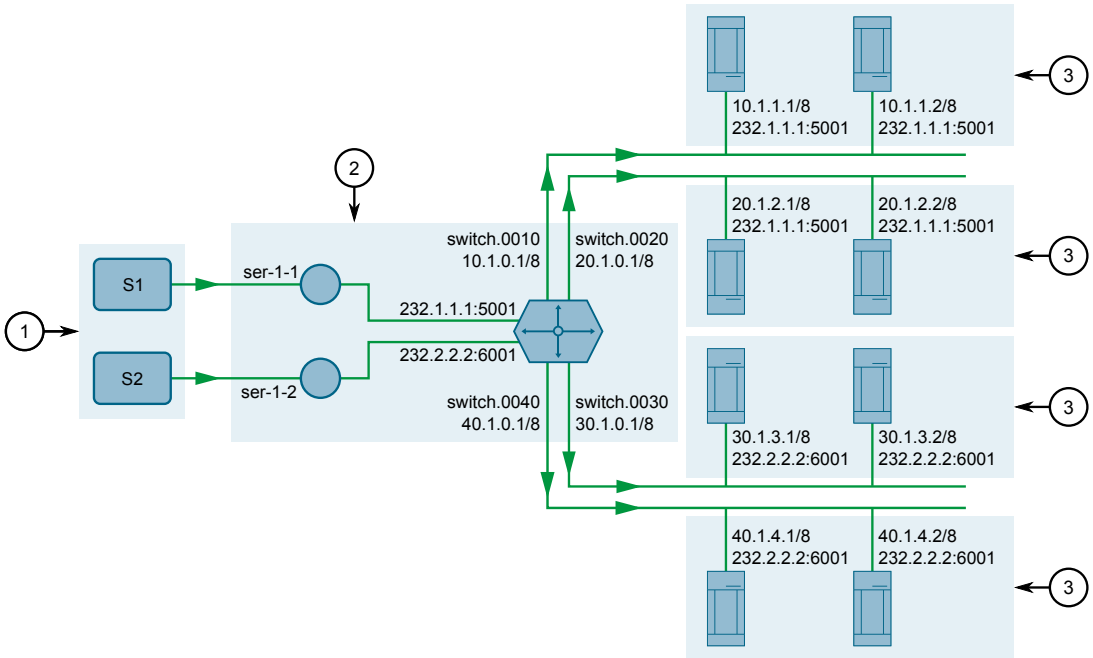
```
serial serport 2
  no alias
  protocols rawsocket
   setrawsocket local-port 6001
   setrawsocket transport udp
   setrawsocket local-host 232.2.2.2
    interface switch.0020
```

9.5.4 Example: Serial Interfaces Configured as a Source for Multicast Streams

This configuration example shows ser-1-1 receiving data on the wire from S1, then creating multiple raw socket remote host interfaces to send the data to both interfaces switch.0010 and switch.0020. This data is then packetized as multicast packets and sent to destination group 232.1.1.1 and destination UDP port 5001.

⚠ NOTICE

The values shown are specific to the provided topology. Actual values can vary based on the user's configuration.



① Serial Devices
② Source Device (RUGGEDCOM RX1400)

③ Listeners

Figure 9.2 Topology – Serial Interfaces Configured as a Source for Multicast Streams

Step 1: Configure ser-1-1

1. Configure IP addresses for the interfaces (switch.0010, switch.0020, switch.0030, and switch.0040). For more information, refer to "Adding an IPv4 Address (Page 251)".
2. Create a raw socket connection for ser-1-1:

   ```
   interface serial serport 1 protocols rawsocket
   ```

   For more information, refer to "Adding a Serial Port Protocol (Page 378)".
3. Set the raw socket of the local port to 10001:

   ```
   setrawsocket local-port 10001
   ```

   For more information, refer to "Configuring the Raw Socket Protocol (Page 380)".
4. Set the transport method to *UDP*:

   ```
   setrawsocket transport udp
   ```

   For more information, refer to "Configuring the Raw Socket Protocol (Page 380)".
5. Set the multicast group for the local host to 232.1.1.1 and the UDP destination port to 5001:

   ```
   setrawsocket remote-host 232.1.1.1 5001
   ```

   For more information, refer to "Adding a Remote Host (Page 397)".
6. Set *switch.0010* and *switch.0020* as the interfaces for the remote host:

   ```
   interface switch.0010
   interface switch.0020
   ```

   For more information, refer to "Adding a Remote Host Interface (Page 401)"
7. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

1. Create a raw socket connection for ser-1-2:

   ```
   interface serial serport 2 protocols rawsocket
   ```

   For more information, refer to "Adding a Serial Port Protocol (Page 378)".
2. Set the rawsocket of the local port to 10002:

   ```
   setrawsocket local-port 10002
   ```

   For more information, refer to "Configuring the Raw Socket Protocol (Page 380)".

3. Set the transport method to *UDP*:

   ```
   setrawsocket  transport  udp
   ```

   For more information, refer to "Configuring the Raw Socket Protocol (Page 380)".

4. Set the multicast group for the local host to 232.2.2.2 and the UDP destination port to 6001:

   ```
   setrawsocket  local-host  232.2.2.2  6001
   ```

   For more information, refer to "Adding a Local Host (Page 399)".

5. Set *switch.0030* and *switch.0040* as the interfaces for the remote host:

   ```
   interface  switch.0030
   interface  switch.0040
   ```

   For more information, refer to "Adding a Remote Host Interface (Page 401)"

6. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

7. Verify the configuration by typing the following:

   ```
   traceserial
   ```

Final Configuration Example

Serial Port 1 Configuration

```
serial serport 1
  no alias
  protocols rawsocket
   setrawsocket local-port 10001
   setrawsocket transport udp
   setrawsocket remote-host 232.1.1.1 5001
    interface switch.0010
    !
    interface switch.0020
```

Serial Port 2 Configuration

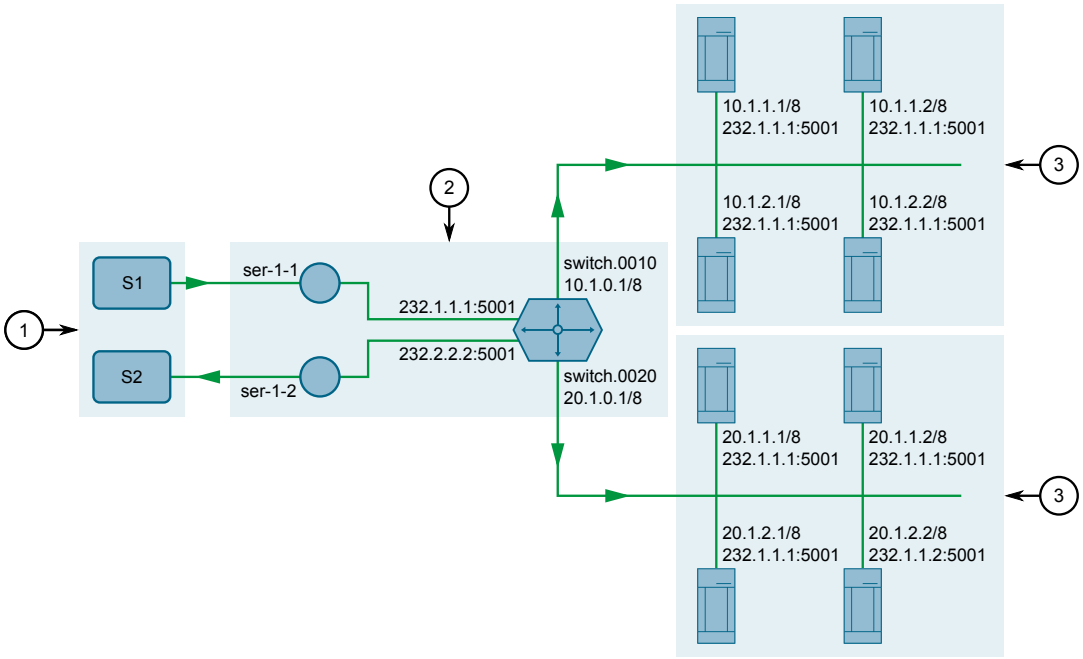
```
serial serport 2
  no alias
  protocols rawsocket
   setrawsocket local-port 10002
   setrawsocket transport udp
   setrawsocket remote-host 232.2.2.2 6001
    interface switch.0030
    !
    interface switch.0040
```

9.5.5 Example: Serial Interfaces Configured as a Source and Sink for Multicast Streams

This configuration example shows ser-1-1 receiving data on the wire from S1, then creating multiple raw socket connections to send the data to both interfaces switch.0010 and switch.0020. This data is then packetized as multicast packets and sent to destination group 232.1.1.1 and destination UDP port 5001. Additionally, ser-1-1 forwards the same data stream to ser-1-2, which then sends the data to S2.

⚠ NOTICE

The values shown are specific to the provided topology. Actual values can vary based on the user's configuration.



① Serial Devices
② Source and Sink Device (RUGGEDCOM RX1400)
③ Listeners
④ Ethernet Network Interfaces

Figure 9.3 Topology – Serial Interfaces Configured as a Source and Sink for Multicast Streams

Configure ser-1-1 and ser-1-2

1. Configure IP addresses for the interfaces (switch.0010 and switch.0020). For more information, refer to "Adding an IPv4 Address (Page 251)".
2. Create a raw socket connection for ser-1-1:

   ```
   interface serial serport 1 protocols rawsocket
   ```

   For more information, refer to "Adding a Serial Port Protocol (Page 378)".

3. Set the raw socket of the local port to 10001:

   ```
   setrawsocket local-port 10001
   ```

   For more information, refer to "Configuring the Raw Socket Protocol (Page 380)".

4. Set the transport method to *UDP*:

   ```
   setrawsocket transport udp
   ```

   For more information, refer to "Configuring the Raw Socket Protocol (Page 380)".

5. Set the multicast group for the remote host to 232.1.1.1 and the UDP destination port to 5001:

   ```
   setrawsocket remote-host 232.1.1.1 5001
   ```

   For more information, refer to "Adding a Remote Host (Page 397)".

6. Set *switch.0010* and *switch.0020* as the interfaces for the remote host:

   ```
   interface switch.0010
   interface switch.0020
   ```

   For more information, refer to "Adding a Remote Host Interface (Page 401)"

7. Enable remote host loopback:

   ```
   loopback true
   ```

   For more information, refer to "Adding a Local Host (Page 399)"

8. Create a raw socket connection for ser-1-2:

   ```
   interface serial serport 2 protocols rawsocket
   ```

   For more information, refer to "Adding a Serial Port Protocol (Page 378)"

9. Set the raw socket of the local port to 5001. This must be the same as the UDP destination port of the multicast remote host configured for ser-1-1:

   ```
   setrawsocket local-port 5001
   ```

   For more information, refer to "Adding a Local Host (Page 399)"

10. Set the transport method to *UDP*:

    ```
    setrawsocket transport udp
    ```

    For more information, refer to "Configuring the Raw Socket Protocol (Page 380)".

11. Set the multicast group for the local host to 232.1.1.1. This must be the same as the destination multicast group configured for the multicast remote host configured for ser-1-1.

    ```
    setrawsocket local-host 232.1.1.1
    ```

For more information, refer to "Adding a Local Host (Page 399)"

12. Enable local host loopback:

    ```
    loopback  true
    ```

    For more information, refer to "Adding a Local Host (Page 399)"

13. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.
14. Verify the configuration by typing the following:

    ```
    traceserial
    ```

Final Configuration Example

Serial Port 1 Configuration

```
serial serport 1
  no alias
  protocols rawsocket
   setrawsocket local-port 10001
   setrawsocket transport udp
   setrawsocket remote-host 232.1.1.1 5001
    loopback true
    interface switch.0010
    !
    interface switch.0020
```

Serial Port 2 Configuration

```
serial serport 2
  no alias
  protocols rawsocket
   setrawsocket local-port 5001
   setrawsocket transport udp
   setrawsocket local-host 232.1.1.1
    loopback true
```

9.6 Managing Remote Hosts

Remote hosts are required when the UDP transport connection protocol is selected for the raw socket protocol.

9.6.1 Viewing a List of Remote Hosts

To view a list of remote hosts configured for a serial port using the raw socket protocol, type:

```
show running-config interface serial protocols
rawsocket setrawsocket remote-host
```

If hosts have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config interface serial protocols rawsocket setrawsocket
 remote-host
interface
serial serport 1
  no alias
  protocols rawsocket
   setrawsocket local-port 30001
   setrawsocket transport udp
   setrawsocket remote-host 1.1.1.2 60001
   !
   setrawsocket remote-host 232.1.1.1 60001
    interface switch.0010
    !
   !
  !
!
!
!
```

If no remote hosts have been configured, add hosts as needed. For more information, refer to "Adding a Remote Host (Page 397)".

9.6.2 Adding a Remote Host

To add a remote host for a serial port using the raw socket protocol, do the following:

Note
A maximum of two multicast remote host entries are permitted per serial interface.

1. Make sure the CLI is in Configuration mode.
2. Add the remote host by typing:

   `interface serial serport { port } protocols rawsocket setrawsocket remote-host { address } { remote-port }`

   Where:

   - `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module
   - `{ address }` is the IP address for the remote host or a multicast group IP address for which the interface is a source
   - `{ remote-port }` is the port number for the remote host
3. Configure the following parameter(s) as required:

Parameter	Description
`loopback { loopback }`	**Synopsis:** [true | false] **Default:** false Enables transmitting to the loopback interface with the destination multicast group IP address and remote port. Matching local hosts with loopback enabled will receive the transmitted data.

4. [Optional] Add a remote host interface. For more information, refer to "Adding a Remote Host Interface (Page 401)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

9.6.3 Deleting a Remote Host

To delete a remote host, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the remote host by typing:

   ```
   no interface serial serport { port } protocols
   rawsocket setrawsocket remote-host { address }
   { remote-port }
   ```

   Where:

   - `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module
   - `{ address }` is the IP address for the remote host
   - `{ remote-port }` is the port number for the remote host
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

9.7 Managing Local Hosts

Local hosts are required when the UDP transport connection protocol is selected and multicast streams are to be received for the raw socket protocol.

9.7.1 Viewing a List of Local Hosts

To view a list of local hosts configured for a serial port using the raw socket protocol, type:

```
show running-config interface serial protocols
rawsocket setrawsocket local-host
```

If hosts have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config interface serial protocols rawsocket setrawsocket
 local-host
interface
 serial serport 1
  protocols rawsocket
   setrawsocket local-host 172.30.151.11 62011
   !
   setrawsocket local-host 172.30.151.22 63000
   !
  !
 !
!
```

If no local hosts have been configured, add hosts as needed. For more information, refer to "Adding a Local Host (Page 399)".

9.7.2 Adding a Local Host

To add a local host for a serial port using the raw socket protocol, do the following:

Note
A maximum of two multicast local host entries are permitted per serial interface.

1. Make sure the CLI is in Configuration mode.
2. Add the local host by typing:

   ```
   interface serial serport { port } protocols
   rawsocket setrawsocket local-host { address }
   ```

   Where:

   - `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module
   - `{ address }` is a multicast group IP address for which the interface is a sink

   Note
   When a local host is added, either loopback must be enabled or a local host interface must be added.

3. If a local host interface is required, proceed to step 4. Otherwise, select **Loopback** to enable the local host to receive data from a loopback interface.

The loopback interface must have the same source multicast group IP address and local port number as the serial port. A matching remote host with loopback enabled must also be configured.

4. [Optional] Add a local host interface. For more information, refer to "Adding a Local Host Interface (Page 403)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

9.7.3 Deleting a Local Host

To delete a local host, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the local host by typing:

   ```
   no interface serial serport { port } protocols rawsocket setrawsocket local-host { address } { local-port }
   ```

   Where:

   - `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module
   - `{ address }` is the IP address for the local host
   - `{ local-port }` is the port number for the local host
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

9.8 Managing Remote Host Interfaces

Remote host interfaces are required when the UDP transport connection protocol is selected for the raw socket protocol and when the remote host is a multicast stream.

9.8.1 Viewing a List of Remote Host Interfaces

To view a list of remote host interfaces configured for a serial port using the raw socket protocol, type:

```
show running-config interface serial serport { port } protocols rawsocket setrawsocket remote-host { remote-host } interface
```

Where:

- `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module
- `{ remote-host }` is the remote host

If interfaces have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config interface serial serport 1 protocols rawsocket
 setrawsocket remote-host 224.1.2.1 interface
interface
 serial serport 1
  protocols rawsocket
   setrawsocket remote-host 224.1.2.1
    interface ge-4-4
    !
   !
  !
 !
!
```

If no remote host interfaces have been configured, add interfaces as needed. For more information, refer to "Adding a Remote Host Interface (Page 401)".

9.8.2 Adding a Remote Host Interface

Note
A maximum of ten interfaces are permitted for each remote host.

To add a remote host interface for a serial port using the raw socket protocol, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to:

   ```
   interface serial serport { port } protocols rawsocket setrawsocket remote-host { remote-host } interface
   ```

   Where:

   - `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module
   - `{ remote-host }` is the remote host
3. Configure the following parameter(s) as required:

Parameter	Description
`name { name }`	**Synopsis:** A string The transmitting interface's name for the destination multicast group IP address and remote port.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

9.8.3 Deleting a Remote Host Interface

To delete a remote host interface, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the remote host by typing:

   ```
   no interface serial serport { port } protocols rawsocket setrawsocket remote-host interface { interface name }
   ```

   Where:

   - `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module
   - `{ remote-host }` is the remote host
   - `{ interface name }` is the name of the interface
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

9.9 Managing Local Host Interfaces

Local host interfaces are required when the UDP transport connection protocol is selected for the raw socket protocol and when a local host is configured.

9.9.1 Viewing a List of Local Host Interfaces

To view a list of local host interfaces configured for a serial port using the raw socket protocol, type:

```
show running-config interface serial serport { port } protocols rawsocket setrawsocket local-host { local-host } interface
```

Where:

- `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module
- `{ local-host }` is the local host

If interfaces have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config interface serial serport 1 protocols rawsocket
 setrawsocket local-host 224.1.2.1 interface
interface
 serial serport 1
  protocols rawsocket
   setrawsocket local-host 224.1.2.1
    interface ge-4-4
    !
```

```
    !
   !
  !
 !
```

If no local host interfaces have been configured, add interfaces as needed. For more information, refer to "Adding a Local Host Interface (Page 403)".

9.9.2 Adding a Local Host Interface

Note
A maximum of two interfaces are permitted for each local host.

To add a local host interface for a serial port using the raw socket protocol, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to:

   ```
   interface serial serport { port } protocols
   rawsocket setrawsocket local-host { local-host }
   interface
   ```

   Where:

   - `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module
   - `{ local-host }` is the local host
3. Configure the following parameter(s) as required:

Parameter	Description
`name { name }`	**Synopsis:** A string The receiving interface's name for the source multicast group IP address and the local port number defined for the serial port.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

9.9.3 Deleting a Local Host Interface

To delete a local host interface, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the local host by typing:

   ```
   no interface serial serport { port } protocols
   rawsocket setrawsocket local-host interface
   { interface name }
   ```

Where:

- `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module
- `{ local-host }` is the local host
- `{ interface name }` is the name of the interface

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

10 WAN and Wireless

This chapter describes how to configure and manage the various WAN and wireless interfaces available in RUGGEDCOM ROX II.

Note
Some features require the device to be equipped with a specific line module.

10.1 Managing the WLAN Interface

This section describes how to configure an interface to a Wireless Local Area Network (WLAN). The device can be configured as an access point or client.

10.1.1 Enabling and Configuring the WLAN Interface

To enable and configure the interface to a WLAN, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable the WLAN interface by typing:

```
interface wlan wlanport 1 enabled
```

3. Configure the following parameter(s) as required:

⚠ NOTICE

The **country** parameter defines the channel (or radio frequency) that can be used by the access point. Some countries restrict the use of certain channels. Make sure the channel selection complies with regional requirements.

Note
The **country** parameter is not configurable on devices certified for use only in the United States.

Parameter	Description
`link-alarms { link-alarms }`	**Synopsis:** [true | false] **Default:** true Disabling link-alarms will prevent alarms and LinkUp and LinkDown SNMP traps from being sent for that interface. Link alarms may also be controlled for the whole system under admin / alarm-cfg.

Parameter	Description
`alias { alias }`	**Synopsis:** A string 64 characters long The SNMP alias name of the interface
`name { name }`	**Synopsis:** A string between 1 and 15 characters long The specific name of the interface
`country { country }`	**Synopsis:** [Afghanistan | Åland Islands | Albania | Algeria | American Samoa | Andorra | Angola | Anguilla | Antarctica | Antigua and Barbuda | Argentina | Armenia | Aruba | Australia | Austria | Azerbaijan | Bahamas | Bahrain | Bangladesh | Barbados | Belarus | Belgium | Belize | Benin | Bermuda | Bhutan | Bolivia | Bonaire | Bosnia and Herzegovina | Botswana | Bouvet Island | Brazil | British Indian Ocean Territory | Brunei Darussalam | Bulgaria | Burkina Faso | Burundi | Cambodia | Cameroon | Canada | Cape Verde | Cayman Islands | Central African Republic | Chad | Chile | China | Christmas Island | Cocos (Keeling) Islands | Colombia | Comoros | Congo | Cook Islands | Costa Rica | Côte d'Ivoire | Croatia | Cuba | Curaçao | Cyprus | Czech Republic | Denmark | Djibouti | Dominica | Dominican Republic | Ecuador | Egypt | El Salvador | Equatorial Guinea | Eritrea | Estonia | Ethiopia | Falkland Islands (Malvinas) | Faroe Islands | Fiji | Finland | France | French Guiana | French Polynesia | French Southern Territories | Gabon | Gambia | Georgia | Germany | Ghana | Gibraltar | Greece | Greenland | Grenada | Guadeloupe | Guam | Guatemala | Guernsey | Guinea | Guinea-Bissau | Guyana | Haiti | Heard Island and McDonald Islands | Holy See (Vatican City State) | Honduras | Hong Kong | Hungary | Iceland | India | Indonesia | Iran | Iraq | Ireland | Isle of Man | Israel | Italy | Jamaica | Japan | Jersey | Jordan | Kazakhstan | Kenya | Kiribati | Korea | Kuwait | Kyrgyzstan | Lao People's Democratic Republic | Latvia | Lebanon | Lesotho | Liberia | Libya | Liechtenstein | Lithuania | Luxembourg | Macao | Macedonia | Madagascar | Malawi | Malaysia | Maldives | Mali | Malta | Marshall Islands | Martinique | Mauritania | Mauritius | Mayotte | Mexico | Micronesia | Moldova | Monaco | Mongolia | Montenegro | Montserrat | Morocco | Mozambique | Myanmar | Namibia | Nauru | Nepal | Netherlands | New Caledonia | New Zealand | Nicaragua | Niger | Nigeria | Niue | Norfolk Island | Northern Mariana Islands | Norway | Oman | Pakistan | Palau | Palestine | Panama | Papua New Guinea | Paraguay | Peru | Philippines | Pitcairn | Poland | Portugal | Puerto Rico | Qatar | Réunion | Romania | Russian Federation | Rwanda | Saint Barthélemy | Saint Helena | Saint Kitts and Nevis | Saint Lucia | Saint Martin (French part) | Saint Pierre and Miquelon | Saint Vincent and the Grenadines | Samoa | San Marino | Sao Tome and Principe | Saudi Arabia | Senegal | Serbia | Seychelles | Sierra Leone | Singapore | Sint Maarten (Dutch part) | Slovakia | Slovenia | Solomon Islands | Somalia | South Africa | South Georgia and the South Sandwich Islands | South Sudan | Spain | Sri Lanka | Sudan | Suriname | Svalbard and Jan Mayen | Swaziland | Sweden | Switzerland | Syrian Arab Republic | Taiwan | Tajikistan | Tanzania | Thailand | Timor-Leste | Togo | Tokelau | Tonga | Trinidad and Tobago | Tunisia | Turkey | Turkmenistan | Turks and Caicos Islands | Tuvalu | Uganda | Ukraine | United Arab Emirates | United Kingdom | United States | United States Minor Outlying Islands | Uruguay | Uzbekistan | Vanuatu | Venezuela |

Parameter	Description
	Viet Nam | Virgin Islands | Wallis and Futuna | Western Sahara | Yemen | Zambia | Zimbabwe] **Default:** United States The country the access point and client are operating within.

4. If the device will act as an access point, add one or more Service Set Identifiers or SSIDs. For more information, refer to "Adding a Wireless Access Point (Page 410)".
5. If the device will act as a client, add one or more aliases. For more information, refer to "Adding a WLAN Client (Page 413)".
6. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

10.1.2 Managing Wireless Access Points

This section describes how to configure the device to act as a Wireless Access Point (WAP) in a WLAN.

⚠ NOTICE

When the device is to be enabled as a WAP, make sure the WLAN client is disabled.

⚠ NOTICE

No more than two WAPs can be enabled at the same time.

10.1.2.1 Viewing a List of Wireless Access Points

To view a list of Wireless Access Points (WAPs) for a WLAN interface, type:

```
show running-config interface wlan wlanport 1 access-point
```

A table or list similar to the following example appears:

```
ruggedcom# show running-config interface wlan wlanport 1 access-point ssids | tab
                                                CHANNEL  HT                        WEP
SSID        ENABLED  INTERFACE  BAND    MODE    WIDTH    MODE  CHANNEL  SECURITY   KEY  PASSPHRASE
-------------------------------------------------------------------------------------------------
RX1400-Air  X        wlan-ap1   2.4GHz  mixed   -        MIMO  6        wpa2_ccmp  -
 $4$05sxb9ZekzsdprcI0d4IDw==
RX1400AP    -        -          2.4GHz  mixed   -        MIMO  auto     wpa2_ccmp  -
 $4$05sxb9ZekzsdhYYI0d4IDw==

 !
!
```

If no WAPs have been configured, add WAPs as needed. For more information, refer to "Adding a Wireless Access Point (Page 410)".

10.1.2.2 Viewing the Status of Wireless Access Points

To view the status of all Wireless Access Point (WAP), type:

```
show interfaces wlan status access_point
```

If WAPs have been configured, a list similar to the following example appears:

```
ruggedcom# show interfaces wlan status access_point
interfaces wlan status access_point RX1400-Air
 interface     wlan-ap1
 mac           7c:ec:79:c0:8a:81
 mimo          2x2
 state         Enabled
 mode          mixed
 band          "2.4 GHz"
 channel       6
 channel width "20 MHz"
 security      "WPA2 CCMP"
 connected-client
BSSID              RX     TX          SIGNAL
-------------------------------------------------
7c:ec:79:c0:93:7c       9643    957975218       -25 dBm
```

The list provides the following information:

Parameter	Description
`{ ssid }`	**Synopsis:** A string SSID of this WLAN.
`interface`	**Synopsis:** A string Interface used by this WLAN.
`mac`	**Synopsis:** A string MAC address of the interface.
`mimo`	**Synopsis:** A string MIMO configuration of the access point.
`state`	**Synopsis:** A string State of this access point.
`mode`	**Synopsis:** A string Mode of this WLAN.
`band`	**Synopsis:** A string Frequency band of this access point.
`channel`	**Synopsis:** A string Channel of this access point.
`channel-width`	**Synopsis:** A string Width of the channel.
`security`	**Synopsis:** A string Security mode of this WLAN.

Parameter	Description
{ bssid }	**Synopsis:** A string The BSSID of associated station.
RX	**Synopsis:** A string The number of bytes received from the client.
TX	**Synopsis:** A string The number of bytes transmitted to the client.
signal	**Synopsis:** A string Average signal strength.

If no WAPs have been configured, configure WAPs as needed. For more information, refer to "Adding a Wireless Access Point (Page 410)".

10.1.2.3 Viewing the Status of WLAN Client Associations

To view the status of WLAN clients connected to a specific Wireless Access Point (WAP), type:

```
show interfaces wlan status access_point { access-point } connected-client
```

Where { access-point } is the desired WAP.

If a client is connected to the WAP, a list similar to the following example appears:

```
ruggedcom# show interfaces wlan status access_point RX1400-Air connected-client
BSSID              RX           TX           SIGNAL
-------------------------------------------------------
7c:ec:79:c0:93:7c       1889951798      1216926171      -64 dBm
```

The list provides the following information:

Parameter	Description
{ bssid }	**Synopsis:** A string The BSSID of associated station.
RX	**Synopsis:** A string The number of bytes received from the client.
TX	**Synopsis:** A string The number of bytes transmitted to the client.
signal	**Synopsis:** A string Average signal strength.

10.1.2.4 Adding a Wireless Access Point

To add a Wireless Access Point (WAP), do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the access point by typing:

   ```
   interface wlan wlanport 1 access-point ssids
   { ssid }
   ```

   Where { ssid } is the Service Set Identifier (SSID) for the access point.

⚠ NOTICE
No more than two WAPs can be enabled at the same time.

3. Configure the following common parameters by typing:

Parameter	Description
`enabled`	When selected (checked), enables the the access point.
`band { band }`	**Synopsis:** [2.4GHz | 5GHz] **Default:** 2.4GHz The frequency band.
`channel { channel }`	**Synopsis:** A string between 1 and 10 characters long **Default:** auto The channel.
`security { security }`	**Synopsis:** [wpa_eap | wpa2_ccmp | wpa2_ccmp_wpa_tkip | wpa_ccmp | wpa_tkip_ccmp | wpa_tkip | wep | open] **Default:** wpa2_ccmp_wpa_tkip The security protocol supported by the WLAN.
`passphrase { passphrase }`	**Synopsis:** A string between 1 and 128 characters long The password for the WLAN. The password must be between 8 and 63 characters. It can contain numbers, uppercase and lowercase characters, and special characters (e.g. !@# $%^&*()_+-={}). For improved security, use a password that is at least 12 characters long and contains at least one uppercase character, lowercase character, number, and special character.

Note
The 5.0 GHz frequency band only supports SISO, which can support a channel width of 20 or 40 MHz. The 2.4 GHz frequency band supports both SISO (20 MHz) and MIMO (40 MHz).

4. Depending on the selected frequency band, configure the following additional parameters:

- **For 2.4 GHz**

Parameter	Description
`mode { mode }`	**Synopsis:** [mixed | b-g-only | b-only | g-only] **Default:** mixed The mode that best matches the clients that will connect to the WLAN.
`ht-mode { ht-mode }`	**Synopsis:** [SISO | MIMO] **Default:** MIMO The MIMO mode.

- **For 5.0 GHz**

Parameter	Description
`channel-width { channel-width }`	**Synopsis:** [20MHz | 40MHz] **Default:** 20MHz The channel width.

5. If *WPA-EAP* is selected as a security protocol, configure WPA-EAP. For more information, refer to "Configuring WPA-EAP (Page 411)".
6. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

10.1.2.5 Configuring WPA-EAP

RUGGEDCOM ROX II supports IEEE 802.1x authentication. For more information about the Extensible Authentication Protocol (EAP), refer to "IEEE 802.1x Authentication (Page 157)".

To configure WPA-EAP, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***interface » wlan » wlanport/1 » access-point » ssids » {name}***, where *name* is the desired service set identifier.
3. Configure the following parameters:

Parameter	Description
`version { version }`	**Synopsis:** [wpa | wpa2 | wpa_wpa2] **Default:** wpa2 The version of WPA.
`cipher { cipher }`	**Synopsis:** [TKIP | CCMP | TKIP_CCMP] **Default:** CCMP The cipher used with WPA.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

10.1.2.6 Deleting a Wireless Access Point

To delete a Wireless Access Point (WAP), do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the WAP by typing:

   ```
   no interface wlan wlanport 1 access-point ssids { ssid }
   ```

   Where { ssid } is the Service Set Identifier (SSID) for the access point.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

10.1.3 Managing WLAN Clients

This section describes how to configure the device to act as a client in the WLAN. This is done by configuring aliases, which are connected to specific access points.

10.1.3.1 Viewing a List of WLAN Clients

To view a list of WLAN clients, type:

```
show running-config interface wlan wlanport 1 client wireless-lans
```

```
ruggedcom# show running-config interface wlan wlanport 1 client wireless-lans | tab
                                                                          IP
                                                                          ADDRESS
WLAN ALIAS    ENABLED  SSID SECURITY       PASSWORD                       SRC
------------------------------------------------------------------------------
WLAN-Client1  X        RX1400AP-Air--WPA2  $4$05sxb9ZekzsdhYYI0d4IDw==  static

 !
!
```

If no WLAN clients have been configured, add clients as needed. For more information, refer to "Adding a WLAN Client (Page 413)".

10.1.3.2 Viewing the Status of the WLAN Clients

To view the status of the WLAN clients, type:

```
show interfaces wlan status link
```

A list similar to the following example appears:

```
ruggedcom# show interfaces wlan status link
interfaces wlan status link
 interface wlan-cl1
 mac       7c:ec:79:c0:93:7c
```

```
  state     Enabled
  ssid      RX1400-Air
  frequency 2437
  signal    "-39 dBm"
```

The list provides the following information:

Parameter	Description
`interface`	**Synopsis:** A string Network interface for this link.
`mac`	**Synopsis:** A string MAC address of the interface.
`state`	**Synopsis:** A string State of this link.
`ssid`	**Synopsis:** A string WLAN this client is connected to.
`frequency`	**Synopsis:** A string Frequency used to communicate with the access point.
`signal`	**Synopsis:** A string Signal strength.

10.1.3.3 Adding a WLAN Client

To add a WLAN client, do the following:

1. Scan the network for all available WLAN clients. Each client discovered will be made selectable when adding the client. For more information, refer to "Scanning for WLAN Clients (Page 416)".
2. Make sure the CLI is in Configuration mode.
3. Add the client by typing:

   ```
   interface wlan wlanport 1 client wireless-lans { name }
   ```

   Where { name } is the client name.
4. Configure the following parameter(s) as required:

Parameter	Description
`enabled`	When selected (checked), enables the WLAN alias.
`ssid-security { ssid-security }`	**Synopsis:** A string The WLAN to connect with. Either select a WLAN from the list or select manual-setup to manually specify a WLAN.
`password { password }`	**Synopsis:** A string between 1 and 32 characters long The password for the WLAN.

Parameter	Description
`ip-address-src { ip-address-src }`	**Synopsis:** [static | dynamic] **Default:** dynamic Determines whether the IP address is static or dynamically assigned via DHCP or BOOTP.
`ipv6-address-src { ipv6-address-src }`	**Synopsis:** [static | dynamic] **Default:** dynamic Determines whether the IP address is static or dynamically assigned via DHCPv6.

5. If **SSID Security** is set to **manual-setup**, configure the following additional parameter(s) as required:

⚠ NOTICE

The WLAN password can contain numbers, uppercase and lowercase characters, and special characters (e.g. *()_+-={}[];:',<.>/?\|`~). For improved security, use a password that is at least 12 characters long and contains at least one uppercase character, lowercase character, number, and special character.

Parameter	Description
`ssid { ssid }`	**Synopsis:** A string The SSID for the WLAN.
`security { security }`	**Synopsis:** [wpa_eap | wpa/wpa2 | wep | open] **Default:** wpa/wpa2 The security protocol supported by the WLAN.
`password { password }`	**Synopsis:** A string between 1 and 32 characters long The password for the WLAN.

6. If *WPA-EAP* is selected as a security protocol, configure WPA-EAP authentication. For more information, refer to "Configuring WPA-EAP Authentication (Page 414)".
7. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

10.1.3.4 Configuring WPA-EAP Authentication

RUGGEDCOM ROX II supports IEEE 802.1x authentication. For more information about the Extensible Authentication Protocol (EAP), refer to "IEEE 802.1x Authentication (Page 157)".

To configure WPA-EAP authentication, do the following:

1. Make sure the CLI is in Configuration mode.

2. Navigate to ***interface » wlan » wlanport/1 » client » wireless-lans » {name} » wpa-eap***, where *{name}* is the desired wireless lan.
3. Configure the following parameter(s) as required:

Parameter	Description
`version { version }`	**Synopsis:** [wpa | wpa2 | wpa_wpa2] WPA version to be used - options are WPA, WPA2 or WPA_WPA2
`ciphers { ciphers }`	**Synopsis:** [TKIP | CCMP | TKIP_CCMP] WPA ciphers to be used - options are TKIP, CCMP or TKIP_CCMP
`authentication-method { authentication-method }`	**Synopsis:** [TLS] **Default:** TLS Authentication method for EAP
`certificate { certificate }`	**Synopsis:** A string between 1 and 255 characters long Local certificate sent to server for authentication
`identity { identity }`	**Synopsis:** A string between 1 and 64 characters long Identity string sent to server
`server-subject-name { server-subject-name }`	**Synopsis:** A string Expected subject name (sub-string match) of the server certificate
`server-domain-name-suffix { server-domain-name-suffix }`	**Synopsis:** A string Expected domain name suffix (suffix match) in DNS entries of alternative subject name or common name fields

4. Add a CA certificate for WPA-EAP authentication. For more information, refer to "Adding a CA Certificate for WPA-EAP Authentication (Page 415)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

10.1.3.5 Adding a CA Certificate for WPA-EAP Authentication

To add a CA Certificate for WPA-EAP authentication, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***interface » wlan » wlanport/1 » client » {wireless-lan} » wpa-eap » Add-ca-cert-list***, where *{wireless-lan)* is the desired wireless lan.

Note
If no certificates have been configured, add certificates as needed. Refer to "Adding a CA Certificate and CRL (Page 200)".

Note
The client CA certificate must match the local certificate. For more information, refer to "Configuring WPA-EAP Authentication (Page 414)".

Note
SHA-1 hashed certificates are not supported for WPA-EAP authentication. Use SHA-256 hashed certificates instead.

3. Configure the following parameter(s) as required:

Parameter	Description
`ca-cert { ca-cert }`	**Synopsis:** A string between 1 and 255 characters long The CA Certificate

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

10.1.3.6 Deleting a WLAN Client

To delete a WLAN client, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the client by typing:

```
no interface wlan wlanport 1 client wireless-lans { name }
```

Where { name } is the client name.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

10.1.3.7 Scanning for WLAN Clients

Before configuring a WLAN client for a device, use the scan utility to find available WLAN clients in the area. WLAN clients found are selectable when configuring an alias for the client and can also be viewed in the scan results.

To scan for available WLAN clients, do the following:

1. Make sure the WLAN interface is enabled. For more information, refer to "Enabling and Configuring the WLAN Interface (Page 405)".
2. Make sure all existing WLAN clients are disabled. For more information, refer to "Adding a WLAN Client (Page 413)".
3. Run the scan utility by typing:

```
interface wlan wlanport 1 scan
```

4. [Optional] Display the scan results by typing:

```
show running-config interface wlan wlanport 1 scan-results
```

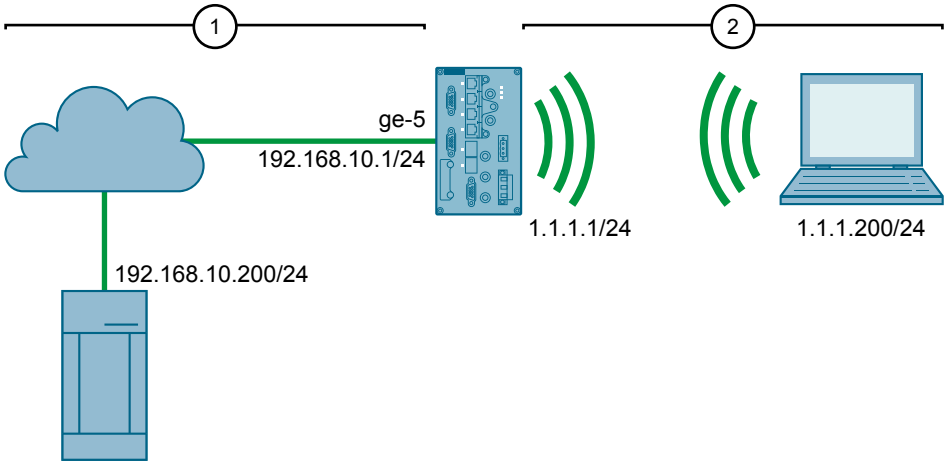
For example:

```
show running-config interface wlan wlanport 1 scan-results | tab
WLAN
--------------------
RX1400AP-Air--WPA2
RuggedCom--OPEN
manual-setup

 !
!
```

10.1.4 Example: Configuring a WLAN with a Firewall

This example demonstrates how to link WAN and LAN networks wirelessly while controlling traffic with a firewall.



① WAN
② LAN

Figure 10.1 WLAN with Firewall Topology

Step 1: Connect the WAN and LAN Networks

1. Make sure the WLAN interface is enabled. For more information, refer to "Enabling and Configuring the WLAN Interface (Page 405)".
2. Configure a wireless access point. For more information, refer to "Adding a Wireless Access Point (Page 410)".
3. Assign an IPv4 or IPv6 address to the interface associated with the new wireless access point. For more information, refer to either "Adding an IPv4 Address (Page 251)" or "Adding an IPv6 Address (Page 252)".
4. Connect the WAN network to an available switched Ethernet port on the device.

5. Configure the port as follows:

Parameter	Value
Switchport	{ disabled }
IP Address Source	static

For more information about configuring a port, refer to "Configuring a Switched Ethernet Port (Page 314)".

Note
When a switched Ethernet port is in direct routing mode (versus switch mode), an interface in the form of *ge-{port}* is added automatically to the **ip** menu. For example, if direct routing mode is configured for port 5, the interface *ge-5* is created.

6. Assign an IPv4 or IPv6 address to the switched Ethernet port connected to the WAN side of the network. For more information, refer to either "Adding an IPv4 Address (Page 251)" or "Adding an IPv6 Address (Page 252)".
7. For each PC on the WAN side of the network, do the following:
   a. Configure an IP address that is on the same subnet as the IP address configured for the switched Ethernet port. For example:

Router IP Address	192.168.10.1/24
PC IP Address	192.168.10.200/24

   This step is operating system specific. For more information, refer to the user documentation for the OS.
   b. Add a static route. For example, on Linux® PCs:

```
# route add 1.1.1.1 mask 255.255.255.0 192.168.10.0
```

   For information about how to add static routes for other operating systems, refer to the user documentation for the OS.
8. For each PC on the LAN side of the network, do the following:
   a. Configure an IP address and default gateway that are on the same subnet as the IP address configured for the access point. For example:

Router IP Address	1.1.1.1/24
PC IP Address	1.1.1.200/24
PC Default Gateway	1.1.1.1

   This step is operating system specific. For more information, refer to the user documentation for the OS.
   b. Add a static route. For example, on Linux® PCs:

```
# route add 192.168.10.0 mask 255.255.255.0 1.1.1.1
```

   For information about how to add static routes for other operating systems, refer to the user documentation for the OS.

c. Connect the PC to the access point and assign the PC's wireless interface an IP address on the same subnet (e.g. 1.1.1.200/24).

9. Click **Commit**.
10. Verify the WAN and LAN networks are connected via the router by sending pings between PCs.

    For example, **1.1.1.200/24** should be able to ping **192.168.10.200/24**, and **192.168.10.200/24** should be able to ping **1.1.1.200/24**.

Step 2: Configure the Firewall

1. Add a new firewall (e.g. WLAN-Firewall). For more information, refer to "Adding a Firewall (Page 221)".
2. Configure a zone for each side of the network, as well as a zone for the firewall itself. For example:

Zone Name	IP Type	Type
WAN	ipv4	ipv4
LAN	ipv4	ipv4
FW	ipv4	firewall

   For information about how to add zones, refer to "Adding a Zone (Page 226)".

3. Add interfaces for the switched Ethernet port, access point, and the device itself. Make sure the switched Ethernet port is associated with the WAN zone and that other interfaces are associated with the LAN zone. For example:

Interface	Predefined Zone
ge-5	WAN
wlan-ap1	LAN
switch.0001	LAN

   For information about adding an interface and associating it with a predefined zone, refer to "Adding an Interface (Page 228)" and "Associating an Interface with a Zone (Page 229)".

4. Add policies to control the flow of traffic between networks. For example:

Name	Source Zone	Destination Zone	Policy
Policy1	WAN	LAN	reject
Policy2	WAN	FW	accept
Policy3	LAN	WAN	accept
Policy4	LAN	FW	accept
Policy5	FW	LAN	accept
Policy6	FW	WAN	accept

   For more information about adding policies, refer to "Adding a Policy (Page 234)".

5. Validate the firewall configuration. For more information, refer to "Validating a Firewall Configuration (Page 245)".
6. Enable the firewall. For more information, refer to "Enabling/Disabling a Firewall (Page 245)".
7. Select the new firewall as the working configuration. For more information, refer to "Working with Multiple Firewall Configurations (Page 222)".
8. Click **Commit**.
9. Verify the WAN and LAN networks are connected via the router by sending pings between PCs.

   For example, **1.1.1.200/24** should be able to ping **192.168.10.200/24**, but **192.168.10.200/24** should not be able to ping **1.1.1.200/24**.

10.2 Managing Cellular Modem Interfaces

This section describes how to configure an interface to a 4G LTE cellular network, as well as how to enable the device's GPS capabilities.

10.2.1 Enabling/Disabling Cellular Modem Interfaces

To enable or disable a cellular modem interface, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***interface » cellmodem » {interface}***, where *{interface}* is the cellular modem interface.
3. Enable or disable the desired cellular modem interface by typing:

   Enable

   ```
   interface wan { interface } enabled
   ```

   Where { interface } is the cellular modem interface.

   Disable

   ```
   no interface wan { interface } enabled
   ```

   Where { interface } is the cellular modem interface.
4. If the interface is enabled, further configure the interface as required. For more information, refer to "Configuring a Cellular Modem Interface (Page 421)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

10.2.2 Configuring a Cellular Modem Interface

To configure a cellular modem interface, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***interface » cellmodem » {interface}***, where *{interface}* is the cellular modem interface.
3. Configure the following parameter(s) as required:

Parameter	Description
`link-alarms { link-alarms }`	**Synopsis:** [true | false] **Default:** true Disabling link-alarms will prevent alarms and LinkUp and LinkDown SNMP traps from being sent for that interface. Link alarms may also be controlled for the whole system under admin / alarm-cfg.
`alias { alias }`	**Synopsis:** A string 64 characters long The SNMP alias name of the interface

4. [Optional] Enable the interface. For more information, refer to "Enabling/ Disabling Cellular Modem Interfaces (Page 420)".
5. Enable and configure LTE on the interface. For more information, refer to "Managing the LTE Modem (Page 427)".
6. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

10.2.3 Activating Dual SIM Cards

The RUGGEDCOM RX1400 supports dual micro-SIM cards for the LTE modem to provide a fail-over mechanism should one of the SIM cards lose connectivity with the network.

To activate both micro-SIM cards, do the following:

1. Make sure both micro-SIM cards are installed. For more information, refer to the " RUGGEDCOM RX1400 Installation Manual".
2. Configure a GSM profile for each micro-SIM card, making sure the fail-over profile for each is the other card. For more information, refer to "Adding a GSM Profile (Page 425)".
3. Configure the cellular modem interface to connect to the cellular network via the primary profile. For more information, refer to "Connecting as a PPP Client (Page 424)".

10.2.4 Viewing a List of Cellular Modem Interfaces

To view a list of cellular modem interfaces, type:

```
show running-config interface cellmodem
```

A table or list similar to the following example appears:

```
ruggedcom# show running-config interface cellmodem
interface
 cellmodem celport 1
  enabled
  no alias
  lte ppp-client connect-to profile1
 !
!
```

10.2.5 Viewing the Status of a Cellular Modem Interface

To view the status of a cellular modem interface, type:

```
show interfaces cellmodem cel-1 lte
```

A table or list similar to the following example appears:

```
ruggedcom# show interfaces cellmodem cel-1 lte
               NETWORK               RSSI       NETWORK   NETWORK  NETWORK  PHONE
IFNAME   TYPE  SUPPORTED  ESN  ECIO  INDICATOR  OPERATOR  IN USE   STATUS   NUMBER
-------------------------------------------------------------------------------------
cel-1    cdma                 0     0                              Unknown
```

This table or list provides the following information:

Parameter	Description
state	**Synopsis:** [not set | up | down | testing | unknown | dormant | notPresent | lowerLayerDown] The port's link status.
media	**Synopsis:** A string 31 characters long The wireless data communication technology that modem is compatible with{ GSM/HSPA, CDMA/EVDO, LTE }.
admin-state	**Synopsis:** [not set | up | down | testing | unknown | dormant | notPresent | lowerLayerDown] The port's administrative status.

10.2.6 Viewing PPP Interface Statistics

To view the statistics for the PPP interface, type:

```
show interfaces cellmodem ppp-connections
```

A table or list similar to the following example appears:

```
interfaces cellmodem cel-1 lte
 ppp-connections
  connection status Disconnected
  local ip          25.77.204.53
  remote ip         25.70.48.89
  apn               SP.TELUS.COM
  username          N/A
  tx bytes          0
  rx bytes          0
  mtu               1500
```

This table or list provides the following information:

Parameter	Description
`connection-status`	**Synopsis:** A string 128 characters long PPP connection status
`local-ip`	**Synopsis:** A string 32 characters long The IP address assigned to the modem by the remote server
`remote-ip`	**Synopsis:** A string 32 characters long The IP address of the remote server
`apn`	**Synopsis:** A string The name of the wireless network access point.
`username`	**Synopsis:** A string **Default:** N/A The user ID to connect to the remote server.
`tx-bytes`	**Synopsis:** An integer The bytes transmitted over the modem
`rx-bytes`	**Synopsis:** An integer The bytes received by the modem
`mtu`	**Synopsis:** An integer MTU (Maximum Transmission Unit) value on the ppp interface

10.3 Running AT Commands

To issue AT (Hayes) commands to the cellular modem, type:

```
interfaces cellmodem cel-1 lte at command
{ command }
```

Where { command } is the AT command.

10.4 Connecting as a PPP Client

To connect or disconnect from a cellular network as a PPP client, do the following:

1. Make sure the CLI is in Configuration mode.
2. Make sure the cellular modem interface has been configured. For more information, refer to "Configuring a Cellular Modem Interface (Page 421)".
3. Make sure an appropriate cellular modem profile has been configured. For more information, refer to "Managing GSM Profiles (Page 424)".
4. Make sure an account has been activated with a service provider for the modem type.
5. Make sure antennas are properly connected to the device before initiating the connection. For more information, refer to the " RUGGEDCOM RX1400 Installation Manual".
6. Insert a SIM card into the cellular modem module.
7. Select the cellular modem profile to use when connecting to the wireless network by typing:

   ```
   interface cellmodem celport 1 lte ppp-client connect-to { profile }
   ```

   Where:

   - `{ profile }` is the cellular modem profile.
8. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

10.5 Managing GSM Profiles

GSM (Global System for Mobile Communications) profiles must be configured before HSPA data is available.

10.5.1 Viewing a List of GSM Profiles

To view a list of GSM profiles, type:

```
show running-config global cellular profiles gsm
```

If profiles have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config global cellular profiles gsm | tab
                                                 USE                       DIAL    DISCONNECT
 FAILOVER
                    APN   DIAL                    PEER                      ON      IDLE        ON
NAME  APN           TYPE  STRING    SIM  PROFILE  DNS   USERNAME  PASSWORD  DEMAND  TIMEOUT     DEMAND
    MTU   AUTHENTICATION
-------------------------------------------------------------------------------------------
```

```
gsm1  apn.gsm2.net  ipv4  *99***1#  1    -        -     N/A       N/A       -       0          -
    1500  none
gsm2  apn.gsm2.net  ipv4  *99***1#  2    gsm1     -     N/A       N/A       -       0          -
    1500  none

!
```

If no GSM profiles have been configured, add profiles as needed. For more information, refer to "Adding a GSM Profile (Page 425)".

10.5.2 Adding a GSM Profile

To add a GSM profile for the cellular modem interface, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the restriction by typing:

   `global cellular profiles gsm { name }`

   Where:

   - `{ name }` is the name of the profile
3. Configure the cellular network by typing the following commands:

Parameter	Description
`apn { apn }`	**Synopsis:** A string **Default:** none The name of the wireless network access point.
`apn-type { apn-type }`	**Synopsis:** [ipv4 | ipv6 | ipv4v6] **Default:** ipv4 Specify APN type used to attach to PDN
`dial-string { dial-string }`	**Synopsis:** A string **Default:** *99***1# The dial string given by the wireless provider to connect to the access point name.
`sim { sim }`	**Synopsis:** An integer between 1 and 2 **Default:** 1 Specify SIM index to be used by this profile
`peer { peer }`	**Synopsis:** A string between 7 and 15 characters long or A string between 6 and 40 characters long The peer address to override the one from carrier.

4. Select the failover profile to use by typing the following command:

Parameter	Description
`profile { profile }`	**Synopsis:** A string 32 characters long Specify the cellular connection profile

5. Configure the GSM PPP settings by typing the following commands:

Parameter	Description
`use-peer-dns`	Enables the DNS server entries that the PPP server recommends. Enables this option unless you provide your own name servers.
`username { username }`	**Synopsis:** A string **Default:** N/A The user ID to connect to the remote server.
`password { password }`	**Synopsis:** A string 255 characters long The password to be authenticated by the remote server. Must not begin with 4.
`dial-on-demand`	Activates dial-on-demand for this connection. The establishment of the PPP connection is postponed until there is data to be transmitted via the interface. If dial-on-demand is configured, Failover on Demand cannot be configured.
`disconnect-idle-timeout { disconnect-idle-timeout }`	**Synopsis:** An integer **Default:** 0 The time in seconds to wait before disconnecting PPP when there is no traffic on the link. This option is only valid when dial-on-demand is enabled.
`failover-on-demand`	Activates link failover on-demand on this device. PPP link establishment on this device is controlled by link failover. If Failover on Demand is configured, Dial on Demand cannot be configured.
`mtu { mtu }`	**Synopsis:** An integer between 128 and 1500 **Default:** 1500 MTU (Maximum Transmission Unit) value on a PPP interface.
`authentication { authentication }`	**Synopsis:** [none | chap | pap] **Default:** none The authentication protocol used to establish a cellular data link

6. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

10.5.3 Deleting a GSM Profile

To delete a GSM Profile, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the chosen key by typing:

   ```
   no global cellular profiles gsm { name }
   ```

   Where:

   - `{ name }` is the name of the profile

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

10.6 Managing the LTE Modem

This section describes how to manage the LTE modem.

10.6.1 Viewing LTE Cellular Modem Information

To view information about the LTE cellular modem, type the following:

```
show interfaces cellmodem cel-1 lte
```

A list similar to the following appears:

```
interfaces cellmodem cel-1 lte
 lte
  network supported "umts,lte"
  imei              35437509018059
  radio             on
  rssi indicator    -73
  network operator  "TELUS"
  network in use    "lte"
  network status    "Registered to Home network"
  sim               8912230100043535630(Sim1)
  active profile    telus1
  ber               2
  imsi              302220023252658
  msisdn            "16472960957"
  mcc               "302"
  mnc               "220"
  gps
   mode standalone
```

This table or list provides the following information:

Parameter	Description
`network-supported`	**Synopsis:** A string 128 characters long Wireless technologies supported by the modem
`imei`	**Synopsis:** A string 128 characters long International Mobile Equipment Indentity
`radio`	**Synopsis:** A string 128 characters long The current RF status of cellmodem
`rssi-indicator`	**Synopsis:** An integer The Received Signal Strength Indicator in dBm
`network-operator`	**Synopsis:** A string 128 characters long The wireless network operator currently in use

Parameter	Description
network-in-use	**Synopsis:** A string 128 characters long The network technology currently in use by the modem
network-status	**Synopsis:** A string 128 characters long The registration status of the modem with the wireless network
sim	**Synopsis:** A string 128 characters long The Subscriber Indentity Module number
active-profile	**Synopsis:** A string 128 characters long The active profile of cellular connection
ber	**Synopsis:** A string 128 characters long The percentage at which errors occur in the transmission of digital data.
imsi	**Synopsis:** A string 128 characters long The unique identifier of a cellular network user.
msisdn	**Synopsis:** A string 128 characters long The identity of a mobile phone number, internationally.
mcc	**Synopsis:** A string 128 characters long The country to which a mobile subscriber belongs.
mnc	**Synopsis:** A string 128 characters long A two or three digit number used to uniquely identify a given network from within a specified country.

10.6.2 Configuring the LTE Modem

To configure the LTE modem, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable the LTE modem. For more information, refer to "Enabling/Disabling the LTE Modem (Page 430)".
3. Navigate to ***interface » cellmodem » celport/1 » lte*** .
4. Configure the following parameter(s) as required:

Parameter	Description
failure-recovery-mode { failure-recovery-mode }	**Synopsis:** [sim-failover | cellular-reset] **Default:** sim-failover The cellular failure recovery mode to be invoked when a cellular network error is detected. • sim-failover: The cellular modem will failover to the secondary SIM card. • cellular-reset: The existing cellular modem connection will be reset by resetting the cellular modem.

Parameter	Description
`max-try { max-try }`	**Synopsis:** An integer between 0 and 65535 **Default:** 0 Specify the maximum number of SIM card failover retries. 0 means re-try forever
`force-hard-reset { force-hard-reset }`	**Synopsis:** [true | false] **Default:** false Perform a hard reset on the celluar modem when all soft reset attempts have been exhausted. A hard reset will perform a power cycle on the cellular modem.
`soft-reset-attempts { soft-reset-attempts }`	**Synopsis:** An integer between 0 and 65535 **Default:** 5 The number of soft resets to attempt before performing a hard reset.
`failure-detect-mode { failure-detect-mode }`	**Synopsis:** [cellular-failure | ip-polling] **Default:** cellular-failure The cellular failure detection mode to determine when a cellular network error exists. • cellular-failure: Detect cell modem (signal loss), SIM card or cellular Access Point faults. • ip-polling: Use pings to poll a remote host to test connectivity.
`failover-timer { failover-timer }`	**Synopsis:** An integer between 1 and 10 **Default:** 2 The time in minutes before initiating SIM card failover.
`ipv4-address { ipv4-address }`	**Synopsis:** A string between 7 and 15 characters long The IPv4 address used for sending pings to test connectivity.
`ip-polling-interval { ip-polling-interval }`	**Synopsis:** An integer between 5 and 65535 **Default:** 60 The time in seconds between each ping message sent to the remote host.
`ip-polling-resp-timeout { ip-polling-resp-timeout }`	**Synopsis:** An integer between 1 and 65535 **Default:** 3 The time in seconds to wait for a response from the IP ping poll request.
`ip-polling-retry-delay { ip-polling-retry-delay }`	**Synopsis:** An integer between 15 and 65535 **Default:** 15 The time in seconds to wait before issuing a ping retry to a remote host address.
`max-ip-poll-failures { max-ip-poll-failures }`	**Synopsis:** An integer between 1 and 65535 **Default:** 3 The number of allowed IP polling response failures before initiating SIM failover.

Parameter	Description
`ip-polling-startup-delay { ip-polling-startup-delay }`	**Synopsis:** An integer between 1 and 65535 **Default:** 3 The time in seconds to wait after system startup before issuing IP ping polls.

5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.
6. [Optional] Enable GPS. For more information, refer to "Enabling/Disabling GPS (Page 432)".

10.6.3 Enabling/Disabling the LTE Modem

To enable or disable the LTE modem for a cellular modem interface, do the following:

Note
The operational state of the LTE modem is determined by the associated cellular modem interface. For more information about enabling or disabling the cellular modem interface, refer to "Enabling/Disabling Cellular Modem Interfaces (Page 420)".

1. Make sure the CLI is in Configuration mode.
2. Enable or disable the LTE modem by typing:

   Enable

   ```
   interface cellmodem celport 1 enabled
   ```

   Disable

   ```
   no interface cellmodem celport 1 enabled
   ```

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

10.6.4 Resetting the Cellular Modem

When a cellular connection failure is detected, RUGGEDCOM ROX II automatically performs a soft reset of the cellular modem to recover the connection. A manual soft reset option is also available, as well as a hard reset in cases where a soft reset fails to restore connectivity.

This section describes how to manually reset the modem and how to enable and disable an automatic hard reset.

10.6.4.1 Performing a Manual Soft Reset

During a soft reset, the cellular modem driver sends AT (Hayes) commands to the cellular modem to re-initialize itself. Power to the cellular modem is maintained throughout the process.

To manually soft-reset the cellular modem, type:

```
interfaces  cellmodem  cel-1  lte  reset
```

10.6.4.2 Enabling/Disabling a Hard Reset

RUGGEDCOM ROX II allows users to configure an automatic hard reset of the cellular modem when a connection fails in cases where a soft reset does not restore cellular connectivity. Both cellular failure and IP polling failure detection methods are supported.

Users can configure the number of soft resets to be attempted before performing a hard reset.

During a hard reset, the cellular modem is powered down and powered back up again. The cellular modem is then re-initialized.

To enable or disable a hard reset of the cellular modem, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable the LTE modem. For more information, refer to "Enabling/Disabling the LTE Modem (Page 430)".
3. Navigate to ***interface » cellmodem » celport/1 » lte*** .
4. Enable or disable a hard reset by typing:

   Enable

   ```
   interface  cellmodem  celport  1  lte  force-hard-reset
   ```

   Disable

   ```
   no  cellmodem  celport  1  lte  force-hard-reset
   ```

5. Configure the number of soft reset attempts by typing:

   ```
   interface  cellmodem  celport/1  lte  soft-reset-
   attempts  { integer }
   ```

   Where { integer } is the desired number of soft reset attempts between 0 to 65535 before performing a hard reset. A value of *0* means no soft resets will be attempted.

6. Configure the related LTE modem parameters as desired. For more information, refer to "Configuring the LTE Modem (Page 428)"
7. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

10.6.5 Enabling/Disabling GPS

When GPS is enabled, users can look up the current location of the device. If configured, RUGGEDCOM ROX II can also send an NMEA GPS data streams via TCP to a server that hosts a GPS application.

To enable or disable GPS on the cellular modem, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable or disable GPS by typing:

   Enabling GPS

   ```
   interface cellmodem celport 1 lte gps enabled
   ```

   Disabling GPS

   ```
   no interface cellmodem celport 1 lte gps enabled
   ```
3. [Optional] Enable or disable NMEA GPS data streams. For more information, refer to "Enabling and Configuring GPS NMEA Data Streams (Page 432)".
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

10.6.6 Viewing the Configured GPS Mode

To view the configured GPS mode for the interface, type the following:

```
show interfaces cellmodem cel-1 lte gps
```

A list similar to the following appears:

```
IFNAME  TYPE  MODE
-------------------------
cel-1   lte   standalone
```

This table or list provides the following information:

Parameter	Description
`mode`	**Synopsis:** A string 64 characters long Shows configured GPS mode

10.6.7 Enabling and Configuring GPS NMEA Data Streams

When GPS and NMEA are enabled, RUGGEDCOM ROX II can receive NMEA data from the cellular modem and relay it to a remote host upon request. This feature can be enabled or disabled independent of the LTE modem configuration.

To enable and configure GPS NMEA data streams, do the following:

1. Make sure the CLI is in Configuration mode.

2. Type the following:

   ```
   interface celport 1 lte gps nmea
   ```

   Where:

   - `{ interface }` is the cellular modem interface

3. Configure the following parameters as required:

Parameter	Description
`enabled`	Enables NMEA stream
`listen-ip { listen-ip }`	**Synopsis:** A string **Default:** 0.0.0.0 The IP Address that device will listen on for remote host request
`local-port { local-port }`	**Synopsis:** An integer between 0 and 65535 **Default:** 10110 The port that device will listen on for remote host request
`extra-ip-ports { extra-ip-ports }`	**Synopsis:** A string The device will also listen on these IP Addresses. For port values, add ':#' to set the non-default port value. (ie. xxx.xxx.xxx.xxx:19343 [::] [::]:16000). If using the default address, do not specify another listen address with the same port.
`max-sessions { max-sessions }`	**Synopsis:** An integer between 1 and 32 **Default:** 10 The maximum number of concurrent tcp/ip sessions.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

10.6.8 Changing the Active SIM Card

When dual SIM cards are installed, the SIM card in Slot 1 is the primary (or active) card by default. The card in Slot 2 is considered the backup should the primary card lose connectivity with the network.

To manually switch which card is the active SIM card, do the following:

1. Switch the SIM cards by typing:

   ```
   interfaces cellmodem cel-1 lte force-switch-profile
   ```

2. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

To verify the SIM cards were successfully switched, type:

```
show interfaces cellmodem cel-1 lte
```

A list similar to the following appears:

```
ruggedcom# show interfaces cellmodem cel-1 lte
interfaces cellmodem cel-1 lte
 lte
  network supported GSM,GPRS,EDGE,UMTS,HSDPA/HSUPA,HSPA+,LTE
  imei              359225052306750
  radio             on
  rssi indicator    -73
  network operator  TELUS
  network in use    LTE
  network status    "Registered to Home network"
  sim               8912230100043535630(Sim1)
  active profile    Profile2
  gps
   mode standalone
```

The currently active SIM card is listed under **active profile**.

10.6.9 Managing Firmware Updates

Firmware for the LTE modem can be upgraded either directly via microSD/microSDHC flash drive or wirelessly via a remote HTTP/HTTPS server.

Note
The SIM card must be installed during the firmware update.

During wireless upgrades, RUGGEDCOM ROX II initiates the connection to the remote server, then pulls and updates the firmware. Firmware can be updated either on-demand or automatically, as defined by the user.

RUGGEDCOM ROX II performs the following actions when updating the firmware:

1. Connects to the microSD/microSDHC flash drive or remote server and verifies the firmware version
2. Downloads the new firmware
3. Validates the new firmware to make sure it is valid for the modem
4. Flashes the new firmware to the modem
5. Logs all firmware update events and actions to the system log (Syslog)
6. Brings the modem back to normal operation

10.6.9.1 Viewing the Firmware Update Status

To view the status of the firmware update, type:

```
show interfaces cellmodem cel-1 firmware-update
```

This table displays the following information:

Parameter	Description
`current-version`	**Synopsis:** A string 64 characters long The current firmware revision
`status-message`	**Synopsis:** A string 128 characters long Additional details on the status of the update.
`last-update-attempt`	**Synopsis:** A string 64 characters long The date and time of the completion of the last update attempt.
`last-update-result`	**Synopsis:** [N/A | Successful | Failed] Indicates whether or not the last firmware update was completed successfully

10.6.9.2 Configuring the Firmware Update Mode and Source

The method in which RUGGEDCOM ROX II discovers and downloads firmware updates is user configurable. The source can also be configured to point to a remote upgrade server or a local microSD/microSDHC flash drive.

To upgrade the firmware update mode and source, do the following:

1. If the firmware will be distributed via a remote upgrade server, make sure the upgrade server is configured and the latest firmware version has been added. For more information, refer to "Managing Upgrade Servers (Page 108)".
2. Make sure the cellular modem interface is enabled. For more information, refer to "Configuring a Cellular Modem Interface (Page 421)".
3. Make sure the CLI is in Configuration mode.
4. Navigate to ***interface » cellmodem » cel-1 » lte » firmware-upgrade***.
5. Configure the following parameter(s) as required:

Parameter	Description
`repository-url { repository-url }`	**Synopsis:** A string 256 characters long The URL of the firmware to download. Supported URIs are HTTP, HTTPS, USB and SD. To update from a USB flash drive or microSD card (if applicable), the URL format is "usb://device-name/path-to-file-on-system" or "sd://device-name/path-to-file-on-system". To determine the device name, insert the storage medium and either navigate "chassis", "storage", "removable" (Web UI) or type "show chassis". For all other protocols, the format is "protocol://host:port/path-to-file". When using the default port for the protocol, omit ":port".
`username { username }`	**Synopsis:** A string 64 characters long The user name required to connect with the upgrade server.

Parameter	Description
`password { password }`	**Synopsis:** A string 1024 characters long The password associated with the username
`mode { mode }`	**Synopsis:** [manual-check-and-update | auto-check-manual-update | auto-check-and-update] **Default:** manual-check-and-update The update mode. Options include: * manual-check-and-update - FOTA checks and installs the firmware when initiated by the user * auto-check-manual-update - FOTA checks for new firmware automatically and installs updates when initiated by the user * auto-check-and-update - FOTA checks for and installs new firmware automatically
`interval { interval }`	**Synopsis:** An integer between 1 and 365 **Default:** 90 The number of days to wait before automatically checking for new firmware.

6. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

10.6.9.3 Launching a Firmware Update

To launch a firmware update, do the following:

⚠ NOTICE

f power is interrupted during the upgrade, the device will become unrecoverable. If this occurs, contact Siemens Customer Support.

⚠ NOTICE

Changes to the LTE modem configuration are not permitted until the upgrade is complete.

Note
If the upgrade fails, refer to "Firmware Updates (Page 943)".

Note
An active cellular connection is not required during the firmware update.

1. Make sure the firmware update mode has been configured. For more information, refer to "Configuring the Firmware Update Mode and Source (Page 435)".
2. Make sure the firmware file is available to the device.

- If using a microSD/microSDHC flash drive, insert the drive in the device. For more information, refer to the "Installation Manual" for the RUGGEDCOM RX1400.
- If using a remote upgrade server, make sure the firmware has been added to the upgrade server. For more information about configuring an upgrade server, refer to "Configuring the Upgrade Server (Page 109)".

3. Make sure the cellular modem interface is enabled. For more information, refer to "Enabling/Disabling Cellular Modem Interfaces (Page 420)".
4. Launch the firmware update by typing:

   ```
   interfaces cellmodem cel-1 firmware-update launch-update
   ```

5. [Optional] Verify the firmware update. For more information, refer to "Viewing the Firmware Update Status (Page 434)".
6. Reset the cellular modem. For more information, refer to "Resetting the Cellular Modem (Page 430)".
7. [Optional] Verify the firmware version installed after the operation is complete.

   For modems other than the LTE global modem, use the following AT command:

   ```
   at#swpkgv
   ```

   For the LTE global modem, use the following AT command:

   ```
   at#firmware
   ```

   For more information, refer to "Running AT Commands (Page 423)".

10.7 Managing PPPoE

The Point-to-Point over Ethernet (PPPoE) is a network protocol that encapsulates Point-to-Point (PPP) protocol frames within Ethernet frames. It allows multiple hosts on the same network to connect to the WAN via a services router (or client), which connects to an access concentrator (or server) via Ethernet.

PPPoE combines Ethernet and PPP protocols to provide a method for authenticating, encrypting, and compressing PPPoE traffic sent by hosts before it is forwarded by the client.

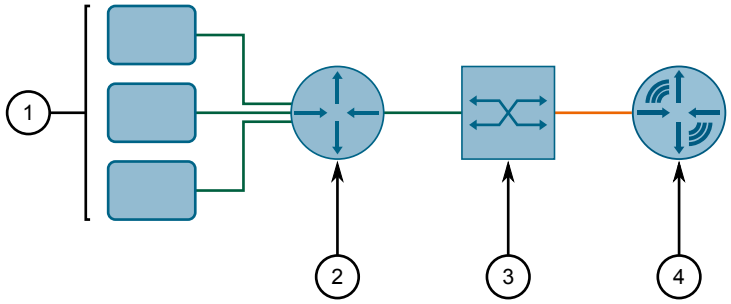
⚠ NOTICE

Security hazard – risk of unauthorized access and/or exploitation

PPPoE communications use protocols that are susceptible to known security issues. Make sure all underlying protocols use strong authentication/encryption to provide security and, where possible, make sure to only use PPPoE in a secure network environment.

10.7.1 Understanding PPPoE

RUGGEDCOM ROX II devices can be configured to act as a services router (or client) for other hosts on the network. The client is connected to modem that has a Digital Subscriber Line (DSL) connection to an ISP's access concentrator (or server). Upon successfully authenticating the PPPoE connection, the ISP grants access to either MPLS or Internet services.



① Hosts
② PPPoE Client (Services Router)
③ DSL Modem
④ PPPoE Server (Access Concentrator)

Figure 10.2

PPPoE Stages

When initialized, PPPoE establishes a connection between the client and server in two stages:

- **Discovery Stage**

  The client finds an available server and establishes a session ID by doing the following:

  - The client broadcasts a PPPoE Active Discovery Initiation (PADI) packet requesting a service.
  - Server's on the LAN that can provide the service reply with a PPPoE Active Discovery Offer (PADO) packet. The PADO includes the server's name, the unicast address of the client, and the service that was requested.
  - Based on the PADO's received, the client selects a server and sends it a PPPoE Active Discovery Request (PADR).
  - The server returns a PPPoE Active Discovery Session-Confirmation (PADS) packet. The packet will include a session ID if the session request is accepted. Otherwise, the packet will include a service name error.

- **Session Stage**

  The server authenticates the client and then negotiates a PPP connection using information collected in the discovery stage.

Once the connection is created an a session is established, all PPPoE packets are encapsulated in the PPPoE and PPP headers.

Authentication Modes

RUGGEDCOM ROX II supports the following authentication modes:

- **PAP** – Password Authentication Protocol
- **CHAP** – Challenge Handshake Authentication Protocol
- **MS-CHAP** – Microsoft Challenge Handshake Authentication Protocol Version 1
- **MS-CHAP2** – Microsoft Challenge Handshake Authentication Protocol Version 2

10.7.2 Managing PPPoE Profiles

A PPPoE profile defines the characteristics of a PPPoE session. This includes defining the maximum packet size, the authentication mode, credentials, and more.

Each PPPoE interface must be mapped to a PPPoE profile.

Multiple PPPoE profiles can be defined, allowing for a variety of different configurations. One such profile could be created to act as a default profile.

10.7.2.1 Viewing a List of PPPoE Profiles

To view a list of PPPoE profiles, type:

```
show running-config global pppoe profiles
```

If profiles have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config global pppoe profiles | tab
                          USE              LCP
                  DEFAULT  PEER  LCP ECHO  ECHO     AUTH
NAME        MTU   ROUTE    DNS   INTERVAL  FAILURE  MODE  USERNAME                PASSWORD
-------------------------------------------------------------------------------------------
pppoe-serv  1452  true     true  4         2        pap   3390006311@company.com
 $4$oe5WCLM68FRwhYYI0d4IDw==

!
```

If no PPPoE profiles have been configured, add profiles as needed. For more information, refer to "Adding PPPoE Profile (Page 439)".

10.7.2.2 Adding PPPoE Profile

To add a PPPoE profile, do the following:

1. Obtain a username and password from the ISP for the PPPoE service.

2. Make sure the CLI is in Configuration mode.
3. Create the PPPoE profile by typing:

   `global pppoe profiles { profile }`

   Where:

   - { profile } is the name of the profile
4. Configure the following parameters as required:

Parameter	Description
`mtu { mtu }`	**Synopsis:** An integer between 16 and 1492 **Default:** 1452 The MTU value for the PPPoE interface.
`default-route { default-route }`	**Synopsis:** [true | false] **Default:** false Enables the default route using this interface whenever it connects.
`use-peer-dns { use-peer-dns }`	**Synopsis:** [true | false] **Default:** false Enables the DNS server entries that the PPPoE server recommends. Enables this option unless you provide your own name servers.
`lcp-echo-interval { lcp-echo-interval }`	**Synopsis:** An integer **Default:** 4 The interval in seconds to send an LCP echo-request frame.
`lcp-echo-failure { lcp-echo-failure }`	**Synopsis:** An integer **Default:** 2 The number of times LCP echo-requests are sent without a valid response. If the number of failures are exceeded, the PPPoE connection will be terminated.
`auth-mode { auth-mode }`	**Synopsis:** [pap | chap | ms-chap | ms-chapv2] **Default:** ms-chapv2 The authentication method used for the PPPoE connection.
`username { username }`	**Synopsis:** A string **Default:** N/A The user ID to connect to the remote server.
`password { password }`	**Synopsis:** A string 255 characters long The password to be authenticated by the remote server.

5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

10.7.2.3 Deleting a PPPoE Profile

To delete a PPPoE profile, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the chosen key by typing:

   ```
   no global pppoe profiles { name }
   ```

   Where:

   - `{ name }` is the name of the profile
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

10.7.3 Managing PPPoE Interfaces

PPPoE interfaces are created automatically whenever PPPoE is enabled for a routable Ethernet port. The interface is created under ***interfaces » pppoe*** and given a name based on the associated Ethernet port. For example, the interface pppoe-1 is associated with port 1.

A maximum of four PPPoE interfaces are supported.

Note
PPPoE interfaces can only be established on switched Ethernet ports that are not in switchport mode. For more information, refer to "Configuring a Switched Ethernet Port (Page 314)".

10.7.3.1 Configuring a PPPoE Interface

To configure a PPPoE interface, do the following:

1. Make sure the CLI is in Configuration mode.
2. Create the PPPoE interface by typing:

   ```
   interface switch swport { port } pppoe profile
   { profile } enabled
   ```

   Where:

   - { port } is the port number (or a list of ports, if aggregated in a port trunk) for the module
   - { profile } is the PPPoE profile
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

10.7.3.2 Viewing PPPoE Statistics

To view statistics collected for each PPPoE interface, type:

```
show  interfaces  pppoe
```

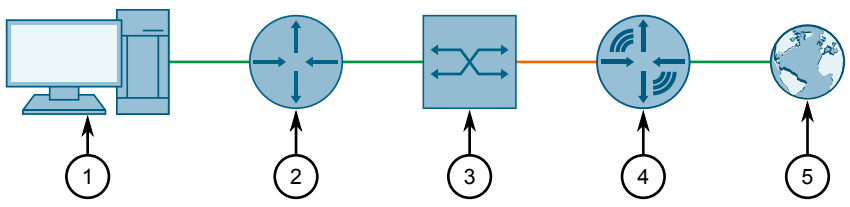
```
ruggedcom# show interfaces pppoe
           CONNECTION
IFNAME     STATUS      LOCAL IP        REMOTE IP     TXBYTES  RXBYTES
-------------------------------------------------------------------------
pppoe-2    up          198.251.59.210  198.251.52.3  960      884
```

This table or list provides the following information:

Parameter	Description
`{ ifname }`	**Synopsis:** A string between 1 and 15 characters long The name of the PPP over Ethernet interface.
`connection-status`	**Synopsis:** [up | down] The status of the connection. Possible values include: • **up** – the PPPoE interface is up and ready to forward packets • **down** – the PPPoE interface is down
`localIp`	**Synopsis:** A string The local IP address assigned by the remote server.
`remoteIp`	**Synopsis:** A string The IP address of the remote server.
`txbytes`	**Synopsis:** An integer The bytes transmitted over the PPPoE link.
`rxbytes`	**Synopsis:** An integer The bytes received over the PPPoE link.

10.7.4 Example: Configuring a PPPoE Connection with an ISP

The following demonstrates how to establish a PPPoE connection with an ISP and provide Internet access to a host.



① Host
② PPPoE Client (Services Router)
③ DSL Modem

④ PPPoE Server (Access Concentrator)
⑤ Internet

Figure 10.3 PPPoE Connection with an ISP

To configure the device, do the following:

1. Add a PPPoE profile with the following settings:

default-route	true
use-peer-dns	true
auth-mode	{ Determined by ISP }
username	{ Provided by ISP }
password	{ Provided by ISP }

   For more information about adding a PPPoE profile, refer to "Adding PPPoE Profile (Page 439)".

2. Enable internal VLANs. For more information, refer to "Configuring the Internal VLAN Range (Page 359)".
3. Commit the changes.
4. Configure a switched Ethernet port as a PPPoE interface. The port must be enabled and not in switchport mode. For more information, refer to "Configuring a PPPoE Interface (Page 441)".
5. Commit the changes.
6. Verify the PPPoE connection over the PPPoE interface. For more information, refer to "Viewing PPPoE Statistics (Page 442)".
7. Since the PPPoE profile was configured to use the default route, verify the default route is installed. For more information, refer to "Viewing the Status of IPv4 Routes (Page 539)".
8. Ping a public IP address to verify access to the Internet. For more information, refer to "Using Network Utilities (Page 27)".
9. Send/receive traffic over the PPPoE connection and then verify the number of bytes sent (TX) and received (RX). For more information, refer to "Viewing PPPoE Statistics (Page 442)".
10. Assign a static IPv4 address to a switched Ethernet port other than the one configured as the PPPoE interface.

    If the port is in switchport mode, the IPv4 address must be assigned to the VLAN interface (e.g. switch.0001). Otherwise, the IPv4 address is assigned to the routing interface (e.g. fe-1).

    For more information, refer to "Adding an IPv4 Address (Page 251)".
11. Ping the local host to verify the connection. For more information, refer to "Using Network Utilities (Page 27)".
12. [Optional] Configure and enable a firewall before connecting the device to a public network. Make sure the firewall is configured to accept connections from

a specific domain and deny all other traffic. The firewall should also enable NAT masquerading. For more information, refer to "Managing Firewalls (Page 217)".

13. Commit the changes.
14. Ping the device from the local host to the public Internet address, and verify the traffic received on the PPPoE interface using Tcpdump. For more information, refer to "Using Network Utilities (Page 27)".

11 Tunneling and VPNs

This chapter describes how to configure various tunnels and Virtual Private Networks (VPNs).

11.1 Managing Virtual Switches

Virtual switches bridge different network segments together in a way that is independent of any particular protocol.

Network traffic between segments is forwarded regardless of the IP and MAC addresses defined in the packet. In a virtual switch, forwarding is done in Layer 2 and allows all network traffic, including Layer 2 Multicast (i.e. GOOSE, ISO), IP Multicast, Unicast and Broadcast messages, to travel through the virtual switch tunnel without any modifications.

A virtual switch can be useful, in particular, for GOOSE messaging when the sender and receiver need to communicate through a routable IP network. Since there is no IP encapsulation for the Layer 2 traffic going through the virtual switch, network latency is minimized for the traffic between end devices.

The virtual switch appears on the device as a virtual Ethernet interface over a physical interface (i.e. Ethernet port) between two routers. Physically, the two routers can be in different locations.

There can be multiple virtual switch instances in a router. Each instance can include two or more interfaces, but an interface can only be a member of one virtual switch instance.

A virtual switch interface in a router can be a routable interface when an IP address is assigned either statically or through DHCP. The network address assigned to the virtual switch interface can be included in the dynamic routing protocol. The interface can also call a routing update. The IP address assigned to the virtual switch can be used as the default gateway for the end devices connected to the virtual switch interface. Network services, such as SSH, DHCP, NTP, VRRP, etc., can be configured to run on the virtual switch interface.

Network traffic can be filtered for select virtual switch interfaces based on destination MAC address, source MAC address, and/or protocol (e.g. iso, arp, ipv4, ipv6, etc.). If a packet meets the filter criteria, it is routed to the appropriate destination. Otherwise, it is dropped.

When configuring a virtual switch, be aware of the following:

- Be careful when adding a VLAN interface (assigned to a switch port on a given line module) in the virtual switch. The VLAN tag on a tagged frame received on the VLAN interface of a switch port may not be preserved when the traffic is

egressed through a routable interface (i.e. cel1 or switch.0001), which is also part of the same virtual switch instance. However, a VLAN tag is preserved when tagged traffic is received on a routable interface.

- Any IP address assigned to an interface becomes inactive and hidden when the interface is added to the virtual switch. The address on the interface is reactivated after removing the interface from the virtual switch.
- Be careful when adding interfaces to the virtual switch. Any network services running on the individual interfaces will need to be reconfigured after adding the interface to the virtual switch. For example, if a DHCP server running on switch.0001 is subsequently made a member of the VirtualSwitch vsw-1, the DHCP configuration must be changed to refer to vsw-1.
- The virtual switch is implemented in the RUGGEDCOM ROX II software. Therefore, a CPU resource is needed to forward broadcast, multicast and unicast traffic.
- If the router is running as a firewall, the **routeback** parameter under ***firewall » fwconfig » fwinterface*** must be enabled for the virtual switch interface. For more information, refer to "Managing Interfaces (Page 227)".

11.1.1 Viewing a List of Virtual Switches

To view a list of virtual switches, type:

```
show  running-config  interface  virtualswitch
```

If virtual switches have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config interface virtualswitch
interface
 virtualswitch vs1
  retain-ip
  no alias
  no proxyarp
  interface fe-cm-1
  !
 !
!
```

If no virtual switches have been configured, add virtual switches as needed. For more information, refer to "Adding a Virtual Switch (Page 446)".

11.1.2 Adding a Virtual Switch

To add a virtual switch, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the virtual switch by typing:

```
interface  virtualswitch  { name }
```

Where:

- `{ name }` is the name assigned to the virtual switch

3. Configure the following parameter(s) as required:

Parameter	Description
`enabled { enabled }`	**Synopsis:** [true | false] **Default:** true Enables this interface.
`retain-ip { retain-ip }`	**Synopsis:** [true | false] **Default:** false Retain IP on bridge device.
`forward-delay { forward-delay }`	**Synopsis:** An integer **Default:** 15 Delay (in seconds) of the listening and learning state before goes to forwarding state.
`alias { alias }`	**Synopsis:** A string 64 characters long The SNMP alias name of the interface
`ip-address-src { ip-address-src }`	**Synopsis:** [static | dynamic] **Default:** static Whether the IP address is static or dynamically assigned via DHCP or BOOTP.
`ipv6-address-src { ipv6-address-src }`	**Synopsis:** [static | dynamic] **Default:** static Whether the IPv6 address is static or dynamically assigned via DHCPv6.
`proxyarp`	Enables/Disables whether the port will respond to ARP requests for hosts other than itself

4. Add one or more interfaces for the virtual switch. For more information, refer to "Adding a Virtual Switch Interface (Page 449)".
5. If **ip-address-src** or **ipv6-address-src** is set to **static**, assign an IP address to the virtual switch if required. For more information, refer to either "Adding an IPv4 Address (Page 251)" or "Adding an IPv6 Address (Page 252)".
6. [Optional] Assign one or more VLANs to the virtual switch. For more information, refer to "Adding a Virtual Switch VLAN (Page 457)".
7. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.1.3 Deleting a Virtual Switch

To delete a virtual switch, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the chosen virtual switch by typing:

   ```
   no interface virtualswitch { name }
   ```

   Where:

   - `{ name }` is the name assigned to the virtual switch
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.1.4 Managing Virtual Switch Interfaces

This section describes how to configure and manage interfaces for virtual switches.

11.1.4.1 Viewing a List of Virtual Switch Interfaces

To view a list of virtual switch interfaces, type:

```
show running-config interface virtualswitch { name } interface
```

Where:

- `{ name }` is the name assigned to the virtual switch

If virtual switch interfaces have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config interface virtualswitch vs1 interface | tab
NAME
-----------------
switch.0100


 !
!
```

If no virtual switch interfaces have been configured, add interfaces as needed. For more information, refer to "Adding a Virtual Switch Interface (Page 449)".

11.1.4.2 Adding a Virtual Switch Interface

To add a virtual switch interface, do the following:

Note
At least two interfaces are required for a virtual switch bridge.

⚠ NOTICE

Accessibility hazard – risk of access disruption

Do not select the interface used to the access the Web interface. Active Web sessions will be lost and the Web interface will be unreachable until the virtual switch is disabled.

Note
The *wlan-cl1* interface is not supported as a virtual switch interface.

1. Make sure the CLI is in Configuration mode.
2. Add an interface to the virtual switch by typing:

   ```
   interface virtualswitch { name } interface
   { interface }
   ```

   Where:

   - `{ name }` is the name assigned to the virtual switch
   - `{ interface }` is the name assigned to the interface

   The new interface is now accessible by typing:

   ```
   ip vsw- { name }
   ```

   The new virtual switch is now visible under the **ip** menu with the prefix *vsw-* (i.e. vsw-vs1, vsw-vs2, etc.).
3. Assign an IPv4 or IPv6 address to the interface. For more information, refer to "Adding an IPv4 Address (Page 251)" or "Adding an IPv6 Address (Page 252)".
4. If necessary, add one or more VLANs to the virtual switch interface. For more information, refer to "Adding a Virtual Switch VLAN (Page 457)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.1.4.3 Deleting a Virtual Switch Interface

To delete a virtual switch interface, do the following:

1. Make sure the CLI is in Configuration mode.

2. Delete the chosen virtual switch interface by typing:

   ```
   no interface virtualswitch { name } interface
   { interface }
   ```

   Where:

   - `{ name }` is the name assigned to the virtual switch
   - `{ interface }` is the name assigned to the interface

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.1.5 Filtering Virtual Switch Traffic

Packets traversing a virtual switch can be filtered based on source MAC address, destination MAC address, and/or protocol (e.g. iso, arp, ipv4, ipv6, etc.). Rules are defined separately and can be applied uniquely to each virtual switch as needed. For example, a single filter can detect traffic destined for a specific MAC address entering via fe-cm-1 and reroute it to switch-001. At the same time, It can also detect and drop any other type of traffic. By default, virtual switch filters drop packets unless otherwise configured.

11.1.5.1 Enabling/Disabling Virtual Switch Filtering

To enable or disable virtual switch filtering, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable or disable virtual switch filtering by typing:

   Enabling Virtual Switch Filtering

   ```
   security virtualswitch-filter enabled
   ```

   Disabling Virtual Switch Filtering

   ```
   no security virtualswitch-filter enabled
   ```

3. If enabled, enable **Retain IP on Bridge Device** for the appropriate virtual switches. This feature enables/disables the switch's ability to retain an Ethernet interface's IP address when it is added to the bridge. When enabled, the IP address is retained and the router can be remotely accessed via the Ethernet interface. When disabled, the IP address must be assigned to the bridge to remotely access the router.

   For more information about enabling/disabling the **Retain IP on Bridge Device** feature, refer to "Adding a Virtual Switch (Page 446)".

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.1.5.2 Viewing a List of Virtual Switch Filters

To view a list of virtual switch filters, type:

```
show running-config security virtualswitch-filter
virtualswitch
```

If filters have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config security virtualswitch-filter virtualswitch | tab
IF
NAME  NAME   ROUTE  NAME         NAME
-----------------------------------------------
vs1
      arp    X
      ipv4   X
      ipv6   -
                    switch.0010
                                 switch.0020
      iso    -
                    switch.0010
                                 switch.0020
      goose  -
                    switch.0010
                                 switch.0020

 !
!
```

If no virtual switch filters have been configured, add filters as needed. For more information, refer to "Adding a Virtual Switch Filter (Page 451)".

11.1.5.3 Adding a Virtual Switch Filter

To add a virtual switch filter, do the following:

1. Make sure the CLI is in Configuration mode.
2. Make sure one or more virtual switches are configured. For more information, refer to "Adding a Virtual Switch (Page 446)".
3. Add the virtual switch filter by typing:

   ```
   security virtualswitch-filter virtualswitch
   { interface }
   ```

   Where:

   - `{ interface }` is a virtual switch interface
4. Configure one or more rules to be used when filtering. For more information, refer to "Adding a Rule (Page 453)".
5. Add the desired rules to the virtual switch filter. For more information, refer to "Adding a Rule to a Virtual Switch Filter (Page 454)".
6. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.1.5.4 Deleting a Virtual Switch Filter

To delete a virtual switch filter, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the virtual switch filter by typing:

   ```
   no security virtualswitch-filter virtualswitch
   { name }
   ```

   Where:

   - `{ name }` is the name of the virtual switch filter
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.1.6 Managing Filtering Rules

A virtual switch filter can apply one or more rules to traffic traversing a virtual switch.

11.1.6.1 Viewing a List of Rules

To view a list of rules that can be used by a virtual switch filter, type:

```
show running-config security virtualswitch-filter rules
```

If rules have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config security virtualswitch-filter rules | tab
NAME   ACTION  SRCMAC             DSTMAC             PROTO
-------------------------------------------------------------
arp    accept  -                  -                  arp
goose  accept  00:00:00:00:11:11  01:0c:cd:01:00:33  0x88b8
ipv4   accept  00:00:00:00:00:01  00:00:00:00:00:02  ipv4
ipv6   accept  -                  -                  ipv6
iso    accept  -                  -                  iso

 !
!
```

If no rules have been configured, add rules as needed. For more information, refer to "Adding a Rule (Page 453)".

11.1.6.2 Viewing a List of Rules Assigned to a Virtual Switch Filter

To view a list of rules assigned to a virtual switch filter, type:

```
show running-config security virtualswitch-filter
virtualswitch { name } rule
```

Where:

- `{ name }` is the name of the virtual switch filter

If rules have been assigned, a table or list similar to the following example appears:

```
ruggedcom# show running-config security virtualswitch-filter virtualswitch vs1 rule
 | tab
NAME   ROUTE  NAME         NAME
----------------------------------------
arp    X
ipv4   X
ipv6   -
               switch.0010
                            switch.0020
iso    -
               switch.0010
                            switch.0020
goose  -
               switch.0010
                            switch.0020

  !
 !
!
```

If no rules have been assigned, assign them as needed. For more information, refer to "Adding a Rule to a Virtual Switch Filter (Page 454)".

11.1.6.3 Adding a Rule

To add a rule that can be used by a virtual switch filter, do the following:

1. Make sure the CLI is in Configuration mode.
2. Make sure one or more virtual switches are configured. For more information, refer to "Adding a Virtual Switch (Page 446)".
3. Add the virtual switch filter by typing:

   ```
   security virtualswitch-filter rules { rule }
   ```

   Where:

   - `{ rule }` is the name of the rule
4. Configure the following parameter(s) as required:

Parameter	Description
`action { action }`	**Synopsis:** [accept | drop] **Default:** accept The action taken when an incoming frame meets the criteria.
`srcmac { srcmac }`	**Synopsis:** A string 17 characters long The required source MAC address for incoming frames.
`dstmac { dstmac }`	**Synopsis:** A string 17 characters long The required destination MAC address for incoming frames.

Parameter	Description
`proto { proto }`	**Synopsis:** A string or [iso | arp | ipv4 | ipv6 | goose] The pre-defined protocol or hex-string (i.e. 0x88A2) used to create the frames.
`goose-ied-name { goose-ied-name }`	**Synopsis:** A string 32 characters long The name of the IED device. Only applicable to the GOOSE protocol.

5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.
6. Add the rule to a virtual switch filter. For more information, refer to "Adding a Rule to a Virtual Switch Filter (Page 454)".

11.1.6.4 Adding a Rule to a Virtual Switch Filter

To add a rule to a virtual switch filter, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the rule by typing:

   ```
   security virtualswitch-filter virtualswitch { name } rule { rule }
   ```

   Where:

   - `{ name }` is the name of the virtual switch filter
   - `{ rule }` is the name of the rule
3. Configure the in/out interfaces for the rule. For more information, refer to "Adding an In/Out Interface (Page 456)".
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.1.6.5 Deleting a Rule

To delete a rule used to filter virtual switch traffic, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the rule by typing:

   ```
   no security virtualswitch-filter rules { rule }
   ```

   Where:

   - `{ rule }` is the name of the rule
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.1.6.6 Deleting a Rule from a Virtual Switch Filter

To delete a rule from a virtual switch filter, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the filter by typing:

   ```
   no security virtualswitch-filter virtualswitch { name } rule { rule }
   ```

   Where:

   - `{ name }` is the name of the virtual switch filter
   - `{ rule }` is the name of the rule
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.1.7 Managing In/Out Interfaces

In/out interfaces for virtual switch filters represent the interface being monitored by the filter (*in* interface) and the destination interface (*out* interface) for network traffic that meets the filter's criteria.

11.1.7.1 Viewing a List of In/Out Interfaces

To view a list of in/out interfaces that can be used by a virtual switch filter, type:

```
show running-config security virtualswitch-filter virtualswitch { name } rule { rule } [ in-interface | out-interface ]
```

Where:

- `{ name }` is the name of the virtual switch filter
- `{ rule }` is the name of the rule

If in/out interfaces have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config security virtualswitch-filter virtualswitch vs1 rule
 in-interface | tab
NAME   NAME
--------------------
ipv6
       switch.0010
iso
       switch.0010
goose
       switch.0010

  !
 !
!
```

If no in/out interfaces have been configured, add interfaces as needed. For more information, refer to "Adding an In/Out Interface (Page 456)".

11.1.7.2 Adding an In/Out Interface

To add an in/out interface that can be used by a virtual switch filter, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the in/out interface by typing:

   ```
   security virtualswitch-filter virtualswitch { name }
   rule { rule } [ in-interface | out-interface ]
   { interface }
   ```

   Where:

   - `{ name }` is the name of the virtual switch filter
   - `{ rule }` is the name of the rule
   - `{ interface }` is the name of the interface
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.1.7.3 Deleting an In/Out Interface

To delete an in/out interface that can be used by a virtual switch filter, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the interface by typing:

   ```
   no security virtualswitch-filter virtualswitch
   { name } rule { rule } [ in-interface | out-
   interface ] { interface }
   ```

   Where:

   - `{ name }` is the name of the virtual switch filter
   - `{ rule }` is the name of the rule
   - `{ interface }` is the name of the interface
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.1.8 Managing VLANs for Virtual Switches

This section describes how to configure and manage VLANs for virtual switches.

11.1.8.1 Viewing a List of Virtual Switch VLANs

To view a list of virtual switch VLANs, type:

```
show running-config interface virtualswitch { id } vlan
```

Where:

- `{ id }` is the ID assigned to the virtual switch

If VLANs have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config interface virtualswitch 1 vlan | tab
     IP
     ADDRESS
VID  SRC      QOS  INGRESS  MARK
---------------------------------
100  static

 !
!
```

If no virtual switch VLANs have been configured, add VLANs as needed. For more information, refer to "Adding a Virtual Switch VLAN (Page 457)".

11.1.8.2 Adding a Virtual Switch VLAN

To add virtual switch VLAN, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the VLAN by typing:

   ```
   interface virtualswitch { id } vlan { vlan-id }
   ```

   Where:

   - `{ id }` is the ID assigned to the virtual switch
   - `{ vlan-id }` is the ID assigned to the VLAN
3. Configure the following parameter(s) as required:

Parameter	Description
`ip-address-src { ip-address-src }`	**Synopsis:** [static | dynamic] **Default:** static Whether the IP address is static or dynamically assigned via DHCP or BOOTP.
`ipv6-address-src { ipv6-address-src }`	**Synopsis:** [static | dynamic] **Default:** static Whether the IPv6 address is static or dynamically assigned via DHCPv6

4. [Optional] Add a QoS map. For more information, refer to "Adding a QoS Map (Page 877)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.1.8.3 Deleting a Virtual Switch VLAN

To delete a virtual switch VLAN, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the chosen VLAN by typing:

   ```
   no interface virtualswitch { id } vlan { vlan-id }
   ```

   Where:

   - `{ id }` is the ID assigned to the virtual switch
   - `{ vlan-id }` is the ID assigned to the VLAN
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.2 Managing the Layer2 Tunnel Daemon

RUGGEDCOM ROX II is capable of extending the range of services that communicate solely via Layer 2 protocols (i.e. at the level of Ethernet) by tunneling them over routed IP networks. The Layer 2 Tunnel Daemon supports the IEC61850 GOOSE protocol as well as a generic mechanism for tunneling by Ethernet type.

11.2.1 Viewing Round Trip Time Statistics

The round trip time statistics reflect the measured round trip time to each remote daemon. The minimum, average, maximum and standard deviation of times is presented. Entries with a large difference between the `transmitted` and `received` parameters indicate potential problems.

To view the round trip time statistics, type:

Note
Round trip time statistics are only available when remote daemon IP addresses are configured for generic tunnels. For more information about remote daemon IP addresses, refer to "Managing Remote Daemon IP Addresses for Generic Tunnels (Page 486)".

```
show tunnel l2tunneld status round-trip-time
```

A table or list similar to the following example appears:

```
ruggedcom# show tunnel l2tunneld status round-trip-time
                                    MINIMUM   AVERAGE   MAXIMUM
REMOTE IP    TRANSMITTED  RECEIVED  RTT       RTT       RTT       DEVIATION
-------------------------------------------------------------------------------
192.168.5.1  45           42        0.277000  0.917000  3.735000  0.556000
```

This table or list provides the following information:

Parameter	Description
`transmitted`	**Synopsis:** An integer The number of beacon frames transmitted through the tunnel.
`received`	**Synopsis:** An integer The number of beacon frames received through the tunnel.
`minimum-rtt`	**Synopsis:** A string 32 characters long The Minimum Beacon Round-Trip-Time.
`average-rtt`	**Synopsis:** A string 32 characters long The Average Beacon Round-Trip-Time.
`maximum-rtt`	**Synopsis:** A string 32 characters long The Maximum Beacon Round-Trip-Time.
`deviation`	**Synopsis:** A string 32 characters long The standard deviation.

11.2.2 Configuring the Layer 2 Tunnel Daemon

To configure the Layer 2 tunnel daemon, do the following:

⚠ NOTICE

Make sure there are no traffic loops possible between the substation LAN and other LANs that could forward GOOSE frames to the LAN. Do not employ a GOOSE gateway between substations that are already connected. The GOOSE daemon issues packets to the network with a built in Time-To-Live (TTL) count that is decremented with each transmission. This prevents an infinite loop of packets, but will not prevent excessive network utilization.

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***tunnel » l2tunneld*** and configure the following parameter(s) as required:

Parameter	Description
`enabled`	Enables the Layer 2 protocols server.
`udp-port { udp-port }`	**Synopsis:** An integer between 1 and 65535 **Default:** 1311 The UDP port to communicate with the other daemon.

Parameter	Description
`beacon-interval { beacon-interval }`	**Synopsis:** An integer between 10 and 3600 or [off] **Default:** 60 The Round Trip Time (RTT) of the sent message

3. Add GOOSE or generic tunnels as required. For more information, refer to "Adding a GOOSE Tunnel (Page 480)" or "Adding a Generic Tunnel (Page 485)".
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.3 Managing L2TP Tunnels

The Layer Two Tunneling Protocol (L2TP) is used primarily to tunnel Point-to-Point Protocol (PPP) packets through an IP network, although it is also capable of tunneling other Layer 2 protocols.

RUGGEDCOM ROX II utilizes L2TPD in conjunction with Libreswan and PPP to provide support for establishing a secure, private connection with the router using the Microsoft Windows VPN/L2TP client.

⚠ NOTICE

L2TPD listens on UDP port 1701. If a firewall is enabled, it must be configured to only allow connections to L2TPD through IPsec. Direct connections to L2TPD must be prevented.

11.3.1 Configuring L2TP Tunnels

To configure L2TP tunnels, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***tunnel » l2tp*** and configure the following parameter(s) as required:

Parameter	Description
`enabled`	Enables L2TP.
`local-ip { local-ip }`	**Synopsis:** A string between 7 and 15 characters long The local IP address. When set, all L2TP interfaces (l2tp-ppp-0, l2tp-ppp-1, etc.) will use the same IP address. To use different local IP addresses (chosen from an IP pool) for different L2TP interfaces, leave this parameter empty.
`first-ip { first-ip }`	**Synopsis:** A string between 7 and 15 characters long The first address in the IP address pool. If local-ip is not set, both local and remote IP addresses will be taken from this pool.

Parameter	Description
`max-connection { max-connection }`	**Synopsis:** An integer between 1 and 10 The maximum number of connections.
`closing-wait-timeout { closing-wait-timeout }`	**Synopsis:** An integer between 5 and 120 **Default:** 60 The number of seconds to wait before the tunnel is cleaned up after the tunnel moves to closing-wait state.

3. Configure Domain Name System (DNS) or Windows Internet Name Service (WINS) servers. For more information, refer to either "Configuring DNS Servers (Page 461)" or "Configuring WINS Servers (Page 462)".
4. Configure L2TP tunnels to carry Point-to-Point Protocol (PPP) sessions. For more information, refer to "Configuring PPP Options (Page 461)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.3.2 Configuring DNS Servers

To configure redundant Domain Name System (DNS) servers for L2TP tunnels, do the following:

1. Make sure the CLI is in Configuration mode.
2. Configure the primary and secondary DNS servers by typing:

   ```
   tunnel l2tp dns-server primary { primary-ip } secondary { secondary-ip }
   ```

   Where:

   - { primary-ip } is the IP address of the primary DNS server
   - { secondary-ip } is the IP address of the secondary DNS server
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.3.3 Configuring PPP Options

To configure L2TP tunnels to carry Point-to-Point Protocol (PPP) sessions, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***tunnel » l2tp » ppp*** and configure the following parameter(s) as required:

Note
If **Authorize Locally** is not enabled, L2TP will use RADIUS authentication. For more information about configuring RADIUS authentication for the PPP services, refer to "Configuring RADIUS Authentication for PPP Services (Page 169)".

Parameter	Description
`auth-local`	Authorizes locally instead of using radius server.
`mtu { mtu }`	**Synopsis:** An integer between 68 and 1410 **Default:** 1410 Maximum transmission unit (largest packet size allowed for this interface).
`mru { mru }`	**Synopsis:** An integer between 68 and 1410 **Default:** 1410 The Maximum Receive Unit (MRU) or maximum packet size passed when received.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.3.4 Configuring WINS Servers

To configure redundant Domain Name System (WINS) servers for L2TP tunnels, do the following:

1. Make sure the CLI is in Configuration mode.
2. Configure the primary and secondary WINS servers by typing:

   ```
   tunnel l2tp WINS-server primary { primary-ip } secondary { secondary-ip }
   ```

   Where:

   - { primary-ip } is the IP address of the primary WINS server
   - { secondary-ip } is the IP address of the secondary WINS server

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.4 Managing L2TPv3 Tunnels

L2TPv3 (Layer 2 Tunneling Protocol Version 3) provides a pseudo-wire service that encapsulates multi-protocol Layer 2 traffic over IP networks. There are no restrictions on the Layer 2 data formats that can be transmitted or received, unlike L2TP.

L2TPv3 is a simplified alternative to MPLS (Multiprotocol Label Switching) that offers improved performance (e.g. high data packet rate and low CPU consumption) over L2TP and IP networks.

Two types of L2TPv3 tunnels are available:

- **Static**

  A static L2TPv3 tunnel is a fixed connection between two Provider Edge devices (PE), where the session IDs and cookies are defined on both devices. This allows the devices to route Layer 2 traffic as soon as the session connects with the attachment circuit.

- **Dynamic**

  A dynamic LTPv3 tunnel creates sessions based on the dynamic exchange of control messages between the PE devices to determine the type of Layer 2 traffic that needs to be routed. Session IDs and cookies are generated by the devices themselves for each session. This allows L2TPv3 to reestablish sessions automatically in the case of a network failure.

⚠ NOTICE
RUGGEDCOM ROX II supports a maximum of 128 tunnel sessions, which in turn support a maximum of 128 VLANs each.

11.4.1 L2TPv3 Tunnel Scenarios

The following illustrates some of the ways in which L2TPv3 tunnels can be implemented.

Basic L2TPv3 Tunnel

In the following topology, an L2TPv3 tunnel is established between routers R1 and R2 over a WAN interface. The tunnel interface is assigned an IPv4 address on both devices. Traffic routed from R1 is encapsulated in an L2TPv3 header and decapsulated by R2. The reverse is true when traffic is routed from R2.

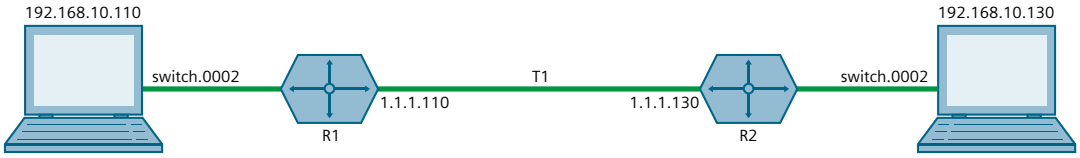


Figure 11.1 Basic L2TPv3 Tunnel

Multiple Sessions

In the following topology, separate bridges have been created between routers R1 and R2 using sessions. Traffic sent via virtual switch switch.0002 traverses the l2t-1-1 tunnel. Traffic sent via virtual switch switch.0003 traverses the l2t-1-2 tunnel.

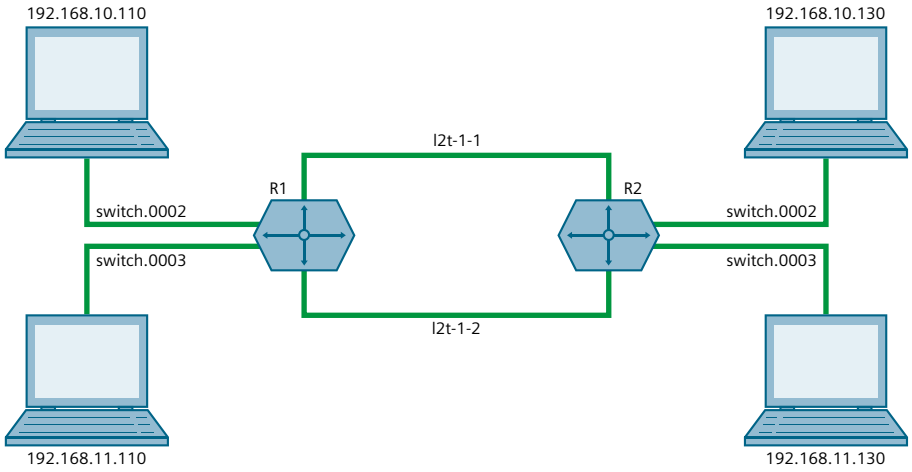


Figure 11.2 Multiple LAN Extensions Over a Single L2TPv3 Tunnel

Multiple L2TPv3 Tunnels

In the following topology, two L2TPv3 tunnels are configured: one from router R1 to R2, and another from R1 to R3. Each is converted to a bridge by the switch.0002 virtual switch.

Traffic sent from 192.158.10.110 to 192.168.10.130 traverses the l2t-1-1 bridge, and vice versa.

Traffic sent from 192.158.10.110 to 192.168.11.110 traverses the l2t-2-1 bridge, and vice versa.

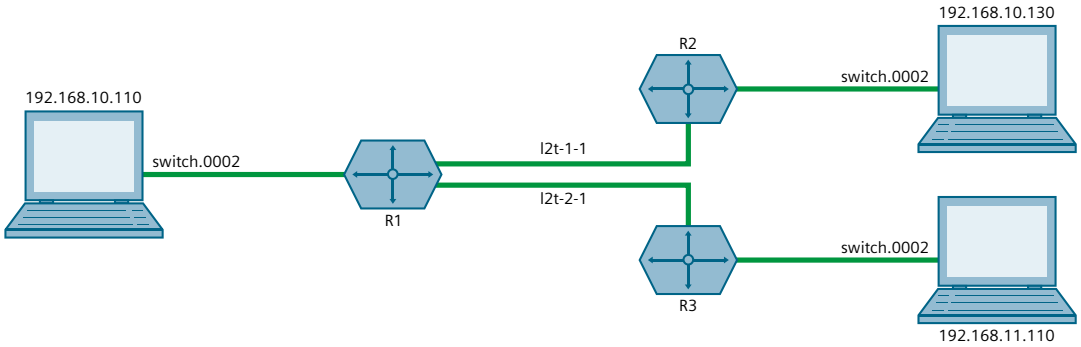


Figure 11.3 Multiple LAN Extensions Over Multiple L2TPv3 Tunnels

11.4.2 Creating an L2TPv3 Tunnel

To create an L2TPv3 tunnel with another Provider Edge (PE) device, do the following:

1. **Create the L2TPv3 Tunnel Interface**

An L2TPv3 tunnel interface is created automatically by RUGGEDCOM ROX II whenever a session is defined. The interface is listed under **ip** in the menu and adheres to the following naming convention:

```
l2t-{tunnel-name}-{session-name}
```

For example:

l2t-1-2

If the session is assigned a VLAN ID, an additional interface is generated in the form of:

```
l2t-{tunnel-name}-{session-name}.{vlan-id}
```

For example:

l2t-1-2.0004

To create the tunnel interface, start by adding a static or dynamic L2TPv3 tunnel. For more information, refer to either "Adding a Static L2TPv3 Tunnel (Page 466)" or "Adding a Dynamic L2TPv3 Tunnel (Page 469)".

2. **Create a Virtual Switch or Assign an IP Address**

   The L2TPv3 tunnel interface is an Ethernet-like interface. As such, it can be added to a virtual switch to form a bridge, or assigned an IP address to route Layer 3 traffic.

   For information about adding the L2TPv3 tunnel interface to a virtual switch, refer to "Adding a Virtual Switch Interface (Page 449)".

   For information about assigning an IP address to the L2TPv3 tunnel interface, refer to either "Managing IPv4 Addresses (Page 250)" or "Managing IPv6 Addresses (Page 252)".

11.4.3 Managing Static L2TPv3 Tunnels

Configure static L2TPv3 tunnels to manually control tunnel and sessions parameters at both ends of the bridge. These fixed tunnels are referred to as *unmanaged*.

11.4.3.1 Enabling/Disabling Static L2TPv3 Tunnels

To enable or disable static L2TPv3 tunnels, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable or disable static L2TPv3 tunnels by typing:

   Enabling Tunnels

   ```
   tunnel  l2tpv3  static  enabled
   ```

   Disabling Tunnels

```
no tunnel l2tpv3 static enabled
```

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.4.3.2 Viewing a List of Static L2TPv3 Tunnels

To view a list of static L2TPv3 tunnels, type:

```
show running-config tunnel l2tpv3 static tunnel
```

If tunnels have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config tunnel l2tpv3 static tunnel
tunnel
 l2tpv3 static tunnel 1
  tunnel-id        1
  remote-tunnel-id 2
  transport-encap  udp
  local-ip         192.168.0.10
  local-port       1024
  remote-ip        192.168.0.11
  remote-port      1025
  session 1
   local-session-id       10
   remote-session-id      20
   l2tp-specific-sublayer default
   vlan 4
   !
  !
  session 2
   local-session-id       30
   remote-session-id      40
   l2tp-specific-sublayer default
  !
 !
!
```

If no tunnels have been configured, add tunnels as needed. For more information, refer to "Adding a Static L2TPv3 Tunnel (Page 466)".

11.4.3.3 Adding a Static L2TPv3 Tunnel

To add a static L2TPv3 tunnel, do the following:

1. Make sure the CLI is in Configuration mode.

Note
The tunnel name must consist of one to three numeric and/or lowercase alphanumeric characters.

2. Add the tunnel by typing:

   ```
   tunnel l2tpv3 static tunnel { name }
   ```

   Where { name } is the name of the tunnel.

3. Configure the following parameter(s) as required:

Parameter	Description
`enabled { enabled }`	**Synopsis:** [true | false] **Default:** true Enables/Disables the tunnel
`tunnel-id { tunnel-id }`	**Synopsis:** An integer between 1 and 65535 The local tunnel-id
`remote-tunnel-id { remote-tunnel-id }`	**Synopsis:** An integer between 1 and 65535 Tunnel-id of remote tunnel endpoint
`transport-encap { transport-encap }`	**Synopsis:** [udp | ip] **Default:** udp The transport protocol (UDP or IP) to encapsulate the tunnel messages
`local-ip { local-ip }`	**Synopsis:** A string between 7 and 15 characters long or A string between 6 and 40 characters long Ip address of local interface
`local-port { local-port }`	**Synopsis:** An integer between 1024 and 65535 Local listening transport port for tunnel service
`remote-ip { remote-ip }`	**Synopsis:** A string between 7 and 15 characters long or A string between 6 and 40 characters long Ip address of remote tunnel endpoint
`remote-port { remote-port }`	**Synopsis:** An integer between 1024 and 65535 The listening transport port of remote device for tunnel service

4. Add one or more sessions to the tunnel configuration. For more information, refer to "Adding a Session (Page 472)".
5. Enter `enable` to enable the tunnel.
6. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.4.3.4 Deleting a Static L2TPv3 Tunnel

To delete a static L2TPv3 tunnel, do the following:

1. Make sure the CLI is in Configuration mode.

2. Delete the tunnel by typing:

   ```
   no tunnel l2tpv3 static tunnel { name }
   ```

   Where { name } is the name of the tunnel.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.4.4 Managing Dynamic L2TPv3 Tunnels

Configure dynamic L2TPv3 tunnels to carry Point-to-Point Protocol (PPP) traffic, as with L2TPv2, or when static L2TPv3 tunnels are not supported by the peer device. Dynamic L2TPv3 tunnels have the ability to automatically negotiate connections, and reestablish connections in the case of a network failure.

11.4.4.1 Enabling and Configuring Dynamic L2TPv3 Tunnels

To enable and configure dynamic L2TPv3 tunnels, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable dynamic L2TPv3 tunnels by typing:

   ```
   tunnel l2tpv3 dynamic enabled
   ```

3. Configure the following parameters as required:

Parameter	Description
`mode { mode }`	**Synopsis:** [lac | lns] **Default:** lns The l2tp operational mode
`log-level { log-level }`	**Synopsis:** [none | error | warning | notice | info | all] **Default:** none Logging message level
`log-message { log-message }`	**Synopsis:** [none | protocol | fsm | api | transport | data | ppp | avp | func | system | all] **Default:** none Logging message category

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.4.4.2 Viewing a List of Dynamic L2TPv3 Tunnels

To view a list of dynamic L2TPv3 tunnels, type:

```
show running-config tunnel l2tpv3 dynamic tunnel
```

If tunnels have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config tunnel l2tpv3 dynamic tunnel
tunnel
 l2tpv3 dynamic tunnel 1
  hostname       ruggedcom
  authentication none
  digest         md5
  interop        0
 !
!
```

If no tunnels have been configured, add tunnels as needed. For more information, refer to "Adding a Dynamic L2TPv3 Tunnel (Page 469)".

11.4.4.3 Adding a Dynamic L2TPv3 Tunnel

To add a dynamic L2TPv3 tunnel, do the following:

1. Make sure the CLI is in Configuration mode.

   Note
   The tunnel name must consist of one to three numeric and/or lowercase alphanumeric characters.

2. Add the tunnel by typing:

   ```
   tunnel l2tpv3 dynamic tunnel { name }
   ```

   Where { name } is the name of the tunnel.

3. Configure the following parameter(s) as required:

   Note
   Transport encapsulation is only configurable when Dynamic L2TPv3 is in **lac** mode.

Parameter	Description
`enabled { enabled }`	**Synopsis:** [true | false] **Default:** true Enables/Disables the tunnel
`remote-ip { remote-ip }`	**Synopsis:** A string between 7 and 15 characters long or A string between 6 and 40 characters long Ip address of remote tunnel endpoint

Parameter	Description
`hostname { hostname }`	**Synopsis:** A string between 1 and 63 characters long Hostname used in AVP
`local-ip { local-ip }`	**Synopsis:** A string between 7 and 15 characters long or A string between 6 and 40 characters long IP address of local interface that is used as Source IP address of outbound traffic over tunnel.
`transport-encap { transport-encap }`	**Synopsis:** [udp | ip] **Default:** udp The transport protocol (UDP or IP) to encapsulate the tunnel messages
`authentication { authentication }`	**Synopsis:** [none | challenge] **Default:** none The authentication of tunnel
`secret { secret }`	**Synopsis:** A string between 1 and 63 characters long The password of tunnel negotiation
`digest { digest }`	**Synopsis:** [md5 | sha1] **Default:** md5 Message digest AVP encryption
`interop { interop }`	**Synopsis:** An integer between 0 and 65535 **Default:** 0 Specify a bitmask of flags to control non-standard behaviour for interopability with other L2TPv3 implementation
`persist-pend-timeout { persist-pend-timeout }`	**Synopsis:** An integer between 10 and 6000 **Default:** 60 The time (in seconds) that a persisting tunnel will wait in RETRY state before trying to establish itself again
`hello { hello }`	**Synopsis:** An integer between 5 and 1000 **Default:** 60 timeout used for periodic L2TP Hello messages (in seconds)
`hidden { hidden }`	**Synopsis:** [true | false] **Default:** false Enables/Disabled AVP hidden
`receive-windows { receive-windows }`	**Synopsis:** An integer between 5 and 512 **Default:** 10 Received windows size
`established-timeout { established-timeout }`	**Synopsis:** An integer between 30 and 1000 **Default:** 120 The time (in seconds) that a tunnel will wait for the peer to complete the tunnel setup message exchange

Parameter	Description
`log { log }`	**Synopsis:** [true | false] **Default:** false Enables/Disables logging tunnel control messages

4. Add one or more sessions to the tunnel configuration. For more information, refer to "Adding a Session (Page 472)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.4.4.4 Deleting a Dynamic L2TPv3 Tunnel

To delete a dynamic L2TPv3 tunnel, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the tunnel by typing:

   ```
   no tunnel l2tpv3 dynamic tunnel { name }
   ```

   Where { name } is the name of the tunnel.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.4.5 Managing Sessions for L2TPv3 Tunnels

This section describes how to create and manage sessions for L2TPv3 tunnels. A single L2TPv3 can support up to 128 active sessions.

11.4.5.1 Viewing a List of Sessions

To view a list of sessions defined for an L2TPv3 tunnel, type:

```
show running-config tunnel l2tpv3 [ static | dynamic ] tunnel { tunnel-name } session
```

Where { tunnel-name } is the name of the tunnel.

If sessions have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config tunnel l2tpv3 static tunnel 1 session
tunnel
 l2tpv3 static tunnel 1
  session 1
   local-session-id       10
   remote-session-id      20
   l2tp-specific-sublayer default
   vlan 4
```

```
    !
   !
   session 2
    local-session-id       30
    remote-session-id      40
    l2tp-specific-sublayer default
   !
  !
 !
```

If no sessions have been configured, add sessions as needed. For more information, refer to "Adding a Session (Page 472)".

11.4.5.2 Adding a Session

To add a session to a static or dynamic L2TPv3 tunnel, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the session by typing:

   ```
   tunnel l2tpv3 [ static | dynamic ] tunnel
   { tunnel-name } session { tunnel-session }
   ```

   Where:

   - { tunnel-name } is the name of the tunnel
   - { tunnel-session } is the name of the tunnel session
3. Configure the following parameter(s) as required:

Note
The **Log** parameter is only applicable to dynamic L2TPv3 tunnel sessions.

Parameter	Description
`enabled { enabled }`	**Synopsis:** [true | false] **Default:** true Enables/Disables the session
`local-session-id { local-session-id }`	**Synopsis:** An integer between 1 and 65535 The local session-id provides the necessary context for all further packet processing
`remote-session-id { remote-session-id }`	**Synopsis:** An integer between 1 and 65535 The remote session-id is used to identify the received data messages from remote session endpoint
`l2tp-specific-sublayer { l2tp-specific-sublayer }`	**Synopsis:** [default | none] **Default:** default L2TP specific sublayer processing type

Parameter	Description
`mtu { mtu }`	**Synopsis:** An integer between 68 and 1488 **Default:** 1488 Maximum transmission unit (largest packet size allowed for this interface).

⚠ NOTICE

Configuration of the local cookie should match the configuration of the remote cookie on the device at the other end of the L2TPv3 tunnel.

4. Type `local-cookie` and then configure the following parameters as required:

Parameter	Description
`size { size }`	**Synopsis:** [4 | 8] Cookie size in byte.
`low-value { low-value }`	**Synopsis:** An integer Lower value of cookie. This value must match with low-value of other endpoint's remote cookie
`high-value { high-value }`	**Synopsis:** An integer Higher value of cookie if the cookie size is 8. This value must match with high-value of other endpoint's remote cookie

⚠ NOTICE

Configuration of the remote cookie should match the configuration of the local cookie on the device at the other end of the L2TPv3 tunnel.

5. Type `remote-cookie` and then configure the following parameters as required:

Parameter	Description
`size { size }`	**Synopsis:** [4 | 8] Cookie size in byte
`low-value { low-value }`	**Synopsis:** An integer Lower value of cookie. This value must match with low-value of other endpoint's local cookie
`high-value { high-value }`	**Synopsis:** An integer Higher value of cookie if its size is 8. This value must match with high-value of other endpoint's local cookie

6. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.4.5.3 Deleting a Session

To delete a session for a static or dynamic L2TPv3 tunnel, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the tunnel by typing:

   ```
   no tunnel l2tpv3 [ static | dynamic ] tunnel
   { tunnel-name } session { tunnel-session }
   ```

   Where:

   - { tunnel-name } is the name of the tunnel
   - { tunnel-session } is the name of the tunnel session
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.4.6 Managing VLANs for L2TPv3 Tunnels

This section describes how to manage VLANs for L2TPv3 tunnel sessions. Each session supports up to 128 VLAN memberships.

11.4.6.1 Viewing a List of VLANs

To view a list of the VLANs configured for a static or dynamic L2TPv3 tunnel session, type:

```
show running-config tunnel l2tpv3 [ static | dynamic
 ] tunnel { tunnel-name } session { tunnel-session }
vlan
```

Where:

- { tunnel-name } is the name of the tunnel
- { tunnel-session } is the name of the tunnel session

A table or list similar to the following example appears:

```
ruggedcom# show running-config tunnel l2tpv3 static tunnel 1 session vlan
tunnel
 l2tpv3 static tunnel 1
  session 1
   vlan 4
   !
  !
 !
!
```

If no VLANs have been configured, add VLANs as needed. For more information, refer to "Adding a VLAN (Page 475)".

11.4.6.2 Adding a VLAN

To add a VLAN to a static or dynamic L2TPv3 tunnel session, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the session by typing:

```
tunnel l2tpv3 [ static | dynamic ] tunnel
{ tunnel-name } session { tunnel-session } vlan
{ vid }
```

   Where:

   - { tunnel-name } is the name of the tunnel.
   - { tunnel-session } is the name of the tunnel session.
   - { vid } is the VLAN ID for the routable logical interface. the value must be between 1 and 4094.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.4.6.3 Deleting a VLAN

To delete a VLAN for a static or dynamic L2TPv3 tunnel session, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the tunnel by typing:

```
no tunnel l2tpv3 [ static | dynamic ] tunnel
{ tunnel-name } session { tunnel-session } vlan
{ vid }
```

   Where:

   - { tunnel-name } is the name of the tunnel
   - { tunnel-session } is the name of the tunnel session
   - { vid } is the VLAN ID for the routable logical interface

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.4.7 Example: Establishing an L2TPv3 Tunnel Between Routers

In the following topology, an L2TPv3 tunnel is established between two RUGGEDCOM ROX II routers (A and B) to allow for bi-directional communication. Both routers are connected to devices that exchange GOOSE messages.

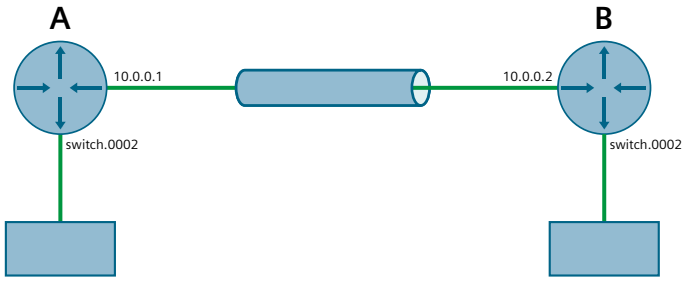


Figure 11.4 L2TPv3 Tunnel Between Routers

Note
GOOSE tunnels are established between two routable interfaces connected either directly or through multiple hops. The interface on either end of the tunnel can be a WAN interface (T1/E1), a cellular modem interface, or an Ethernet interface. For the purpose of this example, an Ethernet interface is used.

To replicate this configuration, do the following:

- **Configuring Router A**

  1. Select a switched Ethernet port and disable switchport mode to make it routable. This will be the port that connects to router B via the L2TPv3 tunnel. For more information, refer to "Configuring a Switched Ethernet Port (Page 314)".

     When switch port mode is disabled, an interface labeled fe-{ port } (e.g. fe-1) is created under **ip**.

  2. Assign the IP address **10.0.0.1/16** to the routable Ethernet port. For more information, refer to "Adding an IPv4 Address (Page 251)".

  3. Select a second switched Ethernet port and assign it to VLAN 2. This will be the port that connects to the host.

     Once the change is committed, the VLAN interface switch.0002 is available under **ip**, if it did not exist previously. For more information about assigning an Ethernet port to a VLAN, refer to "Configuring VLANs for Switched Ethernet Ports (Page 362)".

  4. Add a static L2TPv3 tunnel with the following settings:

name	tunnel1
tunnel-id	1
remote-tunnel-id	1
local-ip	10.0.0.1
local-port	5000
remote-ip	10.0.0.2
remote-port	5001

     For more information about adding a static L2TPv3 tunnel, refer to "Adding a Static L2TPv3 Tunnel (Page 466)".

5. Add a session to the new static tunnel with the following settings:

name	session1
local-session-id	1
remote-session-id	1

Once the change is committed, the interface l2t-1-1 is available under **ip**. For more information about adding a session, refer to "Adding a Session (Page 472)".

6. Combine the VLAN interface switch.0002 and the L2TPv3 session interface l2t-1-1 into a virtual switch. Once the change is committed, the interface vsw-1 is available under **ip**.

- **Configuring Router B**

1. Select a switched Ethernet port and disable switchport mode. This will be the port that connects to router A via the L2TPv3 tunnel. For more information, refer to "Configuring a Switched Ethernet Port (Page 314)".
2. Assign the IP address **10.0.0.2/16** to the interface for the switched Ethernet port. For more information, refer to "Adding an IPv4 Address (Page 251)".
3. Select a second switched Ethernet port and assign it to VLAN 2. This will be the port that connects to the host.

   Once the change is committed, the VLAN interface switch.0002 is available under **ip**, if it did not exist previously. For more information about assigning an Ethernet port to a VLAN, refer to "Configuring VLANs for Switched Ethernet Ports (Page 362)".
4. Add a static L2TPv3 tunnel with the following settings:

name	tunnel1
tunnel-id	1
remote-tunnel-id	1
local-ip	10.0.0.2
local-port	5001
remote-ip	10.0.0.1
remote-port	5000

For more information about adding a static L2TPv3 tunnel, refer to "Adding a Static L2TPv3 Tunnel (Page 466)".

5. Add a session to the new static tunnel with the following settings:

name	session1
local-session-id	1
remote-session-id	1

Once the change is committed, the interface l2t-1-1 is available under **ip**. For more information about adding a session, refer to "Adding a Session (Page 472)".

6. Combine the VLAN interface switch.0002 and the L2TPv3 session interface l2t-1-1 into a virtual switch. Once the change is committed, the interface vsw-1 is available under `ip` .

11.5 Managing GOOSE Tunnels

The GOOSE tunnel feature provides the capability to bridge GOOSE frames over a Wide Area Network (WAN).

GOOSE tunnels provide the following features:

- GOOSE traffic is bridged over the WAN via UDP/IP.
- One GOOSE traffic source can be mapped to multiple remote router Ethernet interfaces in mesh fashion.
- To reduce bandwidth consumption, GOOSE daemons may be located at each of the *legs* and at the center of a star network. The centrally located daemon will accept GOOSE packets and re-distribute them.
- Statistics report availability of remote GOOSE daemons, packet counts and Round Trip Time (RTT) for each remote daemon.
- When the Virtual Router Redundancy Protocol (VRRP) is employed, GOOSE transport is improved by sending redundant GOOSE packets from each VRRP gateway.
- You can enable GOOSE forwarding by configuring a generic Layer 2 tunnel. When configured, the device listens for GOOSE packets on one VLAN and forwards them to another VLAN.

The GOOSE protocol is supported by the Layer 2 Tunnel Daemon. The daemon listens to configured Ethernet interfaces and to the network itself (i.e. for tunnel connections from other daemon instances) on a configurable UDP port.

The Media Access Control (MAC) destination address of frames received from Ethernet is inspected in order to determine which GOOSE group they are in. The frames are then encapsulated in network headers and forwarded (with MAC source and destination addresses intact) to the network as GOOSE packets.

IEC61850 recommends that the MAC destination address should be in the range 01:0c:cd:01:00:00 to 01:0c:cd:01:01:ff.

GOOSE packets received from the network are stripped of their network headers and forwarded to Ethernet ports configured for the same multicast address. The forwarded frames contain the MAC source address or the originating device, and not that of the transmitting interface. The VLAN used will be that programmed locally for the interface and may differ from the original VLAN. The frame will be transmitted with the highest 802.1p priority level (p4).

Packets received from the network will also be forwarded to any other remote daemons included in the group.

To enable forwarding for GOOSE packets, configure a generic Layer 2 tunnel to listen for GOOSE packets on one VLAN and forward them to a second VLAN. To configure the generic Layer 2 tunnel for this operation, set the following for the tunnel:

- Ethernet Interface: select the VLAN on which the GOOSE packets originate
- Ethernet Type: set as 0x88b8
- Remote Daemon: select the VLAN to which to forward the GOOSE packets

11.5.1 Viewing the GOOSE Tunnel Statistics

To view the GOOSE tunnel statistics, type:

```
show tunnel l2tunneld status goose
```

A table or list similar to the following example appears:

```
ruggedcom# show tunnel l2tunneld status goose
l2tunneld status goose test
 ifname    switch.0100
 mac       01:0c:cd:01:00:33
 rx frames 2
 tx frames 0
 rx chars  114
 tx chars  0
 errors    0
 connections
             RX       TX       RX     TX
REMOTE IP    PACKETS  PACKETS  BYTES  BYTES  ERRORS
-------------------------------------------------------
192.168.2.2  2        0        122    0      0
```

This table or list provides the following information:

Parameter	Description
ifname	**Synopsis:** A string between 1 and 15 characters long The name of the VLAN interface.
mac	**Synopsis:** A string 17 characters long The Multicast Destination MAC Address of the Goose message.
rx-frames	**Synopsis:** An integer The number of frames received through the tunnel.
tx-frames	**Synopsis:** An integer The number of frames transmitted through the tunnel.
rx-chars	**Synopsis:** An integer The number of bytes received through the tunnel.
tx-chars	**Synopsis:** An integer The number of bytes transmitted through the tunnel.
errors	**Synopsis:** An integer The number of errors through the tunnel.

11.5.2 Viewing a List of GOOSE Tunnels

To view a list of GOOSE tunnels, type:

```
show running-config tunnel l2tunneld goose
```

If tunnels have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config tunnel l2tunneld goose tunnel | tab
                                          IP
NAME  INTERFACE    MULTICAST MAC      ADDRESS
-----------------------------------------------
1     switch.0001  01:0c:cd:01:01:01

!
```

If no GOOSE tunnels have been configured, add tunnels as needed. For more information, refer to "Adding a GOOSE Tunnel (Page 480)".

11.5.3 Adding a GOOSE Tunnel

To configure a GOOSE tunnel, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the tunnel by typing:

   ```
   tunnel l2tunneld goose tunnel { name }
   ```

   Where:

   - `{ name }` is the name of the GOOSE tunnel
3. Configure the following parameter(s) as required:

Parameter	Description
`interface` `{ interface }`	**Synopsis:** A string The interface to listen on for GOOSE frames.
`multicast-mac` `{ multicast-mac }`	**Synopsis:** A string 17 characters long The multicast MAC address to listen for.

4. If necessary, configure one or more remote daemons for the tunnel. For more information, refer to "Adding a Remote Daemon (Page 481)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.5.4 Deleting a GOOSE Tunnel

To delete a GOOSE tunnel, do the following:

1. Make sure the CLI is in Configuration mode.

2. Delete the GOOSE tunnel by typing:

   ```
   no tunnel l2tunneld goose tunnel { name }
   ```

   Where:

   - `{ name }` is the name of the GOOSE tunnel
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.5.5 Managing Remote Daemons for GOOSE Tunnels

In place of a local Ethernet interface for the tunnel egress, IP addresses for a remote daemon can be specified. Several endpoints may be added with these fields using successive edits of the tunnel configuration.

11.5.5.1 Viewing a List of Remote Daemons

To view a list of remote daemons configured for a GOOSE tunnel, type:

```
show running-config tunnel l2tunneld goose tunnel
{ name } remote-daemon
```

Where:

- `{ name }` is the name of the GOOSE tunnel

If tunnels have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config tunnel l2tunneld goose tunnel 1 remote-daemon
tunnel
 l2tunneld goose tunnel 1
  remote-daemon 192.168.10.2
  !
 !
!
```

If no remote daemons have been configured, add daemons as needed. For more information, refer to "Adding a Remote Daemon (Page 481)".

11.5.5.2 Adding a Remote Daemon

To configure a remote daemon for a GOOSE tunnel, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the remote daemon by typing:

   ```
   tunnel l2tunneld goose tunnel remote-daemon
   { address }
   ```

Where:

- `{ address }` is the IP address of the remote daemon

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.5.5.3 Deleting a Remote Daemon

To delete a remote daemon, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the remote daemon typing:

```
no tunnel l2tunneld goose tunnel { name }
remote-daemon { address }
```

Where:

- `{ name }` is the name of the GOOSE tunnel
- `{ address }` is the IP address of the remote daemon

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.5.6 Example: Establishing a GOOSE Tunnel Between Routers

In the following topology, a GOOSE tunnel is established between two RUGGEDCOM ROX II routers (A and B) to allow for bi-directional communication. Both routers are connected to publisher/subscriber devices.

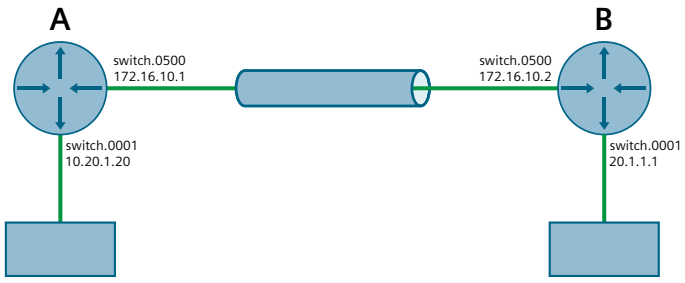


Figure 11.5 GOOSE Tunnel Between Routers

To replicate this configuration, do the following:

- **Configuring Router A**

1. Add a GOOSE tunnel for incoming traffic from the publisher/describer with the following settings:

name	incoming-traffic

interface	switch.0001
multicast-mac	01:0c:cd:01:00:44

For more information about adding a GOOSE tunnel, refer to "Adding a GOOSE Tunnel (Page 480)".

2. Add a GOOSE tunnel for outgoing traffic to router B with the following settings:

name	outgoing-traffic
interface	switch.0500
multicast-mac	01:0c:cd:01:00:41

For more information about adding a GOOSE tunnel, refer to "Adding a GOOSE Tunnel (Page 480)".

3. For the outgoing-traffic tunnel, add a remote daemon with the IP address **172.16.10.2**. For more information, refer to "Configuring the Layer 2 Tunnel Daemon (Page 459)".

- **Configuring Router B**

1. Add a GOOSE tunnel for incoming traffic from the publisher/describer with the following settings:

name	incoming-traffic
interface	switch.0001
multicast-mac	01:0c:cd:01:00:41

For more information about adding a GOOSE tunnel, refer to "Adding a GOOSE Tunnel (Page 480)".

2. Add a GOOSE tunnel for outgoing traffic to router A with the following settings:

name	outgoing-traffic
interface	switch.0500
multicast-mac	01:0c:cd:01:00:44

For more information about adding a GOOSE tunnel, refer to "Adding a GOOSE Tunnel (Page 480)".

3. For the outgoing-traffic tunnel, add a remote daemon with the IP address **172.16.10.1**. For more information, refer to "Configuring the Layer 2 Tunnel Daemon (Page 459)".

11.6 Managing Generic Tunnels

The Layer 2 Tunnel Daemon supports a generic mode of operation based on the Ethernet type of Layer 2 data traffic seen by the router. Multiple tunnels may be configured, each one with:

- an Ethernet type

- a tunnel ingress (Ethernet interface)
- a tunnel egress (either another locally connected Ethernet interface, or the remote IP address of another Layer 2 Tunnel daemon instance running on another Router)

11.6.1 Viewing the Generic Tunnel Statistics

To view the generic tunnel statistics, type:

```
show tunnel l2tunneld status generic
```

A table or list similar to the following example appears:

```
ruggedcom# show tunnel l2tunneld status generic
TUNNEL               RX      TX      RX     TX                              RX       TX
      RX     TX
NAME    IFNAME       FRAMES  FRAMES  CHARS  CHARS  ERRORS  REMOTE IP    PACKETS
 PACKETS  BYTES  BYTES  ERRORS
-------------------------------------------------------------------------------
iso     switch.0002  5       6       300    360    0
                                                   192.168.5.1  11       0
      704    0      0
```

This table or list provides the following information:

Parameter	Description
`{ tunnel-name }`	**Synopsis:** A string 32 characters long The generic tunnel name.
`ifname`	**Synopsis:** A string between 1 and 15 characters long The name of the ingress interface.
`rx-frames`	**Synopsis:** An integer The number of frames received through the tunnel.
`tx-frames`	**Synopsis:** An integer The number of frames transmitted through the tunnel.
`rx-chars`	**Synopsis:** An integer The number of bytes received through the tunnel.
`tx-chars`	**Synopsis:** An integer The number of bytes transmitted through the tunnel.
`errors`	**Synopsis:** An integer The number of errors received through the tunnel.
`rx-packets`	**Synopsis:** An integer The number of frames received through the tunnel.
`tx-packets`	**Synopsis:** An integer The number of frames transmitted through the tunnel.

Parameter	Description
`rx-bytes`	**Synopsis:** An integer The number of bytes received through the tunnel.
`tx-bytes`	**Synopsis:** An integer The number of bytes transmitted through the tunnel.
`errors`	**Synopsis:** An integer The number of errors received through the tunnel.

11.6.2 Viewing a List of Generic Tunnels

To view a list of generic tunnels, type:

```
show running-config tunnel l2tunneld generic tunnel
```

If tunnels have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config tunnel l2tunneld generic tunnel | tab
                  REPLACE        EGRESS  IP
NAME  INGRESS IF  MAC      TYPE  IF      ADDRESS
-------------------------------------------------
1     switch.0001 -
                           iso

!
```

If no generic tunnels have been configured, add tunnels as needed. For more information, refer to "Adding a Generic Tunnel (Page 485)".

11.6.3 Adding a Generic Tunnel

To configure a generic tunnel, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the tunnel by typing:

   ```
   tunnel l2tunneld generic tunnel { name }
   ```

   Where:

   - `{ name }` is the name of the generic tunnel
3. Configure the following parameter(s) as required:

Parameter	Description
`ingress-if { ingress-if }`	**Synopsis:** A string The interface to listen on for Ethernet type frames.
`replace-mac`	Replaces the sender's MAC with the out-interface's MAC.

4. If necessary, configure one or more remote daemon IP addresses for the tunnel. For more information, refer to "Adding an IP Address (Page 487)".
5. If necessary, define one or more Ethernet types to be forwarded. For more information, refer to "Adding an Ethernet Type (Page 489)".
6. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.6.4 Deleting a Generic Tunnel

To delete a generic tunnel, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the generic tunnel by typing:

   ```
   no tunnel l2tunneld generic tunnel { name }
   ```

   Where:

   - `{ name }` is the name of the generic tunnel
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.6.5 Managing Remote Daemon IP Addresses for Generic Tunnels

In place of a local Ethernet interface for the tunnel egress, IP addresses for a remote daemon can be specified. Several endpoints may be added with these fields using successive edits of the tunnel configuration.

Note
When a remote daemon IP address is configured, the interface on the receiver side, where traffic leaves, should be configured on the ingress interface (instead of egress interface).

11.6.5.1 Viewing a List of IP Addresses

To view a list of remote Layer 2 protocol server IP addresses for a generic tunnel configuration, type:

```
show running-config tunnel l2tunneld generic tunnel remote-daemon
```

If tunnels have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config tunnel l2tunneld generic tunnel remote-daemon ip-
address | tab
NAME  IP ADDRESS
```

```
--------------------
1
      172.112.10.1

!
```

If no generic tunnels have been configured, add tunnels as needed. For more information, refer to "Adding a Generic Tunnel (Page 485)".

11.6.5.2 Adding an IP Address

To add the IP address of a remote Layer 2 protocols server to a generic tunnel configuration, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the IP address by typing:

   ```
   tunnel l2tunneld generic tunnel { name } remote-daemon ip-address { address }
   ```

   Where:

   - `{ name }` is the name of the generic tunnel
   - `{ address }` is the IP address of the remote Layer 2 protocols server
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.6.5.3 Deleting an IP Address

To delete the IP address of a remote Layer 2 protocols server from a generic tunnel configuration, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the IP address by typing:

   ```
   no tunnel l2tunneld generic tunnel { name } remote-daemon ip-address { address }
   ```

   Where:

   - `{ name }` is the name of the generic tunnel
   - `{ address }` is the IP address of the remote Layer 2 protocols server
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.6.6 Managing Remote Daemon Egress Interfaces for Generic Tunnels

This section describes how to create and manage remote daemon egress interfaces for generic tunnels.

11.6.6.1 Viewing a List of Egress Interfaces

To view a list of egress interfaces configured for a generic tunnel, type:

```
show running-config tunnel l2tunneld generic tunnel remote-daemon egress-if
```

If egress interfaces have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config tunnel l2tunneld generic tunnel remote-daemon egress-
if | tab
NAME  EGRESS IF
-------------------
1
      switch.0001

!
```

If no egress interfaces have been configured, add interfaces as needed. For more information, refer to "Adding an Egress Interface (Page 488)".

11.6.6.2 Adding an Egress Interface

To add an egress interface for a generic tunnel, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the egress interface by typing:

   ```
   tunnel l2tunneld generic tunnel { name } remote-daemon egress-if { interface }
   ```

   Where:

   - `{ name }` is the name of the generic tunnel
   - `{ interface }` is the egress interface for Ethernet type frames
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.6.6.3 Deleting an Egress Interface

To delete an egress interface for a generic tunnel, do the following:

1. Make sure the CLI is in Configuration mode.

2. Delete the egress interface by typing:

   ```
   no tunnel l2tunneld generic tunnel { name }
   remote-daemon egress-if { interface }
   ```

   Where:

   - `{ name }` is the name of the generic tunnel
   - `{ interface }` is the egress interface for Ethernet type frames

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.6.7 Managing Ethernet Types for Generic Tunnels

This section describes how to define the types of Ethernet protocols that can be forwarded by generic tunnels.

11.6.7.1 Viewing a List of Ethernet Types

To view a list of Ethernet types configured for a generic tunnel, type:

```
show running-config tunnel l2tunneld generic tunnel
ethernet-type
```

If Ethernet types have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config tunnel l2tunneld generic tunnel ethernet-type | tab
NAME  TYPE
------------
1
      iso

!
```

If no Ethernet types have been configured, add types as needed. For more information, refer to "Adding an Ethernet Type (Page 489)".

11.6.7.2 Adding an Ethernet Type

To add an Ethernet type for a generic tunnel, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the Ethernet type by typing:

   ```
   tunnel l2tunneld generic tunnel { name } ethernet-
   type { type }
   ```

   Where:

- `{ name }` is the name of the generic tunnel
- `{ type }` is the Ethernet type to be forwarded (i.e. 0xFEFE)

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.6.7.3 Deleting an Ethernet Type

To delete an Ethernet type for a generic tunnel, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the Ethernet type by typing:

```
no tunnel l2tunneld generic tunnel { name }
ethernet-type { type }
```

Where:

- `{ name }` is the name of the generic tunnel
- `{ type }` is the Ethernet type (i.e. 0xFEFE)

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.7 Managing Generic Routing Encapsulation Tunnels

RUGGEDCOM ROX II can employ the Generic Routing Encapsulation (GRE) protocol to encapsulate multicast traffic and IPv6 packets together and transport them through an IPv4 network tunnel. As such, GRE tunnels can transport traffic through any number of intermediate networks.

The key parameters for GRE tunnels is the tunnel name, local router address, remote router address and remote subnet.

The following illustrates a typical GRE tunnel configuration:



Figure 11.6 Example – GRE Tunnel Configuration

In this example, Router 1 establishes a GRE tunnel to Router 2 using a local router address of 172.16.17.18, a remote router address of 172.19.20.21, and a remote subnet of 192.168.2.0/24.

Note
When connecting a Cisco router (in place of Router 1 in the previous example), the local router address corresponds to the Cisco IOS *source* address and the remote router address corresponds to the *destination* address.

The cost of the GRE tunnel can also be set if another method of routing between Router 1 and Router 2 becomes available. When GRE failover is enabled, the packets will automatically flow through the lowest cost route.

Packets can also be restricted by specifying a local egress device, such as w1pp in the case of Router 1 in the previous example.

11.7.1 Viewing Statistics for GRE Tunnels

To view the statistics collected for GRE tunnels, type:

```
show  interfaces  gre
```

A table or list similar to the following example appears:

```
ruggedcom# show interfaces gre
                TUNNEL  RX       RX      RX     TX       TX      TX
IFNAME  STATUS  STATUS  PACKETS  ERRORS  DROPS  PACKETS  ERRORS  DROPS
-------------------------------------------------------------------------
g1      Active  Up    52        0       0      855      51      0
g2      Active  Up    0          0       0      0           791    0
```

This table or list provides the following information:

Parameter	Description
`{ ifname }`	**Synopsis:** A string between 1 and 10 characters long The name of the GRE tunnel.
`status`	**Synopsis:** A string between 1 and 20 characters long The status of the GRE tunnel interface, possible values include: • **Active** - GRE tunnel interface is up; • **Inactive** - GRE tunnel interface is down
`tunnel-status`	**Synopsis:** A string The status of the GRE tunnel: • **Up** - GRE tunnel is up and running; • **Down** - GRE tunnel interface is inactive or tunnel remote endpoint is not reachable; • **Keepalives Disabled** - Keepalive messages have been disabled, not able to know if the tunnel remote endpoint is reachable or not
`rx-packets`	**Synopsis:** An integer The number of packets received through the tunnel.

Parameter	Description
rx-errors	**Synopsis:** An integer The error packets received through the tunnel.
rx-drops	**Synopsis:** An integer The number of packets dropped by the tunnel.
tx-packets	**Synopsis:** An integer The number of packets transmitted through the tunnel.
tx-errors	**Synopsis:** An integer The number of error packets transmitted through the tunnel.
tx-drops	**Synopsis:** An integer The number of packets dropped by the tunnel.

11.7.2 Viewing a List of GRE Tunnels

To view a list of GRE tunnels, type:

```
show  running-config  tunnel  gre
```

If GRE tunnels have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config tunnel gre | tab
IF
NAME  LOCAL IP      REMOTE IP     REMOTE NET      MTU   MULTICAST  COST
-------------------------------------------------------------------------
gre   172.16.17.18  172.19.20.21  192.168.2.0/24  1476  -          0
```

If no GRE tunnels have been configured, add tunnels as needed. For more information, refer to "Adding a GRE Tunnel (Page 492)".

11.7.3 Adding a GRE Tunnel

To add a GRE tunnel, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the GRE tunnel by typing:

   ```
   tunnel  gre  { name }
   ```

   Where:

   - `{ name }` is the interface name of the GRE tunnel network. The interface name must start with a lowercase letter, but may contain any combination of lowercase letters, numbers and dashes up to a maximum of 10 characters. The prefix *gre-* will be added to this interface name.
3. Configure the following parameter(s) as required:

Parameter	Description
`local-ip { local-ip }`	**Synopsis:** A string between 7 and 15 characters long or A string between 6 and 40 characters long The IP address of the local end of the tunnel.
`remote-ip { remote-ip }`	**Synopsis:** A string between 7 and 15 characters long or A string between 6 and 40 characters long The IP address of the remote end of the tunnel.
`remote-net { remote-net }`	**Synopsis:** A string between 9 and 18 characters long or A string between 4 and 43 characters long The target network of remote end of the tunnel.
`mtu { mtu }`	**Synopsis:** An integer **Default:** 1476 The MTU of the GRE interface.
`multicast`	Enables multicast traffic on the tunnel interface.
`cost { cost }`	**Synopsis:** An integer between 1 and 255 **Default:** 1 The routing cost associated with networking routing that directs traffic through the tunnel.
`key { key }`	**Synopsis:** [none | input | output | both] **Default:** none The key for tunneled packets
`key-id { key-id }`	**Synopsis:** An integer between 0 and 4294967295 **Default:** 0 The key ID for tunneled packets
`checksum { checksum }`	**Synopsis:** [none | input | output | both] **Default:** none The checksum for tunneled packets
`sequence { sequence }`	**Synopsis:** [none | input | output | both] **Default:** none The sequence number for tunneled packets
`alarms { alarms }`	**Synopsis:** [true | false] **Default:** false Enables or disables tunnel up and down alarms. Disabling tunnel alarms will prevent alarms from being sent for that tunnel. GRE tunnel alarms may also be controlled for the whole system under **admin > alarm-cfg** .

4. [Optional] Enable keepalive messages so as to monitor the status of the tunnel's remote endpoint. For more information, refer to "Enabling/Disabling Keepalive Messages (Page 495)".
5. [Optional] Configure the method for assigning Differentiated Services Code Point (DSCP) marks to packets traveling through the GRE tunnel. For more

information, refer to "Configuring a DSCP Marking for GRE Tunnel Traffic (Page 494)".

Note
An interface in the form of *gre-{tunnel}* (e.g. gre-t1) is added automatically to the **ip** menu.

6. Assign an IP address to the tunnel. For more information, refer to either "Adding an IPv4 Address (Page 251)" or "Adding an IPv6 Address (Page 252)".
7. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.7.4 Configuring a DSCP Marking for GRE Tunnel Traffic

Each packet traversing a GRE tunnel can be assigned a Differentiated Services Code Point (DSCP) mark either defined by the device or inherited by the original IP header.

To the configure how DSCP marks are assigned for a specific GRE tunnel, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***tunnel » gre » {tunnel} » mark-choice***, where *{tunnel}* is the name of the GRE tunnel.
3. Configure the DSCP marking by typing:

   ```
   tunnel gre { name } mark-choice dscpmarking dscp-type [ mark | forward ]
   ```

   Where { name } is name of the GRE tunnel.

   Options include:

   - **mark** – Assigns the DSCP marking set by **DSCP Mark** to packets traversing the tunnel
   - **forward** – Assigns the DSCP marking defined in the original IP header of each packet traversing the tunnel
4. If **mark** is selected, select a DSCP mark to assign by typing:

   ```
   dscp-mark [ AF11 | AF12 | AF13 | AF21 | AF22 | AF23 | AF31 | AF32 | AF33 | AF41 | AF42 | AF43 | BE | CS1 | CS2 | CS3 | CS4 | CS5 | CS6 | CS7 | EF ]
   ```

5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.7.5 Enabling/Disabling Keepalive Messages

Keepalive messages enable endpoints of a GRE tunnel to determine one another's current operational status.

Traditionally, GRE tunnels are stateless, meaning that remote endpoints retain no information about one another. As a result, an endpoint will not know when the other endpoint becomes unreachable and continue sending frames, even though the other end is unable to receive them.

With keepalive messages enabled, RUGGEDCOM ROX II will send keepalive messages to the other endpoint and wait for a response. If a response is not received before the next message is scheduled to be sent, it begins to count the number of consecutive messages sent that did not receive a reply. After so many failures to reply, the other endpoint is considered unreachable and a *Link Down* alarm is raised. This is the cue to the network administrator to bring down the GRE tunnel and investigate.

By default, keepalive messages are sent every 10 seconds and the remote endpoint has three opportunities to reply. These thresholds are user configurable.

To enable or disable keepalive messages for a GRE tunnel, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable or disable keepalive messages by typing:

   Enable

   ```
   tunnel gre { name } gre-keepalives enabled
   ```

   Disable

   ```
   no tunnel gre { name } gre-keepalives enabled
   ```

   Where { name } is the interface name of the GRE tunnel network. The interface name must start with a lowercase letter, but may contain any combination of lowercase letters, numbers and dashes up to a maximum of 10 characters. The prefix *gre-* will be added to this interface name.
3. If keepalive messages are enabled, configure the following parameters:

Parameter	Description
`interval { interval }`	**Synopsis:** An integer between 1 and 32767 **Default:** 10 The interval in second(s) at which keepalive messages are sent to the remote endpoint.
`retries { retries }`	**Synopsis:** An integer between 1 and 255 **Default:** 3 The number of keepalive message the remote endpoint can ignore before it is considered unreachable.

Parameter	Description
`failover { failover }`	**Synopsis:** [true | false] **Default:** false Enable this tunnel to support failover.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.7.6 Deleting a GRE Tunnel

To delete a GRE tunnel, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the GRE tunnel by typing:

   ```
   no tunnel gre { name }
   ```

   Where:

   - `{ name }` is the name of the GRE tunnel
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.7.7 Example: Configuring a GRE Tunnel with IPsec

This example describes one method to configure a GRE tunnel with IPsec on RUGGEDCOM ROX II devices.

For more information about IPsec tunnels, refer to "Managing IPsec Tunnels (Page 502)".

⚠ NOTICE

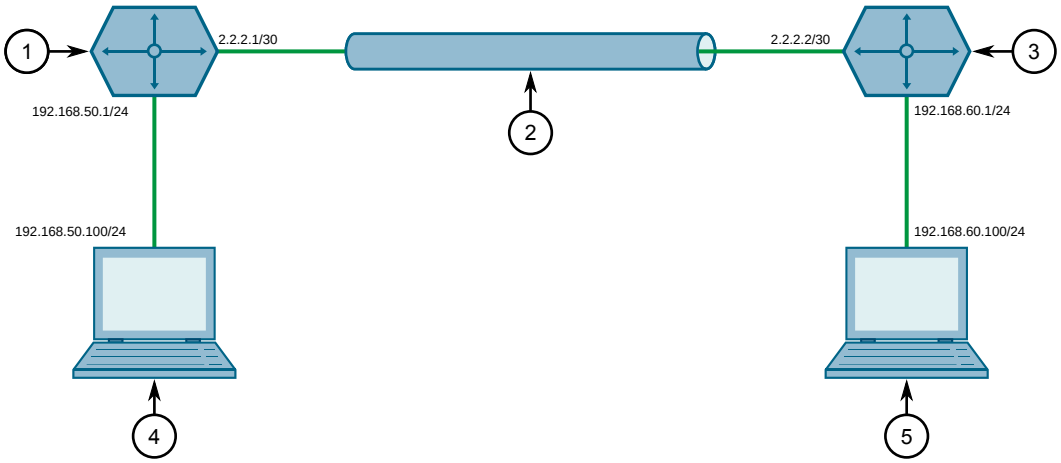
To ensure IPsec connections are independently managed when configuring GRE/IPsec, the following conditions must be met:

- The IPsec connection name must match the GRE tunnel interface name.
- Remote subnets defined under IPsec left/right sections are aware of each other only through the GRE tunnel. As the default value of the nexthop under left/right sections is *right side public-ip*, the nexthop value to the GRE tunnel IP must be configured to allow subnet traffic through the GRE tunnel.

Note
When the IPsec connection name matches the GRE tunnel interface name, the left/rightpublic IP(s) of the IPsec connection are ignored, and the GRE tunnel's local/remote IP is used to establish IPsec tunnel.

NOTICE

The values shown are specific to the provided topology. Actual values can vary based on the user's configuration.



① Device A
② GRE/IPsec Tunnel
③ Device B
④ Client 1
⑤ Client 2

Figure 11.7 Topology – Site-to-Site Encrypted VPN Tunnel with a Pre-Shared Key

To configure a GRE tunnel with IPsec, do the following:

1. Configure Device A:
   a. Configure a host name for the device. For more information, refer to "Configuring the Host Name (Page 127)".
   b. Add a GRE tunnel and configure the following parameters:

Parameter	Value
Local IP	2.2.2.1
Remote IP	2.2.2.2

   For more information, refer to "Adding a GRE Tunnel (Page 492)".
   c. Enable Keepalive messages for GRE tunnel. For more information, refer to "Enabling/Disabling Keepalive Messages (Page 495)".
   d. Assign IP address *172.16.1.1/24* to the gre tunnel interface. For more information, refer to "Adding an IPv4 Address (Page 251)".
   e. Add a unique pre-shared key and configure the following parameters:

Parameter	Value
Local Address	2.2.2.1
Remote Address	2.2.2.2

For more information, refer to "Adding a Pre-Shared Key (Page 509)".

f. Add an IPsec connection and configure the following parameters:

Parameter	Value
Startup Operation	start
Authenticate By	secret
Connection Type	tunnel

For more information about IPsec connections, refer to "Adding a Connection (Page 511)".

g. Configure an Internet Key Exchange (IKE) algorithm with default values. For more information, refer to "Adding an IKE Algorithm (Page 516)".

h. Configure an Encapsulated Security Payload (ESP) algorithm with default values. For more information, refer to "Adding an ESP Algorithm (Page 518)".

i. Configure the left connection end for the IPsec tunnel with the following public IP address parameters:

Parameter	Value
Type	address
Value	2.2.2.1

For more information about configuring connection ends, refer to "Managing Connection Ends (Page 519)".

j. Configure the left connection end for the IPsec tunnel with the following nexthop address parameters:

Parameter	Value
Type	address
Value	172.16.1.2

For more information about configuring connection ends, refer to "Managing Connection Ends (Page 519)".

k. Add subnet *192.168.50.0/24* for the left connection end. For more information, refer to "Adding an Address for a Private Subnet (Page 523)".

l. Configure the right connection end for the IPsec tunnel with the following public IP address parameters:

Parameter	Value
Type	address
Value	2.2.2.2

For more information about configuring connection ends, refer to "Managing Connection Ends (Page 519)".

m. Configure the right connection end for the IPsec tunnel with the following nexthop address parameters:

Parameter	Value
Type	address
Value	172.16.1.1

For more information about configuring connection ends, refer to "Managing Connection Ends (Page 519)".

n. Add subnet *192.168.60.0/24* for the right connection end. For more information, refer to "Adding an Address for a Private Subnet (Page 523)".

2. Configure Device B:

a. Configure a host name for the device. For more information, refer to "Configuring the Host Name (Page 127)".

b. Add a GRE tunnel and configure the following parameters:

Parameter	Value
Local IP	2.2.2.2
Remote IP	2.2.2.1

For more information, refer to "Adding a GRE Tunnel (Page 492)".

c. Enable Keepalive messages for GRE tunnel. For more information, refer to "Enabling/Disabling Keepalive Messages (Page 495)".

d. Assign IP address *172.16.1.2/24* to the gre tunnel interface. For more information, refer to "Adding an IPv4 Address (Page 251)".

e. Add a unique pre-shared key and configure the following parameters:

Parameter	Value
Local Address	2.2.2.2
Remote Address	2.2.2.1

For more information, refer to "Adding a Pre-Shared Key (Page 509)".

f. Add an IPsec connection and configure the following parameters:

Parameter	Value
Startup Operation	start
Authenticate By	secret
Connection Type	tunnel

For more information about IPsec connections, refer to "Adding a Connection (Page 511)".

g. Configure an Internet Key Exchange (IKE) algorithm with default values. For more information, refer to "Adding an IKE Algorithm (Page 516)".

h. Configure an Encapsulated Security Payload (ESP) algorithm with default values. For more information, refer to "Adding an ESP Algorithm (Page 518)".

i. Configure the right connection end for the IPsec tunnel with the following public IP address parameters:

Parameter	Value
Type	address
Value	2.2.2.1

For more information about configuring connection ends, refer to "Managing Connection Ends (Page 519)".

j. Configure the right connection end for the IPsec tunnel with the following nexthop address parameters:

Parameter	Value
Type	address
Value	172.16.1.2

For more information about configuring connection ends, refer to "Managing Connection Ends (Page 519)".

k. Add subnet *192.168.50.0/24* for the right connection end. For more information, refer to "Adding an Address for a Private Subnet (Page 523)".

l. Configure the left connection end for the IPsec tunnel with the following public IP address parameters:

Parameter	Value
Type	address
Value	2.2.2.2

For more information about configuring connection ends, refer to "Managing Connection Ends (Page 519)".

m. Configure the left connection end for the IPsec tunnel with the following nexthop address parameters:

Parameter	Value
Type	address
Value	172.16.1.1

For more information about configuring connection ends, refer to "Managing Connection Ends (Page 519)".

n. Add subnet *192.168.60.0/24* for the left connection end. For more information, refer to "Adding an Address for a Private Subnet (Page 523)".

3. Enable the IPsec tunnel. For more information, refer to "Configuring IPsec Tunnels (Page 505)".
4. Verify the tunnel status and make sure the traffic between the two sites is encrypted:
   - View the IPsec tunnel status and look for a message that includes the connection name and the words *erouted; eroute owner:*. For example:

```
000 "gre-r1-r2":
 192.168.50.0/24===2.2.2.1&amp;lt;2.2.2.1&amp;gt;:47/0---172.16.1.2...2.2.2.2&amp;lt;2.2.2.2&amp;gt;:47/0===192.16
 erouted; eroute owner: #10
```

This indicates the IPsec tunnel is active.

For more information, refer to "Viewing the IPsec Tunnel Status (Page 507)".

Final Configuration Example

The following configuration reflects the topology:

Device A

```
# show full-configuration
tunnel
 gre r1-r2
  local-ip  2.2.2.1
  remote-ip 2.2.2.2
  gre-keepalives enabled
  gre-keepalives interval 10
  gre-keepalives retries 3
 !
 ipsec
  enabled
  no nat-traversal
  preshared-key 2.2.2.2 2.2.2.1
   key $4$wocla9wLwmdwhYYI0d4IDw==
  !
  connection gre-r1-r2
   startup         start
   authenticate    secret
   connection-type tunnel
   dead-peer-detect enabled
   no l2tp
   ike algorithm aes256 sha1 modp1536
   !
   esp modpgroup modp1536
   esp algorithm aes256 sha1
   !
   left
    public-ip type address
    public-ip value 2.2.2.1
    nexthop type address
    nexthop value 172.16.1.2
    subnet 192.168.50.0/24
    !
   !
   right
    public-ip type address
    public-ip value 2.2.2.2
    nexthop type address
    nexthop value 172.16.1.1
    subnet 192.168.60.0/24
    !
   !
  !
ip gre-r1-r2
 no bandwidth
 ipv4
  address 172.16.1.1/24
   no peer
```

```
  !
```

Device B

```
# show full-configuration
tunnel
 gre r1-r2
  local-ip  2.2.2.2
  remote-ip 2.2.2.1
  gre-keepalives enabled
  gre-keepalives interval 10
  gre-keepalives retries 3
 !
 ipsec
  enabled
  no nat-traversal
  keep-alive 10
  preshared-key 2.2.2.1 2.2.2.2
   key $4$wocla9wLwmdwhYYI0d4IDw==
  !
  connection gre-r1-r2
   startup         start
   authenticate    secret
   connection-type tunnel
   dead-peer-detect enabled
   no l2tp
   ike algorithm aes256 sha1 modp1536
   !
   esp modpgroup modp1536
   esp algorithm aes256 sha1
   !
   left
    public-ip type address
    public-ip value 2.2.2.2
    nexthop type address
    nexthop value 172.16.1.1
    subnet 192.168.60.0/24
    !
   !
   right
    public-ip type address
    public-ip value 2.2.2.1
    nexthop type address
    nexthop value 172.16.1.2
    subnet 192.168.50.0/24
    !
   !
  !
ip gre-r1-r2
 no bandwidth
 ipv4
  address 172.16.1.2/24
   no peer
  !
!
```

11.8 Managing IPsec Tunnels

IPsec (Internet Protocol SECurity) uses strong cryptography to provide authentication and encryption services. Authentication ensures that packets are from the right

sender and have not been altered in transit. Encryption prevents unauthorized reading of packet contents.

These services allow secure tunnels to be built through untrusted networks. Everything passing through the untrusted network is encrypted by the IPsec gateway and decrypted by the gateway at the other end. The result is a Virtual Private Network (VPN), a network which is effectively private even though it includes machines at several different sites connected by the insecure Internet.

For more information about IPsec tunnels, refer to "IPsec Tunneling Concepts (Page 503)".

⚠ NOTICE

IPsec is time-sensitive. To make sure proper re-keying between network peers, the time on both peers must be synchronized. It is strongly recommended that NTP (Network Time Protocol) be used on both IPsec peers to synchronize their clocks. For more information about configuring NTP, refer to "Managing NTP Servers (Page 904)".

11.8.1 IPsec Tunneling Concepts

The IPsec suite of protocols were developed by the Internet Engineering Task Force (IETF) and are required as part of IP version 6. Libreswan is the open source implementation of IPsec used by RUGGEDCOM ROX II.

The protocols used by IPsec are the Encapsulating Security Payload (ESP) and Internet Key Exchange (IKE) protocols. ESP provides encryption and authentication (ensuring that a message originated from the expected sender and has not been altered on route). IKE negotiates connection parameters, including keys, for ESP. IKE is based on the Diffie-Hellman key exchange protocol, which allows two parties without any initial shared secret to create one in a manner immune to eavesdropping.

11.8.1.1 IPsec Modes

IPsec has two basic modes of operation:

- **Transport Mode**

  In *transport* mode, IPsec headers are added as the original IP datagram is created. The resultant packet is composed of an IP header, IPsec headers and IP payload (including a transport header). Transport mode is most commonly used between IPsec end-stations, or between an end-station and a gateway.

- **Tunnel Mode**

  In *tunnel* mode, the original IP datagram is created normally and then encapsulated into a new IP datagram. The resultant packet is composed of a new IP header, IPsec headers, old IP header and IP payload. Tunnel mode is most commonly used between gateways, the gateway acting as a proxy for the hosts behind it.

11.8.1.2 Supported Encryption Protocols

Libreswan supports the following standard encryption protocols:

- **3DES (Triple DES)**

  Uses three Data Encryption Standard (DES) encryptions on a single data block, with at least two different keys, to get higher security than is available from a single DES pass. 3DES is the most CPU intensive cipher.

- **AES**

  The Advanced Encryption Standard (AES) protocol cipher uses a 128-bit block and 128, 192 or 256-bit keys. This is the most secure protocol in use today, and is much preferred to 3DES due to its efficiency.

11.8.1.3 Public and Secret Key Cryptography

In *public key* cryptography, keys are created in matched pairs (called public and private keys). The public key is made public while the private key is kept secret. Messages can then be sent by anyone who knows the public key to the holder of the private key. Only the owner of the private key can decrypt the message.

When this form of encryption is used, each router configures its VPN connection to use the RSA algorithm and includes the public signature of its peer.

In *secret key* cryptography, a single key known to both parties is used for both encryption and decryption.

When this form of encryption is used, each router configures its VPN connection to use a secret pre-shared key. For information about how to configure pre-shared keys, refer to "Managing Pre-Shared Keys (Page 509)".

11.8.1.4 X509 Certificates

In addition to pre-shared keys, IPsec also uses certificates to authenticate connections with hosts and routers. Certificates are digital signatures that are produced by a trusted source, namely a Certificate Authority (CA). For each host, the CA creates a certificate that contains CA and host information. The certificate is "signed" by creating a digest of all the fields in the certificate and then encrypting the hash value with its private key. The host's certificate and the CA public key are installed on all gateways that the host connects to.

When the gateway receives a connection request, it uses the CA public key to decrypt the signature back into the digest. It then recomputes its own digest from the plain text in the certificate and compares the two. If both digests match, the integrity of the certificate is verified (it was not tampered with), and the public key in the certificate is assumed to be the valid public key of the connecting host.

11.8.1.5 NAT Traversal

Historically, IPsec has presented problems when connections must traverse a firewall providing Network Address Translation (NAT). The Internet Key Exchange (IKE) used in IPsec is not NAT-translatable. When IPsec connections must traverse a firewall, IKE messages and IPsec-protected packets must be encapsulated as User Datagram Protocol (UDP) messages. The encapsulation allows the original untranslated packet to be examined by IPsec.

Encapsulation is enabled during the IPsec configuration process. For more information, refer to "Configuring IPsec Tunnels (Page 505)".

11.8.1.6 Remote IPsec Client Support

If the router is to support a remote IPsec client and the client will be assigned an address in a subnet of a local interface, a proxy ARP must be activated for that interface. This will cause the router to respond to ARP requests on behalf of the client and direct traffic to it over its connection.

IPsec relies upon the following protocols and ports:

- protocol 51, IPSEC-AH Authentication Header (RFC2402)
- protocol 50, IPSEC-ESP Encapsulating Security Payload (RFC2046)
- UDP port 500

The firewall must be configured to accept connections on these ports and protocols. For more information, refer to "Configuring the Firewall for a VPN (Page 223)".

11.8.1.7 IPsec and Router Interfaces

If IPsec works on an interface which could disappear, such as a PPP connection, or if the IP address could change, the **Monitor Interface** option must be set for the IPsec connection. When this option is set, IPsec will restart when the interface disappears and reappears, or the IP address is changed.

The **Monitor Interface** option is set on the **Connection** form available for each connection. For more information about connections, refer to "Managing Connections (Page 510)".

11.8.2 Configuring IPsec Tunnels

To configure IPsec tunnels, do the following:

Note
RUGGEDCOM ROX II supports the creation of policy-based VPNs, which can be characterized as follows:

- No IPsec network interfaces have been created.

- The routing table is not involved in directing packets to IPsec.
- Only data traffic matching the tunnel's local and remote subnets is forwarded to the tunnel. Normal traffic is routed by one set of firewall rules and VPN traffic is routed based on separate rules.
- The firewall is configured with a VPN zone of type *ipsec*.
- As IPsec packets are received, they are decoded, flagged as IPsec-encoded, and presented as having arrived directly from the same network interface on which they were originally received.
- Firewall rules are written to allow traffic to and from VPN tunnels. These are based on the normal form of source/destination IP addresses, and IP protocol and port numbers. These rules, by virtue of the zones they match, use the policy flags inserted by the netkey to route matching data traffic to the proper interface.

For more information about configuring a policy-based VPN, refer to "Managing Firewalls (Page 217)".

---

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***tunnel » ipsec*** and configure the following parameter(s) as required:

Parameter	Description
`enabled`	Enables IPsec.
`nat-traversal`	This parameter is not supported and any value is ignored by the system. nat-traversal is always enabled in the IPSec VPN system.
`keep-alive { keep-alive }`	**Synopsis:** An integer between 1 and 86400 **Default:** 20 The delay (in seconds) for sending keepalive packets to prevent a NAT router from closing its port when there is not enough traffic on the IPsec connection.

3. Configure one or more pre-shared keys. For more information, refer to "Adding a Pre-Shared Key (Page 509)".
4. Configure one or more encrypted connections. For more information, refer to "Adding a Connection (Page 511)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.8.3 Configuring Certificates and Keys

To configure certificates and keys for IPsec Tunnels, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add a CA certificate and Certificate Revocation List (CRL). For more information, refer to "Adding a CA Certificate and CRL (Page 200)".

3. Add a private key. For more information, refer to "Adding a Private Key (Page 202)".
4. Add a certificate. For more information, refer to "Adding a Certificate (Page 207)".
5. Add a public key. For more information, refer to "Adding a Public Key (Page 204)".
6. Navigate to ***tunnel » ipsec » connection » {connection} » {end}***, where *{connection}* is the name of the connection and *{end}* is the either the left (local router) or right (remote router) connection end.
7. Configure the system public key by typing:

   ```
   tunnel ipsec connection { connection } [ left | right ] key type certificate
   ```

   Where:

   - `{ connection }` is the name of the connection
8. Configure the system identifier by typing:

   ```
   tunnel ipsec connection { connection } [ left | right ] identifier type from-certificate
   ```

   Where:

   - `{ connection }` is the name of the connection
9. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.8.4 Viewing the IPsec Tunnel Status

To view the status of the IPsec tunnel, type:

1. Make sure the CLI is in Configuration mode.
2. Display the status by typing:

   ```
   show tunnel ipsec status
   ```

   A table or list similar to the following example appears:

   ```
   status
   ============================================================
   000 using kernel interface: netkey
   000 interface lo/lo :1
   000 interface lo/lo 127.0.0.1
   000 interface vrf_gw0/vrf_gw0 169.254.0.1
   000 interface switch.0001/switch.0001 192.168.0.2
   000 interface switch.1000/switch.1000 172.30.151.38
   000 %myid = (none)
   000 debug none
   000
   000 virtual_private (%priv):
   000 - allowed 0 subnets:
   000 - disallowed 0 subnets:
   ```

```
000 WARNING: Either virtual_private= is not specified, or there is a syntax
000          error in that line. 'left/rightsubnet=vhost:%priv' will not work!
000 WARNING: Disallowed subnets in virtual_private= is empty. If you have
000          private address space in internal use, it should be excluded!
000
000 algorithm ESP encrypt: id=2, name=ESP_DES, ivlen=8, keysizemin=64,
 keysizemax=64
000 algorithm ESP encrypt: id=3, name=ESP_3DES, ivlen=8, keysizemin=192,
 keysizemax=192
000 algorithm ESP encrypt: id=11, name=ESP_NULL, ivlen=0, keysizemin=0,
 keysizemax=0
000 algorithm ESP encrypt: id=12, name=ESP_AES, ivlen=8, keysizemin=128,
 keysizemax=256
000 algorithm ESP encrypt: id=14, name=ESP_AES_CCM_A, ivlen=8, keysizemin=128,
 keysizemax=256
000 algorithm ESP encrypt: id=15, name=ESP_AES_CCM_B, ivlen=8, keysizemin=128,
 keysizemax=256
000 algorithm ESP encrypt: id=252, name=ESP_SERPENT, ivlen=8, keysizemin=128,
 keysizemax=256
000 algorithm ESP encrypt: id=253, name=ESP_TWOFISH, ivlen=8, keysizemin=128,
 keysizemax=256
000 algorithm ESP auth attr: id=1, name=AUTH_ALGORITHM_HMAC_MD5,
 keysizemin=128, keysizemax=128
000 algorithm ESP auth attr: id=2, name=AUTH_ALGORITHM_HMAC_SHA1,
 keysizemin=160, keysizemax=160
000 algorithm ESP auth attr: id=251, name=(null), keysizemin=0, keysizemax=0
000
000 algorithm IKE encrypt: id=0, name=(null), blocksize=16, keydeflen=131
000 algorithm IKE encrypt: id=3, name=OAKLEY_BLOWFISH_CBC, blocksize=8,
 keydeflen=128
000 algorithm IKE encrypt: id=65289, name=OAKLEY_TWOFISH_CBC_SSH, blocksize=16,
 keydeflen=128
000 algorithm IKE hash: id=1, name=OAKLEY_MD5, hashsize=16
000 algorithm IKE hash: id=2, name=OAKLEY_SHA1, hashsize=20
000 algorithm IKE hash: id=4, name=OAKLEY_SHA2_256, hashsize=32
000 algorithm IKE hash: id=6, name=OAKLEY_SHA2_512, hashsize=64
000 algorithm IKE dh group: id=2, name=OAKLEY_GROUP_MODP1024, bits=1024
000 algorithm IKE dh group: id=5, name=OAKLEY_GROUP_MODP1536, bits=1536
000 algorithm IKE dh group: id=18, name=OAKLEY_GROUP_MODP8192, bits=8192
000
000 stats db_ops: {curr_cnt, total_cnt, maxsz} :context={0,0,0} trans={0,0,0}
 attrs={0,0,0}
000
000 "ipsec-12": 192.168.22.0/24===192.168.12.2&amp;lt;192.168.12.2&amp;gt;
[C=CA, ST=Ontario, O=RuggedCom, CN=router2, E=router2@example.com,
+S=C]...192.168.12.1&amp;lt;192.168.12.1&amp;gt;[C=CA, ST=Ontari o,
 O=RuggedCom, CN=router1, E=router1@example.com,+S=C]===192.168.11.0/24;
 erouted; eroute owner: #2
000 "ipsec-12":     myip=unset; hisip=unset; myup=ipsec _updown --route yes;
 hisup=ipsec _updown --route yes; mycert=router2;
000 "ipsec-12":   CAs: 'C=CA, ST=Ontario, O=RuggedCom, CN=CA,
 E=ca@example.com'...'%any'
000 "ipsec-12":   ike_life: 3600s; ipsec_life: 28800s; rekey_margin: 540s;
 rekey_fuzz: 100%; keyingtries: 0
000 "ipsec-12":   policy: RSASIG+ENCRYPT+TUNNEL+PFS+UP+IKEv2ALLOW+lKOD+rKOD;
 prio: 24,24; interface: switch.0012;
000 "ipsec-12":   newest ISAKMP SA: #4; newest IPsec SA: #2;
000 "ipsec-12":   IKE algorithm newest: AES_CBC_128-SHA1-MODP2048
000
000 #4: "ipsec-12":500 STATE_MAIN_I4 (ISAKMP SA established); EVENT_SA_REPLACE
 in 106s; newest ISAKMP; lastdpd=-1s(seq in:0 out:0); idle; import:admin
 initiate
000 #2: "ipsec-12":500 STATE_QUICK_I2 (sent QI2, IPsec SA established);
 EVENT_SA_REPLACE in 19349s; newest IPSEC; eroute owner; isakmp#1; idle;
 import:admin initiate
000 #2: "ipsec-12" esp.edfbc8f8@192.168.12.1 esp.53ffca14@192.168.12.2
 tun.0@192.168.12.1 tun.0@192.168.12.2 ref=0 refhim=4294901761
```

```
000
```

11.8.5 Managing Pre-Shared Keys

Pre-shared keys are used in *secret key* cryptography. For more information about *secret key* cryptography and pre-shared keys, refer to "Public and Secret Key Cryptography (Page 504)".

11.8.5.1 Viewing a List of Pre-Shared Keys

To view a list of pre-shared keys, type:

```
show running-config tunnel ipsec preshared-key
```

If pre-shared keys have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config tunnel ipsec preshared-key
tunnel
 ipsec
  preshared-key 192.168.12.1 192.168.12.2
   key $4$9YslfOBfkyYV8c1tqN4IDw==
  !
 !
!
```

If no pre-shared keys have been configured, add pre-shared keys as needed. For more information, refer to "Adding a Pre-Shared Key (Page 509)".

11.8.5.2 Adding a Pre-Shared Key

To add a pre-shared key, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the pre-shared key by typing:

   ```
   tunnel ipsec preshared-key [ { remote-address } |
   { local-address } ] key { key }
   ```

   Where:

   - `{ remote-address }` is the remote IP address
   - `{ local-address }` is the local IP address
   - `{ key }` is the is the content of the pre-shared key
3. Configure the following parameter(s) as required:

Parameter	Description
`key { key }`	**Synopsis:** A string between 1 and 8192 characters long The pre-shared key.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.8.5.3 Deleting a Pre-Shared Key

To delete a pre-shared key, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the pre-shared key by typing:

   ```
   no tunnel ipsec preshared-key [ { remote-address } | { local-address } ] key { key }
   ```

   Where:

   - `{ remote-address }` is the remote IP address
   - `{ local-address }` is the local IP address
   - `{ key }` is the is the content of the pre-shared key
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.8.6 Managing Connections

An IPsec connection is an encrypted connection between two devices who share the same pre-authorized authentication key.

11.8.6.1 Viewing a List of Connections

To view a list of connections configured for a VPN, type:

```
show tunnel ipsec connection
```

If connections have been configured, a table similar to the following example appears:

```
ruggedcom# show running-config tunnel ipsec connection
tunnel
 ipsec
  connection ipsec-12
   no l2tp
   ike algorithm 3des md5 modp8192
   !
   esp algorithm aes128 sha1
   !
```

```
    left
     public-ip type default-route
     public-ip value 192.168.11.0/24
    !
    right
     public-ip type any
    !
   !
  !
!
```

If no connections have been configured, add connections as needed. For more information, refer to "Adding a Connection (Page 511)".

11.8.6.2 Adding a Connection

To add a new connection for a VPN, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the connection by typing:

   `tunnel ipsec connection { name }`

   Where:

   - `{ name }` is the connection name. If the name is *default*, this makes it the default setting for all connections.
3. Configure the following parameter(s) as required:

Parameter	Description
`startup { startup }`	**Synopsis:** [ignore | add | start | route | default] **Default:** default The action to take when IPsec is initialized. The default value is 'ignore' unless overwritten by the default connection setting.
`authenticate { authenticate }`	**Synopsis:** [default | rsasig | secret] **Default:** default The authentication method. The default value is 'rsasig' unless overwritten by the default connection setting.
`connection-type { connection-type }`	**Synopsis:** [tunnel | transport | passthrough | default] **Default:** default The connection type/mode. Options include: • tunnel: Encrypts traffic on host-to-host, host-to-subnet or subnet-to-subnet tunnels. This is the default type/mode unless overwritten by the default connection setting. • transport: Encrypts traffic on a host-to-host tunnel. • passthrough: Traffic is not encrypted.

Parameter	Description
`address-family { address-family }`	**Synopsis:** [ipv4 | ipv6] **Default:** ipv4 The address-family to run for the connection. Accepted values include 'ipv4' (default) and 'ipv6'. All addresses used in the connection must have the same address family.
`ike-version { ike-version }`	**Synopsis:** [v1 | v2] **Default:** v2 Option to determine which Internet Key Exchange (IKE) version to use. Options include: • v1: Use IKEv1. • v2: Use IKEv2.
`pfs { pfs }`	**Synopsis:** [default | yes | no] **Default:** default Enables/disables Perfect Forwarding Secrecy (PFS). When enabled, IPsec negotiates new keys for each session. If an attacker compromises a key, only the session protected by the key is revealed. Not all clients support PFS. The default value is 'yes' unless overwritten by the default connection setting.
`keylife { keylife }`	**Synopsis:** [default] or An integer between 1081 and 86400 **Default:** default The lifetime in seconds for the Security Association (SA) key. This determines how long a particular instance of a connection should last, from successful negotiation to expiry. Normally, the connection is renegotiated before it expires. The default value is 28800 unless overwritten by the default connection setting. Peers can specify different lifetime intervals. However, if peers do not agree, an excess of superseded connections will occur on the peer that believes the SA lifetime is longer.
`ike-lifetime { ike-lifetime }`	**Synopsis:** [default] or An integer between 60 and 86400 **Default:** default The lifetime in seconds for for the IKE protocol. This determines how long the IKE keying channel of a connection should last before being renegotiated. The default value is 3600 unless overwritten by the default connection setting. Peers can specify different lifetime intervals. However, if peers do not agree, an excess of superseded connections will occur on the peer that believes the IKE lifetime is longer.
`keyingtries { keyingtries }`	**Synopsis:** [default] or An integer **Default:** default The maximum number of attempts to negotiate or replace a connection before aborting. When set to the default value '%forever', the device attempts to connect an unlimited number of times. This parameter is independent of the other endpoint's configuration.
`l2tp`	Enables/disables L2TP for this connection.

Parameter	Description
`connection-alarms { connection-alarms }`	**Synopsis:** [true | false] **Default:** false Enables or disables connection up and down alarms. Disabling connection alarms will prevent alarms from being sent for that connection. Connection alarms may also be controlled for the whole system under **admin > alarm-cfg** .
`monitor-interface { monitor-interface }`	**Synopsis:** A string The interface to monitor. If the selected interface goes down and then up, this connection will be restarted.

4. If required, enable and configure dead peer detection. For more information, refer to "Configuring Dead Peer Detection (Page 513)".
5. If required, configure the Internet Key Exchange (IKE) protocol by adding one or more algorithms. For more information, refer to "Adding an IKE Algorithm (Page 516)".
6. If required, configure Encapsulated Security Payload (ESP) encryption for the connection. For more information, refer to "Managing the Encapsulated Security Payload (ESP) Protocol (Page 517)".
7. If required, configure the left (local router) and right (remote router) ends of the connection. For more information, refer to "Managing Connection Ends (Page 519)".
8. If required, configure L2TP tunnels. For more information, refer to "Configuring L2TP Tunnels (Page 460)".
9. If certificates and keys are required, make sure they are configured on the device. For more information, refer to "Configuring Certificates and Keys (Page 506)".
10. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.8.6.3 Configuring Dead Peer Detection

Dead Peer Detection (DPD), as defined in RFC 3706 [http://tools.ietf.org/html/rfc3706] is used to detect dead Internet Key Exchange (IKE) peers. In this method, peers exchange DPD Request (ISAKMP R-U-THERE) and DPD Response (ISAKMP R-U-THERE-ACK) messages. If a DPD Response is not received by a peer after a specified time and/or number of attempts, the other peer is considered *dead*. The remaining peer can either hold the connection until other peer responds, clear the connection, restart the connection and renegotiate the Security Association (SA), or restart all SA's to the dead peer.

In RUGGEDCOM ROX II, DPD Requests are sent when there is no traffic detected by the peer. How long to wait before sending a DPD Request and how long to wait for a DPD Response is user configurable.

It is generally recommended that DPD be configured to clear connections with any dead peers.

To configure dead peer detection for an IPsec connection, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable dead peer detection by typing:

   ```
   tunnel ipsec connection { name } dead-peer-detect enabled [ true | false ]
   ```

   Where:

   - `{ name }` is the connection name.
3. Configure the following parameter(s) as required:

   Note
   The timeout period must be two minutes longer than the interval period.

Parameter	Description
`interval { interval }`	**Synopsis:** An integer between 1 and 3600 **Default:** 30 The interval (in seconds) between Dead Peer Detection keepalive messages sent for this connection when no traffic (idle) appears to be sent by a DPD enabled peer.
`timeout { timeout }`	**Synopsis:** An integer between 1 and 28800 **Default:** 120 The time in seconds to wait before a peer is declared dead.
`action { action }`	**Synopsis:** [hold | clear | restart | restart-all-sa] **Default:** restart The action to be taken when a DPD enabled peer is declared dead. Options include: • hold: The route will be put on hold status. • clear: The route and Security Association (SA) will both be cleared • restart: The SA will immediately be renegotiated • restart-all-sa: All SA's to the dead peer will be renegotiated

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.8.6.4 Deleting a Connection

To delete a connection for a VPN, do the following:

1. Make sure the CLI is in Configuration mode.

2. Delete the connection by typing:

   ```
   no tunnel ipsec connection { name }
   ```

   Where:

   - `{ name }` is the name of the connection

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.8.6.5 Viewing the Status of a Connection

To view the status of an IPsec connection, type:

```
show tunnel ipsec connection { name } connection-status
```

Where { name } is the name of the connection. For example:

```
ruggedcom# show tunnel ipsec connection ipsec-12 connection-status
connection status "dead peer detect disabled"
```

Possible values include:

- **dead peer detect disabled** – Dead Peer Detection (DPD) is disabled. DPD must be enabled to report the status of the connection.
- **inactive** – There are currently no established connections on the selected tunnel.
- **active** – There are established peer connections on the selected tunnel. The number of active peers is defined in brackets.
- **IPsec disabled** – IPsec is disabled.

11.8.7 Managing the Internet Key Exchange (IKE) Protocol

The Internet Key Exchange (IKE) protocol negotiates connection parameters, including keys, for the Encapsulated Security Payload (ESP) protocol employed by IPsec. IKE is based on the Diffie-Hellman key exchange protocol, which allows two parties without any initially shared secret to create one in a manner immune to eavesdropping.

11.8.7.1 Viewing a List of IKE Algorithms

To view a list of algorithms for the Internet Key Exchange (IKE) protocol, type:

```
show running-config tunnel ipsec connection
{ connection } ike algorithm
```

Where:

- `{ connection }` is the name of the connection

If algorithms have been configured, a table or list similar to the following example appears:

```
tunnel
 ipsec
  connection ipsec-12
   ike algorithm 3des md5 modp8192
   !
  !
 !
!
```

If no algorithms have been configured, add algorithms as needed. For more information, refer to "Adding an IKE Algorithm (Page 516)".

11.8.7.2 Adding an IKE Algorithm

To add a new algorithm for the Internet Key Exchange (IKE) protocol, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the algorithm by typing:

   ```
   tunnel ipsec connection { connection } ike
   algorithm { cipher } { method } { modpgroup }
   ```

   Where:

   - `{ connection }` is the name of the connection.
   - `{ cipher }` is the cipher algorithm. Options include **3des**, **aes**, **aes128**, **aes192**, **aes256** and **any**. The default is **aes**, unless overwritten by the default connection setting. The option **any** selects the default.
   - `{ method }` is the hash method. Options include **any**, **md5**, **sha1** and **sha2**. The default is **sha2**, unless overwritten by the default connection setting. The option **any** selects the default.
   - `{ modpgroup }` is the value of the Modular Exponential (MODP) group. Options include **any**, **modp1024**, **modp1536**, **modp2048**, **modp3072**, **modp4096**, **modp6144**, **modp8192**, **dh19**, **dh20**, and **dh21**. The default is **modp2048**, unless overwritten by the default connection setting. The option **any** selects the default.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.8.7.3 Deleting an IKE Algorithm

To delete an algorithm for the Internet Key Exchange (IKE) protocol, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the algorithm by typing:

   ```
   no tunnel ipsec connection { connection } ike
   algorithm { cipher } { method } { modpgroup }
   ```

   Where:

   - `{ connection }` is the name of the connection.
   - `{ cipher }` is the cipher algorithm. Options include **3des**, **aes**, **aes128**, **aes192**, **aes256** and **any**.
   - `{ method }` is the hash method. Options include **any**, **md5**, **sha1** and **sha2**.
   - `{ modpgroup }` is the value of the Modular Exponential (MODP) group. Options include **any**, **modp1024**, **modp1536**, **modp2048**, **modp3072**, **modp4096**, **modp6144**, **modp8192**, **dh19**, **dh20**, and **dh21**.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.8.8 Managing the Encapsulated Security Payload (ESP) Protocol

The Encapsulated Security Payload (ESP) employed by IPsec provides encryption and authentication, making sure that messages originated from the expected sender have not been altered in transit.

11.8.8.1 Configuring ESP Encryption

To configure the encryption algorithm for the Encapsulate Security Payload (ESP), do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***tunnel » ipsec » connection » {connection} » esp***, where *{connection}* is the name of the connection.
3. Configure the encryption algorithm by typing:

   ```
   tunnel ipsec connection { connection } esp
   modpgroup { modpgroup }
   ```

   Where:

   - `{ connection }` is the name of the connection.
   - `{ modpgroup }` is the value of the Modular Exponential (MODP) group. Options include **any**, **modp1024**, **modp1536**, **modp2048**, **modp3072**,

modp4096, **modp6144**, **modp8192**, **dh19**, **dh20**, and **dh21**. The default is **modp2048**, unless overwritten by the default connection setting. The option **any** selects the default.

4. If required, add additional cipher algorithms. For more information on how to add algorithms, refer to "Adding an ESP Algorithm (Page 518)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.8.8.2 Viewing a List of ESP Algorithms

To view a list of algorithms for the Encapsulate Security Payload (ESP) protocol, type:

```
show running-config tunnel ipsec connection
{ connection } esp algorithm
```

Where:

- `{ connection }` is the name of the connection

If algorithms have been configured, a table or list similar to the following example appears:

```
tunnel
 ipsec
  connection ipsec-12
   esp algorithm aes256 sha1
   !
  !
 !
!
```

If no algorithms have been configured, add algorithms as needed. For more information, refer to "Adding an ESP Algorithm (Page 518)".

11.8.8.3 Adding an ESP Algorithm

To add a new algorithm for the Encapsulated Security Payload (ESP) protocol, do the following:

Note
If IKE v2 is selected, at least one ESP algorithm must be added.

1. Make sure the CLI is in Configuration mode.
2. Add the algorithm by typing:

   ```
   tunnel ipsec connection { connection } esp
   algorithm { cipher } { method }
   ```

   Where:

   - `{ connection }` is the name of the connection.

- `{ cipher }` is the cipher algorithm. Options include **3des**, **aes**, **aes128**, **aes192**, **aes256**, and **any**. The default is **aes**. The option **any** selects the default.
- `{ method }` is the hash method. Options include **any**, **md5**, **sha1**, and **sha2**. For IKE v1, the default is **sha1**. There is no default value for IKE v2.

  The option **any** selects the default.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.8.8.4 Deleting an ESP Algorithm

To delete an algorithm for the Encapsulated Security Payload (ESP) protocol, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the algorithm by typing:

   ```
   no tunnel ipsec connection { connection } esp algorithm { cipher } { method }
   ```

   Where:

   - `{ connection }` is the name of the connection
   - `{ cipher }` is the cipher algorithm. Options include **3des**, **aes**, **aes128**, **aes192**, **aes256** and **any**. The default is **aes**. The option **any** selects the default.
   - `{ method }` is the hash method. Options include **any**, **md5**, **sha1** and **sha2**. The default is **sha1**. The option **any** selects the default.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.8.9 Managing Connection Ends

Each IPsec tunnel has two ends: the local router and the remote router. These are otherwise referred to as the left and right connections, respectively. Both ends can have the same configuration or a unique configuration.

For each connection end, make sure to configure settings for the public IP address, system public key, system identifier, next hop, and the NAT traversal negotiation method.

11.8.9.1 Configuring the Public IP Address for a Connection End

To configure the public IP address for a connection end, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***tunnel » ipsec » connection » {name} » {end} » public-ip***, where *{name}* is the name of the connection and *{end}* is the either the left (local router) or right (remote router) connection end.
3. Configure the following parameters:

⚠ NOTICE

Do not use a Virtual IP Address (VRIP) as the connection's public IP address if **use-virtual-mac** is enabled under VRRP.

Parameter	Description
`type { type }`	**Synopsis:** [none | default-route | any | address | hostname] **Default:** none The public IP address type.
`value { value }`	**Synopsis:** A string 1024 characters long The public hostname or IP address.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.8.9.2 Configuring the System Public Key for a Connection End

To configure the system public key for a connection end, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***tunnel » ipsec » connection » {name} » {end} » key***, where *{name}* is the name of the connection and *{end}* is the either the left (local router) or right (remote router) connection end.
3. Configure the following parameter:

Parameter	Description
`type { type }`	**Synopsis:** [none | rsasig | certificate-any | certificate | ca-certificate] **Default:** none Key type.

4. Configuring the following parameters based on the type specified in the previous step:

Parameter	Description
`rsa-sig { rsa-sig }`	**Synopsis:** A string between 1 and 255 characters long The RSA signature key name.
`rsa-sig-ipsec`	**Synopsis:** A string between 1 and 8192 characters long The RSA signature in IPsec format.
`certificate { certificate }`	**Synopsis:** A string between 1 and 255 characters long The selected certificate.
`ca-certificate { ca-certificate }`	**Synopsis:** A string between 1 and 255 characters long The selected CA certificate.

5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.8.9.3 Configuring the System Identifier for a Connection End

To configure the system identifier for a connection end, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***tunnel » ipsec » connection » {name} » {end} » identifier***, where *{name}* is the name of the connection and *{end}* is the either the left (local router) or right (remote router) connection end.
3. Configure the system identifier by configuring the following parameters:

Parameter	Description
`type { type }`	**Synopsis:** [default | none | from-certificate | address | hostname | der-asn1-dn | user-fqdn] **Default:** default The system identifier type. The default value is 'left side public-ip' unless overwritten by the default connection setting.
`value { value }`	**Synopsis:** A string 1024 characters long The hostname, IP address or the Distinguished Name in the certificate.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.8.9.4 Configuring the Next Hop for a Connection End

To configure the next hop to the other system for a connection end, do the following:

1. Make sure the CLI is in Configuration mode.

2. Navigate to ***tunnel » ipsec » connection » {name} » {end} » nexthop***, where *{name}* is the name of the connection and *{end}* is the either the left (local router) or right (remote router) connection end.
3. Configure the following parameters:

Parameter	Description
`type { type }`	**Synopsis:** [default | default-route | address] **Default:** default The next hop type. The default value is 'right side public-ip' unless overwritten by the default connection setting.
`value { value }`	**Synopsis:** A string between 7 and 15 characters long The IP address of the next hop that can be used to reach the destination network.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.8.9.5 Configuring the NAT Traversal Negotiation Method for a Connection End

To configure the Network Address Translation (NAT) traversal negotiation mehtod for a connection end, do the following:

Note
Using the RFC 3947 negotiation method over draft-ietf-ipsec-nat-t-ike-02 may cause issues when connecting to the IPsec server, as RFC 3947 uses different identifiers when NAT is involved. For example, when a Windows XP/2003 client connects, Libreswan reports the main mode peer ID as *ID_FQDN: '@example.com'*. However, when a Vista, Windows 7 or other RFC 3947 compliant client connects, Libreswan reports the main mode peer ID as *ID_IPV4_ADDR: '192.168.1.1'*. If possible, use the draft-ietf-ipsec-nat-t-ike-02 method to avoid this issue.

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***tunnel » ipsec » connection » {name} » {end} » nexthop***, where *{name}* is the name of the connection and *{end}* is the either the left (local router) or right (remote router) connection end.
3. Configure the following parameters:

Parameter	Description
`nat-traversal-negotiation { nat-traversal-negotiation }`	**Synopsis:** [default | draft-ietf-ipsec-nat-t-ike-02 | rfc-3947] **Default:** default The NAT traversal negotiation method. Some IPsec endpoints prefer RFC 3947 over draft-ietf-ipsec-nat-t-ike-02 when connecting with Libreswan, as these implementations use different identifiers when NAT is involved. For example, when a Windows XP/2003 client connects, Libreswan reports the main mode peer ID is ID_FQDN: '@example.com', but when a Vista, Windows 7 or other RFC 3947 compliant client connects,

Parameter	Description
	Libreswan reports the main mode peer ID is ID_IPV4_ADDR: '192.168.1.1'. This will cause issues connecting to the IPsec server. In such cases, setting this option to draft-ietf-ipsec-nat-t-ike-02 will solve this problem. The default value is 'rfc-3947' unless overwritten by the default connection setting.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.8.10 Managing Private Subnets

If the device is connected to an internal, private subnet, access to the subnet can be granted to the device at the other end of the IPsec tunnel. Only the IP address and mask of the private subnet is required.

11.8.10.1 Viewing a List of Addresses for Private Subnets

To view a list of IP addresses configured for private subnets, type:

```
show running-config tunnel ipsec connection { name } [ right | left ] subnet
```

Where:

- `{ name }` is the name of the connection

If IP addresses have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config tunnel ipsec connection ipsec-12 left subnet
tunnel
 ipsec
  connection ipsec-12
   left
    subnet 192.168.11.0/24
    !
   !
  !
 !
!
```

If no IP addresses have been configured, add addresses as needed. For more information, refer to "Adding an Address for a Private Subnet (Page 523)".

11.8.10.2 Adding an Address for a Private Subnet

To add an IP address for a private subnet, do the following:

1. Make sure the CLI is in Configuration mode.

2. Add the IP address and prefix by typing:

   ```
   tunnel ipsec connection { name } [ right | left ]
   subnet { address }
   ```

   Where:

   - `{ name }` is the name of the connection
   - `{ address }` is the IP address and prefix of the private subnet

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.8.10.3 Deleting an Address for a Private Subnet

To delete an IP address for a private subnet, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the IP address by typing:

   ```
   no tunnel ipsec connection { name } [ right |
   left ] subnet { address }
   ```

   Where:

   - `{ name }` is the name of the connection
   - `{ address }` is the IP address and prefix of the private subnet

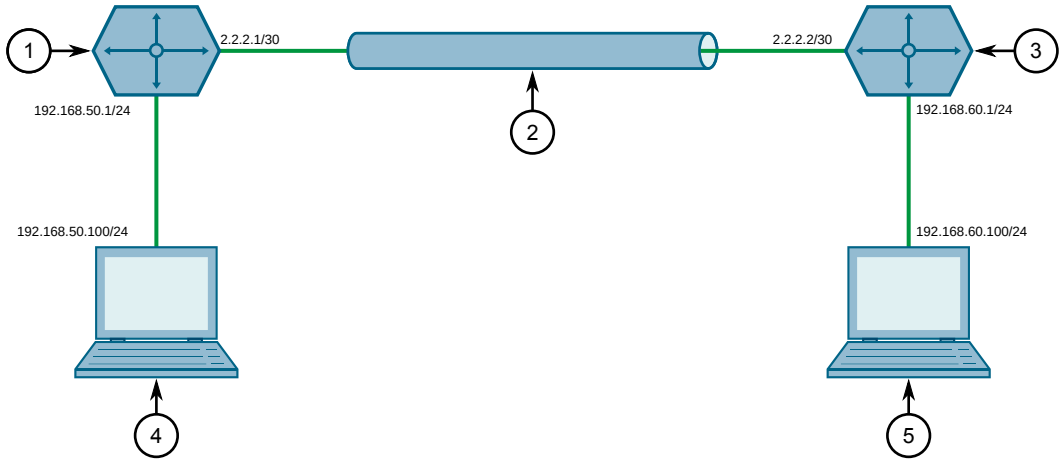
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.8.11 Example: Configuring an Encrypted VPN Tunnel

This example describes how to configure an encrypted VPN tunnel over a public network using Layer 3 RUGGEDCOM ROX II devices.

⚠ NOTICE

The values shown are specific to the provided topology. Actual values can vary based on the user's configuration.



① Device A
② IPsec Encrypted VPN Tunnel
③ Device B
④ Client 1
⑤ Client 2

Figure 11.8 Topology – Site-to-Site Encrypted VPN Tunnel with a Pre-Shared Key

To configure a VPN tunnel, do the following:

1. Configure a connection name for the VPN. For more information, refer to "Adding a Connection (Page 511)".
2. Configure Device A:
   a. Configure a host name for the device. For more information, refer to "Configuring the Host Name (Page 127)".
   b. Add a unique pre-shared key and configure the following parameters:

Parameter	Value
Local Address	2.2.2.1/30
Remote Address	2.2.2.2/30

   For more information, refer to "Adding a Pre-Shared Key (Page 509)".
   c. Add an IPsec connection and configure the following parameters:

Parameter	Value
Startup Operation	start
Authenticate By	secret
Connection Type	tunnel

   For more information about IPsec connections, refer to "Adding a Connection (Page 511)".
   d. Configure an Internet Key Exchange (IKE) algorithm with default values. For more information, refer to "Adding an IKE Algorithm (Page 516)".

e. Configure an Encapsulated Security Payload (ESP) algorithm with default values. For more information, refer to "Adding an ESP Algorithm (Page 518)".

f. Configure the left connection end for the IPsec tunnel with the following public IP address parameters:

Parameter	Value
Type	address
Value	2.2.2.1

For more information about configuring connection ends, refer to "Managing Connection Ends (Page 519)".

g. Add subnet *192.168.50.0/24* for the left connection end. For more information, refer to "Adding an Address for a Private Subnet (Page 523)".

h. Configure the right connection end for the IPsec tunnel with the following public IP address parameters:

Parameter	Value
Type	address
Value	2.2.2.2

For more information about configuring connection ends, refer to "Managing Connection Ends (Page 519)".

i. Add subnet *192.168.60.0/24* for the right connection end. For more information, refer to "Adding an Address for a Private Subnet (Page 523)".

3. Configure Device B:

a. Configure a host name for the device. For more information, refer to "Configuring the Host Name (Page 127)".

b. Add a unique pre-shared key and configure the following parameters:

Parameter	Value
Local Address	2.2.2.2/30
Remote Address	2.2.2.1/30

For more information, refer to "Adding a Pre-Shared Key (Page 509)".

c. Add an IPsec connection and configure the following parameters:

Parameter	Value
Startup Operation	start
Authenticate By	secret
Connection Type	tunnel

For more information about IPsec connections, refer to "Adding a Connection (Page 511)".

d. Configure an Internet Key Exchange (IKE) algorithm with default values. For more information, refer to "Adding an IKE Algorithm (Page 516)".

e. Configure an Encapsulated Security Payload (ESP) algorithm with default values. For more information, refer to "Adding an ESP Algorithm (Page 518)".

f. Configure the right connection end for the IPsec tunnel with the following public IP address parameters:

Parameter	Value
Type	address
Value	2.2.2.2

For more information about configuring connection ends, refer to "Managing Connection Ends (Page 519)".

g. Add subnet *192.168.60.0/24* for the right connection end. For more information, refer to "Adding an Address for a Private Subnet (Page 523)".

h. Configure the left connection end for the IPsec tunnel with the following public IP address parameters:

Parameter	Value
Type	address
Value	2.2.2.1

For more information about configuring connection ends, refer to "Managing Connection Ends (Page 519)".

i. Add subnet *192.168.50.0/24* for the left connection end. For more information, refer to "Adding an Address for a Private Subnet (Page 523)".

4. Enable the IPsec tunnel. For more information, refer to "Configuring IPsec Tunnels (Page 505)".

5. Verify the tunnel status and make sure the traffic between the two sites is encrypted:

a. View the IPsec tunnel status and look for a message that includes the connection name and the words *erouted; eroute owner:*. For example:

```
000 "ipsec-12": 192.168.22.0/24===192.168.12.2&amp;lt;192.168.12.2&amp;gt;
[C=CA, ST=Ontario, O=RuggedCom, CN=router2, E=router2@example.com,
+S=C]...192.168.12.1&amp;lt;192.168.12.1&amp;gt;[C=CA,
 ST=Ontari o, O=RuggedCom, CN=router1, E=router1@example.com,
+S=C]===192.168.11.0/24; erouted; eroute owner: #2
```

This indicates the IPsec tunnel is active.

For more information, refer to "Viewing the IPsec Tunnel Status (Page 507)".

b. Capture the packets using Tcpdump on one of the tunnel interfaces. Encrypted traffic will display an *ESP* header. For more information about using the Tcpdump utility, refer to "Capturing Packets from a Network Interface (Page 29)".

Final Configuration Example

The following configuration reflects the topology:

Device A

```
# show full-configuration
tunnel
ipsec
  enabled
  preshared-key 2.2.2.2 2.2.2.1
   key SiEm3nsRu993dc@m
  !
  connection test
   startup         start
   authenticate    secret
   connection-type tunnel
      ike algorithm any any any
   !
   esp algorithm any any
   !
   left
    public-ip type address
    public-ip value 2.2.2.1
    subnet 192.168.50.0/24
   !
   right
    public-ip type address
    public-ip value 2.2.2.2
    subnet 192.168.60.0/24
```

Device B

```
# show full-configuration
tunnel
ipsec
  enabled
  preshared-key 2.2.2.1 2.2.2.2
   key SiEm3nsRu993dc@m
  !
  connection test
   startup         start
   authenticate    secret
   connection-type tunnel
      ike algorithm any any any
   !
   esp algorithm any any
   !
   left
    public-ip type address
    public-ip value 2.2.2.1
    subnet 192.168.50.0/24
   !
   right
    public-ip type address
    public-ip value 2.2.2.2
    subnet 192.168.60.0/24
```

11.8.12 Example: Configuring an IPsec Tunnel to Use SCEP Certificates

The following describes how to establish an IPsec tunnel over a public network using CA certificates managed by SCEP.

1. Configure the SCEP client and verify communication with a SCEP server. For more information, refer to "Configuring SCEP (Page 211)"
2. Establish an IPsec tunnel between the device and its peer.
3. Configure the left connection end as follows:
   a. Configure the public IP address to be the same as the **subject-alternative-name** parameter in the SCEP client configuration.

      For information about setting the public IP address for a connection end, refer to "Configuring the Public IP Address for a Connection End (Page 520)".

      For information about the **subject-alternative-name** parameter, refer to "Configuring the SCEP Certificate Signing Requests (Page 213)".

   b. Set the system public key type to be **certificate** and then select the certificate managed by SCEP (e.g. scep-cert).

      For more information, refer to "Configuring the System Public Key for a Connection End (Page 520)".
4. Configure the right connection end as follows:
   - Set the system public key type to **ca-certificate** and then select the CA certificate managed by SCEP (e.g. scep-ca).

     For more information setting the system public key, refer to "Configuring the System Public Key for a Connection End (Page 520)".

11.9 Managing 6in4 and 4in6 Tunnels

In networks where IPv4 and IPv6 operate simultaneously, 6in4 and 4in6 tunnels can be used to enable IPv6/IPv4 hosts to reach services using the opposite protocol. IPv6/IPv4 hosts and networks isolated from one another can also use these tunnels to access one another.

In a 6in4 tunnel, IPv6 traffic is encapsulated over configured IPv4 links, and vice versa for 4in6 tunnels.

Note
For information about how to monitor traffic through the tunnel, refer to "Viewing Statistics for Routable Interfaces (Page 249)".

11.9.1 Enabling/Disabling 6in4 or 4in6 Tunnels

To enable or disable all 6in4 or 4in6 tunnels, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable or disable 6in4/4in6 tunnels by typing:

   Enabling

```
tunnel [ ip6in4 | ip4in6 ] enabled
```

Disabling

```
no tunnel [ ip6in4 | ip4in6 ] enabled
```

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.9.2 Viewing a List of 6in4 or 4in6 Tunnels

To view a list of 6in4 or 4in6 tunnels configured on the device, type:

```
show running-config tunnel [ ip6in4 | ip4in6 ] tunnel
```

A table or list similar to the following example appears:

```
ruggedcom# show running-config tunnel ip6in4 tunnel | tab
NAME       ENABLED  LOCAL IP       REMOTE IP     MTU
-----------------------------------------------------
ruggedcom  true     192.168.30.14  172.23.30.14  1480

!
```

11.9.3 Viewing the Status of 6in4/4in6 Tunnels

To view the status of a 6in4 or 4in6 tunnel, type:

```
show interfaces [ ip6in4 | ip4in6 ] tunnel { name }
```

Where:

- `{ name }` is the name of the tunnel

A table or list similar to the following example appears:

```
ruggedcom# show interfaces ip6in4 tunnel
TUNNEL
NAME    LOCAL IP       REMOTE IP      STATUS
-------------------------------------------
tu      192.168.20.10  192.168.20.20  Active
```

11.9.4 Adding a 6in4 or 4in6 Tunnel

To add a 6in4 or 4in6 tunnel, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the tunnel by typing:

```
tunnel [ ip6in4 | ip4in6 ] tunnel { name }
```

Where:

- `{ name }` is the name of the tunnel

3. Configure the following parameter(s) as required:

Parameter	Description
`local-ip`	**Synopsis:** A string between 7 and 15 characters long The interface upon which the tunnel is created
`remote-ip`	**Synopsis:** A string between 7 and 15 characters long Ip address of remote tunnel end
`status`	**Synopsis:** A string Current status of tunnel

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.9.5 Deleting a 6in4 or 4in6 Tunnel

To delete a 6in4 or 4in6 tunnel, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the tunnel by typing:

```
no tunnel [ ip6in4 | ip4in6 ] tunnel { name }
```

Where:

- `{ name }` is the name of the tunnel

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.10 Managing DMVPN

This section describes how to configure the device as a spoke in a Dynamic Multipoint Virtual Private Network (DMVPN) hub-and-spoke network.

11.10.1 Understanding DMVPN

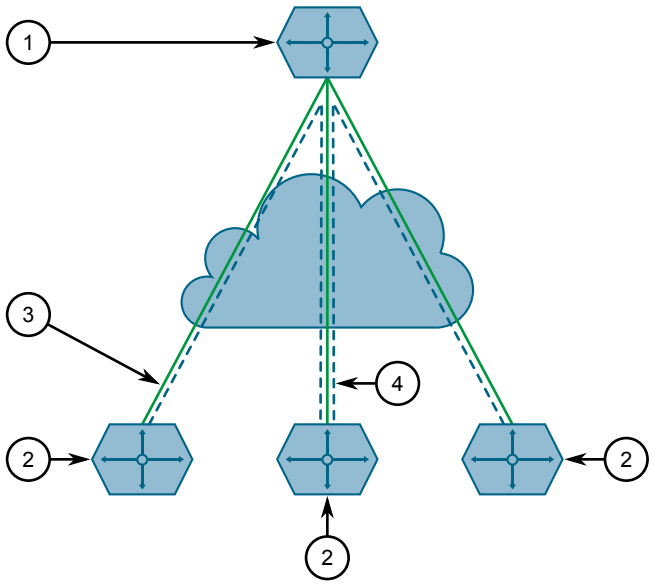
Dynamic Multipoint Virtual Private Network (DMVPN) is a routing solution for building scalable and secure VPN networks. It allows network designers to rapidly deploy routers for medium to large enterprises without having to configure static connections between all devices.

DMPVN can be deployed in one of two ways.

- Hub-and-Spoke

- Spoke-to-Spoke

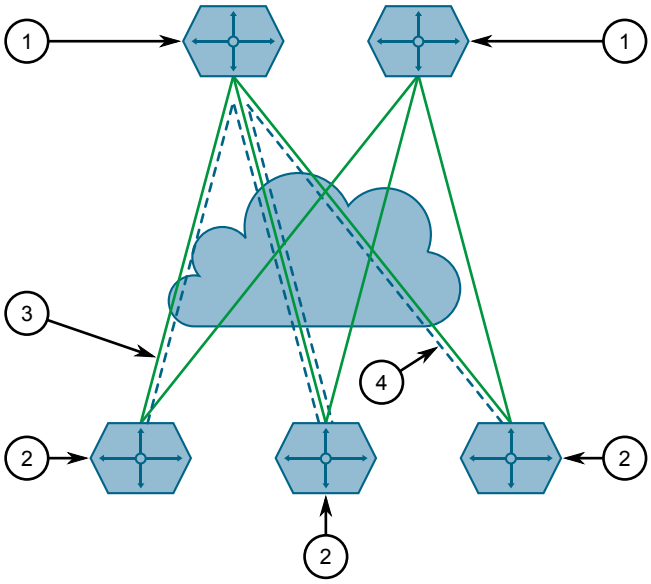
RUGGEDCOM ROX II supports hub-and-spoke deployments where a central router (the hub) uses Multipoint Generic Routing Encapsulation (mGRE) to establish GRE tunnels with one or more routers (the spokes). When spokes need to send traffic to one another, they send it to the hub first and the hub directs the data packets to the appropriate destination. This method allows network designers to avoid the complex task of defining static GRE tunnels for each possible connection.



① Hub (Static IP Address)
② Spoke (Static IP Address)
③ Hub-to-Spoke GRE/IPsec Tunnel

Figure 11.9 Hub-and-Spoke Topology – Single Hub

Spokes can also be connected to a secondary hub when redundancy is required.



① Hub (Static IP Address)
② Spoke (Static IP Address)
③ Hub-to-Spoke GRE/IPsec Tunnel

Figure 11.10 Hub-and-Spoke Topology – Dual Hub

11.10.2 Configuring DMVPN

To configure the device to act as a spoke in a hub-and-spoke network, do the following:

Note
RUGGEDCOM ROX II supports connections with up to two hubs.

1. Determine the static IP address of the hub router.
2. Configure a GRE tunnel to the hub. For more information, refer to "Adding a GRE Tunnel (Page 492)".
3. Configure IPsec for the GRE tunnel, making sure the connection name matches the name of the GRE interface (e.g. gre-t1). For more information, refer to "Configuring IPsec Tunnels (Page 505)".
4. Configure a BGP route for the GRE tunnel. For more information, refer to "Configuring BGP (Page 584)".
5. Enable the DMVPN service by typing:

```
services nhrp enabled
```

Note
RUGGEDCOM ROX II supports up to two DMVPN interfaces, each of which can be assigned to different GRE tunnels.

6. Configure a DMVPN interface for each GRE tunnel. For more information, refer to "Adding a DMVPN Interface (Page 534)".
7. Configure an IPsec/GRE tunnel from the hub to the device, using the IP address defined for the device's DMVPN interface.
8. Verify the status of the DMVPN connection. For more information, refer to "Viewing the Status of DMVPN (Page 536)".

11.10.3 Managing DMVPN Interfaces

Configure a DMVPN interface to connect with a host. Up to two interfaces can be configured, allowing the device to connect with two hubs.

11.10.3.1 Viewing a List of DMVPN Interfaces

To view a DMVPN interfaces, type:

```
show running-config services nhrp interface-nhrp
```

If interfaces have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services nhrp interface-nhrp | tab
IFNAME  ENABLED  ADDRESS           HOLDTIME  AUTHENTICATION  KEY
-------------------------------------------------------------------------------------
gre-t1  true     192.168.0.100/24  10        cisco           $4$wocla9w68FRwhYYI0d4IDw==

 !
!
```

If no interfaces have been configured, add interfaces as needed. For more information, refer to "Adding a DMVPN Interface (Page 534)".

11.10.3.2 Adding a DMVPN Interface

To add a DMVPN interface, do the following:

1. Add the interface for the desired GRE tunnel by typing:

   ```
   services nhrp interface-nhrp { gre-tunnel }
   ```

   Where `{ gre-tunnel }` is the name of the desired GRE tunnel.
2. Configure the following parameter(s) as required:

⚠ NOTICE
Security hazard – risk of unauthorized access and/or exploitation For increased security, Siemens recommends configuring a key to authenticate the NHRP interface.

Parameter	Description
`enabled`	A boolean flag to indicate Next Hop Resolution Protocol (NHRP) is enabled on this interface.
`address { address }`	**Synopsis:** A string between 9 and 18 characters long IPv4 address of remote GRE interface to be used for this NHRP session.
`holdtime { holdtime }`	**Synopsis:** An integer **Default:** 7200 The time (in seconds) that Non-Broadcast Multi-Access (NBMA) addresses are advertised as valid in authoritative NHRP responses. Default is 7200 seconds.
`authentication { authentication }`	**Synopsis:** [none | cisco] The authentication string to allow intercommunication between source and destination NHRP nodes. Maximum length is 8 characters. Currently, only CISCO authentication is supported.
`key { key }`	**Synopsis:** A string The authentication key to allow intercommunication between source and destination NHRP nodes. Maximum length is 8 characters.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.10.3.3 Deleting a DMVPN Interface

To delete a DMVPN interface, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the address pool by typing:

   ```
   no services nhrp interface-nhrp { gre-tunnel }
   ```

   Where `{ gre-tunnel }` is the name of the desired GRE tunnel.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

11.10.4 Viewing the Status of DMVPN

To view the status of the DMVPN service, type:

```
show services nhrp status
```

If DMVPN interfaces have been configured, a table or list similar to the following example appears:

```
ruggedcom# show services nhrp status
ROW  RAW FROM OPENNHRPCTL
--------------------------------------
0
1    Status: ok
2
3    Interface: gre-gre-1
4    Type: local
5    Protocol-Address: 192.168.0.1/32
6    Flags: up
7
8    Status: ok
9
10   Interface: gre-gre-1
11   Type: static
12   Protocol-Address: 192.168.0.2/24
13   NBMA-Address: 61.1.1.2
14   Flags: up
15
16   Status: ok
17
18   Interface: gre-gre-2
19   Type: local
20   Protocol-Address: 192.168.1.1/32
21   Flags: up
22
23   Status: ok
24
25   Interface: gre-gre-2
26   Type: static
27   Protocol-Address: 192.168.1.2/24
28   NBMA-Address: 71.1.1.2
29   Flags: up
30
```

Information provided is taken directly from NHRP. The following are some of the fields that may be displayed:

Note
Some fields only display when applicable.

Field	Description	Example
Status	The status of the interface.	Status: ok
Interface	The name of the interface.	Interface: gre-t1
Type	The NHRP peer type. Possible values: • `shortcut-route` – Received or relayed resolution for the route • `incomplete` – Resolution request sent but no reponse received yet • `negative` – Negative cached	Type: local

Field	Description	Example
	• `cached` – Received or relayed resolution • `dynamic` – NHC registration • `dynamic-nhs` – Dynamic NHS from DNS map • `static` – Static map from the configuration file • `static-dns` – Static DNS map from the configuration file • `local-route` – Non-local destination, with local route • `local` – Local destination, IP or off-NBMA subnet	
Protocol-Address	The interface's IP address.	Protocol-Address: 172.30.168.2/32
Flags	The flag(s) assigned to the last NHRP registration request packet. Possible values: • `unique` – The NHRP peer is unique. Its NRHP mapping entry cannot be overwritten by a mapping entry with the same IP address, even if the associated peer has a different NBMA address. • `used` – The NHRP peer is in the kernel ARP table. • `up` – A connection with the NHRP peer has been established and the link is up. • `lower-up` – A connection with the NHRP peer has been established.	Flags: up
NBMA-Address	The interface's NBMA address.	NBMA-Address: 172.19.20.21
NBMA-NAT_OA-Address	The interface's external IP address and mask. Displays only when the hub is behind a NAT-enabled router.	NBMA-NAT_OA-Address: 172.16.0.0/12
Expires-in	The time in seconds before the NBMA information of the responder is considered invalid and discarded. Displays only when the **holdtime** is configured.	Expires-in: 120
Hostname	The host name of the NBMA responder, when available.	Hostname: ruggedcom

12 Unicast and Multicast Routing

This chapter describes how to configure, monitor and manage static and dynamic routes unicast and multicast traffic.

12.1 Viewing the Status of IPv4 Routes

To view the status of the IPv4 routes configured on the device, type:

Note
It is possible to create a route on a locally connected broadcast network (i.e. without a gateway) without also bringing up a corresponding IP address on that interface. For example, it would be possible to add 192.168.1.0/24 to switch.0001, which has an IP address of 10.0.1.1 but no corresponding alias address on the 192.168.1.0/24 subnet.

```
show routing status ipv4routes
```

If IPv4 routes have been configured, a table or list similar to the following example appears:

```
ruggedcom# show routing status ipv4routes
DESTINATION     GATEWAY  INTERFACE    TYPE    WEIGHT  METRIC
-----------------------------------------------------------------
192.168.0.0/24           switch.0001  kernel
```

This table/list provides the following information:

Parameter	Description
`destination`	**Synopsis:** A string The network/prefix.
`gateway`	**Synopsis:** A string The gateway address.
`interface`	**Synopsis:** A string The interface name.
`type`	**Synopsis:** A string The route type.
`weight`	**Synopsis:** A string The route weight.

Parameter	Description
metric	**Synopsis:** A string The route metric value.

If no IPv4 routes have been configured, add routes as needed. For more information, refer to "Adding an IPv4 Address (Page 251)".

12.2 Viewing the Status of IPv6 Routes

To view the status of the IPv6 routes configured on the device, type:

```
show routing status ipv6routes
```

If IPv6 routes have been configured, a table or list similar to the following example appears:

```
ruggedcom# show routing status ipv6routes
DESTINATION  GATEWAY  INTERFACE    TYPE    WEIGHT  METRIC
-------------------------------------------------------------
fe80:/64             switch       kernel          256
fe80:/64             dp1          kernel          256
fe80:/64             vrf_lo       kernel          256
fe80:/64             switch.0001  kernel          256
fe80:/64             fe-cm-1      kernel          256
fe80:/64             switch.4094  kernel          256
ff00:/8              switch                       256
ff00:/8              dp1                          256
ff00:/8              vrf_lo                       256
ff00:/8              switch.0001                  256
ff00:/8              fe-cm-1                      256
ff00:/8              switch.4094                  256
```

This table/list provides the following information:

Parameter	Description
destination	**Synopsis:** A string The network/prefix.
gateway	**Synopsis:** A string The gateway address.
interface	**Synopsis:** A string The interface name.
type	**Synopsis:** A string The route type.
weight	**Synopsis:** A string The route weight.
metric	**Synopsis:** A string The metric value.

If no IPv6 routes have been configured, add routes as needed. For more information, refer to "Adding an IPv6 Static Route (Page 705)".

12.3 Viewing the Memory Statistics

To view statistics related to the Core, RIP, OSPF and BGP daemons, type:

```
show routing status memory
```

A list similar to the following example appears:

```
ruggedcom# show routing status memory
routing status memory
 zebra
  total 405504
  used  359424
  free  46080
 rip
  total 0
  used  0
  free  0
 ospf
  total 0
  used  0
  free  0
 bgp
  total 0
  used  0
  free  0
```

This list provides the following information:

Parameter	Description
`total`	**Synopsis:** An integer The total heap allocated (in bytes).
`used`	**Synopsis:** An integer The number of used ordinary blocks (in bytes).
`free`	**Synopsis:** An integer The number of free ordinary blocks (in bytes).

12.4 Configuring ICMP

To configure how RUGGEDCOM ROX II manages ICMP redirect messages, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***admin*** and configure the following parameter(s) as required:

Note
ICMP redirect messages are sent by routers to hosts to inform them when a better route is available for a particular destination. However, before enabling

RUGGEDCOM ROX II to send ICMP messages, be aware that ICMP redirects are simple to forge, allowing attackers to control the path by which packets are forwarded, and are sometimes considered a security risk. Send ICMP redirect messages only when appropriate.

Parameter	Description
`ignore-icmp-all { ignore-icmp-all }`	**Synopsis:** [true | false] **Default:** false Ignores all ICMP echo requests sent to it.
`ignore-icmp-broadcast { ignore-icmp-broadcast }`	**Synopsis:** [true | false] **Default:** true Ignores all ICMP ECHO and TIMESTAMP requests sent to it via broadcast/multicast.
`send-icmp-redirect { send-icmp-redirect }`	**Synopsis:** [true | false] **Default:** true Sends the ICMP redirect.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.5 Managing Event Trackers

Trackers monitor the availability of hosts or devices by periodically transmitting ICMP messages (or pings). Based on the ICMP results, the tracker updates operational data with the status of the host or device as it changes (i.e. between "up " and "down" states). Other parts of the system can then subscribe to the operational data to be notified when changes take place.

Where available, a tracker can allow a user greater flexibility when configuring a feature. For example, advertised or received routes can be filtered or blocked entirely, based on the status of the tracker.

Note
Trackers only use ICMP messages to ping an IP target. Therefore, it can only provide availability for an IP device, and only up to the IP layer.

12.5.1 Viewing a List of Event Trackers

To view a list of event trackers, type:

```
show running-config global tracking
```

If event trackers have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config global tracking
```

```
global
 tracking
  event host-in-lan-11
   target   192.168.11.100
   timeout  500
   interval 500
   fall     3
   rise     3
  !
 !
!
```

If no event trackers have been configured, add event trackers as needed. For more information, refer to "Adding an Event Tracker (Page 544)".

12.5.2 Viewing Event Tracker Statistics

RUGGEDCOM ROX II records statistics for each event tracker.

To view the statistics for an event tracker, type:

```
show global tracking event statistics
```

A list similar to the following example appears:

```
ruggedcom# show global tracking event statistics
                                                          STANDARD
                ECHO      ECHO     MIN  AVERAGE  MAX   DEVIATION
NAME            ATTEMPTS  REPLIES  RTT  RTT      RTT   RTT
-------------------------------------------------------------------
host-in-lan-11  0         0        0.0  0.0      0.0   0.0
```

This list provides the following information:

Parameter	Description
`echo-attempts`	**Synopsis:** An integer The number of echo attempts.
`echo-replies`	**Synopsis:** An integer The number of echo replies.
`min-rtt`	**Synopsis:** A string The minimum of the round trip time (in milliseconds).
`average-rtt`	**Synopsis:** A string The average of the round trip time (in milliseconds).
`max-rtt`	**Synopsis:** A string The maximum of the round trip time (in milliseconds).
`standard-deviation-rtt`	**Synopsis:** A string The standard deviation of the round trip time (in milliseconds).

12.5.3 Adding an Event Tracker

To add an event tracker, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the event tracker by typing:

   ```
   global tracking event { name }
   ```

   - `{ name }` is the name of the tracking event
3. Configure the following parameter(s) as required:

Parameter	Description
`target { target }`	**Synopsis:** A string between 1 and 253 characters long Configures the ping target as an IPv4 address or hostname.domain.
`source-ip { source-ip }`	**Synopsis:** A string between 7 and 15 characters long or A string between 6 and 40 characters long Sets the source address to a specified IPv4 address.
`source-interface { source-interface }`	**Synopsis:** A string Forces a ping on a selected interface.
`timeout { timeout }`	**Synopsis:** An integer Determines how many milliseconds to wait for the ICMP response.
`interval { interval }`	**Synopsis:** An integer Determines how many milliseconds to wait before sending another ICMP request.
`fall { fall }`	**Synopsis:** An integer The number of times a failure occurs before changing the tracking state from up to down.
`rise { rise }`	**Synopsis:** An integer The number of times success occurs before changing the tracking state from down to up.
`state`	**Synopsis:** [up | down] **Default:** up The state of the event.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.5.4 Deleting an Event Tracker

To delete an event tracker, do the following:

1. Make sure the CLI is in Configuration mode.

2. Delete the event tracker by typing:

   ```
   no global tracking event { name }
   ```

   - `{ name }` is the name of the tracking event

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.6 Managing IS-IS

Intermediate System - Intermediate System (IS-IS) is one of a suite of routing protocols tasked with sharing routing information between routers. The job of the router is to enable the efficient movement of data over sometimes complex networks. Routing protocols are designed to share routing information across these networks and use sophisticated algorithms to decide the shortest route for the information to travel from point A to point B. One of the first link-state routing protocols was IS-IS developed in 1986 and later published in 1987 by ISO as ISO/IEC 10589. It was later republished as an IETF standard (RFC 1142 [http://tools.ietf.org/html/rfc1142]).

12.6.1 IS-IS Concepts

IS-IS is an Interior Gateway Protocol (IGP) meant to exchange information within Autonomous Systems (AS). It is designed to operate within an administrative domain or network using link-state information to decide optimal data packet routing, similar to OSPF. IS-IS floods the network with link-state information and builds a database of the network's topology. The protocol computes the best path through the network (using Dijkstra's algorithm) and then forwards packets to their destination along that path.

Although it was originally designed as an ISO Connectionless-mode Network Protocol (CLNP), it was later adapted for IP network use (Dual IS-IS) in RFC 1195 [http://tools.ietf.org/html/rfc1195]. IS-IS is used primarily in ISP environments and better suited to *stringy* networks as opposed to central core based networks.

Note
In complex legacy networks, RIP, OSPF, BGP and IS-IS may all be active on the same router at the same time. Typically, however, only one dynamic routing protocol is employed at one time.

12.6.1.1 IS-IS Routers

IS-IS routers can be defined as Level-1, Level-2, or both. Level 1 routers form the area, while Level 2 routers form the backbone of the network. By default, RUGGEDCOM ROX II configures areas to be both (or Level-1-2). This allows the device to inter-operate between different areas with minimal configuration.

- **Level-1** routers are intra-area routers. They maintain a single Link-State Database (LSD) that only contains information about the Level-1 and Level-2 neighbors in its area. To communicate with routers in another area, Level-1 routers forward traffic through their closest Level-2 router.
- **Level-2** routers are inter-area routers, meaning they can communicate with routers in other areas. They also maintain a single LSD, but it only contains information about other Level-2 routers from the router's area or other areas. The router knows nothing about the Level-1 routers in its area.
- **Level-1-2** routers are both inter- and intra-area routers, meaning they can communicate with Level-1 and Level-2 routers in any area. They maintain separate LSDs for Level-1 and Level-2 routers in and outside the router's area.

12.6.1.2 Network Entity Title (NET) Addresses

IS-IS routers are identified by their Network Entity Title (NET) address, which is in Network Service Access Point (NSAP) format (RFC 1237 [http://tools.ietf.org/html/rfc1237]). NSAP addresses range from 8 to 20 octets and consist of the Authority and Format Identifier (1 byte), the Area ID (0 to 12 bytes), the System ID (6 bytes) and the selector (1 byte).

The following is an example of an NSAP address:

```
NSAP address: 49.0001.1921.6800.1001.00

AFI: 49 (typical for IS-IS NET addresses)
Area ID: 0001 (typically 4 bytes)
System ID: 1921.6800.1001 (equates to the IP address 192.168.1.1)
Selector: 00 (NET addresses always have a selector of 00)
```

12.6.1.3 Advantages and Disadvantages of Using IS-IS

The advantages and disadvantages of using IS-IS include the following:

Advantages

- runs natively on the OSI network layer
- can support both IPv4 and IPv6 networks due to it's independence from IP addressing
- IS-IS concept of areas is simpler to understand and implement
- IS-IS updates grouped together and sent as one LSP, rather than several small LSAs as with OSPF
- better scalability than OSPF due to a leaner daemon with less overhead
- gaining popularity among service providers

Disadvantages

- used mostly by service providers
- limited support by network stack vendors and equipment makers
- CLNP addressing can be new and confusing to many users

- integrates with MPLS
- protects from *spoofing* and Denial of Service (DoS) attacks due to use of the data link layer

12.6.2 Configuring IS-IS

To configure dynamic routing with IS-IS, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable IS-IS by typing:

   ```
   routing  isis  enabled
   ```

3. Associate the device with one or more areas in the IS-IS network by defining area tags. For more information, refer to "Managing Area Tags (Page 550)".
4. Configure one or more interfaces on which to perform IS-IS routing. For more information, refer to "Managing Interfaces (Page 553)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

Example

The following illustrates how to configure an IS-IS network that includes all circuit types. In this example, R1 is a Level-1 router that needs to forward traffic to Level-2 routers. R2 and R3 are configured to be Level-1-2 routers to facilitate the connection with routers R4 and R5, which are Level-2-only routers. Each router is configured to have a non-passive interface, use point-to-point network communication, and be in the same area.

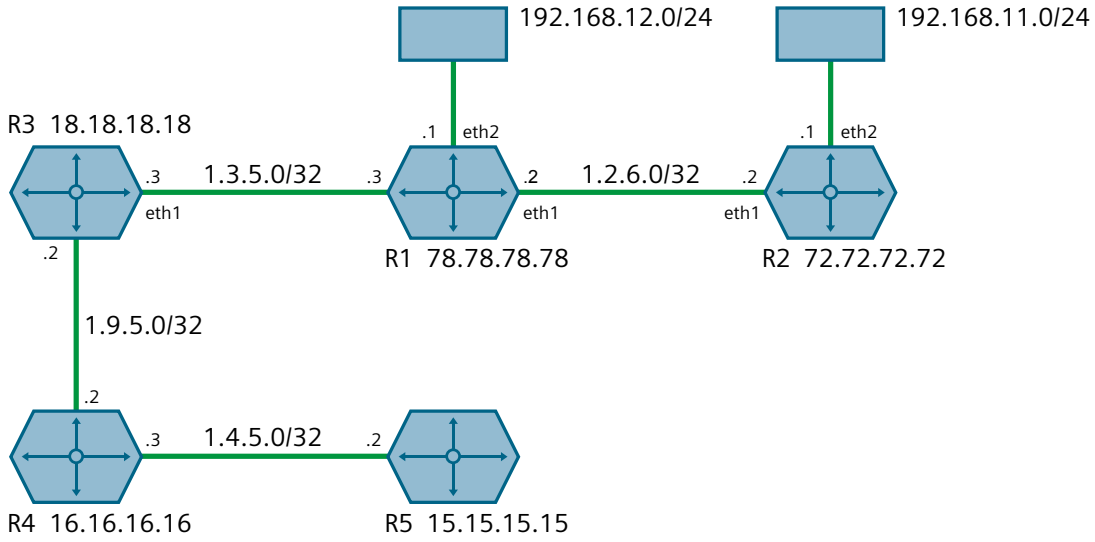


Figure 12.1 Multi-Level IS-IS Configuration

12.6.3 Viewing the Status of Neighbors

To view the status of neighboring devices on an IS-IS network, do the following:

1. Make sure IS-IS is configured. For more information, refer to "Configuring IS-IS (Page 547)".
2. View the status by typing:

   ```
   routing  status  isis  isis-neighbors-status
   ```

   If IS-IS routes have been configured, a table similar to the following example appears:

   ```
   ruggedcom# routing status isis isis-neighbors-status
   isis-neighbors-status
   Area area1:

     System Id           Interface   L  State        Holdtime SNPA

     Spirent-            switch.0012 3  Up           24       2020.2020.2020
   ```

   This table displays the following information:

Parameter	Description
System ID	The system ID.
Interface	The name of the interface.
L	The level. Possible levels are **1**, **2** and **3**, where **3** represents levels 1 and 2.
State	Adjacency state.
Holdtime	The remaining hold time in seconds.
SNPA	The MAC address of the Sub-Network Point of Attachment (SNPA).

12.6.4 Viewing the Status of the Link-State Database

To view the basic status of the link-state database for the IS-IS network, do the following:

1. Make sure IS-IS is configured. For more information, refer to "Configuring IS-IS (Page 547)".
2. Display the basic status by typing:

   ```
   routing  status  isis  isis-database-status
   ```

   Or display a more detailed status by typing:

   ```
   routing  status  isis  isis-database-detail-status
   ```

   If IS-IS routes have been configured, a list similar to the following example appears:

```
ruggedcom# routing status isis isis-database-status
isis-database-status
Area area1:

IS-IS Level-1 link-state database:

LSP ID                  PduLen  SeqNumber   Chksum  Holdtime  ATT/P/OL

R1.00-00             *     75   0x00000015  0xe43a    1129    0/0/0

    1 LSPs


IS-IS Level-2 link-state database:

LSP ID                  PduLen  SeqNumber   Chksum  Holdtime  ATT/P/OL

Spirent-.00-00            121   0x0000000f  0xd5e6     871    0/0/0

R1.00-00             *     75   0x00000015  0xe636    1031    0/0/0

Spirent-right.00-00      1465   0x0000000f  0x3d65     871    0/0/0

Spirent-right.00-01       295   0x0000000f  0x6a0d     872    0/0/0

Spirent-right.00-00      1465   0x0000000f  0x4638     872    0/0/0

Spirent-right.00-01       287   0x0000000f  0x54d0     872    0/0/0

Spirent-right.00-00      1462   0x0000000f  0x6528     872    0/0/0

Spirent-right.00-01       269   0x0000000f  0x7e8a     872    0/0/0

Spirent-right.00-00      1463   0x0000000f  0x99a0     872    0/0/0

Spirent-right.00-01       261   0x0000000f  0xb0d2     872    0/0/0

Spirent-right.00-00      1460   0x0000000f  0x80c6     872    0/0/0

Spirent-right.00-01       253   0x0000000f  0x97fb     872    0/0/0

Spirent-right.00-00      1460   0x0000000f  0x1137     872    0/0/0

Spirent-right.00-01       237   0x0000000f  0x0db7     872    0/0/0

    14 LSPs
```

This list displays the following information:

Parameter	Description
LSP-ID	Link-state PDU identifier.
Pdulength	Size of the PDU packet.
SeqNumber	Sequence number of the link-state PDU.
ChkSum	The checksum value of the link-state PDU.
Holdtime	The age of the link-state PDU in seconds.
ATT	Attach bit indicating the router is attached to another area.
P	Partition bit, set only if LSP supports partition repair.

Parameter	Description
OL	Overload, set only if the originator's LSP database is overloaded.

12.6.5 Managing Area Tags

An IS-IS area is a grouping of inter-connected (or neighboring) IS-IS configured routers. As opposed to OSPF, where an Area Border Router (ABR) can exist in two areas at once, IS-IS routers reside only in one area. It is the link between routers in two different areas that forms the border. This is because an IS-IS router has only one Network Service Access Point (NSAP) address.

A single router can be configured to act as a Level-1, Level-2 or Level-1-2 router in one or more areas.

Routers are associated with areas by area tags, which define the routing type, metric, and authentication/authorization rules.

12.6.5.1 Viewing a List of Area Tags

To view a list of area tags configured for dynamic IS-IS routes, type:

```
show running-config routing isis area
```

If area tags have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing isis area
routing isis
 area Area_1
  is-type               level-1-2
  metric-style          narrow
  area-authorization    md5
  area-password         admin
  area-authentication   validate
  domain-authorization  md5
  domain-password       admin
  domain-authentication validate
  net 49.0001.1921.6800.1001.00
  !
  redistribute bgp
   is-type     level-1-2
   metric-type internal
   metric      10
  !
  lsp-gen-interval is-type level-1-only
   interval 60
  !
  lsp-refresh-interval is-type level-1-2
   interval 20
  !
  max-lsp-lifetime is-type level-2-only
   interval 10
  !
  spf-interval is-type level-1-2
   interval 5
```

```
  !
 !
!
```

If no area tags have been configured, add area tags as needed. For more information, refer to "Adding an Area Tag (Page 551)".

12.6.5.2 Adding an Area Tag

To add an area tag for dynamic IS-IS routes, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the area by typing:

   ```
   routing  isis  area  { name }
   ```

   Where:

   - `{ name }` is the unique name for a routing process that belongs to a specific router.
3. Configure the following parameter(s) as required:

Parameter	Description
`is-type { is-type }`	**Synopsis:** [level-1-only | level-2-only | level-1-2] The IS type for this area: level-1-only, level-2-only or level-1-2. Level-1 routers have neighbors only on the same area. Level-2-only (backbone) can have neighbors on different areas. Level-1-2 can have neighbors on any areas. Default is level-1-2.
`metric-style { metric-style }`	**Synopsis:** [narrow | transition | wide] **Default:** wide The metric style Type Length Value (TLV) for this area: narrow, transition or wide. Default is wide.
`area-authorization { area-authorization }`	**Synopsis:** [clear | md5] **Default:** clear The authorization type for the area password. Default is clear.
`area-password { area-password }`	**Synopsis:** A string 254 characters long The area password to be used for transmission of level-1 LSPs.
`area-authentication { area-authentication }`	**Synopsis:** [send-only | validate] **Default:** send-only The authentication option to be used with the area password on SNP PDUs. Default is send-only.
`domain-authorization { domain-authorization }`	**Synopsis:** [clear | md5] **Default:** clear The authorization type for the domain password. Default is clear.

Parameter	Description
`domain-password { domain-password }`	**Synopsis:** A string 254 characters long The domain password to be used for transmission of level-2 LSPs.
`domain-authentication { domain-authentication }`	**Synopsis:** [send-only | validate] **Default:** send-only The authentication option to be used with the domain password on SNP PDUs. Default is send-only.

4. Add one or more Network Entity Titles (NETs). For more information, refer to "Managing Network Entity Titles (NETs) (Page 562)".
5. If necessary, configure intervals for the generation of Link-State Packets (LSPs). The default is 30 seconds. For more information, refer to "Managing LSP Generation (Page 555)".
6. If necessary, configure refresh intervals for Link-State Packets (LSPs). The default is 900 seconds. For more information, refer to "Managing LSP Refresh Intervals (Page 560)".
7. If necessary, configure the minimum interval between consecutive SPF calculations. The default is 1 second. For more information, refer to "Managing SPF Calculations (Page 556)".
8. If necessary, configure how long LSPs can reside in the device's Link State Database (LSDB) before they are refreshed. The default is 1200 seconds. For more information, refer to "Managing the Lifetime of LSPs (Page 558)".
9. If necessary, define rules for redistributing static, RIP, BGP or OSPF routes. For more information, refer to "Managing Redistribution Metrics (Page 563)".
10. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.6.5.3 Deleting an Area Tag

To delete an area tag for dynamic IS-IS routes, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the area tag by typing:

   ```
   no routing isis area { name }
   ```

   Where:

   - `{ name }` is the unique name for a routing process that belongs to a specific router.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.6.6 Managing Interfaces

IS-IS transmits hello packets and Link-State Packets (LSPs) through IS-IS enabled interfaces.

Note
IS-IS is only supported on Ethernet interfaces.

12.6.6.1 Viewing a List of Interfaces

To view a list of interfaces for dynamic IS-IS routes, type:

```
show running-config routing isis interface
```

If interfaces have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing isis interface | tab
             IPV4                  POINT
             AREA                  TO              CIRCUIT   CIRCUIT                CSNP      HELLO
  HELLO       PSNP
IFNAME       TAG     CIRCUIT TYPE  POINT  PASSIVE  PASSWORD  AUTHORIZATION  METRIC  INTERVAL  INTERVAL
  MULTIPLIER  INTERVAL
-------------------------------------------------------------------------------------
fe-cm-1      Area_1  level-1-2     true   true     admin     md5            10      10        3
  10          2
switch.0001  Area_2  level-1-only  false  true     admin     clear          10      10        3
  10          2

!
```

Interfaces are added automatically when a VLAN is created. For more information about creating a VLAN, refer to "Managing VLANs (Page 352)".

12.6.6.2 Configuring an Interface

When IS-IS is enabled, the *switch.0001* interface is already configured.

To configure optional parameters for this and any other interfaces that have been added for IS-IS, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to the interface by typing:

   ```
   routing isis interface { name }
   ```

   Where:

   - `{ name }` is the name of the interface. If the desired interface is not available, it must be created as a VLAN. For more information about creating a VLAN, refer to "Managing VLANs (Page 352)".
3. Configure the following parameter(s) as required:

Parameter	Description
`ipv4-area-tag { ipv4-area-tag }`	**Synopsis:** A string 64 characters long Name of Area Tag to be used for IS-IS over IPv4.
`circuit-type { circuit-type }`	**Synopsis:** [level-1-only | level-2-only | level-1-2] The IS-IS Circuit Type. Level-1 routers have neighbors only on the same area. Level-2 (backbone) can have neighbors on different areas. Level-1-2 can have neighbors on any areas. Default is level-1-2.
`point-to-point { point-to-point }`	**Synopsis:** [true | false] **Default:** false Enable or disable point-to-point network communication
`passive { passive }`	**Synopsis:** [true | false] **Default:** true Whether an interface is active or passive. Passive interfaces do not send packets to other routers and are not part of an IS-IS area.
`circuit-password { circuit-password }`	**Synopsis:** A string 254 characters long The value to be used as a transmit password in IIH PDUs transmitted by this Intermediate System.
`circuit-authorization { circuit-authorization }`	**Synopsis:** [clear | md5] **Default:** clear The authorization type ot be associated with the transmit password in IIH PDUs transmitted by this Intermediate System.
`metric { metric }`	**Synopsis:** An integer between 1 and 16777214 **Default:** 10 Metric assigned to the link, used to calculate the cost of the route. Value ranges from 1 to 16777214. Default is 10.
`csnp-interval { csnp-interval }`	**Synopsis:** An integer between 1 and 600 **Default:** 10 CSNP interval in seconds, ranging from 1 to 600. Default is 10.
`hello-interval { hello-interval }`	**Synopsis:** An integer between 1 and 600 **Default:** 3 Hello interval in seconds, ranging from 1 to 600. Default is 3.
`hello-multiplier { hello-multiplier }`	**Synopsis:** An integer between 2 and 100 **Default:** 10 Multiplier for Hello holding time. Value ranges from 2 to 100. Default is 10.
`psnp-interval { psnp-interval }`	**Synopsis:** An integer between 1 and 120 **Default:** 2 PSNP interval in seconds, ranging from 1 to 120. Default is 2.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.6.7 Managing LSP Generation

IS-IS generates new Link-State Packets (LSPs) every 30 seconds by default. However, the interval can be configured anywhere between 1 and 120 seconds.

Since the introduction of a new LSP causes other routers in the area to recalculate routes, it is recommended to increase the interval to decrease flooding during periods of network instability, so as to reduce the load on other routers in the area.

12.6.7.1 Viewing a List of LSP Generation Intervals

To view a list of LSP generation intervals configured for an IS-IS area, type:

```
show running-config routing isis area { name } lsp-gen-interval
```

Where:

- `{ name }` is the unique name for a routing process that belongs to a specific router.

If intervals have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing isis area Area_1 lsp-gen-interval | tab
ISTYPE        INTERVAL
------------------------
level-1-only  60

 !
!
```

If no intervals have been configured, add intervals as needed. For more information, refer to "Adding an LSP Generation Interval (Page 555)".

12.6.7.2 Adding an LSP Generation Interval

To add an LSP generation interval to an IS-IS area, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add a new interval by typing:

   ```
   routing isis area { name } lsp-gen-interval is-type [ level-1-2 | level-1-only | level-2-only ] interval { seconds }
   ```

   Where:

- `{ name }` is the unique name for a routing process that belongs to a specific router.
- `{ level }` is the IS type.
- `{ seconds }` is the minimum interval in seconds, ranging from 1 to 120. The default value is 30.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.6.7.3 Deleting an LSP Generation Interval

To delete an LSP generation interval for an IS-IS area, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the LDP interface by typing:

```
no routing isis area { name } lsp-gen-interval
is-type [ level-1-2 | level-1-only | level-2-only ]
interval { seconds }
```

Where:

- `{ name }` is the unique name for a routing process that belongs to a specific router.
- `{ level }` is the IS type.
- `{ seconds }` is the minimum interval in seconds, ranging from 1 to 120. The default value is 30.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.6.8 Managing SPF Calculations

IS-IS uses the Shortest Path First (SPF) algorithm to determine the best routes to every known destination in the network. When the network topology (not external links) changes, a partial recalculation is required.

IS-IS can be configured to perform the SPF calculation every 1 to 120 seconds. By default, IS-IS performs the SPF calculation every second. which could potentially be processor intensive, depending on the size of the area and how often the topology changes.

12.6.8.1 Viewing a List of SPF Calculation Intervals

To view a list of SPF calculation intervals configured for an IS-IS area, type:

```
show running-config routing isis area { name } spf-interval
```

Where:

- `{ name }` is the unique name for a routing process that belongs to a specific router.

If intervals have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing isis area Area_1 spf-interval | tab
ISTYPE        INTERVAL
------------------------
level-1-only  60

 !
!
```

If no intervals have been configured, add intervals as needed. For more information, refer to "Adding an SPF Calculation Interval (Page 557)".

12.6.8.2 Adding an SPF Calculation Interval

To add an SPF calculation interval to an IS-IS area, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add a new interval by typing:

   ```
   routing isis area { name } spf-interval is-type [ level-1-2 | level-1-only | level-2-only ] interval { seconds }
   ```

   Where:

   - `{ name }` is the unique name for a routing process that belongs to a specific router.
   - `{ level }` is the IS type.
   - `{ seconds }` is the minimum interval in seconds, ranging from 1 to 120. The default value is 30.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.6.8.3 Deleting an SPF Calculation Interval

To delete an SPF calculation interval for an IS-IS area, do the following:

1. Make sure the CLI is in Configuration mode.

2. Delete the LDP interface by typing:

   ```
   no routing isis area { name } spf-interval is-type [ level-1-2 | level-1-only | level-2-only ] interval { seconds }
   ```

   Where:

   - `{ name }` is the unique name for a routing process that belongs to a specific router.
   - `{ level }` is the IS type.
   - `{ seconds }` is the minimum interval in seconds, ranging from 1 to 120. The default value is 30.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.6.9 Managing the Lifetime of LSPs

IS-IS retains Link-State Packets (LSP) in the Link-State Database (LSDB) for only a short period of time unless they are refreshed. By default, the maximum time limit is 1200 seconds. However, this interval can be customized for different routing types within the range of 350 to 65535 seconds if needed.

Th lifetime interval is configurable for each area and routing type in the IS-IS network.

Note
For information about configuring the refresh interval for an LSP, refer to "Managing LSP Refresh Intervals (Page 560)".

12.6.9.1 Viewing a List of LSP Lifetime Intervals

To view a list of LSP lifetime intervals configured for an IS-IS area, type:

```
show running-config routing isis area { name } max-lsp-lifetime
```

Where:

- `{ name }` is the unique name for a routing process that belongs to a specific router.

If intervals have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing isis area Area_1 max-lsp-lifetime | tab
ISTYPE        INTERVAL
-----------------------
level-1-only  60

 !
```

```
!
```

If no intervals have been configured, add intervals as needed. For more information, refer to "Adding an LSP Lifetime Interval (Page 559)".

12.6.9.2 Adding an LSP Lifetime Interval

To add an LSP lifetime interval to an IS-IS area, do the following:

⚠ NOTICE

The LSP lifetime interval must be 300 seconds higher than the LSP refresh interval. For more information about LSP refresh intervals, refer to "Managing LSP Refresh Intervals (Page 560)".

1. Make sure the CLI is in Configuration mode.
2. Add a new interval by typing:

   ```
   routing isis area { name } max-lsp-lifetime is-type [ level-1-2 | level-1-only | level-2-only ] interval { seconds }
   ```

   Where:

   - `{ name }` is the unique name for a routing process that belongs to a specific router.
   - `{ level }` is the IS type.
   - `{ seconds }` is the minimum interval in seconds, ranging from 1 to 120. The default value is 30.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.6.9.3 Deleting an LSP Lifetime Interval

To delete an LSP lifetime interval for an IS-IS area, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the LDP interface by typing:

   ```
   no routing isis area { name } max-lsp-lifetime is-type [ level-1-2 | level-1-only | level-2-only ] interval { seconds }
   ```

   Where:

   - `{ name }` is the unique name for a routing process that belongs to a specific router.
   - `{ level }` is the IS type.

- `{ seconds }` is the minimum interval in seconds, ranging from 1 to 120. The default value is 30.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.6.10 Managing LSP Refresh Intervals

IS-IS retains Link-State Packets (LSP) in the Link-State Database (LSDB) for only a short period of time unless they are refreshed. By default, LSPs are retained in the LSDB for 1200 seconds (this is referred to as the *lifetime* of the LSP) and are refreshed every 900 seconds.

The refresh interval is configurable for each area and routing type in the IS-IS network.

Note
For information about configuring the lifetime of an LSP, refer to "Managing the Lifetime of LSPs (Page 558)".

12.6.10.1 Viewing a List of LSP Refresh Intervals

To view a list of LSP refresh intervals configured for an IS-IS area, type:

```
show running-config routing isis area { name } lsp-refresh-interval
```

Where:

- `{ name }` is the unique name for a routing process that belongs to a specific router.

If intervals have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing isis area Area_1 lsp-refresh-interval | tab
ISTYPE        INTERVAL
------------------------
level-1-only  60

 !
!
```

If no intervals have been configured, add intervals as needed. For more information, refer to "Adding an LSP Refresh Interval (Page 561)".

12.6.10.2 Adding an LSP Refresh Interval

To add an LSP refresh interval to an IS-IS area, do the following:

⚠ NOTICE

The LSP refresh interval must be 300 seconds less than the LSP lifetime interval. For more information about LSP refresh intervals, refer to "Managing the Lifetime of LSPs (Page 558)".

1. Make sure the CLI is in Configuration mode.
2. Add a new interval by typing:

   ```
   routing isis area { name } lsp-refresh-interval
   is-type [ level-1-2 | level-1-only | level-2-only ]
   interval { seconds }
   ```

   Where:

   - `{ name }` is the unique name for a routing process that belongs to a specific router.
   - `{ level }` is the IS type.
   - `{ seconds }` is the minimum interval in seconds, ranging from 1 to 120. The default value is 30.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.6.10.3 Deleting an LSP Refresh Interval

To delete an LSP refresh interval for an IS-IS area, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the LDP interface by typing:

   ```
   no routing isis area { name } lsp-refresh-interval
   is-type [ level-1-2 | level-1-only | level-2-only ]
   interval { seconds }
   ```

   Where:

   - `{ name }` is the unique name for a routing process that belongs to a specific router.
   - `{ level }` is the IS type.
   - `{ seconds }` is the minimum interval in seconds, ranging from 1 to 120. The default value is 30.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.6.11 Managing Network Entity Titles (NETs)

Network Entity Titles (NETs) define the area address and system ID for the router. Traffic received from another router that shares the same area address and system ID will be forwarded to this router.

RUGGEDCOM ROX II supports IS-IS multi-homing, which allows for multiple NETs to be defined for a single router and increases the list of possible traffic sources.

Each NET has a hexadecimal value, which can be between 8 and 20 octets long, although 10 octets is most common. The value includes an Authority and Format Identifier (AFI), an area ID, a system identifier, and a selector. The following is an example of an NET address:

```
49.0001.1921.6800.1001.00
```

- *49* is the AFI. Use *49* for private addressing.
- *0001* is the area ID. In this example, the area is *1*.
- *1921.6800.1001* is the system identifier. Any number can be used, but typically the system identifier is a modified form of the router's IP address. For example, the system identifier in this example translates to *192.168.1.1*. To convert the address in the opposite direction, pad the IP address with zeros (0) and rearrange the decimal points to form to make three two-byte numbers.
- *00* is the selector.

⚠ NOTICE

The system identifier must be unique to the network.

12.6.11.1 Viewing a List of NETs

To view a list of areas configured for dynamic IS-IS routes, type:

```
show running-config routing isis area { name } net
```

Where:

- `{ name }` is the unique name for a routing process that belongs to a specific router.

If NETs have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing isis area Area_1 net | tab
NET TITLE
--------------------------
49.0001.1921.6800.1001.00

 !
!
```

If no NETs have been configured, add NETs as needed. For more information, refer to "Adding a NET (Page 563)".

12.6.11.2 Adding a NET

To add a Network Entity Title (NET) for an IS-IS area, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the NET by typing:

   ```
   routing isis area { name } net { title }
   ```

   Where:

   - `{ name }` is the unique name for a routing process that belongs to a specific router.
   - `{ title }` is the NET for the router, consisting of a two-octet area ID, a three-octet system ID and a one-octet selector. For example: 0001.1921.6800.1001.00
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.6.11.3 Deleting a NET

To delete a Network Entity Title (NET) for an IS-IS area, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the NET by typing:

   ```
   no routing isis area { name } net { title }
   ```

   Where:

   - `{ name }` is the unique name for a routing process that belongs to a specific router.
   - `{ title }` is the NET for the router, consisting of a two-octet area ID, a three-octet system ID and a one-octet selector. For example: 0001.1921.6800.1001.00
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.6.12 Managing Redistribution Metrics

Redistribution in general is the advertisement of routes by one protocol that have been learned via another dynamic routing protocol, a static route, or a directly connected router. It is deployed to promote interoperability between networks running different routing protocols.

The redistribution of a route is achieved by defining a metric for the source routing protocol. As each routing protocol calculates routes differently, care must be taken to define a metric that is understood by the protocol.

There are two types of metrics: internal and external. Both types can be assigned a value between 0 and 63. However, to prevent external metrics from competing with internal metrics, 64 is automatically added to any external metric. This puts external metrics in the range of 64 to 128, even though the metric value defined is only in the range of 0 to 63.

There is no default metric for IS-IS. A metric should be defined for each routing protocol, otherwise a metric value of zero (0) is automatically applied.

12.6.12.1 Viewing a List of Redistribution Metrics

To view a list of redistribution metrics defined for an IS-IS area, type:

```
show running-config routing isis area { name } redistribute
```

Where:

- `{ name }` is the unique name for a routing process that belongs to a specific router.

If metrics have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing isis area Area_1 redistribute | tab
                  METRIC
SOURCE  IS TYPE   TYPE      METRIC
-------------------------------------
bgp     level-1-2 internal  10

 !
!
```

If no redistribution metrics have been configured, add metrics as needed. For more information, refer to "Adding a Redistribution Metric (Page 564)".

12.6.12.2 Adding a Redistribution Metric

To add a redistribution metric for an IS-IS area, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the metric by typing:

   ```
   routing isis area { name } redistribute { source }
   ```

   Where:

   - `{ name }` is the unique name for a routing process that belongs to a specific router.
   - `{ source }` is the protocol transmitting packets over the IS-IS route. Options include bgp, connected, kernel, ospf, rip, and static.
3. Configure the following parameter(s) as required:

Parameter	Description
`is-type { is-type }`	**Synopsis:** [level-1-only | level-2-only | level-1-2] IS type of the IS-IS information, specified as level-1-only, level-2-only or level-1-2. If not provided, uses IS type from area.
`metric-type { metric-type }`	**Synopsis:** [internal | external] **Default:** external The IS-IS metric type for redistributed routes. Default is external
`metric { metric }`	**Synopsis:** An integer between 0 and 16777214 The metric for redistributed routes.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.6.12.3 Deleting a Redistribution Metric

To delete a redistribution metric for an IS-IS area, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the metric by typing:

   ```
   no routing isis area { name } redistribute { source }
   ```

   Where:

   - `{ name }` is the unique name for a routing process that belongs to a specific router.
   - `{ source }` is the protocol transmitting packets over the IS-IS route. Options include bgp, connected, kernel, ospf, rip, and static.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.7 Managing RIP

The Routing Information Protocol (RIP) determines the best path for routing IP traffic over a TCP/IP network based on the number of hops between any two routers. It uses the shortest route available to a given network as the route to use for sending packets to that network.

The RUGGEDCOM ROX II RIP daemon is an RFC 1058 [http://tools.ietf.org/rfc/rfc1058.txt] compliant implementation of RIP that supports RIP version 1 and 2. RIP version 1 is limited to obsolete class-based networks, while RIP version 2 supports subnet masks, as well as simple authentication for controlling which routers to accept route exchanges with.

RIP uses network and neighbor entries to control which routers it will exchange routes with. A network is either a subnet or a physical (broadcast-capable) network interface. Any router that is part of that subnet or connected to that interface may exchange routes. A neighbor is a specific router, specified by its IP address, to exchange routes with. For point to point links, neighbor entries must be used to add other routers to exchange routes with. The maximum number of hops between two points on a RIP network is 15, placing a limit on network size.

Link failures will eventually be noticed when using RIP, although it is not unusual for RIP to take many minutes for a dead route to disappear from the whole network. Large RIP networks could take over an hour to converge when link or route changes occur. For fast convergence and recovery, OSPF is recommended. For more information about OSPF, refer to "Managing OSPF (Page 626)".

RIP is a legacy routing protocol that has mostly been superseded by OSPF.

Note
In complex legacy networks, RIP, OSPF, BGP and IS-IS may all be active on the same router at the same time. Typically, however, only one dynamic routing protocol is employed at one time.

12.7.1 Configuring RIP

To configure dynamic routing using the Routing Information Protocol (RIP) daemon, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***routing » rip*** and configure the following parameter(s) as required:

Parameter	Description
`update { update }`	**Synopsis:** An integer between 5 and 2147483647 **Default:** 30 The routing table update timer (in seconds).
`timeout { timeout }`	**Synopsis:** An integer between 5 and 2147483647 **Default:** 180 The routing information timeout timer (in seconds).
`garbage { garbage }`	**Synopsis:** An integer between 5 and 2147483647 **Default:** 120 The garbage collection timer (in seconds).
`enabled`	Enables the RIP dynamic routing protocol.
`default-information-originate`	The route element makes a static route only inside RIP. This element should be used only by advanced users who are particularly knowledgeable about the RIP protocol. In most cases, we recommend creating a static route and redistributing it in RIP using the redistribute element with static type.

Parameter	Description
`default-metric { default-metric }`	**Synopsis:** An integer between 1 and 16 **Default:** 1 Sets the default metric. With the exception of connected route types, the default metric is advertised when a metric has not been configured for a redistributed route. For connected route types, the default metric is 1 despite the value of this parameter.
`distance-default { distance-default }`	**Synopsis:** An integer between 1 and 255 Sets the default RIP distance.
`version { version }`	**Synopsis:** An integer between 1 and 2 Set the RIP version to accept for reads and send. The version can be either 1 or 2. Disabling RIPv1 by specifying version 2 is STRONGLY encouraged.

3. Configure prefix lists. For more information, refer to "Adding a Prefix List (Page 570)".
4. Configure a network. For more information, refer to "Configuring a Network (Page 572)".
5. Configure the prefix list distribution. For more information, refer to "Adding a Prefix List Distribution Path (Page 577)".
6. Configure key chains. For more information, refer to "Adding a Key Chain (Page 579)".
7. Configure redistribution metrics. For more information, refer to "Adding a Redistribution Metric (Page 582)".
8. Configure interfaces. For more information, refer to "Configuring a Routing Interface (Page 583)".
9. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.7.2 Viewing the Status of Dynamic RIP Routes

To view the status of the dynamic RIP routes configured on the device, type:

```
show routing status rip route
```

If RIP routes have been configured, a table or list similar to the following example appears:

```
ruggedcom# show routing status rip route | tab
NETWORK          TYPE       SUB TYPE   NEXT HOP     METRIC  FROM         TAG  TI
-------------------------------------------------------------------------------
192.168.0.0/24   connected  interface  0.0.0.0      1       self         0
192.168.5.0/24   rip        normal     192.168.0.3  2       192.168.0.3  0    02
192.168.6.0/24   rip        normal     192.168.0.3  2       192.168.0.3  0    02
192.168.50.0/24  connected  interface  0.0.0.0      1       self         0
```

```
192.168.60.0/24  connected  interface  0.0.0.0      1       self         0
```

This list provides the following information:

Parameter	Description
`{ network }`	**Synopsis:** A string The network.
`type`	**Synopsis:** A string The route type.
`sub-type`	**Synopsis:** A string The route sub type.
`next-hop`	**Synopsis:** A string The next hop.
`metric`	**Synopsis:** A string The metric value.
`from`	**Synopsis:** A string Where this route comes from.
`tag`	**Synopsis:** A string Tag.
`time`	**Synopsis:** A string The route update time.

To view the status of the RIP interfaces configured on the device, type:

```
show routing status rip interface
```

If RIP interfaces have been configured, a table or list similar to the following example appears:

```
ruggedcom# show routing status rip interface | tab
                                                    NEXT
NAME         NETWORK          TYPE       SUB TYPE   HOP      METRIC  FROM  TAG  TIME
-------------------------------------------------------------------------------------
switch.1112
             192.168.11.0/24  connected  interface  0.0.0.0  1       self  0
```

This list provides the following information:

Parameter	Description
`{ network }`	**Synopsis:** A string The network.
`type`	**Synopsis:** A string The route type.
`sub-type`	**Synopsis:** A string The route sub type.

Parameter	Description
`next-hop`	**Synopsis:** A string Next hop.
`metric`	**Synopsis:** A string The metric value.
`from`	**Synopsis:** A string Where this route comes from.
`tag`	**Synopsis:** A string Tag.
`time`	**Synopsis:** A string The route update time.

If no dynamic RIP routes have been configured, configure RIP and add routes as needed. For more information about configuring RIP, refer to "Configuring RIP (Page 566)".

12.7.3 Managing Prefix Lists and Entries

Neighbors can be associated with prefix lists, which allow the RIPs daemon to filter incoming or outgoing routes based on the *allow* and *deny* entries in the prefix list.

12.7.3.1 Viewing a List of Prefix Lists

To view a list of prefix lists for dynamic RIP routes, type:

```
show running-config routing rip filter prefix-list
```

If prefix lists have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing rip filter prefix-list | tab
NAME                 DESCRIPTION  SEQ  ACTION  SUBNET           LE  GE
-------------------------------------------------------------------------
list-permit-lan-22   -
                                  100  permit  192.168.33.0/24  -   -
list-withdraw-lan-11 -
                                  100  permit  192.168.33.0/24  -   -
                                  200  permit  192.168.33.0/24  32  -

!
```

If no prefix lists have been configured, add lists as needed. For more information, refer to "Adding a Prefix List (Page 570)".

12.7.3.2 Viewing a List of Prefix Entries

To view a list of entries for dynamic RIP prefix lists, type:

```
show running-config routing rip filter prefix-list
{ name } entry
```

Where:

- `{ name }` is the name of the prefix list

If entries have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing rip filter prefix-list test entry | tab
SEQ  ACTION  SUBNET           LE  GE
-------------------------------------------
5    permit  192.168.40.0/24  32  -
6    deny    192.168.5.21/32     -   -

 !
!
```

If no entries have been configured, add entries as needed. For more information, refer to "Adding a Prefix Entry (Page 571)".

12.7.3.3 Adding a Prefix List

To add a prefix list for dynamic RIP routes, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the list by typing:

   ```
   routing rip filter prefix-list { name }
   ```

   Where:

   - `{ name }` is the name of the prefix list
3. Configure the following parameter(s) as required:

Parameter	Description
`description { description }`	**Synopsis:** A string 1024 characters long The description of the prefix list.

4. Add prefix entries as needed. For more information, refer to "Adding a Prefix Entry (Page 571)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.7.3.4 Adding a Prefix Entry

To add an entry for a dynamic RIP prefix list, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the entry by typing:

   ```
   routing rip filter prefix-list { name } entry { number }
   ```

   Where:

   - `{ name }` is the name of the prefix list
   - `{ number }` is the sequence number for the entry
3. Configure the following parameter(s) as required:

Parameter	Description
`action { action }`	**Synopsis:** [deny | permit] **Default:** permit The action that will be performed.
`subnet { subnet }`	**Synopsis:** A string between 9 and 18 characters long The IPv4 network address and prefix.
`le { le }`	**Synopsis:** An integer between 1 and 32 The maximum prefix length to be matched.
`ge { ge }`	**Synopsis:** An integer between 1 and 32 The minimum prefix length to be matched.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.7.3.5 Deleting a Prefix List

To delete a prefix list for dynamic RIP routes, do the following:

1. Make sure the CLI is in Configuration mode.

   Note
   Deleting a prefix list removes all associate prefix entries as well.

2. Delete the list by typing:

   ```
   no routing rip filter prefix-list { name }
   ```

   Where:

   - `{ name }` is the name of the prefix list
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.7.3.6 Deleting a Prefix Entry

To delete an entry for a dynamic RIP prefix list, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the entry by typing:

   ```
   no routing rip filter prefix-list { name } entry { number }
   ```

   Where:

   - `{ name }` is the name of the prefix list
   - `{ number }` is the sequence number for the entry
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.7.4 Managing Networks

As opposed to neighbors, which are specific routers with which to exchange routes, networks are groups of routers that are either part of a specific subnet or connected to a specific network interface. They can be used at the same time as neighbors.

Note
For point to point links, specify neighbors instead of a network. For more information, refer to "Adding a Neighbor (Page 576)".

Note
RIP v1 does not send subnet mask information in its updates. Any networks defined are restricted to the classic (i.e. Class A, B and C) networks.

Note
If neighbors are specified but no networks are specified, the router will receive routing information from its neighbors but will not advertise any routes to them. For more information about neighbors, refer to "Managing Neighbors (Page 575)".

12.7.4.1 Configuring a Network

To configure a network for the RIP protocol, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add one or more network IP addresses. For more information, refer to "Adding a Network IP Address (Page 574)".
3. Add one or more network interfaces. For more information, refer to "Adding a Network Interface (Page 575)".
4. Add one or more neighbors. For more information, refer to "Adding a Neighbor (Page 576)".

12.7.4.2 Tracking Commands

Network commands can be tracked using event trackers configured under ***global » tracking***. For more information about event trackers, refer to "Managing Event Trackers (Page 542)".

A network command is activated based on the event tracker's state. The `apply-when` parameter determines when the command is activated. For example, if the `apply-when` parameter is set to **`down`**, the network command becomes active (thereby advertising the network to a router's RIP peers) when the tracked target is unavailable.

To track a command for a RIP network, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***routing » rip » distribute-prefix-list » {direction} {interface} » track***, where *{direction}* is the direction (incoming or outgoing) in which to filter routing updates and *{interface}* is the name of the interface.
3. Configure the following parameter(s) as required:

Parameter	Description
`event { event }`	**Synopsis:** A string 64 characters long Selects an event to track. The distribute-prefix-list is applied only when the tracked event is in the UP state.
`apply-when { apply-when }`	**Synopsis:** [up | down] **Default:** up Applies the distribute-prefix-list when the tracked event goes UP or DOWN.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.7.5 Managing Network IP Addresses

This section describes how to manage IP addresses for RIP networks.

12.7.5.1 Viewing a List of Network IP Addresses

To view a list of IP addresses configured for a RIP network, type:

```
show running-config routing rip network ip
```

If addresses have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing rip network ip
routing rip
 network ip 192.168.33.0/24
 !
```

```
!
```

If no IP addresses have been configured, add addresses as needed. For more information, refer to "Adding a Network IP Address (Page 574)".

12.7.5.2 Adding a Network IP Address

To add an IP address for a RIP network, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the neighbor by typing:

   ```
   routing rip network ip { address }
   ```

   Where:

   - `{ address }` is the IP subnet address and prefix for the network
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.7.5.3 Deleting a Network IP Address

To delete an IP address from a RIP network, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the IP address by typing:

   ```
   no routing rip network ip { address }
   ```

   Where:

   - `{ address }` is the IP subnet address and prefix for the network
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.7.6 Managing Network Interfaces

This section describes how to manage interfaces used by RIP networks.

12.7.6.1 Viewing a List of Network Interfaces

To view a list of interfaces configured for a RIP network, type:

```
show running-config routing rip network interface
```

If interfaces have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing rip network interface
routing rip
 network interface switch.4084
 !
!
```

If no interfaces have been configured, add neighbors as needed. For more information, refer to "Adding a Neighbor (Page 576)".

12.7.6.2 Adding a Network Interface

To add an interface for a RIP network, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the neighbor by typing:

   `routing rip network interface { name }`

   Where:

   - `{ name }` is the name of the interface
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.7.6.3 Deleting a Network Interface

To delete an interface from a RIP network, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the network by typing:

   `no routing rip network interface { name }`

   Where:

   - `{ name }` is the name of the interface
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.7.7 Managing Neighbors

Neighbors are other routers with which to exchange routes.

12.7.7.1 Viewing a List of Neighbors

To view a list of neighbors configured for a RIP network, type:

```
show running-config routing rip network neighbor
```

If neighbors have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing rip network neighbor
routing rip
 network neighbor 192.168.33.2
 !
!
```

If no neighbors have been configured, add neighbors as needed. For more information, refer to "Adding a Neighbor (Page 576)".

12.7.7.2 Adding a Neighbor

To add a neighbor for a RIP network, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the neighbor by typing:

   ```
   routing rip network neighbor { address }
   ```

   Where:

   - `{ address }` is the IP address of the neighbor
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.7.7.3 Deleting a Neighbor

To delete a neighbor from a RIP network, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the network by typing:

   ```
   no routing rip network neighbor { address }
   ```

   Where:

   - `{ address }` is the IP address of the neighbor
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.7.8 Managing the Prefix List Distribution

This section describes how to manage the distribution of prefix lists.

12.7.8.1 Viewing a List of Prefix List Distribution Paths

To view a list of prefix list distribution paths for dynamic RIP routes, type:

```
show running-config routing rip distribute-prefix-list
```

If distribution paths have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing rip distribute-prefix-list
routing rip
 distribute-prefix-list out ""
  prefix-list list-permit-lan-22
 !
!
```

If no prefix list distribution paths have been configured, add distribution paths as needed. For more information, refer to "Adding a Prefix List Distribution Path (Page 577)".

12.7.8.2 Adding a Prefix List Distribution Path

To add a prefix list distribution path for dynamic RIP routes, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the path by typing:

   ```
   routing rip distribute-prefix-list { direction }
   { interface }
   ```

   Where:

   - `{ direction }` is the direction (incoming or outgoing) in which to filter routing updates.
   - `{ interface }` is the name of the interface. This parameter is optional.
3. Configure the following parameter(s) as required:

Parameter	Description
`prefix-list { prefix-list }`	**Synopsis:** A string between 1 and 1024 characters long The name of the prefix list.

4. If necessary, configure an event tracker to track network commands. For more information, refer to "Tracking Commands (Page 573)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.7.8.3 Deleting a Prefix List Distribution Path

To delete a prefix list distribution path for dynamic RIP routes, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the path by typing:

   ```
   no routing rip distribute-prefix-list { direction } { interface }
   ```

   Where:

   - `{ direction }` is the direction (incoming or outgoing) in which to filter routing updates.
   - `{ interface }` is the name of the interface. This parameter is optional.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.7.9 Managing Key Chains and Keys

Key chains are collections of keys (or shared secrets), which are used to authenticate communications over a dynamic RIP network. Only routers with the same key are able to send and receive advertisements.

Multiple key chains can be configured for different groups of interfaces and the lifetime for each key within a chain can be separately configured.

12.7.9.1 Viewing a List of Key Chains

To view a list of key chains for dynamic RIP routes, type:

```
show running-config routing rip key-chain
```

If key chains have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing rip key-chain
routing rip
 key-chain key-1
  key 1
   key-string RUGGEDCOM
   accept-lifetime start 2013-01-01T01:01:01-00:00
   accept-lifetime expire 2022-01-01T01:01:01-00:00
   send-lifetime start 2013-01-01T01:01:01-00:00
   send-lifetime expire 2022-01-01T01:01:01-00:00
  !
 !
!
```

If no key chains have been configured, add key chains as needed. For more information, refer to "Adding a Key Chain (Page 579)".

12.7.9.2 Viewing a List of Keys

To view a list of keys in a key chain, type:

```
show running-config routing rip rip key-chain
{ name } key
```

Where:

- `{ name }` is the name of the key chain

If keys have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing rip key-chain key
routing rip
 key-chain key-1
  key 1
   key-string RUGGEDCOM
   accept-lifetime start 2013-01-01T01:01:01-00:00
   accept-lifetime expire 2022-01-01T01:01:01-00:00
   send-lifetime start 2013-01-01T01:01:01-00:00
   send-lifetime expire 2022-01-01T01:01:01-00:00
  !
 !
!
```

If no keys have been configured, add keys as needed. For more information, refer to "Adding a Key (Page 579)".

12.7.9.3 Adding a Key Chain

To add a key chain for dynamic RIP routes, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the path by typing:

   ```
   routing rip key-chain { name }
   ```

   Where:

   - `{ name }` is the name of the key chain
3. Configure one or more keys for the key chain. For more information, refer to "Adding a Key (Page 579)".
4. Configure a routing interface to use the key chain for authentication purposes. For more information, refer to "Configuring a Routing Interface (Page 583)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.7.9.4 Adding a Key

Keys (or shared secrets) are used to authenticate communications over a RIP network. To maintain network stability, each key is assigned an accept and send lifetime.

The *accept* lifetime is the time period in which the key is accepted by the device.

The *send* lifetime is the time period in which they key can be sent to other devices.

This is referred to as hitless authentication key rollover, a method for seamlessly updating authentication keys without having to reset network sessions.

To add a key to a key chain, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the key by typing:

   `routing rip key-chain { name } key { id }`

   Where:

   - `{ name }` is the name of the key chain
   - `{ id }` is the ID of the key
3. Configure the key name setting by configuring the following parameter(s):

Parameter	Description
`key-string { key-string }`	**Synopsis:** A string Sets the key string.

4. Configure the accept lifetime settings by configuring the following parameter(s):

Parameter	Description
`start { start }`	**Synopsis:** A string The beginning time in which the key is considered valid.
`expire { expire }`	**Synopsis:** A string or [infinite] Expire time.

5. Configure the send lifetime settings by configuring the following parameter(s):

Parameter	Description
`start { start }`	**Synopsis:** A string Sets the time period in which the key on the key chain is considered valid.
`expire { expire }`	**Synopsis:** A string or [infinite] The time at which the key expires.

6. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.7.9.5 Deleting a Key Chain

To delete a key chain for dynamic RIP routes, do the following:

1. Make sure the CLI is in Configuration mode.

2. Delete the key chain by typing:

   `no routing rip key-chain { name }`

   Where:

   - `{ name }` is the name of the key chain

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.7.9.6 Deleting a Key

To delete a key from a key chain, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the key by typing:

   `no routing rip key-chain { name } key { id }`

   Where:

   - `{ name }` is the name of the key chain
   - `{ id }` is the ID of the key

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.7.10 Managing Redistribution Metrics

Redistribution metrics redistribute routing information from other routing protocols, static routes or routes handled by the kernel. Routes for subnets that are directly connected to the router, but not part of the RIP networks, can also be advertised.

12.7.10.1 Viewing a List of Redistribution Metrics

To view a list of redistribution metrics for dynamic RIP routes, type:

`show running-config routing rip redistribute`

If metrics have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing rip redistribute
routing rip
 redistribute bgp
  no metric
 !
!
```

If no redistribution metrics have been configured, add metrics as needed. For more information, refer to "Adding a Redistribution Metric (Page 582)".

12.7.10.2 Adding a Redistribution Metric

To add a redistribution metric for dynamic RIP routes, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the metric by typing:

   ```
   routing rip redistribute [ { bgp } | { ospf } | { connected } | { static } | { kernel } ]
   ```

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.7.10.3 Deleting a Redistribution Metric

To delete a redistribution metric for dynamic RIP routes, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the metric by typing:

   ```
   no routing rip redistribute [ { bgp } | { ospf } | { connected } | { static } | { kernel } ]
   ```

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.7.11 Managing Routing Interfaces

This section describes how to manage interfaces for RIP routes.

12.7.11.1 Viewing a List of Routing Interfaces

To view a list of routing interfaces for a RIP network, type:

```
show running-config routing rip interface
```

A table or list similar to the following example appears:

```
ruggedcom# show running-config routing rip interface | tab
                  KEY                     RECEIVE  SEND     SPLIT
IFNAME       MODE CHAIN  STRING  PASSIVE  VERSION  VERSION  HORIZON
-------------------------------------------------------------------
dummy0       -    -      -       -        -        -        yes
fe-cm-1      -    -      -       -        -        -        yes
switch.0001  -    -      -       -        -        -        yes
```

12.7.11.2 Configuring a Routing Interface

To configure a routing interface for a RIP network, do the following:

Note
OSPF regards router interfaces as either passive or active, sending OSPF messages on active interfaces and ignoring passive interfaces.

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***routing » rip » interface » {name}***, where *{name}* is the name of the interface.
3. Configure the authentication settings by typing the following commands:

Parameter	Description
`mode { mode }`	**Synopsis:** [md5-rfc | md5-old-ripd | text | none] The authentication mode.
`key-chain { key-chain }`	**Synopsis:** A string between 1 and 1024 characters long The authentication key chain.
`string { string }`	**Synopsis:** A string 16 characters long The authentication string.

4. Configure the interface settings by typing the following commands:

Parameter	Description
`passive`	The specified interface is set to passive mode. In passive mode, all received packets are processed normally and RIPd sends neither multicast nor unicast RIP packets except to RIP neighbors specified with a neighbor element.
`receive-version { receive-version }`	**Synopsis:** [1 | 2 | 1,2 | 2,1] The version of RIP packets that will be accepted on this interface. By default, version 1 and version 2 packets will be accepted.
`send-version { send-version }`	**Synopsis:** [1 | 2 | 1,2 | 2,1] The version of RIP to send packets with. By default, version 2 packets will be sent.
`split-horizon { split-horizon }`	**Synopsis:** [yes | no | poisoned-reverse] **Default:** yes A split horizon.

5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8 Managing BGP

The Border Gateway Protocol (BGP) as defined by RFC 4271 [http://tools.ietf.org/rfc/rfc4271.txt] is a robust and scalable routing protocol. BGP is designed to manage a routing table of up to 90000 routes. Therefore, it is used in large networks or among groups of networks which have common administrative and routing policies. External BGP (eBGP) is used to exchange routes between different Autonomous Systems (AS). Interior BGP (iBGP) is used to exchange routes within autonomous system (AS).

BGP is used by the bgpd daemon to handle communications with other routers. The daemon also determines which routers it prefers to forward traffic to for each known network route.

Note
In complex legacy networks, RIP, OSPF, BGP and IS-IS may all be active on the same router at the same time. Typically, however, only one dynamic routing protocol is employed at one time.

12.8.1 Configuring BGP

To configure dynamic routing with BGP, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***routing » bgp*** and configure the following parameter(s) as required:

Parameter	Description
`enabled`	Enables BGP.
`as-id { as-id }`	**Synopsis:** An integer between 1 and 65535 Autonomous System ID.
`always-compare-med`	Always comparing MED from different neighbors.
`reachability-check { reachability-check }`	**Synopsis:** [true | false] **Default:** true Enables or disables the reachability check for advertised routes. When enabled, before advertising a self-generated BGP route to other BGP peers, the BGP daemon checks if the advertised route is reachable locally by default before advertising it to other BGP peers. The route is only advertised if it exists in the kernel routing table.
`default-local-preference { default-local-preference }`	**Synopsis:** An integer **Default:** 100 Default local preference value.
`deterministic-med`	Pick the best-MED path among paths advertised from neighboring AS.

Parameter	Description
`router-id { router-id }`	**Synopsis:** A string between 7 and 15 characters long Router ID for BGP.

3. Configure autonomous system path filters. For more information, refer to "Adding an Autonomous System Path Filter (Page 598)".
4. Configure prefix list filters. For more information, refer to "Adding a Prefix List (Page 595)".
5. Configure route map filters. For more information, refer to "Adding a Route Map Filter (Page 586)".
6. Configure a network. For more information, refer to "Adding a Network (Page 603)".
7. Configure IP addresses for neighbors. For more information, refer to "Adding a Neighbor (Page 600)".
8. Configure aggregate addresses. For more information, refer to "Adding an Aggregate Address (Page 605)".
9. Configure redistribution metrics. For more information, refer to "Adding a Redistribution Metric (Page 608)".
10. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

Note
Following a change in the routing policy due to a configuration change, the BGP session must be reset for the new policy to take effect.

11. Reset the BGP session. For more information, refer to "Resetting a BGP Session (Page 624)".

12.8.2 Managing Route Maps

Route maps are sequential statements used to filter routes that meet the defined criteria. If a route meets the criteria of the applied route map, it can either be excluded from the routing table or prevented from being redistributed.

Each route map requires a sequence number (e.g. 10, 20, 30, etc.), which allows for multiple route maps to be run in sequence until a match is found. It is recommended to create sequence numbers in intervals of 10, in case a new route map is required later between two existing route maps.

12.8.2.1 Viewing a List of Route Map Filters

To view a list of route map filters for either dynamic BGP routes, type:

```
show running-config routing bgp filter route-map
```

If filters have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing bgp filter route-map | tab
                        ON
                        MATCH  AS    PREFIX  PREFIX  PREFIX                                  LOCAL
                  NEXT           ORIGINATOR
TAG  SEQ  ACTION  CALL  GOTO   PATH  LIST    LIST    LIST    METRIC  PEER  ORIGIN  AS  IP  PREFERENCE
 OPERATION  VALUE  HOP   ORIGIN  ID          WEIGHT
-------------------------------------------------------------------------------
map
     10   permit  -     -      -     -       -       -       -       -     -       -   -   -
 -          -      -     -       -           -

!
```

If no filters have been configured, add filters as needed. For more information, refer to "Adding an Autonomous System Path Filter (Page 598)".

12.8.2.2 Viewing a List of Route Map Filter Entries

To view a list of entries for a route map filter for either BGP, type:

```
show running-config routing bgp filter route-map
{ tag } entry
```

Where:

- `{ tag }` is the tag for the route map filter

If entries have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing bgp filter route-map map entry | tab
                   ON
                   MATCH  AS    PREFIX  PREFIX  PREFIX                                  LOCAL
               NEXT           ORIGINATOR
SEQ  ACTION  CALL  GOTO   PATH  LIST    LIST    LIST    METRIC  PEER  ORIGIN  AS  IP  PREFERENCE
 OPERATION  VALUE  HOP   ORIGIN  ID          WEIGHT  AS
-------------------------------------------------------------------------------
10   permit  -     -      -     -       -       -       -       -     -       -   -   -           -
       -      -     -       -           -

 !
!
```

If no filters have been configured, add filters as needed. For more information, refer to "Adding an Autonomous System Path Filter (Page 598)".

12.8.2.3 Adding a Route Map Filter

To add a route map filter for dynamic BGP routes, do the following:

1. Make sure the CLI is in Configuration mode.

2. Add the new filter by typing:

   ```
   routing bgp filter route-map { tag }
   ```

   Where:

   - `{ tag }` is the tag for the route map filter
3. Add one or more entries. For more information, refer to "Adding a Route Map Filter Entry (Page 587)".
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8.2.4 Adding a Route Map Filter Entry

To add an entry for an route map filter, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the new filter by typing:

   ```
   routing bgp filter route-map { tag } entry
   { number }
   ```

   Where:

   - `{ tag }` is the tag for the route map filter
   - `{ number }` is the sequence number for the entry
3. Configure the following parameter(s) as required:

Parameter	Description
`action { action }`	**Synopsis:** [deny | permit] **Default:** permit Action.
`call { call }`	**Synopsis:** A string between 1 and 1024 characters long Jump to another route-map after match+set.
`on-match-goto { on-match-goto }`	**Synopsis:** An integer between 1 and 65535 Go to this entry on match.

4. Configure the match rules for the route map filter. For more information, refer to "Configuring Match Rules (Page 588)".
5. Configure a set for the route map filter. For more information, refer to "Configuring a Set (Page 589)".
6. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8.2.5 Deleting a Route Map Filter

To delete a route map filter for dynamic BGP routes, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the filter key by typing:

   ```
   no routing bgp filter route-map { tag }
   ```

   Where:

   - `{ tag }` is the tag for the route map filter
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8.2.6 Deleting a Route Map Filter Entry

To delete an entry for a route map filter, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the filter key by typing:

   ```
   no routing bgp filter route-map { tag } entry
   { number }
   ```

   Where:

   - `{ tag }` is the tag for the route map filter
   - `{ number }` is the sequence number for the entry
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8.2.7 Configuring Match Rules

To configure match rules for a route map filter entry, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***routing » bgp » filter » route-map » {tag} » entry » {number} » match***, where *{tag}* is the tag for the route map filter and *{number}* is the sequence number for the entry.
3. Configure the following parameters:

Parameter	Description
`as-path { as-path }`	**Synopsis:** A string between 1 and 1024 characters long Match the BGP AS path filter.
`metric { metric }`	**Synopsis:** An integer Match the route metric.

Parameter	Description
`peer { peer }`	**Synopsis:** A string between 7 and 15 characters long This parameter is not supported and any value is ignored by the system.s
`origin { origin }`	**Synopsis:** [egp | igp | incomplete] Match the BGP origin code.

4. To match based on the route's IP address, navigate to **ip** and configure the following parameters:

Parameter	Description
`prefix-list { prefix-list }`	**Synopsis:** A string between 1 and 1024 characters long The prefix list name.

5. To match based on the route's next hop address, navigate to **next-hop** and configure the following parameters:

Parameter	Description
`prefix-list { prefix-list }`	**Synopsis:** A string between 1 and 1024 characters long The prefix list name.

6. To match based on the route's advertised source address, navigate to **route-source** and configure the following parameters:

Parameter	Description
`prefix-list { prefix-list }`	**Synopsis:** A string between 1 and 1024 characters long The prefix list name.

7. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8.2.8 Configuring a Set

To configure a set for a route map filter entry, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***routing » bgp » filter » route-map » {tag} » entry » {number} » set***, where *{tag}* is the tag for the route map filter and *{number}* is the sequence number for the entry.
3. Configure the entry set by configuring the following parameters:

Parameter	Description
`local-preference { local-preference }`	**Synopsis:** An integer Local preference.

Parameter	Description
`next-hop { next-hop }`	**Synopsis:** A string between 7 and 15 characters long or [peer] The next hop address (xxx.xxx.xxx.xxx/xx or peer to use peer address).
`origin { origin }`	**Synopsis:** [egp | igp | incomplete] The origin code.
`originator-id { originator-id }`	**Synopsis:** A string between 7 and 15 characters long This parameter is not supported and any value is ignored by the system.
`weight { weight }`	**Synopsis:** An integer Weight.

4. Configure the aggregator settings by configuring the following parameters:

Parameter	Description
`as { as }`	**Synopsis:** An integer between 1 and 4294967295 AS number.
`ip { ip }`	**Synopsis:** A string between 7 and 15 characters long IP address of aggregator.

5. Configure the metric settings by configuring the following parameters:

Parameter	Description
`operation { operation }`	**Synopsis:** [set | add | sub] Set , add or subtract the metric value.
`value { value }`	**Synopsis:** An integer Value.

6. Add pre-pended and/or excluded autonomous system paths. For more information, refer to "Adding a Prepended Autonomous System Path Filter (Page 592)" and/or "Adding an Excluded Autonomous System Path filter (Page 592)".
7. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8.3 Managing Prepended and Excluded Autonomous System Path Filters

This section describes how to configure and manage prepended and excluded autonomous system path filters.

12.8.3.1 Viewing a List of Prepended Autonomous System Path Filters

To view a list of prepended autonomous system path filters configured for a BGP route map entry, type:

```
show running-config routing bgp filter route-map
{ name } entry { number } set as-path prepend
```

Where:

- `{ name }` is the name of the route map
- `{ number }` is the entry number

Note
The repeat count is only displayed when higher than 1.

If filters have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing bgp filter route-map route entry 10 set as-
path prepend
routing bgp
 filter route-map route
  entry 10
   set as-path prepend 120
    repeat-count 2
   !
  !
 !
!
```

If no prepended autonomous system path filters have been configured, add filters as needed. For more information, refer to "Adding a Prepended Autonomous System Path Filter (Page 592)".

12.8.3.2 Viewing a List of Excluded Autonomous System Paths

To view a list of excluded autonomous system path filters configured for a BGP route map entry, type:

```
show running-config routing bgp filter route-map
{ name } entry { number } set as-path exclude
```

Where:

- `{ name }` is the name of the route map
- `{ number }` is the entry number

If filters have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing bgp filter route-map route entry 10 set as-
path exclude
routing bgp
 filter route-map route
  entry 10
```

```
    set as-path exclude 110
    !
   !
  !
 !
```

If no excluded autonomous system path filters have been configured, add filters as needed. For more information, refer to "Adding an Excluded Autonomous System Path filter (Page 592)".

12.8.3.3 Adding a Prepended Autonomous System Path Filter

To add a prepended autonomous system path filter to a BGP route map entry, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the path by typing:

   ```
   routing bgp filter route-map { name } entry
   { number } set as-path prepend { path }
   ```

   Where:

   - `{ name }` is the name of the route map
   - `{ number }` is the entry number
   - `{ path }` is the number for the autonomous system path
3. [Optional] To prepend the AS number more than once, set the repeat count by typing:

   ```
   repeat-count { number }
   ```

   Where:

   - `{ number }` is the number of times the AS number is repeated. An AS number can be repeated up to 9 times. The default value is 1.
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8.3.4 Adding an Excluded Autonomous System Path filter

To add an excluded autonomous system path filter to a BGP route map entry, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the path by typing:

   ```
   routing bgp filter route-map { name } entry
   { number } set as-path exclude { path }
   ```

   Where:

- `{ name }` is the name of the route map
- `{ number }` is the entry number
- `{ path }` is the number for the autonomous system path

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8.3.5 Deleting a Prepended Autonomous System Path Filter

To delete a prepended autonomous system path filter from a BGP route map entry, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the network by typing:

```
no routing bgp filter route-map { name } entry
{ number } set as-path prepend { path }
```

Where:

- `{ name }` is the name of the route map
- `{ number }` is the entry number
- `{ path }` is the number for the autonomous system path

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8.3.6 Deleting an Excluded Autonomous System Path Filter

To delete an excluded autonomous system path filter from a BGP route map entry, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the network by typing:

```
no routing bgp filter route-map { name } entry
{ number } set as-path exclude { path }
```

Where:

- `{ name }` is the name of the route map
- `{ number }` is the entry number
- `{ path }` is the number for the autonomous system path

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8.4 Managing Prefix Lists and Entries

Neighbors can be associated with prefix lists, which allow the BGP daemon to filter incoming or outgoing routes based on the *allow* and *deny* entries in the prefix list.

12.8.4.1 Viewing a List of Prefix Lists

To view a list of prefix lists for dynamic BGP routes, type:

```
routing  bgp  filter  prefix-list
```

If prefix lists have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing bgp filter prefix-list | tab
NAME                 DESCBGPTION  SEQ  ACTION  SUBNET           LE  GE
-------------------------------------------------------------------------
list-permit-lan-22   -
                                  100  permit  192.168.33.0/24  -   -
list-withdraw-lan-11 -
                                  100  permit  192.168.33.0/24  -   -
                                  200  permit  192.168.33.0/24  32  -

!
```

If no prefix lists have been configured, add lists as needed. For more information, refer to "Adding a Prefix List (Page 595)".

12.8.4.2 Viewing a List of Prefix Entries

To view a list of entries for dynamic BGP, OSPF, or BGP prefix lists, type:

```
routing  bgp  filter  prefix-list  { name }  entry
```

Where:

- `{ name }` is the name of the prefix list

If entries have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing bgp filter prefix-list test entry | tab
SEQ  ACTION  SUBNET           LE  GE
-------------------------------------------
5    permit  192.168.40.0/24  32  -
6    deny    192.168.5.21/32    -   -

 !
!
```

If no entries have been configured, add entries as needed. For more information, refer to "Adding a Prefix Entry (Page 595)".

12.8.4.3 Adding a Prefix List

To add a prefix list for dynamic BGP routes, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the list by typing:

   `routing bgp filter prefix-list { name }`

   Where:

   - `{ name }` is the name of the prefix list
3. Configure the following parameter(s) as required:

Parameter	Description
`description { description }`	**Synopsis:** A string 1024 characters long The description of the prefix list.

4. Add prefix entries as needed. For more information, refer to "Adding a Prefix Entry (Page 595)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8.4.4 Adding a Prefix Entry

To add an entry for a dynamic BGP prefix list, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the entry by typing:

   `routing bgp filter prefix-list { name } entry { number }`

   Where:

   - `{ name }` is the name of the prefix list
   - `{ number }` is the sequence number for the entry
3. Configure the following parameter(s) as required:

Parameter	Description
`action { action }`	**Synopsis:** [deny | permit] **Default:** permit Action.
`subnet { subnet }`	**Synopsis:** A string between 9 and 18 characters long Network (xxx.xxx.xxx.xxx/xx).
`le { le }`	**Synopsis:** An integer between 1 and 32 The maximum prefix length to match ipaddress within subnet.

Parameter	Description
`ge { ge }`	**Synopsis:** An integer between 1 and 32 The minimum prefix length to match ipaddress within subnet.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8.4.5 Deleting a Prefix List

To delete a prefix list for dynamic BGP routes, do the following:

1. Make sure the CLI is in Configuration mode.

   Note
   Deleting a prefix list removes all associate prefix entries as well.

2. Delete the list by typing:

   ```
   no routing bgp filter prefix-list { name }
   ```

   Where:

   - `{ name }` is the name of the prefix list

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8.4.6 Deleting a Prefix Entry

To delete an entry for a dynamic BGP prefix list, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the entry by typing:

   ```
   no routing bgp filter prefix-list { name } entry
   { number }
   ```

   Where:

   - `{ name }` is the name of the prefix list
   - `{ number }` is the sequence number for the entry

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8.5 Managing Autonomous System Paths and Entries

This section describes how to configure autonomous system paths and entries for dynamic BGP routes.

12.8.5.1 Viewing a List of Autonomous System Paths

To view a list of autonomous system path filters for dynamic BGP routes, type:

```
show running-config routing bgp filter as-path
```

If filters have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing bgp filter as-path | tab
NAME              ACTION  MATCH
---------------------------------
filter-allow-120
                  permit  120

!
```

If no filters have been configured, add filters as needed. For more information, refer to "Adding an Autonomous System Path Filter (Page 598)".

12.8.5.2 Viewing a List of Autonomous System Path Entries

To view a list of entries for an autonomous system path filter, type:

```
show running-config routing bgp filter as-path
{ name } entry
```

Where:

- `{ name }` is the name of the autonomous system path filter

If entries have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing bgp filter as-path filter-allow-120 entry |
 tab
ACTION  MATCH
--------------
permit  120

 !
!
```

If no filters have been configured, add filters as needed. For more information, refer to "Adding an Autonomous System Path Filter (Page 598)".

12.8.5.3 Adding an Autonomous System Path Filter

To add an autonomous system path filter for dynamic BGP routes, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the new filter by typing:

   ```
   routing bgp filter as-path { name }
   ```

   Where:

   - `{ name }` is the name of the autonomous system path filter
3. Add one or more entries. For more information, refer to "Adding an Autonomous System Path Filter Entry (Page 598)".
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8.5.4 Adding an Autonomous System Path Filter Entry

Create an entry for an autonomous system path filter to match a string or integer value in AS path and then perform an action. The match criteria is defined using regular expressions.

To add an entry for an autonomous system path filter, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the new filter by typing:

   ```
   routing bgp filter as-path { name } entry
   { action } { match }
   ```

   Where:

   - `{ name }` is the name of the autonomous system path filter.
   - `{ action }` is the action.
   - `{ match }` is the regular expression to match with the autonomous system path. For more information about regular expressions, refer to "Using Regular Expressions (Page 42)".
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8.5.5 Deleting an Autonomous System Path

To delete an autonomous system path filter for dynamic BGP routes, do the following:

1. Make sure the CLI is in Configuration mode.

2. Delete the filter key by typing:

   ```
   no routing bgp filter as-path { name }
   ```

   Where:

   - `{ name }` is the name of the autonomous system path filter

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8.5.6 Deleting an Autonomous System Path Filter Entry

To delete an entry for an autonomous system path filter, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the filter key by typing:

   ```
   no routing bgp filter as-path { name } entry
   { action } { match }
   ```

   Where:

   - `{ name }` is the name of the autonomous system path filter
   - `{ action }` is the action
   - `{ match }` is the regular expression to match with the autonomous system path

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8.6 Managing Neighbors

Neighbors are other routers with which to exchange routes. One or more neighbors must be specified in order for BGP to operate.

Note
If neighbors are specified but no networks are specified, the router will receive BGP routing information from its neighbors but will not advertise any routes to them. For more information about networks, refer to "Managing Networks (Page 603)".

12.8.6.1 Viewing a List of Neighbors

To view a list of neighbors configured for a BGP network, type:

```
show running-config routing bgp neighbor
```

If neighbors have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing bgp neighbor
routing bgp
 neighbor 192.168.123.3
  remote-as 100
  no ebgp-multihop
  no maximum-prefix
  no next-hop-self
  no password
  no route-map in
  no route-map out
  no soft-reconfiguration
  no weight
 !
!
```

If no neighbors have been configured, add neighbors as needed. For more information, refer to "Adding a Neighbor (Page 600)".

12.8.6.2 Adding a Neighbor

To add a neighbor for a BGP network, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the neighbor by typing:

   `routing bgp neighbor { address }`

   Where:

   - `{ address }` is the IP address of the neighbor
3. [Optional] Enable the neighbor as a route reflector client by configuring the following parameter:

Parameter	Description
`enabled`	If enabled and Route Reflector enabled, makes this neighbor a client for Route Reflector.

4. [Optional] Configure the route map settings by configuring the following parameter(s):

Parameter	Description
`in { in }`	**Synopsis:** A string between 1 and 1024 characters long Apply route map to incoming routes.
`out { out }`	**Synopsis:** A string between 1 and 1024 characters long Apply route map to outbound routes.

5. [Optional] Configure the neighbor settings by configuring the following parameter(s):

Parameter	Description
`remote-as { remote-as }`	**Synopsis:** An integer between 1 and 65535 A BGP neighbor.
`ebgp-multihop { ebgp-multihop }`	**Synopsis:** An integer between 1 and 255 The maximum hop count. This allows EBGP neighbors not on directly connected networks.
`maximum-prefix { maximum-prefix }`	**Synopsis:** An integer between 1 and 4294967295 The maximum prefix number accepted from this peer.
`next-hop-self`	Disables the next hop calculation for this neighbor.
`password { password }`	**Synopsis:** A string between 1 and 1024 characters long Password.
`update-source { update-source }`	**Synopsis:** A string between 7 and 15 characters long Source IP address of routing updates.
`disable-connected-check`	Disables connection verification when establishing an eBGP peering session with a single-hop peer that uses a loopback interface.
`soft-reconfiguration`	Per neighbor soft reconfiguration.
`weight { weight }`	**Synopsis:** An integer The default weight for routes from this neighbor.

6. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8.6.3 Configuring the Distribution of Prefix Lists

To configure the distribution of prefix lists for a neighbor in a BGP network, do the following:

1. Make sure the CLI is in Configuration mode.
2. Apply the desired prefix list the chosen route direction (incoming or outbound) by typing:

   ```
   routing bgp neighbor { address } distribute-prefix-list [ in | out ] prefix-list { prefix }
   ```

   Where:

   - `{ address }` is the address of the chosen neighbor
   - `{ prefix }` is the chosen BGP prefix list
3. If necessary, configure an event tracker to track network commands. For more information, refer to "Tracking Commands for BGP Neighbors (Page 602)".
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8.6.4 Tracking Commands for BGP Neighbors

Network commands can be tracked using event trackers configured under ***global » tracking***. For more information about event trackers, refer to "Managing Event Trackers (Page 542)".

The network command is activated based on the event tracker's state. The `apply-when` parameter determines when the command is activated. For example, if the `apply-when` parameter is set to **down**, the network command becomes active (thereby advertising the network to a router's BGP peers) when the tracked target is unavailable.

To track a command for a BGP neighbor, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***routing » dynamic » bgp » network » {address} » track***, where *{address}* is the IP address of the neighbor.
3. Configure the following parameter(s) as required:

Parameter	Description
`event { event }`	**Synopsis:** A string 64 characters long Select to track an event, apply the distribute-prefix-list only when the tracked event goes to UP state.
`apply-when { apply-when }`	**Synopsis:** [up | down] **Default:** up Applies the distribute-prefix-list when the tracked event goes UP or DOWN.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8.6.5 Deleting a Neighbor

To delete a neighbor from a BGP network, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the network by typing:

   ```
   no routing bgp neighbor { address }
   ```

   Where:

   - `{ address }` is the IP address of the neighbor
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8.7 Managing Networks

As opposed to neighbors, which are specific routers with which to exchange routes, networks are groups of routers that are either part of a specific subnet or connected to a specific network interface. They can be used at the same time as neighbors.

Note
For point-to-point links, specify neighbors instead of a network. For more information, refer to "Adding a Neighbor (Page 600)".

Note
Networks for the BGP protocol do not require a valid entry in the routing table. Since BGP is a broader gateway protocol, a more general network specification would typically be entered. For example, if a routed network inside the Autonomous System (AS) was comprised of many different Class C subnets (/24) of the 192.168.0.0/16 range, it is more efficient to advertise the one Class B network specification, 192.168.0.0/16, to its BGP neighbors.

Note
If neighbors are specified but no networks are specified, the router will receive routing information from its neighbors but will not advertise any routes to them. For more information about neighbors, refer to "Managing Neighbors (Page 599)".

12.8.7.1 Viewing a List of Networks

To view a list of networks configured for the BGP protocol, type:

```
show running-config routing bgp network
```

If networks have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing bgp network
routing bgp
 network 192.168.12.0/24
 !
 network 192.168.123.0/24
 !
!
```

If no networks have been configured, add networks as needed. For more information, refer to "Adding a Network (Page 603)".

12.8.7.2 Adding a Network

To add a network for the BGP protocol, do the following:

1. Make sure the CLI is in Configuration mode.

2. Add the network by typing:

   `routing bgp network { address }`

   Where:

   - `{ address }` is the IP subnet address and prefix for the network
3. If necessary, configure an event tracker to track network commands. For more information, refer to "Tracking Commands for a BGP Network (Page 604)".
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8.7.3 Tracking Commands for a BGP Network

Network commands can be tracked using event trackers configured under ***global » tracking***. For more information about event trackers, refer to "Managing Event Trackers (Page 542)".

The network command is activated based on the event tracker's state. The `apply-when` parameter determines when the command is activated. For example, if the `apply-when` parameter is set to **down**, the network command becomes active (thereby advertising the network to a router's BGP peers) when the tracked target is unavailable.

To track a command for a BGP network, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***routing » bgp » network » {address} » track***, where *{address}* is the IP subnet address and prefix for the network.
3. Configure the following parameter(s) as required:

Parameter	Description
`event { event }`	**Synopsis:** A string 64 characters long Select an event.
`apply-when { apply-when }`	**Synopsis:** [up | down] **Default:** up Advertises the network when the tracked event state goes UP or stops advertising the network when the tracked event goes DOWN.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8.7.4 Deleting a Network

To delete a network configured for the BGP protocol, do the following:

1. Make sure the CLI is in Configuration mode.

2. Delete the network by typing:

   `no routing bgp network { address }`

   Where:

   - `{ address }` is the IP subnet address and prefix for the network

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8.8 Managing Aggregate Addresses

This section describes how to aggregate multiple addresses into a single dynamic BGP route.

12.8.8.1 Viewing a List of Aggregate Addresses

To view a list of aggregate addresses for dynamic BGP routes, type:

`show running-config routing bgp aggregate-address`

If addresses have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing bgp aggregate-address
routing bgp
 aggregate-address 11.11.0.0/16
  options summary-only
  !
 !
!
```

If no aggregate addresses have been configured, add addresses as needed. For more information, refer to "Adding an Aggregate Address (Page 605)".

12.8.8.2 Adding an Aggregate Address

To add an aggregate address for dynamic BGP routes, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the path by typing:

   `routing bgp aggregate-address { address }`

   Where:

   - `{ address }` is the subnet address and prefix for the aggregate address

3. If necessary, configure options for the address. For more information, refer to "Adding an Aggregate Address Option (Page 606)".

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8.8.3 Deleting an Aggregate Address

To delete an aggregate address for dynamic BGP routes, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the address by typing:

   ```
   no routing bgp aggregate-address { address }
   ```

   Where:

   - `{ address }` is the subnet address and prefix for the aggregate address
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8.9 Managing Aggregate Address Options

This section describes how to set the **as-set** and **summary-only** options for BGP aggregate addresses.

12.8.9.1 Viewing a List of Aggregate Address Options

To view a list of options for an aggregate address, type:

```
routing bgp aggregate-address { address } options
```

If options have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing bgp aggregate-address 11.11.0.0/16 options
routing bgp
 aggregate-address 11.11.0.0/16
  options summary-only
  !
 !
!
```

If no options have been configured, add options as needed. For more information, refer to "Adding an Aggregate Address Option (Page 606)".

12.8.9.2 Adding an Aggregate Address Option

To add an option for an aggregate address, do the following:

1. Make sure the CLI is in Configuration mode.

2. Add the path by typing:

   ```
   routing bgp aggregate-address { address } options
   [ summary-only | as-set ]
   ```

   Where:

   - { address } is the subnet address and prefix for the aggregate address

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8.9.3 Deleting an Aggregate Address Option

To delete an option for an aggregate address, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the option by typing:

   ```
   no routing bgp aggregate-address { address }
   options [ { summary-only } | { as-set } ]
   ```

   Where:

   - `{ address }` is the subnet address and prefix for the aggregate address

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8.10 Managing Redistribution Metrics

Redistribution metrics redistribute routing information from other routing protocols, static routes or routes handled by the kernel. Routes for subnets that are directly connected to the router, but not part of the BGP network, can also be advertised.

12.8.10.1 Viewing a List of Redistribution Metrics

To view a list of redistribution metrics for dynamic BGP routes, type:

```
show running-config routing bgp redistribute
```

If metrics have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing bgp redistribute
routing bgp
 redistribute rip
  no metric
 !
!
```

If no redistribution metrics have been configured, add metrics as needed. For more information, refer to "Adding a Redistribution Metric (Page 608)".

12.8.10.2 Adding a Redistribution Metric

To add a redistribution metric for dynamic BGP routes, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the metric by typing:

   ```
   routing bgp redistribute [ { rip } | { ospf } |
   { connected } | { static } | { kernel } ] metric
   { metric }
   ```

   Where:

   - `{ metric }` is the metric for redistributed routes
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8.10.3 Deleting a Redistribution Metric

To delete a redistribution metric for dynamic BGP routes, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the metric by typing:

   ```
   no routing bgp redistribute [ { rip } | { ospf }
   | { connected } | { static } | { kernel } ]
   ```

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8.11 Managing Route Reflector Options

This section describes how to configure the device as a route reflector for BGP networks.

12.8.11.1 Understanding Route Reflectors

Route reflectors offer a method for simplifying BGP network topologies and improving scalability.

The Full-Mesh Requirement

Due to BGP route advertisement rules, BGP requires a logical full-mesh topology, wherein each router advertises and forwards its routes to each of its neighbors. This requirement is easily met by external BGP (eBGP) networks, where connections are established between Autonomous Systems (AS). Routers can easily avoid loops by dropping any routes that share the same AS numeric identifier. However, in internal BGP (iBGP), each router shares the same AS numeric identifier, so all routes received by a router would be dropped.

One method for solving this problem is to have each iBGP router establish neighborship with its peers, but that would result in a significant number of BGP sessions and unnecessary traffic on large networks. The formula for determining the number of BGP sessions for X number of routers is **X*(X-1)/2** . Therefore, 20 iBGP routers would generate 190 BGP sessions (20*[20-1]/2 = 190).

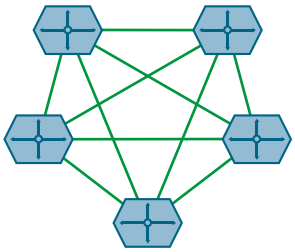


Figure 12.2 A Simple BGP Topology Without a Route Reflector

The Route Reflector Solution

Route reflectors simplify the topology by grouping routers into a cluster. In the cluster, the route reflector establishes a BGP session with each client (BGP neighbor). The clients are not required to establish BGP sessions with each other, nor are they required to be fully-meshed. All routes are advertised to the route reflector, who in turn reflects the routes to its clients, thus meeting the logical full-mesh requirement. RUGGEDCOM ROX II does not use BGP routes to resolve BGP next-hop values.

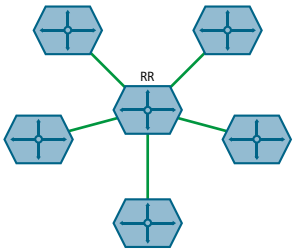
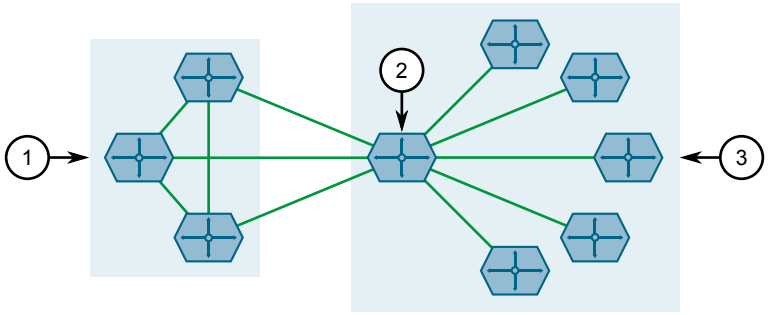


Figure 12.3 A Simple BGP Topology With a Route Reflector

Route reflectors can also share routes with routers outside of their clusters. These are referred to as *non-clients*. Non-clients are required to be fully-meshed.



① Fully Meshed iBGP Peers (Non-Clients)
② Route Reflector
③ Cluster (Clients)

Figure 12.4 A Complex BGP Topology

Combining Clusters for Scalability

Multiple clusters can be linked together via their route reflectors to form a full-mesh topology of internal peers. In this configuration, routes advertised to a route reflector are not only re-advertised to its clients, but also with the other route reflectors who in turn advertise the routes to their clients. This allows routes to propagate through the entire AS without the scaling problems associated with the full-mesh requirement.

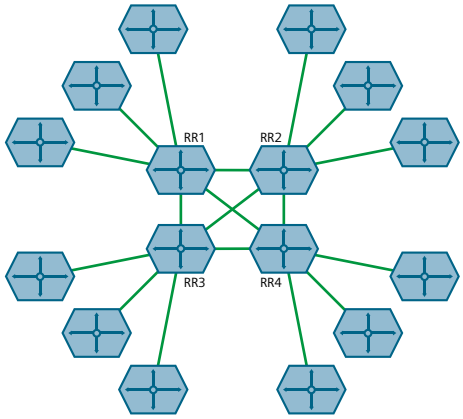


Figure 12.5 Multiple Clusters Fully-Meshed

Route reflectors can also be partially-meshed by combining them in a cluster of their own.

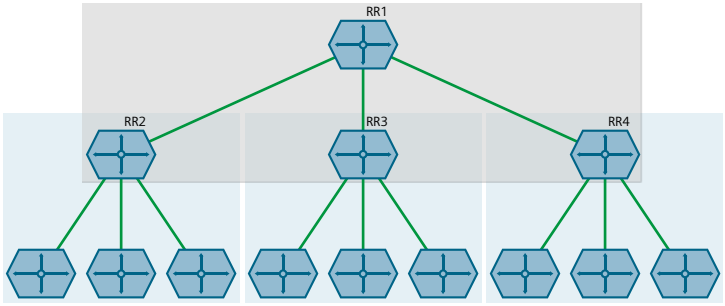
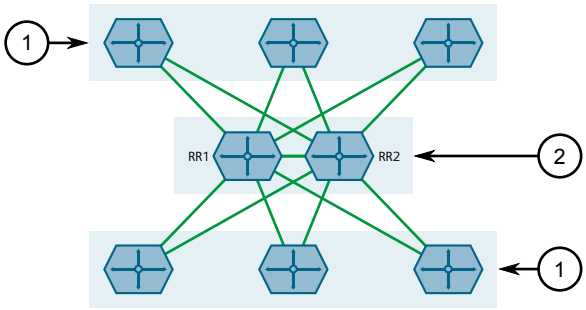


Figure 12.6 Multiple Clusters Partially-Meshed

Redundant Route Reflectors

To avoid a single point of failure in the BGP network, each cluster should be served by more than one route reflector to provide redundancy in case of failure. In this arrangement, each route reflectors are configured to have the same BGP neighbors as clients.



① Cluster
② Route Reflector

Figure 12.7 Redundant Route Reflector Topology

12.8.11.2 Configuring the Device as a Route Reflector

To configure the device to be a route reflector for a specific cluster, do the following:

1. Make sure the CLI is in Configuration mode.
2. Configure the device as a route reflector by typing:

   ```
   routing bgp route-reflector enabled cluster-id { id }
   ```

   Where { id } is the 4-byte ID of the cluster to which the device belongs (e.g. 1.2.3.4).

3. Configure one or more BGP neighbors to be clients of the device. For more information, refer to "Configuring BGP Neighbors as Clients (Page 612)".
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8.11.3 Configuring BGP Neighbors as Clients

When the device is configured to be a route reflector, BGP neighbors can then be configured to be clients of the reflector.

BGP Neighbors

To configure a BGP neighbor to be a client of the device, do the following:

1. Make sure a BGP neighbor is defined. For more information, refer to "Adding a Neighbor (Page 600)".
2. Configure the desired BGP neighbor to be a client of the route reflector by typing:

   ```
   routing bgp neighbor { address } route-reflector-client enabled
   ```

   Where { address } is the IP address of the BGP neighbor.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

BGP Neighbors In an IPv4 Address Family

To configure a BPG neighbor that belongs to an IPv4 address family to be a client of the device, do the following:

1. Make sure an IPv4 address family is defined. For more information, refer to "Adding an IPv4 Address Family (Page 687)".
2. Configure the desired BGP neighbor in the IPv4 address family to be a client of the route reflector by typing:

   ```
   routing bgp address-family vrf { definition } neighbor { address } route-reflector-client enabled
   ```

   Where:

   - { definition } is the name of the VRF definition
   - { address } is the IP address of the BGP neighbor
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

BGP Neighbors In a VPNv4 Address Family

To configure a BPG neighbor that belongs to a VPNv4 address family to be a client of the device, do the following:

1. Make sure a VPNv4 address family is defined. For more information, refer to "Adding a Neighbor (Page 685)".
2. Configure the desired BGP neighbor in the VPNv4 address family to be a client of the route reflector by typing:

   ```
   routing bgp address-family vpnv4 { address }
   route-reflector-client enabled
   ```

   Where { address } is the IP address of the BGP neighbor.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.8.11.4 Example: Basic Route Reflection

This example demonstrates how to configure a partially-meshed Autonomous System (AS) where a route reflector advertises routes to clients and non-clients.

Overview

In the following topology, routes advertised by the external BGP (eBGP) router (labeled as R1) are forwarded to the route reflector (labeled as RR). The route reflector then in turn readvertises the routes to its BGP neighbors. Neighbors within the route reflector's cluster are the clients (labeled C1, C2 and C3). Neighbors outside of the cluster are non-clients (labeled NC1, NC2 and NC3).

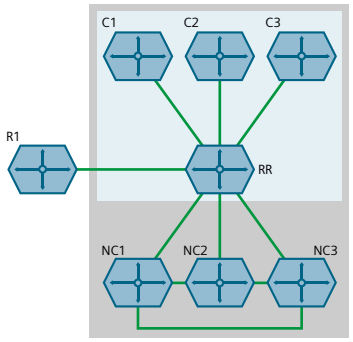


Figure 12.8 Basic Route Reflection Topology

Similarly, routes advertised by a non-client (NC1, NC2 or NC3) are forwarded to its BGP neighbors, including the route reflector. The route reflector in turn readvertises the routes to its BGP neighbors, which includes those in its cluster and the eBGP router (R1).

With the exception of the eBGP router (R1), all devices are within the same Autonomous System (AS).

Configuration

To configure the device to act as the route reflector in this scenario, do the following:

1. Enable the route reflector feature and assign a cluster ID to the device. For more information, refer to "Configuring the Device as a Route Reflector (Page 611)".
2. For each router that advertises and forwards routes to the route reflector, define a BGP neighbor. Make sure each belongs to the same AS. For more information, refer to "Adding a Neighbor (Page 600)".
3. For each BGP neighbor that belongs to the route reflector's cluster, enable the neighbor as a route reflector client. For more information, refer to "Configuring BGP Neighbors as Clients (Page 612)".

Final Configuration Example

```
routing bgp
 enabled
 as-id              100
 route-reflector enabled
 route-reflector cluster-id 10.11.12.13
 !
 neighbor 172.30.140.10
                        { Client }

  remote-as 100
  route-reflector-client enabled
 !
 neighbor 172.30.140.20
                        { Client }

  remote-as 100
  route-reflector-client enabled
 !
 neighbor 172.30.140.30
                        { Client }

  remote-as 100
  route-reflector-client enabled
 !
 neighbor 172.30.150.10
                        { Non-Client }

  remote-as 100
  no route-reflector-client enabled
 !
 neighbor 172.30.150.20
                        { Non-Client }

  remote-as 100
  no route-reflector-client enabled
 !
 neighbor 172.30.150.30
                        { Non-Client }

  remote-as 100
  no route-reflector-client enabled
 !
!
```

12.8.11.5 Example: Linking Clusters

This example demonstrates how to link two multiple clusters together by connecting each route reflector in a full-mesh topology.

Overview

In the following topology, three route reflectors (RR1, RR2 and RR3) are internal peers of one another.

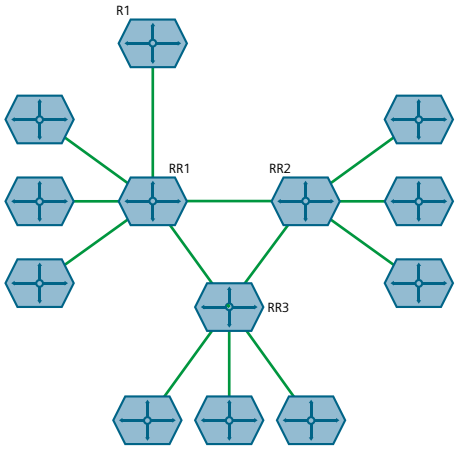


Figure 12.9 Linked Clusters

When an external BGP (eBGP) router (R1) advertises routes to RR1, RR1 readvertises the routes to RR2, RR3 and its clients. RR2 and RR3 then readvertise the routes again to their clients.

Configuration

To configure this topology, do the following:

1. Configure the clusters for RR1, RR2, RR3. For more information, refer to "Configuring the Device as a Route Reflector (Page 611)".
2. For each route reflector, define the other route reflectors as BGP neighbors. For more information, refer to "Adding a Neighbor (Page 600)".

Final Configuration Example

RR1 (172.30.110.10)

```
routing bgp
 enabled
 as-id              100
 route-reflector cluster-id 0.1.2.3
 !
 neighbor 172.30.110.20                    { RR2 }
  remote-as 100
  no route-reflector-client enabled
 !
```

```
 neighbor 172.30.110.30                  { RR3 }
  remote-as 100
  no route-reflector-client enabled
 !
 neighbor 172.30.140.10                  { Client }
  remote-as 100
  route-reflector-client enabled
 !
 neighbor 172.30.140.20                  { Client }
  remote-as 100
  route-reflector-client enabled
 !
 neighbor 172.30.140.30                  { Client }
  remote-as 100
  route-reflector-client enabled
 !
!
```

RR2 (172.30.110.20)

```
routing bgp
 enabled
 as-id              100
 route-reflector cluster-id 10.11.12.13
 !
 neighbor 172.30.110.10                  { RR1 }
  remote-as 100
  no route-reflector-client enabled
 !
 neighbor 172.30.110.30                  { RR3 }
  remote-as 100
  no route-reflector-client enabled
 !
 neighbor 172.30.150.10                  { Client }
  remote-as 100
  route-reflector-client enabled
 !
 neighbor 172.30.150.30                  { Client }
  remote-as 100
  route-reflector-client enabled
 !
 neighbor 172.30.150.20                  { Client }
  remote-as 100
  route-reflector-client enabled
 !
!
```

RR3 (172.30.110.30)

```
routing bgp
 enabled
 as-id              100
 route-reflector cluster-id 20.21.22.23
 !
 neighbor 172.30.110.10                  { RR1 }
  remote-as 100
  no route-reflector-client enabled
 !
 neighbor 172.30.110.20                  { RR2 }
  remote-as 100
  no route-reflector-client enabled
 !
 neighbor 172.30.160.10                  { Client }
  remote-as 100
  route-reflector-client enabled
```

```
  !
 neighbor 172.30.160.20                    { Client }
  remote-as 100
  route-reflector-client enabled
 !
!
```

12.8.11.6 Example: Clusters in Clusters

This example demonstrates how to group clusters into a hierarchical structure (clusters of clusters).

Overview

In the following topology, a route reflector (RR1) forms a cluster with two other route reflectors (RR2 and RR3). RR2 and RR3 are also part of their own individual clusters, each of which consists of three clients.

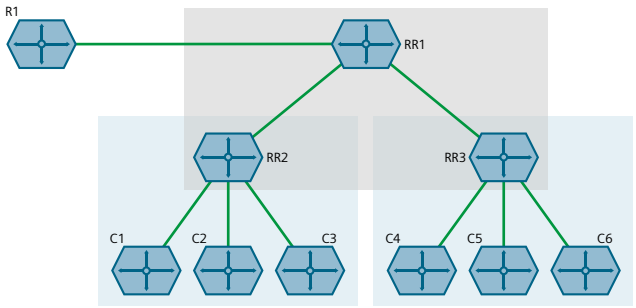


Figure 12.10 Hierarchical Clusters Topology

When an external BGP (eBGP) router (R1) advertises routes to RR1, RR1 readvertises the routes to RR2 and RR3. RR2 and RR3 then readvertise the routes again to their clients.

Configuration

To configure this topology, do the following:

1. Configure the clusters for RR2 and RR3. For more information, refer to "Configuring the Device as a Route Reflector (Page 611)".
2. Configure RR1 as a route reflector and define RR2 and RR3 as its clients. For more information, refer to "Configuring the Device as a Route Reflector (Page 611)".

Final Configuration Example

RR1 (172.30.140.10)

```
routing bgp
```

```
 enabled
 as-id              100
 route-reflector enabled
 route-reflector cluster-id 0.1.2.3
 !
 neighbor 172.30.140.20                    { RR2 }
  remote-as 100
  route-reflector-client enabled
 !
 neighbor 172.30.140.30                    { RR3 }
  remote-as 100
  route-reflector-client enabled
 !
```

RR2 (172.30.140.20)

```
routing bgp
 enabled
 as-id              100
 route-reflector enabled
 route-reflector cluster-id 10.11.12.13
 !
 neighbor 172.30.140.10                    { RR1 }
  remote-as 100
  no route-reflector-client enabled
 !
 neighbor 172.30.150.10                    { Client }
  remote-as 100
  route-reflector-client enabled
 !
 neighbor 172.30.150.20                    { Client }
  remote-as 100
  route-reflector-client enabled
 !
 neighbor 172.30.150.30                    { Client }
  remote-as 100
  route-reflector-client enabled
 !
!
```

RR3 (172.30.140.30)

```
routing bgp
 enabled
 as-id              100
 route-reflector enabled
 route-reflector cluster-id 20.21.22.23
 !
 neighbor 172.30.140.10                    { RR1 }
  remote-as 100
  no route-reflector-client enabled
 !
 neighbor 172.30.160.10                    { Client }
  remote-as 100
  route-reflector-client enabled
 !
 neighbor 172.30.160.20                    { Client }
  remote-as 100
  route-reflector-client enabled
 !
 neighbor 172.30.160.30                    { Client }
  remote-as 100
  route-reflector-client enabled
 !
```

```
!
```

12.8.11.7 Example: Route Reflection in a VRF Instance

This example demonstrates how to configure BGP route reflection in a VRF instance.

Overview

In the following topology, router RR is a BGP route reflector configured with a VRF instance (VRF1). The VRF instance is configured with a single IPv4 address family consisting of routers R2 and R3. All three routers belong to the same autonomous system (AS1).

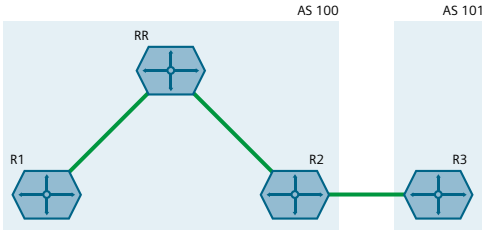


Figure 12.11 Route Reflection in a VRF Instance

RR receives BGP routing information from R2 via its VRF interface, 1.1.2.1. It then readvertises the information to its client, R1.

R2 receives BGP routing information from R3, an external BGP (eBGP) router.

Configuration

To configure this topology, do the following:

1. **Configure RR**
   a. Configure a VRF definition for *VRF1* with a route distinguisher of **100:1**. For more information, refer to "Adding a VRF Definition (Page 674)".
   b. Define a route target for VRF1 of type **both** with the export community set to **100:1**. For more information, refer to "Adding a Route Target (Page 676)".
   c. Make sure interfaces are configured with the IP addresses 1.1.12/24 and 1.1.2.1/24.
   d. Assign the interfaces in step 1.c to forward traffic to VRF1. For more information, refer to "Configuring a VRF Interface (Page 672)".
   e. Enable BGP and configure the following parameters:

Parameter	Value
Autonomous System ID	100
Router ID	5.5.5.5

f. Enable the router as a BGP route reflector and set the cluster ID to **5.5.5.5**. For more information, refer to "Configuring the Device as a Route Reflector (Page 611)".

g. Define an IPv4 address family for VRF1 with the following neighbors:

- **Neighbor 1.1.1.1**

Parameter	Value
Neighbor IP Address	1.1.1.1
Autonomous System ID	100
Route Reflector Client	Enabled

- **Neighbor 1.1.2.2**

Parameter	Value
Neighbor IP Address	1.1.2.2
Autonomous System ID	100
Route Reflector Client	Enabled

For more information, refer to "Adding an IPv4 Address Family (Page 687)".

h. Define a redistribution metric for IPv4 family of type **connected**. For more information, refer to "Adding a Redistribution (Page 688)".

2. **Configure R1**

a. Enable BGP and configure the following parameters:

Parameter	Value
Autonomous System ID	100
Router ID	5.5.5.1

For more information, refer to "Configuring BGP (Page 584)".

b. Define the following BGP neighbor:

Parameter	Value
Neighbor IP Address	1.1.1.2
Autonomous System ID	100

For more information, refer to "Adding a Neighbor (Page 600)".

c. Define a redistribution metric for BGP of type **connected**. For more information, refer to "Adding a Redistribution Metric (Page 608)".

3. **Configure R2**

a. Enable BGP and configure the following parameters:

Parameter	Value
Autonomous System ID	100
Router ID	5.5.5.2

For more information, refer to "Configuring BGP (Page 584)".

b. Define the following BGP neighbors:

- **Neighbor 1.1.2.1**

Parameter	Value
Neighbor IP Address	1.1.2.1
Autonomous System ID	100

- **Neighbor 1.1.3.2**

Parameter	Value
Neighbor IP Address	1.1.3.2
Autonomous System ID	101

For more information, refer to "Adding a Neighbor (Page 600)".

c. Define a redistribution metric for BGP of type **connected**. For more information, refer to "Adding a Redistribution Metric (Page 608)".

4. **Configure R3**

a. Enable BGP and configure the following parameters:

Parameter	Value
Autonomous System ID	101
Router ID	5.5.5.3

For more information, refer to "Configuring BGP (Page 584)".

b. Define the following BGP neighbor:

Parameter	Value
Neighbor IP Address	1.1.3.1
Autonomous System ID	101

For more information, refer to "Adding a Neighbor (Page 600)".

c. Define a redistribution metric for BGP of type **connected**. For more information, refer to "Adding a Redistribution Metric (Page 608)".

Verification

Verify the configuration by navigating to ***routing » status » bgp » route*** on R1. The following routes should be displayed:

```
                                                    LOCAL              AS
NETWORK       ADDRESS      SELECTED  INTERNAL  METRIC  PREFERENCE  WEIGHT  PATH  ORIGIN
-------------------------------------------------------------------------------------------
1.1.1.0/30
     1.1.1.2           true      true      0       100         0             Unspecified
1.1.2.0/30
     1.1.1.2           true      true      0       100         0             Unspecified
1.1.3.0/30
     1.1.2.2           true      true      0       100         0             Unspecified
```

Final Configuration Example

RR Configuration

```
global
 vrf
  definition vrf1
   rd 100:1
   route-target both 100:1
ip fe-1-1
 vrf-forwarding vrf1
 ipv4
  address 1.1.1.2/30
ip fe-1-2
 vrf-forwarding vrf1
 ipv4
  address 1.1.2.1/30
routing bgp
 enabled
 as-id              100
 router-id          5.5.5.5
 route-reflector enabled
 route-reflector cluster-id 5.5.5.5
 address-family ipv4
  vrf vrf1
   redistribute connected
   neighbor 1.1.1.1
    remote-as 100
    route-reflector-client enabled
   neighbor 1.1.2.2
    remote-as 100
    route-reflector-client enabled
```

R1 Configuration

```
routing bgp
 enabled
 as-id 100
 router-id 5.5.5.1
  neighbor 1.1.1.2
    remote-as 100
 redistribute connected
```

R2 Configuration

```
routing bgp
 enabled
 as-id 100
 router-id 5.5.5.2
  neighbor 1.1.2.1
    remote-as 100
  neighbor 1.1.3.2
    remote-as 101
 redistribute connected
```

R3 Configuration

```
routing bgp
 enabled
 as-id 100
 router-id 5.5.5.3
  neighbor 1.1.3.1
    remote-as 100
 redistribute connected
```

12.8.11.8 Example: Route Reflection with VPNv4 Clients

BGP route reflection can be used to advertise VPNv4 routes between Provider Edge (PE) devices inside a provider network. This specific application is complicated by the fact that VPNv4 routes to the Customer Edge (CE) devices are within VRFs that are not known to the global VRF shared by each PE device.

For more information about configuring this type of topology, refer to the application description " Using BGP Route Reflection with VPNv4 Clients [https://support.industry.siemens.com/cs/ww/en/view/109757209] ".

12.8.12 Viewing the Status of Dynamic BGP Routes

To view the status of the dynamic BGP routes configured on the device, type:

```
show routing status bgp route
```

If BGP routes have been configured, a table or list similar to the following example appears:

```
ruggedcom# show routing status bgp route | tab
                                                          LOCAL               AS
NETWORK       ADDRESS      SELECTED  INTERNAL  METRIC  PREFERENCE  WEIGHT  PATH  ORIGIN
-------------------------------------------------------------------------------------------
192.168.1.0
              192.168.1.2  true      true      0       100         0             IGP
192.168.6.0
              2.0.0.1      true      false     0                   0       200   IGP
192.168.12.0
              192.168.1.2  true      true      0       100         0             IGP
192.168.13.0
              0.0.0.0      true      false     0                   32768         IGP
```

The list provides the following information:

Parameter	Description
`network`	**Synopsis:** A string Network.
`{ address }`	**Synopsis:** A string Next-hop address.
`selected`	**Synopsis:** [true | false] Selected next-hop for this route.
`internal`	**Synopsis:** [true | false] Internal route.
`metric`	**Synopsis:** A string Metric.
`local-preference`	**Synopsis:** A string Local preference.
`weight`	**Synopsis:** An integer Weight.
`as-path`	**Synopsis:** A string AS path.
`origin`	**Synopsis:** A string Origin.

To view the routing information advertised to the network by a BGP neighbor, type:

```
show routing status bgp neighbor { IP Address } advertised-router
```

Where:

- { IP Address } is the IP address of a specific neighbor

If BGP neighbors have been configured, a table or list similar to the following example appears:

```
ruggedcom# show routing status bgp neighbor 2.0.0.2 advertised-route | tab
                                                                  LOCAL
NETWORK             NEXT HOP         SELECTED  INTERNAL  METRIC  PREFERENCE  WEIGHT  AS PATH
        ORIGIN
-------------------------------------------------------------------------------------------------
192.168.11.0        2.0.0.1          true      true      0                   32768   100 100 100 100
 100 ...  IGP
192.168.12.0        2.0.0.1          true      true      0       100         0       100 100 100 100
 100 ...  IGP
```

The list provides the following information:

Parameter	Description
`{ network }`	**Synopsis:** A string Network.
`next-hop`	**Synopsis:** A string Next-hop address.
`selected`	**Synopsis:** [true | false] Selected next-hop for this route.
`internal`	**Synopsis:** [true | false] Internal route.
`metric`	**Synopsis:** An integer Metric value.
`local-preference`	**Synopsis:** A string Local preference.
`weight`	**Synopsis:** An integer Weight.
`as-path`	**Synopsis:** A string Path.
`origin`	**Synopsis:** A string Origin.

If no dynamic BGP routes have been configured, configure BGP and add routes as needed. For more information about configuring BGP, refer to "Configuring BGP (Page 584)".

12.8.13 Resetting a BGP Session

Whenever there is a change in the routing policy due to a configuration change, the BGP session must be reset for the new policy to take effect.

RUGGEDCOM ROX II allows users to perform either a hard or soft reset on both incoming and outbound sessions, as selected.

A BGP session can be reset for all routing tables, or for a specified neighbor.

Resetting All BGP Sessions

To reset all BGP sessions, do the following:

1. Navigate to:

   `routing dynamic bgp all-peers-reset`

2. Configure the following parameter(s) as required:

Parameter	Description
`reset-type { reset-type }`	**Synopsis:** [hard | soft-inbound | soft-outbound | soft] The method for resetting all BGP peering sessions. Options include: • hard: Tears down and re-establishes all BGP sessions. • soft: The existing peering sessions continue to run while running both inbound and outbound actions. • soft-inbound: The existing peering sessions continue to run while generating inbound updates from all neighbors. • soft-outbound: The existing peering sessions continue to run while sending outbound updates to all neighbors.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

Resetting a BGP Session for a Specified Neighbor

To reset a BGP session for a specified neighbor, do the following:

1. Navigate to:

   `routing dynamic bgp neighbor { ip address } peer-reset`

   Where:

   • `{ ip address }` is the ip address of the neighbor

2. Configure the following parameter(s) as required:

Parameter	Description
`reset-type { reset-type }`	**Synopsis:** [hard | soft-inbound | soft-outbound | soft] The method for resetting the selected BGP peering session. Options include: • hard: Tears down the existing peering session then re-establishes it. • soft: The existing peering session continues to run while running both inbound and outbound actions. • soft-inbound: The existing peering session continues to run while generating inbound updates from its neighbor. • soft-outbound: The existing peering session continues to run while sending outbound updates to its neighbor.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.9 Managing OSPF

The Open Shortest Path First (OSPF) protocol determines the best path for routing IP traffic over a TCP/IP network based on link cost and quality. Unlike static routing, OSPF takes link failures and other network topology changes into account. OSPF also differs from RIP in that it provides less router to router update traffic.

The RUGGEDCOM ROX II OSPF daemon (ospfd) is an RFC 2178 [http://tools.ietf.org/html/rfc2178] compliant implementation of OSPF version 2. The daemon also adheres to the Opaque LSA (RFC 2370 [http://tools.ietf.org/html/rfc2370]) and ABR-Types (RFC 3509 [http://tools.ietf.org/html/rfc3509]) extensions.

OSPF network design usually involves partitioning a network into a number of self-contained areas. The areas are chosen to minimize intra-area router traffic, making more manageable and reducing the number of advertised routes. Area numbers are assigned to each area. All routers in the area are known as Area routers. If traffic must flow between two areas a router with links in each area is selected to be an Area Border router, and serves as a gateway.

Note
The `router-id` parameter defines the ID of the router. By default this is the highest IP assigned to the router. It is recommended to configure this value manually to avoid the ID changing if interfaces are added or deleted from the router. During elections for the master router, the ID is one of the values used to pick the winner. Keeping the ID fixed will avoid any unexpected changes in the election of the master router.

Note
In complex legacy networks, RIP, OSPF, BGP and IS-IS may all be active on the same router at the same time. Typically, however, only one dynamic routing protocol is employed at one time.

Note
Specific routes for Virtual Routing and Forwarding (VRF) interfaces can be configured. For more information about VRF, refer to "Managing Virtual Routing and Forwarding (VRF) (Page 669)".

12.9.1 OSPF Concepts

When an OSPF configured router starts operating, it issues a *hello* packet. Routers having the same OSPF Area, hello-interval and dead-interval timers will communicate with each other and are said to be neighbors.

After discovering its neighbors, a router will exchange Link State Advertisements in order to determine the network topology.

Every 30 minutes (by default), the entire topology of the network must be sent to all routers in an area.

If the link speeds are too low, the links are too busy or there are too many routes, some routes may fail to get re-announced and will be aged out.

Splitting the network into smaller areas to reduce the number of routes within an area or reducing the number of routes to be advertised may help to avoid this problem.

In shared access networks (i.e. routers connected by switches or hubs) a designated router and a backup designated are elected to receive route changes from subnets in the area. Once a designated router is picked, all routing state changes are sent to the designated router, which then sends the resulting changes to all the routers.

The election is decided based on the priority assigned to the interface of each router. The highest priority wins. If the priority is tied, the highest router-id wins.

12.9.2 Configuring OSPF

To configure dynamic routing using the Open Shortest Path First (OSPF) daemon, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***routing » ospf*** and configure the following parameter(s) as required:

Parameter	Description
`enabled`	Enables the OSPF dynamic routing protocol.
`abr-type { abr-type }`	**Synopsis:** [cisco | ibm | shortcut | standard] **Default:** cisco The OSPF ABR type.
`auto-cost-reference-bandwidth { auto-cost-reference-bandwidth }`	**Synopsis:** An integer between 1 and 4294967 **Default:** 100 Calculates the OSPF interface cost according to bandwidth [1-4294967 Mbps]
`compatible-rfc1583`	Enables the compatibility with the obsolete RFC1583 OSPF (the current is RFC2178)
`default-information-originate`	Advertises the default route.
`default-metric { default-metric }`	**Synopsis:** An integer between 0 and 16777214 The default metric of redistribute routes.
`distance { distance }`	**Synopsis:** An integer between 1 and 255 The administrative distance.
`opaque-lsa`	Enables the Opaque-LSA capability (RFC2370).

Parameter	Description
`passive-default { passive-default }`	**Synopsis:** [true | false] **Default:** true Default passive value for new interface.
`refresh-timer { refresh-timer }`	**Synopsis:** An integer between 10 and 1800 **Default:** 10 The refresh timer.
`router-id { router-id }`	**Synopsis:** A string between 7 and 15 characters long The Router ID for OSPF.

3. Configure the OSPF distance settings by configuring the following parameters:

Parameter	Description
`external { external }`	**Synopsis:** An integer between 1 and 255 The administrative distance for external routes.
`inter-area { inter-area }`	**Synopsis:** An integer between 1 and 255 The administrative distance for inter-area routes.
`intra-area { intra-area }`	**Synopsis:** An integer between 1 and 255 The administrative distance for intra-area routes.

4. Configure the OSPF distance settings by configuring the following parameters:

Parameter	Description
`external { external }`	**Synopsis:** An integer between 1 and 255 The administrative distance for external routes.
`inter-area { inter-area }`	**Synopsis:** An integer between 1 and 255 The administrative distance for inter-area routes.
`intra-area { intra-area }`	**Synopsis:** An integer between 1 and 255 The administrative distance for intra-area routes.

5. If **default-information-originate** was enabled in step 3, configure the following:

Parameter	Description
`always { always }`	**Synopsis:** [true | false] **Default:** false Always advertise default route even when there is no default route present in routing table.
`metric { metric }`	**Synopsis:** An integer between 0 and 16777214 The metric value for default route.

Parameter	Description
`metric-type { metric-type }`	**Synopsis:** An integer between 1 and 2 **Default:** 2 The metric type for default route.
`route-map { route-map }`	**Synopsis:** A string between 1 and 1024 characters long The route map name.

6. Configure prefix list filters. For more information, refer to "Adding a Prefix List (Page 634)".
7. Configure areas. For more information, refer to "Adding an Area (Page 637)".
8. Configure route map filters. For more information, refer to "Adding a Route Map Filter (Page 640)".
9. Configure redistribution metrics. For more information, refer to "Adding a Redistribution Metric (Page 645)".
10. Configure interfaces. For more information, refer to "Configuring a Routing Interface (Page 647)".
11. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.9.3 Viewing the Status of Dynamic OSPF Routes

To view the status of the dynamic OSPF routes configured on the device, type:

```
show routing status ospf route network
```

If OSPF routes have been configured, a table or list similar to the following example appears:

```
ruggedcom# show routing status ospf route network | tab
ID              DISCARD  INTER AREA  COST  AREA     HOW
-------------------------------------------------------------------------------
192.168.1.0/24  no       intra area  10    0.0.0.0
                                                    directly attached to fe-1-2
192.168.2.0/24  no       intra area  10    0.0.0.0
                                                    directly attached to fe-1-4
```

This list provides the following information:

Parameter	Description
`{ id }`	**Synopsis:** A string Network Prefix.
`destination`	**Synopsis:** A string Destination (network or discard).
`path-type`	**Synopsis:** A string Path type (inter-area or intra-area).

Parameter	Description
cost	**Synopsis:** A string Cost.
area	**Synopsis:** A string Area.
how	**Synopsis:** A string How to reach this network.

To view the status of the dynamic OSPF neighbor configured on the device, type:

```
show routing status ospf neighbor
```

If an OSPF neighbor have been configured, a table or list similar to the following example appears:

```
ruggedcom# show routing status ospf neighbor
                                                                                DEAD
ID           ADDRESS         INTERFACE                    PRIORITY  STATE       TIME
-------------------------------------------------------------------------------------
21.21.21.21  192.168.212.21  switch.0212:192.168.212.22  1         Full/Backup  31.249s
```

This list provides the following information:

Parameter	Description
{ id }	**Synopsis:** A string Neighbor ID.
{ address }	**Synopsis:** A string Address.
{ interface }	**Synopsis:** A string Interface.
priority	**Synopsis:** A string Priority.
state	**Synopsis:** A string State.
dead-time	**Synopsis:** A string Dead Time.

To view the status of the dynamic OSPF database configured on the device, type:

```
show routing status ospf database
```

If an OSPF neighbor have been configured, a table or list similar to the following example appears:

```
ruggedcom# show routing status ospf database
 router
                                                          LINK
ID           AREA     ADV ROUTER   AGE   SEQNUM      COUNT
```

```
-------------------------------------------------------------
21.21.21.21  0.0.0.0  21.21.21.21  1307  0x80000017  2
22.22.22.22  0.0.0.0  22.22.22.22  614   0x8000001c  1
22.22.22.22  0.0.0.1  22.22.22.22  1364  0x8000000e  1

 net
ID              AREA     ADV ROUTER   AGE  SEQNUM
-----------------------------------------------------
192.168.212.22  0.0.0.0  22.22.22.22  584  0x80000009

 summary
ID             AREA     ADV ROUTER   AGE   SEQNUM      ROUTE
-------------------------------------------------------------------------
192.168.22.0   0.0.0.0  22.22.22.22  1354  0x80000008  192.168.22.0/24
192.168.21.0   0.0.0.1  22.22.22.22  1434  0x80000009  192.168.21.0/24
192.168.212.0  0.0.0.1  22.22.22.22  44    0x80000008  192.168.212.0/24

 as-external
                                          METRIC
```

This list provides the following information:

Router

Parameter	Description
`area`	**Synopsis:** A string Area.
`{ link-id }`	**Synopsis:** A string Link ID.
`{ adv-router }`	**Synopsis:** A string Advertising Router.
`age`	**Synopsis:** A string Age.
`seqnum`	**Synopsis:** A string Sequence number.
`checksum`	**Synopsis:** A string Checksum.
`link-count`	**Synopsis:** A string Link count.

Net

Parameter	Description
`area`	**Synopsis:** A string Area ID.
`{ link-id }`	**Synopsis:** A string Link ID.
`{ adv-router }`	**Synopsis:** A string Advertising Router.

Parameter	Description
`age`	**Synopsis:** A string Age.
`seqnum`	**Synopsis:** A string Sequence number.

Summary

Parameter	Description
`area`	**Synopsis:** A string Area ID.
`{ link-id }`	**Synopsis:** A string Link ID.
`{ adv-router }`	**Synopsis:** A string Advertising Router.
`age`	**Synopsis:** A string Age.
`seqnum`	**Synopsis:** A string Sequence number.
`route`	**Synopsis:** A string Route.

If no dynamic OSPF routes have been configured, configure OSPF and add routes as needed. For more information about configuring OSPF, refer to "Configuring OSPF (Page 627)".

12.9.4 Managing Prefix Lists and Entries

Neighbors can be associated with prefix lists, which allow the OSPF daemon to filter incoming or outgoing routes based on the *allow* and *deny* entries in the prefix list.

12.9.4.1 Viewing a List of Prefix Lists

To view a list of prefix lists for dynamic OSPF routes, type:

- **For Standard OSPF Routes**

  ```
  routing ospf filter prefix-list
  ```

- **For VRF Routes via OSPF**

  ```
  routing ospf vrf { vrf } filter prefix-list
  ```

Where:

- `{ vrf }` is the name of the chosen VRF

If prefix lists have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing ospf filter prefix-list | tab
NAME                 DESCOSPFTION  SEQ  ACTION  SUBNET           LE  GE
-------------------------------------------------------------------------
list-permit-lan-22   -
                                   100  permit  192.168.33.0/24  -   -
list-withdraw-lan-11 -
                                   100  permit  192.168.33.0/24  -   -
                                   200  permit  192.168.33.0/24  32  -

!
```

If no prefix lists have been configured, add lists as needed. For more information, refer to "Adding a Prefix List (Page 634)".

12.9.4.2 Viewing a List of Prefix Entries

To view a list of entries for dynamic OSPF, OSPF, or OSPF prefix lists, type:

- **For Standard OSPF Routes**

  `routing ospf filter prefix-list { name } entry`

- **For VRF Routes via OSPF**

  `routing ospf vrf { vrf } filter prefix-list { name } entry`

Where:

- `{ vrf }` is the name of the chosen VRF
- `{ name }` is the name of the prefix list

If entries have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing ospf filter prefix-list test entry | tab
SEQ  ACTION  SUBNET           LE  GE
-------------------------------------------
5    permit  192.168.40.0/24  32  -
6    deny    192.168.5.21/32    -   -

 !
!
```

If no entries have been configured, add entries as needed. For more information, refer to "Adding a Prefix Entry (Page 634)".

12.9.4.3 Adding a Prefix List

To add a prefix list for dynamic OSPF routes, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the list by typing:
   - **For Standard OSPF Routes**

     ```
     routing ospf filter prefix-list { name }
     ```

   - **For VRF Routes via OSPF**

     ```
     routing ospf vrf { vrf } filter prefix-list
     { name }
     ```

   Where:
   - `{ vrf }` is the name of the chosen VRF
   - `{ name }` is the name of the prefix list
3. Configure the following parameter(s) as required:

Parameter	Description
`description { description }`	**Synopsis:** A string 1024 characters long The description of the prefix list.

4. Add prefix entries as needed. For more information, refer to "Adding a Prefix Entry (Page 634)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.9.4.4 Adding a Prefix Entry

To add an entry for a dynamic OSPF prefix list, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the entry by typing:
   - **For Standard OSPF Routes**

     ```
     routing ospf filter prefix-list { name } entry
     { number }
     ```

   - **For VRF Routes via OSPF**

     ```
     routing ospf vrf { vrf } filter prefix-list
     { name } entry { number }
     ```

   Where:
   - `{ vrf }` is the name of the chosen VRF
   - `{ name }` is the name of the prefix list

- `{ number }` is the sequence number for the entry

3. Configure the following parameter(s) as required:

Parameter	Description
`action { action }`	**Synopsis:** [deny | permit] **Default:** permit Action.
`subnet { subnet }`	**Synopsis:** A string between 9 and 18 characters long Network (xxx.xxx.xxx.xxx/xx).
`le { le }`	**Synopsis:** An integer between 1 and 32 The maximum prefix length to match ipaddress within subnet.
`ge { ge }`	**Synopsis:** An integer between 1 and 32 The minimum prefix length to match ipaddress within subnet.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.9.4.5 Deleting a Prefix List

To delete a prefix list for dynamic OSPF routes, do the following:

1. Make sure the CLI is in Configuration mode.

Note
Deleting a prefix list removes all associate prefix entries as well.

2. Delete the list by typing:
   - **For Standard OSPF Routes**

     ```
     no routing ospf filter prefix-list { name }
     ```

   - **For VRF Routes via OSPF**

     ```
     no routing ospf vrf { vrf } filter prefix-list { name }
     ```

     Where:
     - `{ vrf }` is the name of the chosen VRF
     - `{ name }` is the name of the prefix list

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.9.4.6 Deleting a Prefix Entry

To delete an entry for a dynamic OSPF prefix list, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the entry by typing:
   - **For Standard OSPF Routes**

     ```
     no routing ospf filter prefix-list { name } entry { number }
     ```

   - **For VRF Routes via OSPF**

     ```
     no routing ospf vrf { vrf } filter prefix-list { name } entry { number }
     ```

   Where:
   - `{ vrf }` is the name of the chosen VRF
   - `{ name }` is the name of the prefix list
   - `{ number }` is the sequence number for the entry
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.9.5 Managing Areas

Network areas determine the regions within which routes are distributed to other routers. The subnets at a particular router can be added to its OSPF Area. The router will advertise these subnets to all routers in its area.

OSPF areas must be designed such that no single link failure will cause the network to be split into two disjointed networks.

A router can be part of multiple areas and function as a gateway between areas. When multiple areas are used on a network, area zero (0) is the backbone area. All areas must have a router connecting them to area zero (0).

12.9.5.1 Viewing a List of Areas

To view a list of areas configured for dynamic OSPF routes, type:

- **For Standard OSPF Routes**

  ```
  show running-config routing ospf area
  ```

- **For VRF Routes via OSPF**

  ```
  show running-config routing ospf vrf { vrf } area
  ```

Where:

- `{ vrf }` is the name of the chosen VRF

If areas have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing ospf area | tab
AREA     NETWORK
-------------------------
0.0.0.0  192.168.12.0/24

!
```

If no areas have been configured, add areas as needed. For more information, refer to "Adding an Area (Page 637)".

12.9.5.2 Adding an Area

To add an area for dynamic OSPF routes, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the area by typing:
   - **For Standard OSPF Routes**

     `routing ospf area { id } { network/prefix }`

   - **For VRF Routes via OSPF**

     `routing ospf vrf { vrf } area { id } { network/prefix }`

   Where:
   - `{ vrf }` is the name of the chosen VRF
   - `{ id }` is the ID for the OSPF area. The ID must be in the format of *A.B.C.D*.
   - `{ network/prefix }` is the network and prefix for the OSPF area.
3. Configure the following parameter(s) as required:

Parameter	Description
`shortcut { shortcut }`	**Synopsis:** [default | disable | enable] **Default:** default Sets the area's shortcutting mode. Options include: • Default: If the Area Border Router (ABR) has an active backbone connection, the area is not used for shortcutting and a new bit (S-bit) is not set by the ABR in the router-LSA originated for the area. The opposite is true if the ABR does not have an active backbone connection. • Enable: If the ABR has an active backbone connection, it sets the new bit (S-bit) in the router-LSA originated for the area and uses it for shortcutting. Other ABRs in the area must also report the new bit. However, if the ABR does not have an active backbone connection, it uses the area

Parameter	Description
	unconditionally for shortcutting and sets the new bit in the router-LSA originated for the area. • Disable: The ABR does not use this area for shortcutting, or set the new bit (S-bit) in the router-LSA originated for it.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.9.5.3 Deleting an Area

To delete an area for dynamic OSPF routes, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the area by typing:
   - **For Standard OSPF Routes**

     ```
     no routing ospf area { id } { network/prefix }
     ```

   - **For VRF Routes via OSPF**

     ```
     no routing ospf vrf { vrf } area { id }
     { network/prefix }
     ```

   Where:
   - `{ vrf }` is the name of the chosen VRF
   - `{ id }` is the ID for the OSPF area. The ID must be in the format of *A.B.C.D*
   - `{ network/prefix }` is the network and prefix for the OSPF area
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.9.6 Managing Route Maps

Route maps are sequential statements used to filter routes that meet the defined criteria. If a route meets the criteria of the applied route map, it can either be excluded from the routing table or prevented from being redistributed. In RUGGEDCOM ROX II, route maps are configured to filter routes based on their metric value, which defines the cost of the route. Once a match is found, the assigned action is taken.

Each route map requires a sequence number (e.g. 10, 20, 30, etc.), which allows for multiple route maps to be run in sequence until a match is found. It is recommended to create sequence numbers in intervals of 10, in case a new route map is required later between two existing route maps.

12.9.6.1 Viewing a List of Route Map Filters

To view a list of route map filters for either dynamic OSPF routes, type:

- **For Standard OSPF Routes**

  ```
  show running-config routing ospf filter route-map
  ```

- **For VRF Routes via OSPF**

  ```
  show running-config routing ospf vrf { vrf }
  filter route-map
  ```

Where:

- `{ vrf }` is the name of the chosen VRF

If filters have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing ospf filter route-map | tab
                      ON
                      MATCH  AS    PREFIX  PREFIX  PREFIX                                LOCAL
                  NEXT          ORIGINATOR
TAG  SEQ  ACTION  CALL  GOTO   PATH  LIST    LIST    LIST    METRIC  PEER  ORIGIN  AS  IP  PREFERENCE
 OPERATION  VALUE  HOP   ORIGIN  ID          WEIGHT
-------------------------------------------------------------------------------------------------
map
     10   permit  -     -      -     -       -       -       -       -     -       -   -   -
 -          -      -     -       -           -

!
```

If no filters have been configured, add filters as needed. For more information, refer to "Adding a Route Map Filter (Page 640)".

12.9.6.2 Viewing a List of Route Map Filter Entries

To view a list of entries for a route map filter for either OSPF, type:

- **For Standard OSPF Routes**

  ```
  show running-config routing ospf filter route-map
  { tag } entry
  ```

- **For VRF Routes via OSPF**

  ```
  show running-config routing ospf vrf { vrf }
  filter route-map { tag } entry
  ```

Where:

- `{ vrf }` is the name of the chosen VRF
- `{ tag }` is the tag for the route map filter

If entries have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing ospf filter route-map map entry | tab
                  ON
                  MATCH  AS    PREFIX  PREFIX  PREFIX                              LOCAL
              NEXT          ORIGINATOR
SEQ  ACTION  CALL  GOTO   PATH  LIST    LIST    LIST    METRIC  PEER  ORIGIN  AS  IP  PREFERENCE
 OPERATION  VALUE  HOP   ORIGIN  ID          WEIGHT  AS
-------------------------------------------------------------------------------------------
10   permit  -     -      -     -       -       -       -       -     -       -   -   -          -
       -      -     -       -           -

 !
!
```

If no filters have been configured, add filters as needed. For more information, refer to "Adding a Route Map Filter Entry (Page 640)".

12.9.6.3 Adding a Route Map Filter

To add a route map filter for dynamic OSPF routes, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the new filter by typing:
   - **For Standard OSPF Routes**

     ```
     routing ospf filter route-map { tag }
     ```

   - **For VRF Routes via OSPF**

     ```
     routing ospf vrf { vrf } filter route-map
     { tag }
     ```

     Where:
     - `{ vrf }` is the name of the chosen VRF
     - `{ tag }` is the tag for the route map filter
3. Add one or more entries. For more information, refer to "Adding a Route Map Filter Entry (Page 640)".
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.9.6.4 Adding a Route Map Filter Entry

To add an entry for an route map filter, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the new filter by typing:
   - **For Standard OSPF Routes**

     ```
     routing ospf filter route-map { tag } entry
     { number }
     ```

- **For VRF Routes via OSPF**

```
routing ospf vrf { vrf } filter route-map
{ tag } entry { number }
```

Where:

- `{ vrf }` is the name of the chosen VRF
- `{ tag }` is the tag for the route map filter
- `{ number }` is the sequence number for the entry

3. Configure the following parameter(s) as required:

Parameter	Description
`action { action }`	**Synopsis:** [deny | permit] **Default:** permit Action.
`call { call }`	**Synopsis:** A string between 1 and 1024 characters long Jump to another route-map after match+set.
`on-match-goto { on-match-goto }`	**Synopsis:** An integer between 1 and 65535 Go to this entry on match.
`metric { metric }`	**Synopsis:** An integer Metric value.
`metric-type { metric-type }`	**Synopsis:** An integer between 1 and 2 External route type.

4. Configure the match rules for the route map filter. For more information, refer to "Configuring Match Rules (Page 642)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.9.6.5 Deleting a Route Map Filter

To delete a route map filter for dynamic OSPF routes, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the filter key by typing:
   - **For Standard OSPF Routes**

```
no routing ospf filter route-map { tag }
```

   - **For VRF Routes via OSPF**

```
no routing ospf vrf { vrf } filter route-map
{ tag }
```

Where:

- `{ vrf }` is the name of the chosen VRF
- `{ tag }` is the tag for the route map filter

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.9.6.6 Deleting a Route Map Filter Entry

To delete an entry for a route map filter, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the filter key by typing:
   - **For Standard OSPF Routes**

     ```
     no routing ospf filter route-map { tag } entry { number }
     ```

   - **For VRF Routes via OSPF**

     ```
     no routing ospf vrf { vrf } filter route-map { tag } entry { number }
     ```

   Where:
   - `{ vrf }` is the name of the chosen VRF
   - `{ tag }` is the tag for the route map filter
   - `{ number }` is the sequence number for the entry
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.9.6.7 Configuring Match Rules

To configure match rules for a route map filter entry, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to either:
   - **For Standard OSPF Routes**

     routing » dynamic » ospf » filter » route-map » {tag} » entry » {number} » match

   - **For VRF Routes via OSPF**

     routing » dynamic » ospf » vrf » {vrf} » filter » route-map » {tag} » entry » {number} » match

   Where:

- *{vrf}* is the chosen VRF
- *{tag}* is the tag for the route map filter
- *{number}* is the sequence number for the entry

3. Configure the following parameters as required:

Parameter	Description
`prefix-list { prefix-list }`	**Synopsis:** A string between 1 and 1024 characters long The prefix list name.
`prefix-list { prefix-list }`	**Synopsis:** A string between 1 and 1024 characters long The prefix list name.
`ifname { ifname }`	**Synopsis:** A string between 1 and 32 characters long The interface name.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.9.7 Managing Incoming Route Filters

Incoming route advertisements can be filtered by assigning one or route map filters. This can be useful for excluding specific OSPF routes from the routing table.

Note
For more information about route map filters, refer to "Managing Route Maps (Page 638)".

12.9.7.1 Viewing List of Incoming Route Filters

To view a list of route filters configured for incoming advertised routes, type:

- **For Standard OSPF Routes**

```
show running-config routing ospf incoming-route-filter
```

- **For VRF Routes via OSPF**

```
show running-config routing ospf vrf { vrf } incoming-route-filter
```

Where:

- `{ vrf }` is the name of the chosen VRF

If route filters have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing ospf incoming-route-filter
```

```
routing ospf
 incoming-route-filter ospf_route_1
 !
!
```

If no route filters have been configured, add filters as needed. For more information, refer to "Adding an Incoming Route Filter (Page 644)".

12.9.7.2 Adding an Incoming Route Filter

To add a route filter for incoming advertised routes, do the following:

1. Make sure the CLI is in Configuration mode.
2. Make sure a route map has been configured. For more information, refer to "Managing Route Maps (Page 638)".
3. Create the new incoming route filter by typing:
   - **For Standard OSPF Routes**

     `routing ospf incoming-route-filter { route-map }`
   - **For VRF Routes via OSPF**

     `routing ospf vrf { vrf } incoming-route-filter { route-map }`

   Where:
   - `{ vrf }` is the name of the chosen VRF
   - `{ route-map }` is the name of the route map
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.9.7.3 Deleting an Incoming Route Filter

To delete a route filter configured for incoming advertised routes, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the address by typing:
   - **For Standard OSPF Routes**

     `no routing ospf incoming-route-filter { route-map }`
   - **For VRF Routes via OSPF**

     `no routing ospf vrf { vrf } incoming-route-filter { route-map }`

   Where:

- `{ vrf }` is the name of the chosen VRF
- `{ route-map }` is the name of the route map

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.9.8 Managing Redistribution Metrics

Redistribution metrics redistribute routing information from other routing protocols, static routes or routes handled by the kernel. Routes for subnets that are directly connected to the router, but not part of the OSPF areas, can also be advertised.

12.9.8.1 Viewing a List of Redistribution Metrics

To view a list of redistribution metrics for dynamic OSPF routes, type:

- **For Standard OSPF Routes**

  ```
  routing ospf redistribute
  ```

- **For VRF Routes via OSPF**

  ```
  routing ospf vrf { vrf } redistribute
  ```

Where:

- `{ vrf }` is the name of the chosen VRF

If metrics have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing ospf redistribute
routing ospf
 redistribute bgp
  no metric-type
  no metric
 !
!
```

If no redistribution metrics have been configured, add metrics as needed. For more information, refer to "Adding a Redistribution Metric (Page 645)".

12.9.8.2 Adding a Redistribution Metric

To add a redistribution metric for dynamic OSPF routes, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the metric by typing:

- **For Standard OSPF Routes**

```
routing ospf redistribute [ { bgp } | { rip } |
{ connected } | { static } | { kernel } ]
```

- **For VRF Routes via OSPF**

```
routing ospf vrf { vrf } redistribute [
{ bgp } | { rip } | { connected } | { static } |
{ kernel } ]
```

Where:

- `{ vrf }` is the name of the chosen VRF

3. Configure the following parameter(s) as required:

Parameter	Description
`metric-type { metric-type }`	**Synopsis:** An integer between 1 and 2 **Default:** 2 The OSPF exterior metric type for redistributed routes.
`metric { metric }`	**Synopsis:** An integer between 0 and 16777214 The metric for redistributed routes.
`route-map { route-map }`	**Synopsis:** A string between 1 and 1024 characters long The route map name.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.9.8.3 Deleting a Redistribution Metric

To delete a redistribution metric for dynamic OSPF routes, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the metric by typing:

- **For Standard OSPF Routes**

```
no routing ospf redistribute [ { bgp } |
{ rip } | { connected } | { static } | { kernel }
 ]
```

- **For VRF Routes via OSPF**

```
no routing ospf vrf { vrf } redistribute [
{ bgp } | { rip } | { connected } | { static } |
{ kernel } ]
```

Where:

- `{ vrf }` is the name of the chosen VRF

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.9.9 Managing Routing Interfaces

This section describes how to manage interfaces for OSPF routes.

12.9.9.1 Viewing a List of Routing Interfaces

To view a list of routing interfaces for an OSPF network, type:

- **For Standard OSPF Routes**

  ```
  show running-config routing ospf interface
  ```

- **For VRF Routes via OSPF**

  ```
  show running-config routing ospf vrf { vrf } interface
  ```

Where:

- `{ vrf }` is the name of the chosen VRF

A table or list similar to the following example appears:

```
ruggedcom# show running-config routing ospf interface | tab
                                        MINIMAL
                                DEAD    HELLO     HELLO                       RETRANSMIT
 TRANSMIT  KEY
IFNAME       AUTHENTICATION  COST  INTERVAL  MULTIPLIER  INTERVAL  PRIORITY  PASSIVE  INTERVAL
 DELAY     ID   MD5
-------------------------------------------------------------------------------------------
dummy0       -               -     40        -           10        1         true     5           1
fe-cm-1      -               -     40        -           10        1         true     5           1
switch.0001  -               -     40        -           10        1         true     5           1
```

12.9.9.2 Configuring a Routing Interface

To configure a routing interface for an OSPF network, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to either:
   - **For Standard OSPF Routes**

     routing » dynamic » ospf » interface » {name}
   - **For VRF Routes via OSPF**

     routing » dynamic » ospf » vrf » {vrf} » interface » {name}

   Where:

   - *{vrf}* is the chosen VRF

- *{name}* is the name of the interface

3. Configure the dead interval settings by typing the following commands:

Note
For reliable operation, it is recommended that the `dead-interval` value be at least four times the number of Hellos per second.

Note
Lower values of `dead-interval` and `minimal-hello-multiplier` will help speed up the change in network routes when the topology of the network changes. It will also increase the load on the router and the links, due to higher traffic caused by the increase in messages.

Lower values will also put limits on the number of routes that can be distributed within an OSPF network area, as will running over slower links.

⚠ NOTICE
The `dead-interval` and number of Hellos per second must be identical on every router in an OSPF network area.

Parameter	Description
`dead-interval { dead-interval }`	**Synopsis:** An integer between 1 and 65535 **Default:** 40 The time before considering a router dead (in seconds).
`minimal-hello-multiplier { minimal-hello-multiplier }`	**Synopsis:** An integer between 1 and 10 The number of times a hello message can be sent within one second.

4. Configure the interface settings by typing the following commands:

Note
Link detection is enabled automatically for active network interfaces. It makes sure the appropriate routing daemon is notified when an interface goes down and stops advertising subnets associated with that interface. The routing daemon resumes advertising the subnet when the link is restored. This allows routing daemons to detect link failures more rapidly, as the router does not have to wait for the **dead interval** to time out. Link detection also causes **redistributed** routes to start and stop being advertised based on the status of their interface links.

Note
The link cost determines which route to use when multiple links can reach a given destination. By default, OSPF assigns the same cost to all links unless it is provided with extra information about the links. Each interface is assumed to be 10 Mbit, unless otherwise specified by the `auto-cost-bandwidth` parameter set for the interface. For more information about the `auto-cost-bandwidth` , refer to "Configuring Costing for Routable Interfaces (Page 249)".

The default OSPF reference bandwidth for link cost calculations is 100 Mbit. The reference bandwidth divided by the link bandwidth gives the default cost for a link, which by default is 10. If a specific bandwidth is assigned to each link, the costs take this into account.

Link costs can be assigned manually under OSPF to each routable interface. This should be done when the speed of the link should not be used as the method for choosing the best link.

Parameter	Description
`authentication { authentication }`	**Synopsis:** [message-digest | null] The authentication type on this interface.
`cost { cost }`	**Synopsis:** An integer between 1 and 65535 The link cost. If not set, the cost is based on calculation of reference bandwidth divide by interface bandwidth.
`hello-interval { hello-interval }`	**Synopsis:** An integer between 1 and 65535 **Default:** 10 The time (in seconds) between sending hello packets.
`priority { priority }`	**Synopsis:** An integer between 0 and 255 **Default:** 1 Priority of interface.
`passive { passive }`	**Synopsis:** [true | false] **Default:** true Whether an interface is active or passive. Passive interfaces do not send LSAs to other routers and are not part of an OSPF area.
`retransmit-interval { retransmit-interval }`	**Synopsis:** An integer between 1 and 65535 **Default:** 5 Time (in seconds) between retransmitting lost link state advertisements.
`transmit-delay { transmit-delay }`	**Synopsis:** An integer between 1 and 65535 **Default:** 1 The link state transmit delay (in seconds).

5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.9.10 Managing Message Digest Keys

Message digest keys use the MD5 algorithm to authenticate OSPF neighbors and prevent unauthorized routers from joining the OSPF network. By enabling authentication and configuring a shared key on all the routers, only routers which have the same authentication key will be able to send and receive advertisements within the OSPF network.

An ID for each key allows the router to use multiple passwords and prevent replay attacks where OSPF packets are captured, modified and transmitted to a router. To change passwords, simply create a new key and delete the old key.

⚠ NOTICE

The router can only share routing information with neighbors that use the same authentication method and password.

Note

Authentication adds a small overhead due to the encryption of messages. It is not recommended for completely private networks with controlled access.

12.9.10.1 Viewing a List of Message Digest Keys

To view a list of message digest keys for an OSPF routing interface, type:

- **For Standard OSPF Routes**

```
show running-config routing ospf interface
{ name } message-digest-key
```

- **For VRF Routes via OSPF**

```
show running-config routing ospf interface
{ name } message-digest-key
```

Where:

- `{ vrf }` is the name of the chosen VRF
- `{ name }` is the name of the routing interface

If keys have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing ospf interface switch.0001 message-digest-key
routing ospf
 interface switch.0001
  message-digest-key 1
   md5 RUGGEDCOM
  !
 !
!
```

If no message digest keys have been configured, add keys as needed. For more information, refer to "Adding a Message Digest Key (Page 650)".

12.9.10.2 Adding a Message Digest Key

To add a message digest key to an OSPF routing interface, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the key by typing:

- **For Standard OSPF Routes**

  ```
  routing ospf interface { name } message-digest-key { id }
  ```

- **For VRF Routes via OSPF**

  ```
  routing ospf vrf { vrf } interface { name } message-digest-key { id }
  ```

  Where:

  - `{ vrf }` is the name of the chosen VRF
  - `{ name }` is the name of the routing interface
  - `{ id }` is the ID for the message digest key

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.9.10.3 Deleting a Message Digest Key

To delete a message digest key from an OSPF routing interface, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the key by typing:

   - **For Standard OSPF Routes**

     ```
     no routing ospf interface { name } message-digest-key { id }
     ```

   - **For VRF Routes via OSPF**

     ```
     no routing ospf vrf { vrf } interface { name } message-digest-key { id }
     ```

     Where:

     - `{ vrf }` is the name of the chosen VRF
     - `{ name }` is the name of the routing interface
     - `{ id }` is the ID for the message digest key

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.9.11 Managing ABR Route Summarization

An inherent problem with OSFP is the number of Link-State Advertisements (LSAs) generated per area. When a route disappears in an area, the Link-State Database (LSDB) can be flooded with multiple advertisements from other areas describing

individual routes. This not only creates large routing tables, it also consumes memory and increases CPU utilization.

This can be avoided by enabling an Area Border Router (ABR) to summarize all type-3 summary LSAs for its area into a single type-3 summary LSA.

This section describes ABR route summarization for OSPF and how to configure it.

12.9.11.1 Understanding ABR Route Summarization

ABR route summarization reduces the number of type-3 summary LSAs sent between OSPF areas. When ABR route summarization is enabled, type-3 summary LSAs within a specific subnet range(s) received by the ABR are summarized and forwarded to the next area as a single type-3 summary LSA. This significantly reduces traffic between areas and reduces CPU utilization.

ABR route summarization requires the configuration of one or more area ranges for an ABR. An area range defines a network prefix and area ID. An action type (advertise or not advertise) and cost can also be applied. Type-3 LSAs that fall within the specified range are collected by the ABR.

Choosing to not advertise LSAs within a specific area range helps filter LSAs, and prevents any route happening in one area from propagating from one area into others.

12.9.11.2 Viewing a List of Summary Routes

To view a list of summary routes configured on the device, type:

```
show running-config routing ospf area-range
```

If summary routes have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing ospf area-range | tab
                              ACTION
AREA ID  AREA RANGE           TYPE       COST
-------------------------------------------
0.0.0.0  192.168.10.0/24      advertise  -
0.0.0.1  172.168.1.0/24       advertise  -

!
```

If no summary routes have been configured, add routes as needed. For more information, refer to "Adding a Summary Route (Page 652)".

12.9.11.3 Adding a Summary Route

To add a summary route, do the following:

1. Make sure the CLI is in Configuration mode.

2. Add the area range by typing:

   ```
   routing ospf area-range { area-id } { network-prefix } action-type [ advertise | not-advertise ] cost { cost }
   ```

   Where:

   - { area-id } is the ID (in the form of A.B.C.D) of the area to be summarized
   - { network-prefix } is the network range and prefix of the associated area
   - { cost } is the cost of the summarized route

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.9.11.4 Deleting a Summary Route

To delete a summary route, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the area range by typing:

   ```
   no routing ospf area-range { area-id } { network-prefix }
   ```

   Where:

   - { area-id } is the ID (in the form of A.B.C.D) of the area to be summarized
   - { network-prefix } is the network range and prefix of the associated area

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.9.11.5 Example: Basic Route Summarization

The following demonstrates how to define a series of summary routes for an ABR in a simple OSPF network. In the following topology:

- R1 resides in area 0.0.0.0, the backbone of the OSPF network
- R2 acts as the ABR for areas 0.0.0.0 and 0.0.0.1
- R3 resides in area 0.0.0.1 and is connected to four stub networks (192.168.*.0/24)

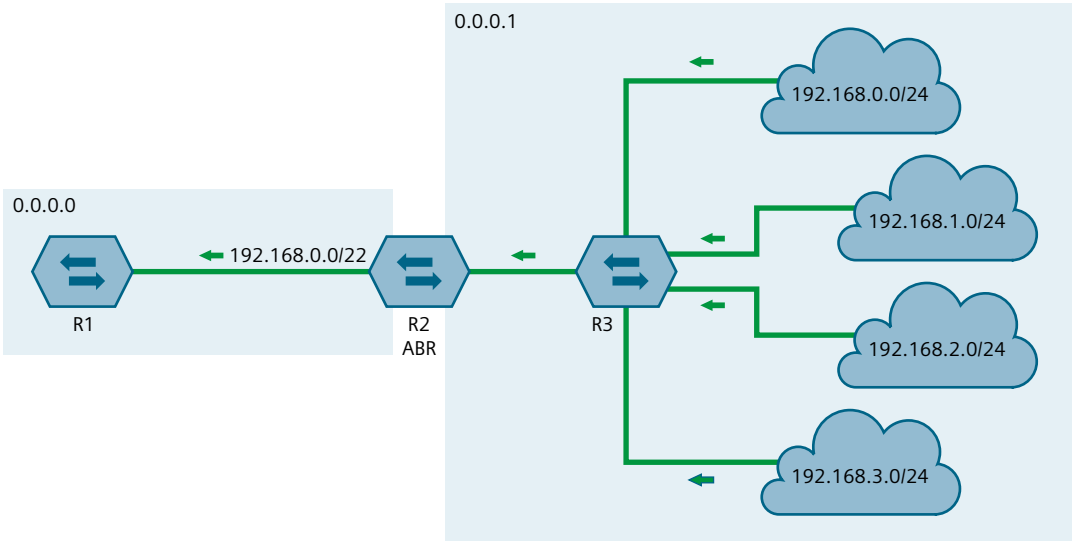


Figure 12.12 Basic ABR Router Summarization

Configuring a Summary Route to Summarize LSAs

To configure a summary route for R2, do the following:

1. Assign IP interfaces to interfaces.

Interface	IP Address/Prefix
fe-1	172.168.1.2/24
fe-2	192.168.10.2/24

2. Configure OSPF.
   a. Enable OSPF
   b. Add the following areas:

Area ID	IP Address/Prefix
0.0.0.0	192.168.10.0/24
0.0.0.1	172.168.1.0/24

   c. Define fe-1 and fe-2 as routing interfaces.
3. Configure a summary route to capture all LSAs advertised by area 0.0.0.1.

Area ID	0.0.0.1
IP Address/Prefix	192.168.0.0/22

4. On R1, review the routing table and verify the only LSA recieved from the ABR is a type-3 summary LSA. For example:

Destination	Gateway	Interface	Type	Weight	Metric
172.168.1.0/24	192.168.10.2	fe-1-2	zebra		20
192.168.0.0/22	**192.168.10.2**	**fe-1-2**	**zebra**		**20**
192.168.10.0/24		fe-1-2	kernel		

Configuring a Cost to a Summary Route

The default cost for each summary route is 20. To change the cost for the R2's area range, do the following:

1. Navigate to area range 0.0.0.1 for IP address 192.168.0.0/22.
2. Change **cost** to any number between 1 and 65535.
3. On R1, review the routing table and verify the cost assigned to the type-3 summary LSA forwarded by the ABR. For example:

Destination	Gateway	Interface	Type	Weight	Metric
172.168.1.0/24	192.168.10.2	fe-1-2	zebra		20
192.168.0.0/22	192.168.10.2	fe-1-2	zebra		**30**
192.168.10.0/24		fe-1-2	kernel		

Configuring a Summary Route to Not Advertise Routes

By default, an ABR will advertise all summary LSAs. To configure R2 to summarize but not advertise the LSAs forward by R3, do the following:

1. Navigate to area range 0.0.0.1 for IP address 192.168.0.0/22.
2. Change **action-type** from **advertise** to **not-advertise** .
3. On R1, review the routing table and confirm the ABR is not forwarding any LSAs. For example:

Destination	Gateway	Interface	Type	Weight	Metric
172.168.1.0/24	192.168.10.2	fe-1-2	zebra		20
192.168.10.0/24		fe-1-2	kernel		

12.10 Managing MPLS

MPLS (Multi-Protocol Label Switching) operates between Layer 2 and Layer 3 of the OSI (Open Systems Interconnection) model and provides a mechanism to carry traffic for any network layer protocol. MPLS makes forwarding decisions based on labels where the labels are mapped to destination IP networks. MPLS traffic flows are connection-oriented, as they operate on pre-configured LSPs (Label Switch Paths) built based on the dynamic Label Distribution Protocol (LDP), or through static label bindings.

12.10.1 Viewing the Status of IP Binding

To view the status of the IP binding on the device, type:

```
show mpls status ip-binding
```

If IP binding has been configured, a table similar to the following example appears:

```
ruggedcom# show mpls status ip-binding
                  LOCAL                    REMOTE
PREFIX            LABEL     NEXT HOP       LABEL
-------------------------------------------------------
1.1.1.1/32        17        192.168.10.1   imp-null
2.2.2.2/32        18        192.168.10.1   imp-null
3.3.3.3/32        imp-null
4.4.4.4/32        imp-null
5.5.5.5/32        19        192.168.20.2   imp-null
6.6.6.6/32        20        192.168.20.2   imp-null
10.200.16.0/20    16
172.30.128.0/19   imp-null
192.168.10.0/24   imp-null
192.168.20.0/24   imp-null
192.168.100.0/24  21        192.168.10.1   imp-null
192.168.200.0/24  22        192.168.20.2   imp-null
```

This table provides the following information:

Parameter	Description
`prefix`	**Synopsis:** A string The destination address prefix.
`local-label`	**Synopsis:** A string The incoming (local) label.
`next-hop`	**Synopsis:** A string The destination next hop router.
`remote-label`	**Synopsis:** A string The remote label

12.10.2 Viewing the Status of the Forwarding Table

To view the status of the forwarding table on the device, type:

```
show mpls status forwarding-table
```

A table or list similar to the following example appears:

```
ruggedcom# show mpls status forwarding-table
LOCAL  OUTGOING                    OUTGOING
LABEL  LABEL     PREFIX            INTERFACE    NEXT HOP      UPTIME
-------------------------------------------------------------------------
17     Pop       1.1.1.1/32        switch.0010  192.168.10.1  01:04:31
18     Pop       2.2.2.2/32        switch.0010  192.168.10.1  01:04:31
19     Pop       5.5.5.5/32        switch.0020  192.168.20.2  01:04:33
20     Pop       6.6.6.6/32        switch.0020  192.168.20.2  01:04:33
21     Pop       192.168.100.0/24  switch.0010  192.168.10.1  01:04:31
22     Pop       192.168.200.0/24  switch.0020  192.168.20.2  01:04:33
```

This table or list provides the following information:

Parameter	Description
`local-label`	**Synopsis:** A string The incoming (local) label
`outgoing-label`	**Synopsis:** A string The outgoing (remote) label.
`prefix`	**Synopsis:** A string The destination address prefix.
`outgoing-interface`	**Synopsis:** A string The outgoing interface.
`next-hop`	**Synopsis:** A string The destination next hop router.
`uptime`	**Synopsis:** A string The time this entry has been up.

12.10.3 Enabling/Disabling MPLS

To enable MPLS routing, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable or disable MPLS by typing the following commands:

   Enable

   ```
   mpls  enable
   ```

   Disable

   ```
   no  mpls  enable
   ```

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.10.4 Managing the MPLS Interfaces

This section describes how to manage the MPLS interfaces.

12.10.4.1 Viewing the Status of MPLS Interfaces

To view the status of the MPLS interfaces on the device, type:

```
show  mpls  status  interfaces
```

If MPLS interfaces have been enabled on the device, a table similar to the following example appears:

```
show mpls status interfaces
MPLS
INTERFACES   STATUS
--------------------
switch.0010  yes
switch.0020  yes
```

This table provides the following information:

Parameter	Description
`mpls-interfaces`	**Synopsis:** A string The interface that has been enabled for MPLS.
`status`	**Synopsis:** A string The operational status.

If no MPLS interface has been enabled, enable interfaces as needed. For more information about enabling MPLS interfaces, refer to "Enabling/Disabling an MPLS Interface (Page 659)".

12.10.4.2 Viewing a List of MPLS Interfaces

To view a list of MPLS interfaces, type:

`show running-config mpls interface-mpls`

If interfaces have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config mpls interface-mpls | tab
IFNAME     ENABLED
----------------------
fe-cm-1     false
switch.0001  false
switch.0010  true
switch.0020  false

!
```

Where:

- `{ IFNAME }` is the name of the interface
- `{ ENABLED }` refers to the status of the MPLS operation on the interface

If no MPLS interfaces have been configured, enable interfaces as needed. For more information about enabling MPLS interfaces, refer to "Enabling/Disabling an MPLS Interface (Page 659)".

12.10.4.3 Enabling/Disabling an MPLS Interface

To enable or disable an MPLS interface, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable or disable MPLS interfaces by typing the following commands:

   Enable

   ```
   mpls interface-mpls { interface } enable
   ```

   Disable

   ```
   no mpls interface-mpls { interface } enable
   ```

   Where:

   - `{ interface }` is the name of the interface
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.10.5 Managing Static Label Binding

This section describes how to bind (or reserve) labels for IPv4 network prefixes.

12.10.5.1 Viewing the Status of Static Label Binding

To view the status of all configured static label binding, type:

```
show mpls status static-binding
```

If static label binding has been configured, a table similar to the following example appears:

```
ruggedcom# show mpls status static-binding
                  IN     OUT
IP ADDRESS        LABEL  LABEL  NEXTHOP
-----------------------------------------------
192.168.20.0/24   90     101    192.168.10.2
192.168.200.0/24  95     100    192.168.10.2
```

This table provides the following information:

Parameter	Description
`ip-address`	**Synopsis:** A string The destination address prefix.
`in-label`	**Synopsis:** A string The incoming (local) label.
`out-label`	**Synopsis:** A string The outgoing (remote) label.

Parameter	Description
`nexthop`	**Synopsis:** A string The destination next hop router.

If no static label binding has been configured, configure binding as needed. For more information about configuring static-binding, refer to "Adding a Static Label (Page 660)".

12.10.5.2 Viewing a List of Static Labels

To view a list of static labels, type:

```
show running-config mpls static-mpls binding ipv4
```

If static labels have been configured, a list similar to the following example appears:

```
ruggedcom# show running-config mpls static-mpls binding ipv4
mpls
 static-mpls
  binding
   ipv4
    dest-address 192.168.52.52/32
     next-hop  192.168.10.2
     out-label 16
    !
   !
  !
 !
!
```

If no static labels have been configured, add labels as needed. For more information about adding static labels, refer to "Adding a Static Label (Page 660)".

12.10.5.3 Adding a Static Label

To add a static label, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add a static label by typing:

   ```
   mpls static-mpls binding ipv4 dest-address
   { address }
   ```

   Where:

   - `{ address }` is the destination address and prefix.
3. Configure the following parameter(s) as required:

Parameter	Description
`in-label { in-label }`	**Synopsis:** An integer between 16 and 1048575 The incoming label: integer 16 -> 1048575.

Parameter	Description
`next-hop { next-hop }`	**Synopsis:** A string between 7 and 15 characters long The IP address for the destination next-hop router.
`out-label { out-label }`	**Synopsis:** [explicit-null | implicit-null] or An integer between 16 and 1048575 The outgoing label: • **implicit null** - The label has a value of 3, meaning the penultimate (next-to-last) router performs a pop operation and forwards the remainder of the packet to the egress router. Penultimate Hop Popping (PHP) reduces the number of label lookups that need to be performed by the egress router • **explicit null** - The label has a value of 0, meaning that, in place of a pop operation, the penultimate (next-to-last) router forwards an IPv4 packet with an outgoing MPLS label of 0 to the egress router

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.10.5.4 Deleting a Static Label

To delete a static label, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete a static label by typing:

   ```
   no mpls static-mpls binding ipv4 dest-address { address }
   ```

   Where:

   - `{ address }` is the destination address and prefix.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.10.6 Managing Static Cross-Connects

Configure MPLS static cross-connects when the device is the core MPLS router. Cross-connects build Label Switch Paths (LSPs) when neighboring routers do not deploy the Label Distribution Protocol (LDP). The entry for static cross-connects is added to the Label Forwarding Information Base (LFIB). And, as such, label binding is not required in the Label Information Base (LIB).

12.10.6.1 Viewing the Status of Static Cross-Connects

To view the status of all configured static cross-connects, type:

```
show mpls status static-crossconnect
```

If static cross-connects have been configured, a table similar to the following example appears:

```
ruggedcom# show mpls status static-crossconnect
LOCAL  OUTGOING  OUTGOING
LABEL  LABEL     INTERFACE    NEXT HOP
-----------------------------------------
200    205       switch.0010  192.168.10.2
215    250       switch.0010  192.168.10.2
```

This table provides the following information:

Parameter	Description
`local-label`	**Synopsis:** A string The incoming (local) label.
`outgoing-label`	**Synopsis:** A string The outgoing (remote) label.
`outgoing-interface`	**Synopsis:** A string The outgoing interface.
`next-hop`	**Synopsis:** A string The destination next hop router.

If no static cross-connects have been configured, add cross-connects as needed. For more information about adding static cross-connects, refer to "Adding a Static Cross-Connect (Page 663)".

12.10.6.2 Viewing a List of Static Cross-Connects

To view a list of configured static cross-connects, type:

```
show running-config mpls static-mpls crossconnects
```

If static cross-connects have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config mpls static-mpls crossconnect | tab
       OUT                        OUT
LABEL  INTERFACE    NEXT HOP      LABEL
---------------------------------------
20     switch.0001  192.168.10.2  32

 !
!
```

If no static cross-connects have been configured, add cross-connects as needed. For more information about adding static cross-connects, refer to "Adding a Static Cross-Connect (Page 663)".

12.10.6.3 Adding a Static Cross-Connect

To add a static cross-connect, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add a static cross-connect by typing:

   ```
   mpls static-mpls crossconnect in-label { in-label }
   ```

   Where:

   - `{ in-label }` is the incoming label
3. Configure the following parameter(s) as required:

Parameter	Description
`out-interface { out-interface }`	**Synopsis:** A string The outgoing interface.
`next-hop { next-hop }`	**Synopsis:** A string between 7 and 15 characters long or A string between 6 and 40 characters long The destination next-hop router (IPv4 or IPv6 format).
`out-label { out-label }`	**Synopsis:** [explicit-null | implicit-null] or An integer between 16 and 1048575 The outgoing label: 'explicit-null', 'implicit-null' or integer 16 - > 1048575.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.10.6.4 Deleting a Static Cross-Connect

To delete a static cross-connect, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete a static cross-connect by typing:

   ```
   no mpls static-mpls crossconnect in-label { in-label }
   ```

   Where:

   - `{ in-label }` is the incoming label
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.10.7 Managing LDP

LDP (Label Distribution Protocol), defined by RFC 5036 [http://tools.ietf.org/html/rfc5036], is a protocol that enables an MPLS capable router to exchange MPLS label information. The labels are distributed in both directions so that an LSP (Label Switched Path) can be established and managed within an MPLS network dynamically, as opposed to configuring static routes. LDP takes advantage of already established routing information (using OSPF or IS-IS) to distribute label information amongst the MPLS enabled routers).

LDP works by enabling Label Switch Routers (LSRs) to discover and bind labels to their neighbors within the MPLS network. The LSRs then identify their peers and exchange their label information with one another. Label information is stored in Label Information Base (LIB) and Label Forwarding Information Base (LFIB) tables.

12.10.7.1 Viewing the Status of LDP Binding

To view the status of the LDP binding on the device, type:

```
show mpls ldp status binding
```

A table or list similar to the following example appears:

```
ruggedcom# show mpls ldp status binding
                LOCAL     NEXT      REMOTE
PREFIX          LABEL     HOP       LABEL     IN USE
-------------------------------------------------------
1.1.1.1         17        2.2.2.2   imp-null  in-use
1.1.1.1         17        6.6.6.6   17
2.2.2.2         18        2.2.2.2   imp-null  in-use
2.2.2.2         18        6.6.6.6   18
3.3.3.3         imp-null
4.4.4.4         imp-null
5.5.5.5         19        2.2.2.2   19
5.5.5.5         19        6.6.6.6   imp-null  in-use
```

This table or list provides the following information:

Parameter	Description
`prefix`	**Synopsis:** A string The LDP transport prefix.
`local-label`	**Synopsis:** A string The incoming (local) label.
`next-hop`	**Synopsis:** A string The destination next hop router.
`remote-label`	**Synopsis:** A string The LDP remote label.
`in-use`	**Synopsis:** A string The LDP in-use flag.

12.10.7.2 Viewing the Status of the LDP Discovery Interfaces

To view the status of the LDP discovery interfaces on the device, type:

```
show mpls ldp status discovery
```

If LDP discovery interfaces have been configured, a table similar to the following example appears:

```
ruggedcom# show mpls ldp status discovery
status discovery
 local id 4.4.4.4
 interfaces
INTERFACE    SRC IP ADDR   PEER ID  PEER IP       STATE
-----------------------------------------------------------
switch.0010  192.168.10.2  2.2.2.2  192.168.10.1  OPER
switch.0020  192.168.20.1  6.6.6.6  192.168.20.2  OPER
```

This table provides the following information:

Parameter	Description
`interface`	**Synopsis:** A string The LDP discovery interface.
`src-ip-addr`	**Synopsis:** A string The LDP discovery source IP address.
`peer-id`	**Synopsis:** A string The LDP discovery peer ID.
`peer-ip`	**Synopsis:** A string LDP discovery peer IP address
`state`	**Synopsis:** A string The LDP discovery interface state.

For more information about configuring LDP discovery interfaces, refer to "Enabling/Disabling an LDP Interface (Page 669)".

12.10.7.3 Viewing the Status of the LDP Neighbor Local Node Information

To view the status of the local node(s) for the LDP neighbor on the device, type:

```
show mpls ldp status neighbor local-node-information
```

A table or list similar to the following example appears:

```
ruggedcom# show mpls ldp status neighbor local-node-information
                  KEEPALIVE
LDP ID   HOLDTIME  INTERVAL
-----------------------------
4.4.4.4   15s       180s
```

This table or list provides the following information:

Parameter	Description
`ldp-id`	**Synopsis:** A string The LDP ID of the neighbor local node.
`hello-holdtime`	**Synopsis:** A string LDP hello holdtime of the neighbor local node.
`session-holdtime`	**Synopsis:** A string The LDP session holdtime of the neighbor local node.

12.10.7.4 Viewing the Status of the LDP Neighbor Connection Information

To view the status of the LDP neighbor connection on the device, type:

`show mpls ldp status neighbor connection-information`

A table similar to the following example appears:

```
ruggedcom# show mpls ldp status neighbor connection-information
          TCP
PEER ID   CONNECTION     STATE  UPTIME
---------------------------------------
2.2.2.2   192.168.10.1   OPER   00:51:51
-         192.168.10.2
6.6.6.6   192.168.20.2   OPER   00:51:53
-         192.168.20.1
```

This table provides the following information:

Parameter	Description
`peer-id`	**Synopsis:** A string The peer ID of the LDP neighbor connection.
`tcp-connection`	**Synopsis:** A string The TCP connection of the LDP neighbor connection.
`state`	**Synopsis:** A string The state of the LDP neighbor connection.
`uptime`	**Synopsis:** A string The up time of the LDP neighbor connection.

12.10.7.5 Viewing the Status of the LDP Neighbor Discovery Information

To view the status of the LDP neighbor discovery information on the device, type:

`show mpls ldp status neighbor discovery-information`

A table or list similar to the following example appears:

```
ruggedcom# show mpls ldp status neighbor discovery-information
```

```
                                                                  P
                                                        P         KEEPALIVE
PEER ID  PEER IP       INTERFACE    LOCAL IP      HOLDTIME  INTERVAL
-------------------------------------------------------------------------
2.2.2.2  192.168.10.1  switch.0010  192.168.10.2  15s       180s
6.6.6.6  192.168.20.2  switch.0020  192.168.20.1  15s       180s
```

This table or list provides the following information:

Parameter	Description
`peer-id`	**Synopsis:** A string The peer ID of the LDP neighbor discovery.
`peer-ip`	**Synopsis:** A string The peer ID of the LDP neighbor discovery.
`interface`	**Synopsis:** A string The local IP address of the LDP neighbor discovery.
`local-ip`	**Synopsis:** A string LDP neighbor discovery state.
`peer-hello-holdtime`	**Synopsis:** A string The peer hello holdtime of the LDP neighbor discovery.
`agreed-hello-holdtime`	**Synopsis:** A string The agreed upon hello holdtime (shorter holdtime of local/peer) of the LDP neighbor discovery.
`peer-session-holdtime`	**Synopsis:** A string The peer session holdtime of the LDP neighbor discovery.

12.10.7.6 Configuring LDP

To configure the LDP, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable or disable the LDP by typing the following commands:

   Enable

   ```
   mpls  ldp   enable
   ```

   Disable

   ```
   no  mpls   ldp   enable
   ```

3. Configure the following parameter(s) as required:

Parameter	Description
`enabled { enabled }`	**Synopsis:** [true | false] **Default:** false A boolean flag to indicate that Label Distribution Protocol (LDP) is enabled.
`holdtime { holdtime }`	**Synopsis:** An integer **Default:** 180 The session holdtime (in seconds), used as the keepalive timeout to maintain the Label Distribution Protocol (LDP) session in the absence of LDP messages from the session peer.

12.10.7.7 Configuring Neighbor Discovery

To configure the LDP neighbor discovery, do the following:

1. Make sure the CLI is in Configuration mode.
2. To configure the LDP Neighbor Discovery, type the following command:

   ```
   mpls ldp discovery
   ```

3. Configure the following parameter(s) as required:

Parameter	Description
`interval { interval }`	**Synopsis:** An integer **Default:** 5 The time (in seconds) between the sending of consecutive Hello messages.
`holdtime { holdtime }`	**Synopsis:** An integer **Default:** 15 The time (in seconds) that a discovered LDP neighbor is remembered without receipt of an LDP Hello message from the neighbor.

12.10.7.8 Viewing a List of LDP Interfaces

To view a list of LDP interfaces, type:

```
show running-config mpls ldp interface-ldp
```

If interfaces have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config mpls ldp interface-ldp | tab
TRANSPORT             TRANSPORT IP
IFNAME       ENABLED  ADDRESS
-------------------------------------
```

```
fe-cm-1      false    -
switch.0001  false    -
switch.0010  true     192.168.10.1
switch.0020  false    -

 !
!
```

For more information about enabling LDP interfaces, refer to "Enabling/Disabling an LDP Interface (Page 669)".

12.10.7.9 Enabling/Disabling an LDP Interface

To enable or disable an LDP interface, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable/disable the LDP interface by typing the following commands:

   Enable

   ```
   mpls  ldp  interface-ldp  { name }
   ```

   Disable

   ```
   no  mpls  ldp  interface-ldp  { name }
   ```

   Where:

   - `{ name }` is the name of the transport interface to be enabled or disabled.
3. Set the IP address for the transport interface, by typing:

   ```
   mpls  ldp  interface-ldp  transport-ip-address
   { address }
   ```

   Where { address } is an IPv4 address.
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.11 Managing Virtual Routing and Forwarding (VRF)

Virtual Routing and Forwarding (VRF) allows multiple routing instances to exist at the same time on a network router without conflicting with one another or the global routing table. This feature is used typically by service providers to route different types of traffic emanating from the same router.

Each routing instance is completely isolated and has its own set of interfaces. Any traffic sent on those interfaces is considered to be part of that VRF only.

An MPLS label can be applied as well to traffic traversing the tunnel to improve security. This is considered full VRF, as compared to VRF-Lite (first introduced by Cisco).

The RUGGEDCOM RX1400 can be configured to act as a CE, PE or P (provider core) router.

12.11.1 VRF Concepts

This section describes some of the concepts important to the implementation of Virtual Routing and Forwarding (VRF) in RUGGEDCOM ROX II.

12.11.1.1 VRF and VRF-Lite

Both full VRF and VRF-Lite employ the concept of VRFs to isolate interfaces, provide IP address reuse and manage routing tables. Both also provide a level of security for those interfaces forward to the VRFs. Under full VRF, MPLS is used in conjunction with IP/VPNs to provide a greater level of security than VRF-Lite.

RUGGEDCOM ROX II supports both VRF and VRF-Lite simultaneously. Use of full VRF interfaces and VRF-Lite interfaces can be mixed.

12.11.1.2 Advantages and Disadvantages of Using VRF

The advantages and disadvantages of using VRF include the following:

Advantages

- Create multiple isolated network pipes for various data streams
- Provide individualized security for each VRF
- Manage each VRF separately for audit and billing purposes
- Create separate Intranets within one work environment
- Create VRFs based on differing services (e.g. Finance, engineering, HR, etc.)
- Reduce the size of routing tables
- Re-use of IP addresses or subnets
- MPLS IP VPNs can replace much more expensive, leased T1/E1 lines, while providing the same level of security

Disadvantages

- Greater memory consumption. Each VRF configured results in BGP route replication and requires new FIBs and IP routing tables
- Extra processing (overhead) and memory consumption due to namespace management

12.11.2 Viewing VRF Interface Statistics

To view statistics for interfaces associated with a VRF instance, type:

```
show interfaces vrf { vrf } ip
```

Where:

- `{ vrf }` is the chosen VRF list

A table or list similar to the following example appears:

```
ruggedcom# show interfaces vrf VRF1 ip | tab
        ADMIN                          RX       RX       RX      RX       TX       TX       TX      TX
       TX          IPV4
NAME    STATE    STATE    POINTOPOINT  BYTES    PACKETS  ERRORS  DROPPED  BYTES    PACKETS  ERRORS
 DROPPED  COLLISIONS  ADDRESS
-------------------------------------------------------------------------------------------------------
fe-1-1  not set  not set  false        8842726  117751   0       0        5366914  64721    0       0
       0

                  1.9.5.2/24
fe-1-2  not set  not set  false        4874496  70821    0       0        5849272  71022    0       0
       0

                  1.7.5.1/24
fe-1-3  not set  not set  false        7730176  120784   0       0        9423076  120810   0       0
       0

                  1.1.1.1/32
```

This table or list provides the following information:

Parameter	Description
`admin-state`	**Synopsis:** [not set | up | down | testing | unknown | dormant | notPresent | lowerLayerDown] The port's administrative status.
`state`	**Synopsis:** [not set | up | down | testing | unknown | dormant | notPresent | lowerLayerDown] Shows whether the link is up or down.
`pointopoint`	**Synopsis:** [true | false] The point-to-point link.

12.11.3 Configuring VRF

To configure Virtual Routing and Forwarding (VRF), do the following:

⚠ **NOTICE**
BGP routing must be enabled before VRF is configured.

Full VRF Configuration

1. Make sure BGP is enabled and configure the Autonomous System ID for the Border Gateway Protocol (BGP). For more information, refer to "Configuring BGP (Page 584)".
2. Configure a VRF definition and route targets for each Customer Edge (CE) router. For more information, refer to "Adding a VRF Definition (Page 674)".
3. Configure a routable interface and IP address for each VRF definition. For more information, refer to "Configuring a VRF Interface (Page 672)".
4. Enable OSPF. For more information, refer to "Configuring OSPF (Page 627)".
5. Configure one or more VRF instances for OSPF. For more information, refer to "Configuring OSPF (Page 627)".
6. Add one or more BGP neighbors. For more information, refer to "Adding a Neighbor (Page 600)".
7. Configure one or more IP/VPN tunnels for each interface. For more information, refer to "Adding an IP/VPN Tunnel (Page 684)".
8. Add one or more BGP neighbors to the VPNv4 address family. For more information, refer to "Adding a Neighbor (Page 685)".
9. Verify the network configuration.

VRF-Lite Configuration

1. Make sure BGP is enabled and configure the Autonomous System ID for the Border Gateway Protocol (BGP). For more information, refer to "Configuring BGP (Page 584)".
2. Configure a VRF definition and route targets for each Customer Edge (CE) router. For more information, refer to "Adding a VRF Definition (Page 674)".
3. Configure a routable interface and IP address for each VRF definition. For more information, refer to "Configuring a VRF Interface (Page 672)".
4. Enable OSPF. For more information, refer to "Configuring OSPF (Page 627)".
5. Configure one or more VRF instances for OSPF. For more information, refer to "Configuring OSPF (Page 627)".
6. Configure an IPv4 address family for each VRF instance. For more information, refer to "Adding an IPv4 Address Family (Page 687)".
7. Configure one or more static VRF routes. For more information, refer to "Adding a Static VRF Route (Page 693)".
8. Verify the network configuration.

12.11.4 Configuring a VRF Interface

Each VRF definition must be associated with at least one routable interface that has been assigned an IP address.

To configure a routable interface to forward VRF traffic for a specific VRF definition, do the following:

1. Make sure the CLI is in Configuration mode.
2. Set the costing by typing:

   ```
   ip { interface } vrf-forwarding { vrf }
   ```

   Where:

   - `{ interface }` is the name of the routable interface
   - `{ vrf }` is the desired VRF instance
3. Configure an IPv4 or IPv6 address for the interface. For more information, refer to "Adding an IPv4 Address (Page 251)" or "Adding an IPv6 Address (Page 252)".
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.11.5 Managing VRF Definitions

VRF definitions represent individual Customer Edge (CE) routers in the VRF topology. RUGGEDCOM ROX II supports up to eight definitions in total, each composed of a unique VRF name, an optional description and a Route Distinguisher (RD). The Route Distinguisher is an 8 octet field typically made up of an AS number or IP address followed by a colon (:) and the site ID (e.g. 6500:20 or 172.20.120.12:10). When prefixed to the IPv4 address of the associated interface, it uniquely identifies each IP packet, allowing the Provider Edge (PE) to determine which VPN tunnel the packet belongs to.

Each VRF definition can also be associated with one or more route targets.

12.11.5.1 Viewing a List of VRF Definitions

To view a list of VRF definitions, type:

```
show running-config global vrf
```

If definitions have been configured, a table or list similar to the following example appears:

```
show running-config global vrf | tab
global
 vrf
  definition
VRF   VRF                EXPORT     IMPORT     BOTH
NAME  DESCRIPTION  RD    COMMUNITY  COMMUNITY  COMMUNITY
-------------------------------------------------------------
vrf1  Site A       100:1
                                               100:2
vrf2  Site B       100:2
                                               100:1

 !
```

```
!
```

If no VRF definitions have been configured, add definitions as needed. For more information, refer to "Adding a VRF Definition (Page 674)".

12.11.5.2 Adding a VRF Definition

To add a VRF definition, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the definition by typing:

   `global vrf definition { name }`

   Where:

   - `{ name }` is the name for definition. The name must be unique and not exceed 32 characters or contain spaces. The first character must also not be a special character. Only the following special characters are permitted in the remainder of the name: hyphen (-), underscore (_), colon (:), and period (.).
3. Configure the following parameter(s) as required:

Parameter	Description
`vrf-description { vrf-description }`	**Synopsis:** A string between 0 and 256 characters long A string that can be used to describe the vrf. Maximum length 256 characters, including blanks.
`rd { rd }`	**Synopsis:** A string between 0 and 32 characters long The VRF's route distinguisher: 8-byte value, typical format is (as-number:id | ip-address:id) (e.g. 6500:20). It will be prepended to the IPv4 prefix to create the VPN IPv4 prefix. Note that changing the route distinguisher will affect the route targets: it is recommended that you verify that the configured route targets used in your network will still be correct.

4. Add one or more route targets. For more information, refer to "Adding a Route Target (Page 676)".
5. Configure a routable interface for the VRF instance. For more information, refer to "Configuring a VRF Interface (Page 672)".
6. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.11.5.3 Deleting a VRF Definition

To delete a VRF definition, do the following:

1. Make sure the CLI is in Configuration mode.

2. Set **vrf-forwarding** for the associated routable interface to another VRF definition or none at all.
3. Delete the associated VRF instance under OSPF. For more information, refer to "Deleting a VRF Instance (Page 683)".
4. Delete the associated IPv4 address family under BGP. For more information, refer to "Deleting an IPv4 Address Family (Page 687)".
5. Delete the definition key by typing:

   ```
   no routing vrf definition { name }
   ```

   Where:

   - `{ name }` is the name of the definition
6. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.11.6 Managing Route Targets

Route targets identify those routes to import/export within the Multi-Protocol BGP (MBGP) network. Similar to the normal global routing instance, the route target sets the route import and export parameters for BGP. This parameter enables users to specify which prefixes they wish to import to other neighbors and which ones to export.

12.11.6.1 Viewing a List of Route Targets

To view a list of VRF definitions, type:

```
show running-config global vrf definition { name }
routing-target
```

If definitions have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config global vrf definition vrf1 route-target
global
 vrf
  definition vrf1
   route-target export 200:1
   !
   route-target import 200:2
   !
   route-target both 100:2
   !
  !
 !
!
```

If no VRF definitions have been configured, add definitions as needed. For more information, refer to "Adding a VRF Definition (Page 674)".

12.11.6.2 Adding a Route Target

To add a route target, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the definition by typing:

   ```
   global vrf definition { name } routing-target [ export | import | both ] { community }
   ```

   Where:

   - `{ name }` is the name of the VRF definition
   - `{ community }` is the route distinguisher for the target VRF to either export the routing table to, import the routing table from, or both
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.11.6.3 Deleting a Route Target

To delete a route target, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the definition key by typing:

   ```
   no global vrf definition { name } routing-target [ export | import | both ] { community }
   ```

   Where:

   - `{ name }` is the name of the VRF definition
   - `{ community }` is the route distinguisher for the target VRF to either export the routing table to, import the routing table from, or both
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.11.7 Managing VRF Instances and OSPF

OSPF can be configured for one or more VRF definitions. This is done by by enabling OSPF for a VRF instance and then configuring the required OSPF parameters.

OSPF can be run on any physical or switched interface, as well as VRF-Lite interfaces (IPv4) and full VRF interfaces (IP/VPN using MPLS).

12.11.7.1 Viewing a List of VRF Instances

To view a list of VRF instances defined for OSPF, type:

```
show running-config routing ospf vrf
```

If definitions have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing ospf vrf
routing ospf
 vrf VRF1
  enabled
.
.
.
 vrf VRF2
  enabled
.
.
.
```

If no VRF definitions have been configured, add definitions as needed. For more information, refer to "Adding a VRF Definition (Page 674)".

12.11.7.2 Adding a VRF Instance and Configuring OSPF

To add a VRF instance and configure OSPF, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***routing » dynamic » ospf » vrf*** and configure the following parameter(s) as required:

Parameter	Description
`{ vrf-name }`	**Synopsis:** A string between 1 and 32 characters long The VRF name.
`enabled`	Enables the OSPF dynamic routing protocol.
`abr-type { abr-type }`	**Synopsis:** [cisco | ibm | shortcut | standard] **Default:** cisco The OSPF ABR type.
`auto-cost-reference-bandwidth { auto-cost-reference-bandwidth }`	**Synopsis:** An integer between 1 and 4294967 **Default:** 100 Calculates the OSPF interface cost according to bandwidth [1-4294967 Mbps]
`compatible-rfc1583`	Enables the compatibility with the obsolete RFC1583 OSPF (the current is RFC2178)
`default-information-originate`	Advertises the default route.

Parameter	Description
`default-metric { default-metric }`	**Synopsis:** An integer between 0 and 16777214 The default metric of redistribute routes.
`distance { distance }`	**Synopsis:** An integer between 1 and 255 The administrative distance.
`opaque-lsa`	Enables the Opaque-LSA capability (RFC2370).
`passive-default { passive-default }`	**Synopsis:** [true | false] **Default:** true Default passive value for new interface.
`refresh-timer { refresh-timer }`	**Synopsis:** An integer between 10 and 1800 **Default:** 10 The refresh timer.
`router-id { router-id }`	**Synopsis:** A string between 7 and 15 characters long The Router ID for OSPF.
`{ name }`	**Synopsis:** A string between 1 and 1024 characters long The name of the prefix list.
`description { description }`	**Synopsis:** A string 1024 characters long The description of the prefix list.
`{ seq }`	**Synopsis:** An integer between 1 and 4294967295 Sequence number of the entry.
`action { action }`	**Synopsis:** [deny | permit] **Default:** permit Action.
`subnet { subnet }`	**Synopsis:** A string between 9 and 18 characters long Network (xxx.xxx.xxx.xxx/xx).
`le { le }`	**Synopsis:** An integer between 1 and 32 The maximum prefix length to match ipaddress within subnet.
`ge { ge }`	**Synopsis:** An integer between 1 and 32 The minimum prefix length to match ipaddress within subnet.
`tag { tag }`	**Synopsis:** A string between 1 and 1024 characters long Route map tag.
`{ seq }`	**Synopsis:** An integer between 1 and 65535 The sequence number of the route-map entry.
`action { action }`	**Synopsis:** [deny | permit] **Default:** permit Action.
`call { call }`	**Synopsis:** A string between 1 and 1024 characters long Jump to another route-map after match+set.

Parameter	Description
`on-match-goto { on-match-goto }`	**Synopsis:** An integer between 1 and 65535 Go to this entry on match.
`prefix-list { prefix-list }`	**Synopsis:** A string between 1 and 1024 characters long The prefix list name.
`prefix-list { prefix-list }`	**Synopsis:** A string between 1 and 1024 characters long The prefix list name.
`ifname { ifname }`	**Synopsis:** A string The interface name.
`metric { metric }`	**Synopsis:** An integer Metric value.
`metric-type { metric-type }`	**Synopsis:** An integer between 1 and 2 External route type.
`route-map { route-map }`	**Synopsis:** A string between 1 and 1024 characters long Route map name.
`{ area }`	**Synopsis:** A string between 7 and 15 characters long The OSPF Area ID (format: A.B.C.D).
`{ network }`	**Synopsis:** A string between 9 and 18 characters long The OSPF area network/prefix.
`shortcut { shortcut }`	**Synopsis:** [default | disable | enable] **Default:** default Sets the area's shortcutting mode. Options include: • Default: If the Area Border Router (ABR) has an active backbone connection, the area is not used for shortcutting and a new bit (S-bit) is not set by the ABR in the router-LSA originated for the area. The opposite is true if the ABR does not have an active backbone connection. • Enable: If the ABR has an active backbone connection, it sets the new bit (S-bit) in the router-LSA originated for the area and uses it for shortcutting. Other ABRs in the area must also report the new bit. However, if the ABR does not have an active backbone connection, it uses the area unconditionally for shortcutting and sets the new bit in the router-LSA originated for the area. • Disable: The ABR does not use this area for shortcutting, or set the new bit (S-bit) in the router-LSA originated for it.
`always { always }`	**Synopsis:** [true | false] **Default:** false Always advertise default route even when there is no default route present in routing table.
`metric { metric }`	**Synopsis:** An integer between 0 and 16777214 The metric value for default route.

Parameter	Description
`metric-type { metric-type }`	**Synopsis:** An integer between 1 and 2 **Default:** 2 The metric type for default route.
`route-map { route-map }`	**Synopsis:** A string between 1 and 1024 characters long The route map name.
`external { external }`	**Synopsis:** An integer between 1 and 255 The administrative distance for external routes.
`inter-area { inter-area }`	**Synopsis:** An integer between 1 and 255 The administrative distance for inter-area routes.
`intra-area { intra-area }`	**Synopsis:** An integer between 1 and 255 The administrative distance for intra-area routes.
`{ type }`	**Synopsis:** [kernel | static | connected | rip | bgp] Redistributes the route type.
`metric-type { metric-type }`	**Synopsis:** An integer between 1 and 2 **Default:** 2 The OSPF exterior metric type for redistributed routes.
`metric { metric }`	**Synopsis:** An integer between 0 and 16777214 The metric for redistributed routes.
`route-map { route-map }`	**Synopsis:** A string between 1 and 1024 characters long The route map name.
`{ ifname }`	**Synopsis:** A string Interface name.
`authentication { authentication }`	**Synopsis:** [message-digest | null] The authentication type on this interface.
`cost { cost }`	**Synopsis:** An integer between 1 and 65535 The link cost. If not set, the cost is based on calculation of reference bandwidth divide by interface bandwidth.
`hello-interval { hello-interval }`	**Synopsis:** An integer between 1 and 65535 **Default:** 10 The time (in seconds) between sending hello packets.
`priority { priority }`	**Synopsis:** An integer between 0 and 255 **Default:** 1 Priority of interface.
`passive { passive }`	**Synopsis:** [true | false] **Default:** true Whether an interface is active or passive. Passive interfaces do not send LSAs to other routers and are not part of an OSPF area.

Parameter	Description
`retransmit-interval { retransmit-interval }`	**Synopsis:** An integer between 1 and 65535 **Default:** 5 Time (in seconds) between retransmitting lost link state advertisements.
`transmit-delay { transmit-delay }`	**Synopsis:** An integer between 1 and 65535 **Default:** 1 The link state transmit delay (in seconds).
`dead-interval { dead-interval }`	**Synopsis:** An integer between 1 and 65535 **Default:** 40 The time before considering a router dead (in seconds).
`minimal-hello-multiplier { minimal-hello-multiplier }`	**Synopsis:** An integer between 1 and 10 The number of times a hello message can be sent within one second.
`{ key-id }`	**Synopsis:** An integer The key ID.
`md5 { md5 }`	**Synopsis:** A string 1024 characters long The OSPF password (key).

3. Add the VRF instance:

   `routing ospf vrf { name }`

4. Configure the following parameter(s) as required to configure the VRF instance:

Parameter	Description
`enabled`	Enables the OSPF dynamic routing protocol.
`abr-type { abr-type }`	**Synopsis:** [cisco | ibm | shortcut | standard] **Default:** cisco The OSPF ABR type.
`auto-cost-reference-bandwidth { auto-cost-reference-bandwidth }`	**Synopsis:** An integer between 1 and 4294967 **Default:** 100 Calculates the OSPF interface cost according to bandwidth [1-4294967 Mbps]
`compatible-rfc1583`	Enables the compatibility with the obsolete RFC1583 OSPF (the current is RFC2178)
`default-information-originate`	Advertises the default route.
`default-metric { default-metric }`	**Synopsis:** An integer between 0 and 16777214 The default metric of redistribute routes.
`distance { distance }`	**Synopsis:** An integer between 1 and 255 The administrative distance.

Parameter	Description
`opaque-lsa`	Enables the Opaque-LSA capability (RFC2370).
`passive-default { passive-default }`	**Synopsis:** [true | false] **Default:** true Default passive value for new interface.
`refresh-timer { refresh-timer }`	**Synopsis:** An integer between 10 and 1800 **Default:** 10 The refresh timer.
`router-id { router-id }`	**Synopsis:** A string between 7 and 15 characters long The Router ID for OSPF.

5. Configure the following parameter(s) as required to configure the distances for routes:

Parameter	Description
`external { external }`	**Synopsis:** An integer between 1 and 255 The administrative distance for external routes.
`inter-area { inter-area }`	**Synopsis:** An integer between 1 and 255 The administrative distance for inter-area routes.
`intra-area { intra-area }`	**Synopsis:** An integer between 1 and 255 The administrative distance for intra-area routes.

6. If **Default Information Originate** is enabled, configure the following parameter(s) as required:

Parameter	Description
`always { always }`	**Synopsis:** [true | false] **Default:** false Always advertise default route even when there is no default route present in routing table.
`metric { metric }`	**Synopsis:** An integer between 0 and 16777214 The metric value for default route.
`metric-type { metric-type }`	**Synopsis:** An integer between 1 and 2 **Default:** 2 The metric type for default route.
`route-map { route-map }`	**Synopsis:** A string between 1 and 1024 characters long The route map name.

7. Configure prefix list filters for the VRF instance. For more information, refer to "Adding a Prefix List (Page 634)".
8. Configure areas for the VRF instance. For more information, refer to "Adding an Area (Page 637)".

9. Configure route map filters for the VRF instance. For more information, refer to "Adding a Route Map Filter (Page 640)".
10. Configure redistribution metrics for the VRF instance. For more information, refer to "Adding a Redistribution Metric (Page 645)".
11. Configure interfaces for the VRF instance. For more information, refer to "Configuring a Routing Interface (Page 647)".
12. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.11.7.3 Deleting a VRF Instance

To delete a VRF instance under OSPF, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the definition key by typing:

   ```
   no routing ospf vrf { name }
   ```

   Where:

   - `{ name }` is the name of the VRF instance
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.11.8 Managing IP/VPN Tunnels

IP/VPN tunnels use the VPNv4 protocol to exchange customer prefixes (i.e. route distributions and route targets) and labels between Provider Edge (PE) routers. IP/VPNs provide isolation of the interfaces connecting each end of the VPN.

Note
VRF maintains a table listing each interface belonging to each IP/VPN tunnel.

12.11.8.1 Viewing a List of IP/VPN Tunnels

To view a list of IP/VPN tunnels configured for VRF, type:

```
show running-config routing bgp address-family vpnv4
```

A table or list similar to the following example appears:

```
ruggedcom# show running-config routing bgp address-family vpnv4 | tab
routing bgp
 address-family vpnv4
  neighbor
         SEND
IP       COMMUNITY
--------------------
```

```
1.2.6.2  both

 !
!
```

12.11.8.2 Adding an IP/VPN Tunnel

To add a new IP/VPN tunnel for VRF, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the neighbor by typing:

   ```
   routing bgp address-family vpnv4 neighbor
   { address }
   ```

   Where:

   - `{ address }` is the IP address of the neighbor
3. [Optional] Set the send community by typing:

   ```
   send-community [ both | extended | none | standard
    ]
   ```

4. [Optional] Enable the IP/VPN tunnel as a VPNv4 route reflector client by typing:

   ```
   route-reflector-client enabled
   ```

5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.11.8.3 Deleting an IP/VPN Tunnels

To delete an IP/VPN tunnel, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the address by typing:

   ```
   no routing bgp address-family vpnv4 neighbor
   { address }
   ```

   Where:

   - `{ address }` is the IP address of the neighbor
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.11.9 Managing VPNv4 Neighbors

VPNv4 neighbors are other routers with which to exchange routes. One or more neighbors must be specified in order for VRF-Lite to operate.

12.11.9.1 Viewing a List of Neighbors

To view a list of configured VPNv4 neighbors, type:

```
show running-config routing bgp address-family vpnv4 neighbor
```

If neighbors have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing bgp address-family vpnv4 neighbor | tab
         SEND
IP       COMMUNITY
--------------------
1.2.6.2  both

 !
!
```

If no neighbors have been configured, add neighbors as needed. For more information, refer to "Adding a Neighbor (Page 690)".

12.11.9.2 Adding a Neighbor

To add a new VPNv4 neighbor, do the following:

1. Make sure the CLI is in Configuration mode.
2. Make sure the desired neighbor is configured for the BGP network. For more information, refer to "Adding a Neighbor (Page 600)".
3. Add the neighbor by typing:

   ```
   routing bgp address-family vpnv4 neighbor { address }
   ```

   Where:

   - `{ address }` is the IP address of the neighbor
4. [Optional] Set the send community by typing:

   ```
   send-community [ both | extended | none | standard ]
   ```

5. [Optional] Enable the neighbor as a route reflector client by typing:

   ```
   route-reflector-client enabled
   ```

6. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.11.9.3 Deleting a Neighbor

To delete a VPNv4 neighbor, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the network by typing:

   `no routing bgp address-family vpnv4 neighbor { address }`

   Where:

   - `{ address }` is the IP address of the neighbor
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.11.10 Managing IPv4 Address Families

IPv4 address families are configured when deploying VRF-Lite. Address families under BGP specify the neighbors with whom the router will share VRF routing information and what type of routing distribution method is permitted. One or more address families can be configured for each VRF instance.

Route distribution can be limited directly connected routes, static routes, or OSPF learned routes.

12.11.10.1 Viewing a List of IPv4 Address Families

To view a list of IPv4 address families configured for VRF, type:

`show running-config routing bgp address-family ipv4 vrf`

If IPv4 address families have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing bgp address-family ipv4 vrf
routing bgp
 address-family ipv4
  vrf VRF1
   redistribute connected
    no metric
    no route-map
   !
   redistribute ospf
    no metric
    no route-map
   !
   redistribute static
    no metric
    no route-map
   !
  !
 !
```

```
!
```

If no IPv4 address families have been configured, add them as needed. For more information, refer to "Adding an IPv4 Address Family (Page 687)".

12.11.10.2 Adding an IPv4 Address Family

To add an IPv4 address family, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the IPv4 address family by typing:

   ```
   routing bgp address-family ipv4 vrf { vrf }
   ```

   Where:

   - `{ vrf }` is the name of the associated VRF definition
3. [Optional] Add one or more neighbors. For more information, refer to "Adding a Neighbor (Page 690)".
4. [Optional] Add one or more redistributions. For more information, refer to "Adding a Redistribution (Page 688)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.11.10.3 Deleting an IPv4 Address Family

To delete an IPv4 address family, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the IPv4 address family by typing:

   ```
   no routing bgp address-family ipv4 vrf { vrf }
   ```

   Where:

   - `{ vrf }` is the name of the associated VRF definition
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.11.11 Managing Redistribution for IPv4 Address Families

Redistribution in general is the advertisement of routes by one protocol that have been learned via another dynamic routing protocol, a static route, or a directly connected router. It is deployed to promote interoperability between networks running different routing protocols. In the case of VRF, the OSPF dynamic routing protocol is supported.

For each VRF instance, one or more redistributions can be defined. A redistribution defines the source of the routing information, a metric and (optional) a pre-defined routing map.

The metric is used for route decision making within the Autonomous System (AS). Care must be taken to define a metric that is understood by the OSPF routing protocol.

12.11.11.1 Viewing a List of Redistributions

To view a list of redistributions for an IPv4 address family, type:

```
show running-config routing bgp address-family ipv4 vrf { vrf } redistribute
```

Where:

- `{ vrf }` is the chosen VRF instance

If redistributions have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing bgp address-family ipv4 vrf VRF1 redistribute
 | tab
                  ROUTE
SOURCE     METRIC  MAP
--------------------------
connected  -       -
ospf       -       -
static     -       -

  !
 !
!
```

If no redistributions have been configured, add them as needed. For more information, refer to "Adding a Redistribution (Page 688)".

12.11.11.2 Adding a Redistribution

To add a redistribution for an IPv4 address family, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the redistribution by typing:

   ```
   routing bgp address-family ipv4 vrf { vrf } redistribute [ { connected } | { ospf } | { static } ]
   ```

   Where:

   - `{ vrf }` is the chosen VRF instance
3. Configure the following parameter(s) as required:

Parameter	Description
`metric { metric }`	**Synopsis:** An integer between 0 and 4294967295 The metric for redistributed routes.
`route-map { route-map }`	**Synopsis:** A string between 1 and 1024 characters long The route map name.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.11.11.3 Deleting a Redistribution

To delete a redistribution defined for an IPv4 address family, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the redistribution by typing:

   ```
   no routing bgp address-family ipv4 vrf { vrf } redistribute [ { connected } | { ospf } | { static } ]
   ```

   Where:

   - `{ vrf }` is the chosen VRF instance
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.11.12 Managing Neighbors for IPv4 Address Families

Neighbors are other routers with which to exchange routes. One or more neighbors must be specified in order for VRF to operate.

12.11.12.1 Viewing a List of Neighbors

To view a list of neighbors configured for an IPv4 address family, type:

```
show running-config routing bgp address-family ipv4 vrf { vrf } neighbor
```

Where:

- `{ vrf }` is the chosen VRF instance

If neighbors have been configured, a table or list similar to the following example appears:

```
show running-config routing bgp address-family ipv4 vrf VRF1 neighbor
routing bgp
```

```
 address-family ipv4
  vrf VRF1
   neighbor 192.168.12.30
    remote-as 1
    no ebgp-multihop
    no maximum-prefix
    no next-hop-self
    no password
    no disable-connected-check
    no soft-reconfiguration
    no weight
    no route-map in
    no route-map out
   !
  !
 !
!
```

If no neighbors have been configured, add neighbors as needed. For more information, refer to "Adding a Neighbor (Page 690)".

12.11.12.2 Adding a Neighbor

To add a new neighbor to an IPv4 address family, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the neighbor by typing:

   `routing bgp address-family ipv4 vrf { vrf } neighbor { address }`

   Where:

   - `{ vrf }` is the chosen VRF instance
   - `{ address }` is the IP address of the neighbor
3. Configure the neighbor settings by configuring the following parameter(s):

Parameter	Description
`send-community { send-community }`	**Synopsis:** [standard | extended | both | none] **Default:** both Identifies the send Community. Default is both.
`remote-as { remote-as }`	**Synopsis:** An integer between 1 and 65535 A BGP neighbor.
`ebgp-multihop { ebgp-multihop }`	**Synopsis:** An integer between 1 and 255 The maximum hop count. This allows EBGP neighbors not on directly connected networks.
`maximum-prefix { maximum-prefix }`	**Synopsis:** An integer between 1 and 4294967295 The maximum prefix number accepted from this peer.
`next-hop-self`	Disables the next hop calculation for this neighbor.

Parameter	Description
`password { password }`	**Synopsis:** A string between 1 and 1024 characters long Password.
`update-source { update-source }`	**Synopsis:** A string between 7 and 15 characters long Source IP address of routing updates.
`disable-connected-check`	Disables connection verification when establishing an eBGP peering session with a single-hop peer that uses a loopback interface.
`soft-reconfiguration`	Per neighbor soft reconfiguration.
`weight { weight }`	**Synopsis:** An integer The default weight for routes from this neighbor.

4. Configure the route map settings by configuring the following parameter(s):

Parameter	Description
`in { in }`	**Synopsis:** A string between 1 and 1024 characters long Apply route map to incoming routes.
`out { out }`	**Synopsis:** A string between 1 and 1024 characters long Apply route map to outbound routes.

5. Configure the prefix list distribution. For more information, refer to "Configuring the Distribution of Prefix Lists (Page 691)".
6. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.11.12.3 Configuring the Distribution of Prefix Lists

To configure the distribution of prefix lists for a neighbor in an IPv4 address family, do the following:

1. Make sure the CLI is in Configuration mode.
2. Apply the desired prefix list the chosen route direction (incoming or outbound) by typing:

```
routing bgp address-family ipv4 vrf { vrf } neighbor { address } distribute-prefix-list [ in | out ] prefix-list { prefix }
```

Where:

- `{ vrf }` is the chosen VRF instance
- `{ address }` is the address of the chosen neighbor
- `{ prefix }` is the chosen BGP prefix list

3. If necessary, configure an event tracker to track network commands. For more information, refer to "Tracking Commands (Page 692)".
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.11.12.4 Tracking Commands

Network commands can be tracked using event trackers configured under ***global » tracking***. For more information about event trackers, refer to "Managing Event Trackers (Page 542)".

A network command is activated based on the event tracker's state. The `apply-when` parameter determines when the command is activated. For example, if the `apply-when` parameter is set to **down**, the network command becomes active (thereby advertising the network to a router's RIP peers) when the tracked target is unavailable.

To track a command for an IPv4 address family, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***routing » dynamic » bgp » address-family » ipv4 » {vrf} » neighbor » {address} » distribute-prefix-list » In|out***, where *{vrf}* is the chosen VRF instance and *{address}* is the IP address of the neighbor.
3. Configure the following parameter(s) as required:

Parameter	Description
`event { event }`	**Synopsis:** A string 64 characters long Select to track an event, apply the distribute-prefix-list only when the tracked event goes to UP state.
`apply-when { apply-when }`	**Synopsis:** [up | down] **Default:** up Applies the distribute-prefix-list when the tracked event goes UP or DOWN.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.11.12.5 Deleting a Neighbor

To delete a VPNv4 neighbor, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the network by typing:

```
no routing address-family ipv4 vrf { vrf }
neighbor { address }
```

Where:

- `{ vrf }` is the chosen VRF instance
- `{ address }` is the IP address of the neighbor

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.11.13 Managing Static VRF Routes

Routing information can be shared between routers using dynamic routing data or they can be manually configured. Static routes are explicit paths between routers that are manually configured. Static routes are commonly used for stable, often smaller networks whose configurations are not prone to change. They can be used to supplement dynamic routes.

12.11.13.1 Viewing a List of Static VRF Routes

To view a list of routable Ethernet ports, type:

```
show running-config routing vrf { vrf } ipv4
```

Where:

- `{ vrf }` is the chosen VRF instance

If routes have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing vrf VRF1 ipv4 | tab
                          HW
NETWORK          DISTANCE ACCELERATE GW       DISTANCE INTERFACE DISTANCE
-------------------------------------------------------------------------------
192.168.10.0/24  -        -
                                     1.9.5.1  -

!
```

If no static routes have been configured, add routes as needed. For more information, refer to "Adding a Static VRF Route (Page 693)".

12.11.13.2 Adding a Static VRF Route

To add an IPv4 static route for a VRF instance, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the static VRF route by typing:

   ```
   routing vrf { vrf } ipv4 route { subnet }
   ```

   Where:

- `{ vrf }` is the chosen VRF instance
- `{ subnet }` is the subnet (network/prefix) of the static route

3. If the device has a Layer 3 switch installed, configure the following parameter(s) as required:

Note
Only TCP and UDP traffic flows will be accelerated by the IP/Layer 3 switch fabric. Non-IP packet types, such as ICMP and IGMP, will not be accelerated.

Parameter	Description
`hw-accelerate`	If the static unicast route can be hardware accelerated, this option will be available. For a static unicast route to be accelerated, the ingress and egress interfaces must be switched.

4. If necessary, configure a black hole connection for the static route. For more information, refer to "Configuring a Black Hole Connection for a Static VRF Route (Page 694)".
5. If necessary, add gateways for the static route. For more information, refer to "Adding a Gateway for a Static VRF Route (Page 695)".
6. If necessary, add interfaces for the static route. For more information, refer to "Adding an Interface for a Static VRF Route (Page 697)".
7. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.11.13.3 Configuring a Black Hole Connection for a Static VRF Route

To configure a black hole connection for a static VRF route, do the following:

1. Make sure the CLI is in Configuration mode.
2. Configure the black hole connection by typing:

```
routing vrf { vrf } ipv4 route { subnet }
blackhole distance { distance }
```

Where:

- `{ vrf }` is the chosen VRF instance.
- `{ subnet }` is the subnet (network/prefix) of the static route.
- `{ distance }` is the administrative distance. The default value is 1.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.11.13.4 Deleting a Static VRF Route

To delete an IPv4 static route configured for a VRF instance, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the static route by typing:

   `no routing vrf { vrf } ipv4 route { subnet }`

   Where:

   - `{ vrf }` is the chosen VRF instance
   - `{ subnet }` is the subnet (network/prefix) of the static route
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.11.14 Managing Gateways for Static VRF Routes

This section describes how to configure and manage gateways for static VRF routes.

12.11.14.1 Viewing a List of Gateways for Static VRF Routes

To view a list of gateway addresses assigned to an IPv4 static route, type:

`show running-config routing vrf { vrf } ipv4 route { subnet } via`

Where:

- `{ vrf }` is the chosen VRF instance.
- `{ subnet }` is the subnet (network/prefix) of the static route

If gateway addresses have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing vrf VRF1 ipv4 route via | tab
NETWORK          GW       DISTANCE
-------------------------------------
192.168.10.0/24
                 1.9.5.1  -

!
```

If no gateway addresses have been configured, add addresses as needed. For more information, refer to "Adding a Gateway for a Static VRF Route (Page 695)".

12.11.14.2 Adding a Gateway for a Static VRF Route

To add a gateway address for a static VRF route, do the following:

1. Make sure the CLI is in Configuration mode.

2. Add the gateway address by typing:

   ```
   routing vrf { vrf } ipv4 route { subnet } via { gateway }
   ```

   Where:

   - `{ vrf }` is the chosen VRF instance.
   - `{ subnet }` is the subnet (network/prefix) of the static route
   - `{ gateway }` is the gateway address for the static route

3. Configure the following parameter(s) as required:

Parameter	Description
`distance { distance }`	**Synopsis:** An integer between 1 and 255 The distance for the static route.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.11.14.3 Deleting a Gateway for a Static VRF Route

To delete a gateway address assigned to a static VRF route, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the gateway address by typing:

   ```
   no routing vrf { vrf } ipv4 route { subnet } via { gateway }
   ```

   Where:

   - `{ vrf }` is the chosen VRF instance.
   - `{ subnet }` is the subnet (network/prefix) of the static route
   - `{ gateway }` is the gateway address for the static route

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.11.15 Managing Interfaces for Static VRF Routes

This section describes how to manage interfaces used for static VRF routes.

12.11.15.1 Viewing a List of Interfaces for Static VRF Routes

To view a list of interfaces assigned to an IPv4 static route, type:

```
show running-config routing vrf { vrf } ipv4 route dev
```

Where:

- `{ vrf }` is the chosen VRF instance.

If gateway addresses have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing vrf VRF1 ipv4 route dev | tab
NETWORK          INTERFACE  DISTANCE
-------------------------------------
192.168.10.0/24
                 fe-cm-1    -

!
```

If no gateway addresses have been configured, add addresses as needed. For more information, refer to "Adding an Interface for a Static VRF Route (Page 697)".

12.11.15.2 Adding an Interface for a Static VRF Route

To add an interface for a static VRF route, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the gateway address by typing:

   ```
   routing vrf { vrf } ipv4 route { subnet } dev { interface }
   ```

   Where:

   - `{ vrf }` is the chosen VRF instance.
   - `{ subnet }` is the subnet (network/prefix) of the static route
   - `{ interface }` is the name of the interface for the static route
3. Configure the following parameter(s) as required:

Parameter	Description
`distance { distance }`	**Synopsis:** An integer between 1 and 255 The distance for the static route.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.11.15.3 Deleting a Gateway for a Static VRF Route

To delete an interface assigned to a static VRF route, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the gateway address by typing:

   ```
   no routing vrf { vrf } ipv4 route { subnet } dev { gateway }
   ```

   Where:

   - `{ vrf }` is the chosen VRF instance.
   - `{ subnet }` is the subnet (network/prefix) of the static route
   - `{ interface }` is the name of the interface for the static route
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.11.16 Example: Configuring OSPF on a VRF-Lite Instance

This configuration example shows a Customer Edge device *R2* which is not VRF aware, establishing a neighbor relationship with Provider Edge device *R3*, which is VRF aware.

⚠ NOTICE

The values shown are specific to the provided topology. Actual values can vary based on the user's configuration.

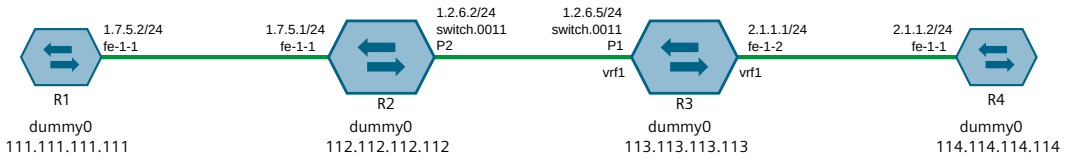


Figure 12.13 Topology – VRF-Lite Instance Configured with OSPF

Step 1: Configure OSPF on Router R2

In this scenario R2 is a RUGGEDCOM ROX II device acting as a non-VRF aware Customer Edge (CE) router.

1. Enable OSPF. For more information, refer to "Configuring OSPF (Page 627)".
2. Set the router ID for OSPF to *112.112.112.112*. For more information, refer to "Adding a VRF Instance and Configuring OSPF (Page 677)".
3. Add area ID *0.0.0.0 0.0.0.0/0* for the dynamic OSPF route. For more information, refer to "Adding an Area (Page 637)".

4. Add interface *fe-1-1* for the OSPF network. For more information, refer to "Configuring a Routing Interface (Page 647)".
5. Set the default passive value of the interface to *false*. For more information, refer to "Adding a VRF Instance and Configuring OSPF (Page 677)".
6. Add interface *switch.0011*. For more information, refer to "Configuring a Routing Interface (Page 647)".
7. Assign IP address *1.2.6.2/24* to the switch.0011 interface. For more information, refer to "Adding an IPv4 Address (Page 251)".
8. Set the default passive value of the interface to *false*. For more information, refer to "Adding a VRF Instance and Configuring OSPF (Page 677)".
9. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

Step 2: Configure OSPF on Router R3

In this scenario R3 is a RUGGEDCOM ROX II device acting as a VRF aware Provider Edge (PE) router.

1. Enable OSPF. For more information, refer to "Adding a VRF Instance and Configuring OSPF (Page 677)".
2. Configure a VRF definition for *vrf1* with a route distinguisher of *10*. For more information, refer to "Adding a VRF Definition (Page 674)".
3. Define a route target for VRF1 of type **both** with the export community set to **`100:1`**. For more information, refer to "Adding a Route Target (Page 676)".
4. Set the router ID for OSPF to *113.113.113.113*. For more information, refer to "Adding a VRF Instance and Configuring OSPF (Page 677)".
5. Add area ID *0.0.0.0 0.0.0.0/0* for the dynamic OSPF route. For more information, refer to "Adding an Area (Page 637)".
6. Add interface *fe-1-2* for the OSPF network. For more information, refer to "Configuring a Routing Interface (Page 647)".
7. Set the default passive value of the interface to *false*. For more information, refer to "Adding a VRF Instance and Configuring OSPF (Page 677)".
8. Add interface *switch.0011*. For more information, refer to "Configuring a Routing Interface (Page 647)".
9. Assign IP address *1.2.6.5/24* to the switch.0011 interface. For more information, refer to "Adding an IPv4 Address (Page 251)".
10. Set the default passive value of the interface to *false*. For more information, refer to "Adding a VRF Instance and Configuring OSPF (Page 677)".
11. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

Step 3: Verify the configuration

1. Verify R2 and R3 have established an OSPF neighbor relationship.
   - For R2, type:

     ```
     show routing status OSPF neighbor
     ```

     Values similar to the following are provided:

ID	113.113.113.113
Address	1.2.6.5
Interface	switch.0011:1.2.6.2
Priority	1
State	Full/Back
Dead Time	38.320s

   - For R3, type:

     ```
     show ip OSPF vrf1 neighbor
     ```

     Values similar to the following are provided:

Neighbor ID	112.112.112.112
Pri	1
State	Full/DR
Dead Time	36.247s
Address	1.2.6.2
Interface	switch.0011:1.2.6.5
RXmtL	0
RqstL	0
DBsmL	0
2. VRF ping 1.7.5.1 from R3. If the configuration is successful R2 will respond. For more information, refer to "Pinging VRF Endpoints (Page 28)".
3. Ping 2.1.1.1 from R2. If the configuration is successful R3 will respond.

Final Configuration Example

R2 Configuration

```
routing ospf
 enabled
router-id       112.112.112.112
 area 0.0.0.0 0.0.0.0/0
 !

 interface fe-1-1
  no passive

interface switch.0011
  no passive
```

R3 Configuration

```
routing ospf
 enabled
vrf vrf1
  enabled
router-id       113.113.113.113
  area 0.0.0.0 0.0.0.0/0
interface fe-1-2
  no passive
interface switch.0011
  no passive
```

12.11.17 Example: Configuring BGP on a VRF-Lite Instance

This configuration example shows a Customer Edge device *R2* which is not VRF aware, establishing a neighbor relationship with Provider Edge device *R3*, which is VRF aware.

> **⚠ NOTICE**
>
> The values shown are specific to the provided topology. Actual values can vary based on the user's configuration.

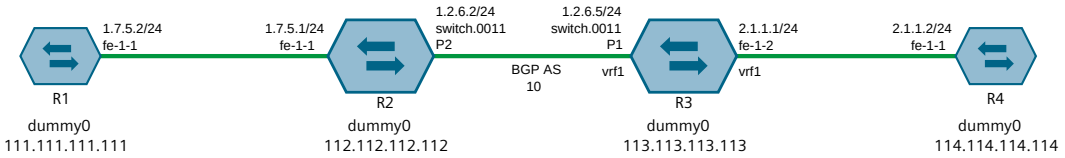


Figure 12.14 Topology – VRF-Lite Instance Configured with BGP

Step 1: Configure Router R2

In this scenario R2 is a RUGGEDCOM ROX II device acting as a non-VRF aware Customer Edge (CE) router.

1. Add VLAN 11. For more information, refer to "Adding a Static VLAN (Page 363)".
2. Assign PVID 11 to port P2. For more information, refer to "Configuring a Switched Ethernet Port (Page 314)".
3. Assign IP address *1.2.6.2/24* to the switch.0011 interface. For more information, refer to "Adding an IPv4 Address (Page 251)".
4. Assign IP address *112.112.112.112* to the *dummy0* interface. For more information, refer to "Adding an IPv4 Address (Page 251)".
5. Enable BGP. For more information, refer to "Configuring BGP (Page 584)".
6. Assign Autonomous System ID (AS-ID) 10. For more information, refer to "Configuring BGP (Page 584)".
7. Add neighbor 1.2.6.5 and remote AS 10. For more information, refer to "Adding a Neighbor (Page 600)".
8. Define a redistribution metric for IPv4 family of type **connected**. For more information, refer to "Adding a Redistribution (Page 688)".
9. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

Step 2: Configure Router R3

In this scenario R3 is a RUGGEDCOM ROX II device acting as a VRF aware Provider Edge (PE) router.

1. Assign IP address *113.113.113.113* to the *dummy0* interface. For more information, refer to "Adding an IPv4 Address (Page 251)".
2. Configure a VRF definition for *VRF1* with a route distinguisher of **200:1**. For more information, refer to "Adding a VRF Definition (Page 674)".
3. Define a route target for VRF1 of type **both** with the export community set to **100:1**. For more information, refer to "Adding a Route Target (Page 676)".
4. Make sure interfaces are configured with the IP addresses 1.2.6.5/24 and 2.1.1.1/24.
5. Assign the interfaces in step 4 to forward traffic to VRF1. For more information, refer to "Configuring a VRF Interface (Page 672)".
6. Enable BGP. For more information, refer to "Configuring BGP (Page 584)".
7. Assign Autonomous System ID (AS-ID) 10. For more information, refer to "Configuring BGP (Page 584)".
8. Add neighbor 1.2.6.2 and remote AS 10. For more information, refer to "Adding a Neighbor (Page 685)".
9. Define a redistribution metric for IPv4 family of type **connected**. For more information, refer to "Adding a Redistribution (Page 688)".
10. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

Step 3: Verify the configuration

1. Verify R2 and R3 have established an OSPF neighbor relationship.
   - For R2, type:

     ```
     show routing status bgp neighbor
     ```

     Values similar to the following are provided:

ID	1.2.6.5
Version	4
Local AS	10
MSGRCVD	6
MSGSENT	13
Uptime	00:04:25
State	Established
Prefix Received	1

   - For R3, type:

     ```
     show ip bgp vrf1 neighbors
     ```

     Values similar to the following are provided:

BGP Neighbor	1.2.6.2
Remote AS	10

Local AS	10
BGP Version	4
Remote Router ID	192.168.1.112
BGP State	Established
Up For	00:24:44
Last Read	05:52:03
Hold Time	180
Keepalive Interval	60 seconds

2. VRF ping 1.7.5.1 from R3. If the configuration is successful R2 will respond. For more information, refer to "Pinging VRF Endpoints (Page 28)".
3. Ping 2.1.1.1 from R2. If the configuration is successful R3 will respond.

Final Configuration R2

Interface Configuration

```
# interface switch lm1 2 vlan pvid 11
#ip switch.0011 ipv4 address 1.2.6.2/24
#ip dummy0 ipv4 address 112.112.112.112/24
```

BGP Configuration

```
routing bgp
enabled
as-id   10
neighbor 1.2.6.5
remote-as 10
!
redistribute connected
no metric
!
!
```

Final Configuration R3

Interface Configuration

```
#ip dummy0 ipv4 address 113.113.113.113/24
```

VRF Definitions

```
global
 vrf
  definition vrf1
   rd 200:1
   route-target both 100:1
```

BGP Configuration

```
routing bgp
enabled
 as-id              10
```

```
 address-family ipv4
  vrf vrf1
   redistribute connected
   neighbor 1.2.6.2
    remote-as 10
```

VRF Interface Configuration

```
ip switch.0011
 vrf-forwarding vrf1
 ipv4
  address 1.2.6.5/24
ip fe-1-2
 vrf-forwarding vrf1
 ipv4
  address 2.1.1.1/24
```

12.12 Managing Static Routing

Static routes can be manually added to the routing table when there are no notifications sent by other routers regarding network topology changes.

12.12.1 Viewing a List of Static Routes

To view a list of routable Ethernet ports, type:

`show running-config routing { protocol }`

Where:

- `{ protocol }` is either *IPv4* or *IPv6*

If routes have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing ipv4 | tab
                          HW
NETWORK         DISTANCE  ACCELERATE  GW            DISTANCE  INTERFACE    DISTANCE
-------------------------------------------------------------------------------------
0.0.0.0/0       -         -
                                      172.30.128.1  -
                                                              switch.0001  -
10.200.16.0/20  -         -
```

If no static routes have been configured, add routes as needed. For more information, refer to "Adding an IPv4 Static Route (Page 704)" or "Adding an IPv6 Static Route (Page 705)".

12.12.2 Adding an IPv4 Static Route

To add an IPv4 static route, do the following:

1. Make sure the CLI is in Configuration mode.

⚠ NOTICE
If the route is to be configured as a black hole route, make sure the subnet matches that of another static route. The black hole route will then act as a backup should the other static route go down.

2. Add the IPv4 static route by typing:

   `routing ipv4 route { subnet }`

   Where:

   - `{ subnet }` is the subnet (network/prefix) of the static route

3. If the device has a Layer 3 switch installed, configure the following parameter(s) as required:

   Note
   Only TCP and UDP traffic flows will be accelerated by the IP/Layer 3 switch fabric. Non-IP packet types, such as ICMP and IGMP, will not be accelerated.

Parameter	Description
`hw-accelerate`	If the static unicast route can be hardware accelerated, this option will be available. For a static unicast route to be accelerated, the ingress and egress interfaces must be switched.

4. [Optional] Configure the route as a black hole route. For more information, refer to "Configuring a Black Hole Connection for an IPv4 Static Route (Page 706)".
5. [Optional] If the static route is not a black hole route, configure either the interface that connects to the next-hop router (if there is a direct connection) or the IP address (gateway) of the next-hop router. Only one can be configured per static route. For more information, refer to either "Adding a Gateway for an IPv4 Static Route (Page 707)" or "Adding an Interface for an IPv4 Static Route (Page 709)".
6. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.12.3 Adding an IPv6 Static Route

To add an IPv6 static route, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the IPv6 static route by typing:

   `routing ipv6 route { subnet }`

   Where:

   - `{ subnet }` is the subnet (network/prefix) of the static route

3. Configure the next hop IP address (gateway) or interface. Only one can be configured per static route. For more information, refer to "Configuring Gateways for IPv6 Static Routes (Page 707)" or "Configuring Interfaces for IPv6 Static Routes (Page 708)".
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.12.4 Deleting a Static Route

To delete a static route, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the static route by typing:

   ```
   no routing { protocol } route { subnet }
   ```

   Where:

   - `{ protocol }` is either *IPv4* or *IPv6*
   - `{ subnet }` is the subnet (network/prefix) of the static route
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.12.5 Configuring a Black Hole Connection for an IPv4 Static Route

To configure a black hole connection for an IPV4 static route, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***routing » ipv4 » {subnet} » blackhole***, where *subnet* is the subnet (network/prefix) of the static route.
3. Configure the following parameter(s) as required:

Parameter	Description
`distance { distance }`	**Synopsis:** An integer between 1 and 255 **Default:** 1 The distance for this static route's blackhole. Default is 1.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.12.6 Managing Gateways for Static Routes

If the device is not directly connected to the next-hop router, configure a static route to forward traffic to the next-hop router's IP address. This is referred to as a *gateway*.

In the case of IPv6 static routes, only one gateway can be selected per route.

12.12.6.1 Configuring Gateways for IPv6 Static Routes

To configure a gateway address for an IPv6 static route, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***routing » ipv6 » route » {subnet} » via***, where *subnet* is the subnet (network/prefix) of the static route.
3. Configure the following parameter(s) as required:

Parameter	Description
`gw { gw }`	**Synopsis:** A string between 6 and 40 characters long The gateway for the static route.
`distance { distance }`	**Synopsis:** An integer between 1 and 255 The distance for the static route.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.12.6.2 Viewing a List of Gateways for IPv4 Static Routes

To view a list of gateway addresses assigned to an IPv4 static route, type:

```
show running-config routing ipv4 route { subnet } via
```

Where:

- `{ subnet }` is the subnet (network/prefix) of the static route

If gateway addresses have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing ipv4 route 0.0.0.0/0 via
routing ipv4 route 0.0.0.0/0
 via 172.30.128.1
  no distance
 !
!
```

If no gateway addresses have been configured, add addresses as needed. For more information, refer to "Adding a Gateway for an IPv4 Static Route (Page 707)".

12.12.6.3 Adding a Gateway for an IPv4 Static Route

To add a gateway address for an IPv4 static route, do the following:

1. Make sure the CLI is in Configuration mode.

2. Add the gateway address by typing:

   ```
   routing ipv4 route { subnet } via { gateway }
   ```

   Where:

   - `{ subnet }` is the subnet (network/prefix) of the static route
   - `{ gateway }` is the gateway address for the static route

3. Configure the following parameter(s) as required:

Parameter	Description
`distance { distance }`	**Synopsis:** An integer between 1 and 255 The distance for the static route.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.12.6.4 Deleting a Gateway for an IPv4 Static Route

To delete a gateway for an IPv4 static route, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the gateway address by typing:

   ```
   no routing ipv4 route { subnet } via { gateway }
   ```

   Where:

   - `{ subnet }` is the subnet (network/prefix) of the static route
   - `{ gateway }` is the gateway address for the static route

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.12.7 Managing Interfaces for Static Routes

Static routes can be configured to forward packets to an exit interface. Assuming the device is directly connected to a neighboring router, the device will send Address Resolution Protocol (ARP) requests to determines the next hop IP address.

In the case of IPv6 static routes, only one interface can be selected per route.

12.12.7.1 Configuring Interfaces for IPv6 Static Routes

To configure an interface for an IPv6 static route, do the following:

1. Make sure the CLI is in Configuration mode.

2. Navigate to ***routing » ipv6 » route » {subnet} » dev***, where *subnet* is the subnet (network/prefix) of the static route.
3. Configure the following parameter(s) as required:

Parameter	Description
`interface { interface }`	**Synopsis:** A string The interface for the static route.
`distance { distance }`	**Synopsis:** An integer between 1 and 255 The distance for the static route.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.12.7.2 Viewing a List of Interfaces for IPv4 Static Routes

To view a list of interfaces assigned to an IPv4 static route, type:

```
show running-config routing ipv4 route { subnet } dev
```

Where:

- `{ subnet }` is the subnet (network/prefix) of the static route

If interfaces have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing ipv4 route 0.0.0.0/0 dev
routing ipv4 route 0.0.0.0/0
 dev switch.0001
  no distance
 !
!
```

If no interfaces have been configured, add interfaces as needed. For more information, refer to "Adding an Interface for an IPv4 Static Route (Page 709)".

12.12.7.3 Adding an Interface for an IPv4 Static Route

To add an interface for an IPv4 static route, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the gateway address by typing:

   ```
   routing ipv4 route { subnet } dev { interface }
   ```

   Where:

   - `{ subnet }` is the subnet (network/prefix) of the static route
   - `{ interface }` is the name of the interface for the static route

3. Configure the following parameter(s) as required:

Parameter	Description
`distance { distance }`	**Synopsis:** An integer between 1 and 255 The distance for the static route.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.12.7.4 Deleting an Interface for an IPv4 Static Route

To delete an interface for an IPv4 static route, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the gateway address by typing:

   ```
   no routing ipv4 route { subnet } dev
   { interface }
   ```

   Where:

   - `{ subnet }` is the subnet (network/prefix) of the static route
   - `{ interface }` is the name of the interface for the static route
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.13 Managing Static Multicast Routing

Static multicast routing allows network designers to control the flow of multicast traffic by manually adding static routes to the routing table.

12.13.1 Enabling/Disabling Static Multicast Routing

To enable or disable static multicast routing, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable or disable static multicast routing by typing:

   ```
   routing multicast static [ enable | disable ]
   ```

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.13.2 Managing Static Multicast Groups

Define a static multicast group for each multicast route. Multiple routes can be configured, as long as the source and multicast IP addresses are unique to the route.

⚠ NOTICE

The source IP address for static routes is always a unicast address (e.g. 192.168.0.10), while the destination IP address is always a multicast address (e.g. 225.2.100.1).

12.13.2.1 Viewing a List of Static Multicast Groups

To view a list of static multicast groups, type:

```
show running-config routing multicast static
```

If static multicast groups have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing multicast static | tab
routing multicast static enabled
routing multicast static mcast-groups
                            MULTICAST    IN           HW
DESCRIPTION  SOURCE IP      IP           INTERFACE    ACCELERATE  IFNAME
-------------------------------------------------------------------------
test.001     169.150.24.12  238.1.12.12  switch.0001  -           fe-cm-1
```

If no static multicast groups have been configured, add groups as needed. For more information about adding static multicast groups, refer to "Adding a Static Multicast Group (Page 711)".

12.13.2.2 Adding a Static Multicast Group

To add a static multicast group, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the multicast group by typing:

   ```
   routing multicast static mcast-groups
   { description }
   ```

   Where:

   - `{ description }` is the name of the multicast group. Up to 32 characters are allowed, excluding spaces.
3. Configure the following parameter(s) as required:

Parameter	Description
`source-ip { source-ip }`	**Synopsis:** A string between 7 and 15 characters long or A string between 6 and 40 characters long The expected source IP address of the multicast packet, in the format xxx.xxx.xxx.xxx. This address is uniquely paired with the multicast address. You cannot use this IP address to create another multicast routing entry with a different Multicast-IP address.
`multicast-ip { multicast-ip }`	**Synopsis:** A string between 7 and 15 characters long or A string between 7 and 39 characters long The multicast IP address to be forwarded, in the format xxx.xxx.xxx.xxx The address must be in the range of 224.0.0.0 to 239.255.255.255. This address is uniquely paired with the source IP address. You cannot use this IP address to create another multicast routing entry with a different Source-IP address.
`in-interface { in-interface }`	**Synopsis:** A string The interface upon which the multicast packet arrives.
`hw-accelerate`	If the multicast route can be hardware accelerated, the option will be available. For a multicast route to be accelerated, the ingress and egress interfaces must be switched.

4. Configure out-interfaces. For more information, refer to "Adding an Out-Interface (Page 713)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.13.2.3 Deleting a Static Multicast Group

To delete a static multicast group, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the multicast group by typing:

   ```
   no routing multicast static mcast-groups
   { description }
   ```

   Where:

   - `{ description }` is the name of the multicast group to be deleted
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.13.3 Managing Out-Interfaces

An out-interface is the interface to which multicast packets are forwarded. Multiple out-interfaces can be defined for each static multicast group.

12.13.3.1 Viewing a List of Out-Interfaces

To view a list of out-interfaces, type:

```
show runing-config routing multicast static mcast-group out-interface
```

If out-interfaces have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing multicast static mcast-groups out-interface
routing multicast static mcast-groups test
 out-interface fe-cm-1
 !
!
```

If no out-interfaces have been configured, add groups as needed. For more information about adding out-interfaces, refer to "Adding an Out-Interface (Page 713)".

12.13.3.2 Adding an Out-Interface

To add an out-interface, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the out-interface by typing:

   ```
   routing multicast static mcast-groups { group } out-interface { ifname }
   ```

   Where:

   - `{ group }` is the name of the multicast group
   - `{ ifname }` is a string of up to 15 characters used to name the out-interface
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.13.3.3 Deleting an Out-Interface

To delete an out-interface, do the following:

1. Make sure the CLI is in Configuration mode.

2. Delete the out-interface by typing:

   ```
   no routing multicast static mcast-groups { group }
   out-interface { ifname }
   ```

   Where:

   - `{ group }` is the name of the group with the out-interface to be deleted
   - `{ ifname }` is the name of the out-interface to be deleted

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.14 Managing Dynamic Multicast Routing

This section describes concepts and configuration related to dynamic multicast routing using PIM-SM and PIM-SSM.

12.14.1 Understanding Protocol Independent Multicast

Protocol Independent Multicast (PIM) is a collection of multicast routing protocols that provide one-to-many and many-to-many distribution of multicast packets over an IP network. PIM is protocol-independent in that it does not include its own topology discovery mechanism, but instead uses routing information supplied by other routing protocols. PIM can accommodate any unicast routing protocol in use on the network.

RUGGEDCOM ROX II supports two types of PIM: PIM - Sparse Mode (PIM-SM) and PIM - Source Specific Multicast (PIM-SSM).

12.14.1.1 PIM-SM Concepts

Protocol Independent Multicast - Sparse Mode (PIM-SM) is a dynamic multicast routing protocol that can dynamically prune and maintain multicast routes. PIM relies on the router's unicast routing table for its capabilities and does not rely on any specific method for learning routes, therefore it is "Protocol Independent".

PIM-SM Terms

The following terms are used in PIM-SM:

- **Rendezvous Point**

  The rendezvous point (RP) is a destination in the network (one of the routers), where all multicast traffic is first registered. Whenever a PIM router receives a multicast stream, the source and the multicast address are registered with the rendezvous point.

- **Boot Strap Router**

  A PIM-SM boot strap router (BSR) is a router that announces the location of the rendezvous point to all other PIM routers on the network.

- **Designated Router**

  A designated router (DR) is a router directly attached to a multicast host or device.

- **Shared Tree**

  The shared tree, also known as the RP-Tree, is a traffic distribution tree which begins from the rendezvous point. The rendezvous point will forward the particular multicast group traffic through this tree whenever there are subscribers for a given multicast flow. Note that the shared tree is on a per-group basis. This means that the shared tree for one group could be different than the shared tree for another on the same network depending on the distribution of the multicast traffic subscribers.

- **Shortest Path Tree**

  The shortest path tree (SPT) is a traffic distribution tree which begins at the source of the multicast traffic or rather the router nearest to the source. The shortest path tree is activated whenever there is a shorter path between the source and the receiver. The shortest path tree can only be triggered by the rendezvous point or the router connected directly to the subscriber.

- **mroute**

  The routing paths between the producer IP host and the rendezvous point.

- **groute**

  The routing paths between the multicast traffic subscriber and the rendezvous point.

PIM-SM Operation

When a PIM router receives a subscription from a host, e.g. Host A, for particular multicast traffic, the directly attached designated router (DR) sends an IGMP **Join** message for this multicast group towards the rendezvous point (RP). The message is sent hop-by-hop and thus any routers encountering the message would register the group and send the message onwards towards the RP. This would create the shared tree (RP-tree). The tree will not be complete, however, until any sources appear.

When a host or device sends multicast traffic destined to the multicast group subscribed by A, the directly attached designated router takes the traffic, encapsulates it with PIM Register headers and unicasts them to the RP. When the RP receives this traffic, it decapsulates the packets and sends the data towards the subscriber through the RP tree. The routers that receive these packets simply pass them on over the RP-Tree until it reaches the subscriber. Note that there may be other subscribers in the network and the path to those subscribers from the RP is also part of the RP Tree.

After the shared tree has been established, the traffic flows from the source to the RP to the receiver. There are two inefficiencies in this process. One, the traffic is encapsulated at the source and decapsulated at the RP, which may be a performance penalty for a high level of traffic. Two, the traffic may be taking a longer path than necessary to reach its receivers.

After the shared tree has been established, the RP may choose to to send a **Join** message to the source declaring that it only wants traffic for a group (e.g. group G) from the source (e.g. source S). The DR for the source then starts sending the traffic in multicast form (instead of unicast). Without encapsulation, there is little performance overhead other than what is normal for the traffic when routing in general. The RP will continue sending the traffic over the RP-tree after it receives it. This also means that the traffic may reach the RP-tree before it reaches the RP (in the case where the source branches off the RP-tree itself) which will also have the additional benefit of traffic flowing more efficiently towards receivers that are on the same side of the RP-tree as the source.

If the DR to the receiver decided that traffic coming from the RP-tree was using a sub-optimal path than if it was received from the source itself, it would issue a source-specific **Join** message towards the source. This would then make all intermediate routers register the Join message and then traffic would start flowing along that tree. This is the shortest path tree (SP-tree). At this point, the receiver would receive the traffic from both the RP-tree and the SP-tree. After the flow starts from the SP-tree, the DR will drop the packets from the RP-tree and send a prune message for that traffic towards the RP. This will stop the traffic from arriving from the RP. This scenario will most likely only occur when the traffic has to take a detour when arriving from the RP. Otherwise the RP-tree itself is used.

PIM-SM and VRRP Interoperability

PIM-SM and VRRP operate independently. As such, Reverse Path Forwarding (RPF) checks will fail if the RP is behind a VRIP address.

12.14.1.2 Internet Group Management Protocol

Internet Group Management Protocol (IGMP) is the protocol used by hosts and routers to join and leave multicast groups. Routers will send IGMP queries at regular intervals querying whether there are any hosts interested in IP multicast traffic. Whenever an attached host is interested in receiving traffic for a certain group, it will send an IGMP report message expressing its interest. The router will then a) propagate this Join message to another router and b) send the relevant traffic to the segment to which the host is attached.

RUGGEDCOM ROX II supports both IGMPv2 and IGMPv3. IGMPv3 is backwards compatible with IGMPv2.

PIM-SM operates with IGMPv2. PIM-SSM operates with IGMPv3, which supports source-specific multicast capability.

12.14.1.3 PIM-SSM

Protocol Independent Multicast - Source Specific Multicast (PIM-SSM) is derived from PIM-SM. Where PIM-SM accepts traffic from any multicast source on the network, the PIM-SSM protocol instead specifies the host(s) from which it will accept multicast traffic.

PIM-SSM operates with the IGMPv3 protocol. IGMPv3 supports source filtering, and is backwards-compatible with IGMPv2. For SSM to run with IGMPv3, SSM must be supported in the device, the host where the application is running, and the application itself. For more information about enabling IGMPv3 on the device, refer to "Enabling/Disabling a PIM-SM Interface (Page 725)".

In a network topology, only the last-hop device(s) must be PIM-SSM-compatible. Other devices in the network can be running PIM-SM.

A network configured to accept PIM-SM traffic can support PIM-SSM traffic at the same time. However, the full range of protocols required with PIM-SM (i.e. Rendezvous Point, Bootstrap Router, Designated Router, Shared Tree and Shortest Path Tree) are not required with PIM-SSM.

Note
IGMPv3 and PIM-SSM

IGMP **Join** messages from Designated Routers can only be received by PIM-SSM if the **source-filter** for the DR is set to **include** mode.

12.14.2 Viewing the Status of PIM-SM

To view the status of PIM-SM, do the following:

1. Make sure the CLI is in Configuration mode.
2. At the command prompt, type **`show routing status pim-sm`** and press **Enter**. The PIM-SM routing status information appears:

Note
A default routing protocol with a local address of *169.254.0.1* always appears when the **`show routing status pim-sm`** command is run. This internal routing protocol is a placeholder to reserve the source-specific multicast address range.

```
ruggedcom# show routing status pim-sm
routing status pim-sm
 bsr 192.168.30.1
 vinterface
INDEX  LOCAL ADDRESS  SUBNET           FLAGS      ID
-----------------------------------------------------------------
0      172.30.157.78  172.30.128.0/19  DISABLED
1      169.254.72.4   169.254.72.0/28  DISABLED
2      169.254.0.1    169.254.0.0/24   DISABLED
3      192.168.13.3   192.168.13.0/24  DR PIM
                                                 192.168.13.1
4      192.168.0.2    192.168.0.0/24   DISABLED
5      192.168.30.1   192.168.30.0/24  DR NO-NBR
```

```
 mroute
GROUP             SOURCE            RP ADDR           FLAGS
------------------------------------------------------------------------
239.0.1.0         192.168.20.2      192.168.30.1      SPT CACHE SG
239.0.1.1         192.168.20.2      192.168.30.1      SPT CACHE SG
239.0.1.2         192.168.20.2      192.168.30.1      SPT CACHE SG
239.0.1.3         192.168.20.2      192.168.30.1      SPT CACHE SG
239.0.1.4         192.168.20.2      192.168.30.1      SPT CACHE SG
239.0.1.5         192.168.20.2      192.168.30.1      SPT CACHE SG
239.0.1.6         192.168.20.2      192.168.30.1      SPT CACHE SG
```

Parameter	Description
`{ index }`	**Synopsis:** An integer Virtual interface index.
`local-address`	**Synopsis:** A string between 1 and 16 characters long Local address.
`subnet`	**Synopsis:** A string between 1 and 20 characters long Subnet.
`flags`	**Synopsis:** A string between 1 and 128 characters long Flags indicates virtual interface information. • DISABLED: The virtual interface is administratively disabled for PIM-SM. • DOWN: This virtual interface is down. • DR: Designated router. • NO-NBR: No neighbor on this virtual interface. • PIM: PIM neighbor. • DVMRP: DVMRP neighbor.
`id`	**Synopsis:** A string between 1 and 16 characters long Neighbor address.

3. At the command prompt, type **`show routing status pim-sm bsr`** and press **Enter**. The address of the BSR appears:

```
ruggedcom# show routing status pim-sm bsr
routing status pim-sm bsr 192.168.30.1
```

Parameter	Description
`bsr`	**Synopsis:** A string between 1 and 16 characters long Current BSR (bootstrap router) address.

4. At the command prompt, type **`show routing status pim-sm vinterface`** and press **Enter**. The PIM-SM virtual interface routing status information appears:

```
ruggedcom# show routing status pim-sm vinterface
INDEX  LOCAL ADDRESS  SUBNET           FLAGS      ID
------------------------------------------------------------------
```

```
0       172.30.157.78  172.30.128.0/19  DISABLED
1       169.254.72.4   169.254.72.0/28  DISABLED
2       169.254.0.1    169.254.0.0/24   DISABLED
3       192.168.13.3   192.168.13.0/24  DR PIM
                                                  192.168.13.1
4       192.168.0.2    192.168.0.0/24   DISABLED
5       192.168.30.1   192.168.30.0/24  DR NO-NBR
```

Parameter	Description
`{ index }`	**Synopsis:** An integer Virtual interface index.
`local-address`	**Synopsis:** A string between 1 and 16 characters long Local address.
`subnet`	**Synopsis:** A string between 1 and 20 characters long Subnet.
`flags`	**Synopsis:** A string between 1 and 128 characters long Flags indicates virtual interface information. • DISABLED: The virtual interface is administratively disabled for PIM-SM. • DOWN: This virtual interface is down. • DR: Designated router. • NO-NBR: No neighbor on this virtual interface. • PIM: PIM neighbor. • DVMRP: DVMRP neighbor.
`id`	**Synopsis:** A string between 1 and 16 characters long Neighbor address.

5. At the command prompt, type **`show routing status pim-sm rp`** and press **Enter**. The PIM-SM rendezvous point routing status information appears:

```
show routing status pim-sm rp
ID                PREFIX                PRIORITY  HOLDTIME
-----------------------------------------------------------
192.168.30.1
                  239.0.0.0/16          100       125
169.254.0.1
                  232.0.0.0/8           1         65535
```

Parameter	Description
`id`	**Synopsis:** A string between 1 and 16 characters long RP address.
`{ prefix }`	**Synopsis:** A string between 1 and 20 characters long Group prefix.
`priority`	**Synopsis:** A string between 1 and 20 characters long Priority.

Parameter	Description
`holdtime`	**Synopsis:** A string between 1 and 20 characters long The RP holdtime.

6. At the command prompt, type **`show routing status pim-sm mroute`** and press **Enter**. The PIM-SM (S,G) routing status information appears:

```
ruggedcom# show routing status pim-sm mroute
GROUP             SOURCE            RP ADDR           FLAGS
------------------------------------------------------------------
239.0.1.0         192.168.20.2      192.168.30.1      SPT SG
239.0.1.1         192.168.20.2      192.168.30.1      SPT SG
239.0.1.2         192.168.20.2      192.168.30.1      SPT SG
239.0.1.3         192.168.20.2      192.168.30.1      SPT SG
239.0.1.4         192.168.20.2      192.168.30.1      SPT SG
239.0.1.5         192.168.20.2      192.168.30.1      SPT SG
239.0.1.6         192.168.20.2      192.168.30.1      SPT SG
239.0.1.7         192.168.20.2      192.168.30.1      SPT SG
239.0.1.8         192.168.20.2      192.168.30.1      SPT SG
239.0.1.9         192.168.20.2      192.168.30.1      SPT SG
239.0.1.10        192.168.20.2      192.168.30.1      SPT SG
239.0.1.11        192.168.20.2      192.168.30.1      SPT SG
239.0.1.12        192.168.20.2      192.168.30.1      SPT SG
239.0.1.13        192.168.20.2      192.168.30.1      SPT SG
239.0.1.14        192.168.20.2      192.168.30.1      SPT SG
239.0.1.15        192.168.20.2      192.168.30.1      SPT SG
239.0.1.16        192.168.20.2      192.168.30.1      SPT SG
239.0.1.18        192.168.20.2      192.168.30.1      SPT SG
239.0.1.19        192.168.20.2      192.168.30.1      SPT SG
239.0.1.20        192.168.20.2      192.168.30.1      SPT SG
239.0.1.21        192.168.20.2      192.168.30.1      SPT SG
239.0.1.22        192.168.20.2      192.168.30.1      SPT SG
239.0.1.23        192.168.20.2      192.168.30.1      SPT SG
239.0.1.24        192.168.20.2      192.168.30.1      SPT SG
239.0.1.25        192.168.20.2      192.168.30.1      SPT SG
```

Parameter	Description
`{ group }`	**Synopsis:** A string between 1 and 16 characters long Multicast group address.
`{ source }`	**Synopsis:** A string between 1 and 16 characters long Source IP address.
`rp-addr`	**Synopsis:** A string between 1 and 16 characters long RP (Rendezvous Point) address.
`flags`	**Synopsis:** A string between 1 and 128 characters long Flags. • SPT: IIF (incoming interface) toward source. • WC: (*,G) entry. • RP: IIF (incoming interface) toward RP. • CACHE: A mirror for the kernel cach. • ASSERT: Upstream is not that of source. • SG: (S,G) pure, not hanging off of (*,G). • PMBR: (*,*,RP) entry (for interop).

7. At the command prompt, type **`show routing status pim-sm ssmgroup`** and press **Enter**. The SSM Group routing status information appears:

```
ruggedcom# show routing status pim-sm ssmgroup
MCAST                    VINTERFACE
GROUP      SOURCE IP     INDEX
-------------------------------------
232.1.2.5
           192.168.11.4  1
```

Parameter	Description
`mcast-group`	**Synopsis:** A string between 1 and 16 characters long Multicast group address.
`{ source-ip }`	**Synopsis:** A string between 1 and 16 characters long Source IP address.
`vinterface-index`	**Synopsis:** An integer Virtual interface index.

8. At the command prompt, type **`show routing status pim-sm groute`** and press **Enter**. The PIM-SM (*,G) routing status information appears:

```
ruggedcom# show routing status pim-sm groute
GROUP             RP ADDR           FLAGS
-----------------------------------------
239.0.1.0         192.168.30.1      WC RP
239.0.1.1         192.168.30.1      WC RP
239.0.1.2         192.168.30.1      WC RP
239.0.1.3         192.168.30.1      WC RP
239.0.1.4         192.168.30.1      WC RP
239.0.1.5         192.168.30.1      WC RP
239.0.1.6         192.168.30.1      WC RP
239.0.1.7         192.168.30.1      WC RP
239.0.1.8         192.168.30.1      WC RP
239.0.1.9         192.168.30.1      WC RP
239.0.1.10        192.168.30.1      WC RP
239.0.1.11        192.168.30.1      WC RP
239.0.1.12        192.168.30.1      WC RP
239.0.1.13        192.168.30.1      WC RP
239.0.1.14        192.168.30.1      WC RP
239.0.1.15        192.168.30.1      WC RP
239.0.1.16        192.168.30.1      WC RP
239.0.1.17        192.168.30.1      WC RP
239.0.1.18        192.168.30.1      WC RP
239.0.1.19        192.168.30.1      WC RP
239.0.1.20        192.168.30.1      WC RP
239.0.1.21        192.168.30.1      WC RP
239.0.1.22        192.168.30.1      WC RP
239.0.1.23        192.168.30.1      WC RP
239.0.1.24        192.168.30.1      WC RP
```

Parameter	Description
`{ group }`	**Synopsis:** A string between 1 and 16 characters long Multicast group address.
`rp-addr`	**Synopsis:** A string between 1 and 16 characters long RP (Rendezvous Point) address.

Parameter	Description
`flags`	**Synopsis:** A string between 1 and 128 characters long Flags. • SPT: IIF (incoming interface) toward source. • WC: (*,G) entry. • RP: IIF (incoming interface) toward RP. • CACHE: A mirror for the kernel cach. • ASSERT: Upstream is not that of source. • SG: (S,G) pure, not hanging off of (*,G). • PMBR: (*,*,RP) entry (for interop).

12.14.3 Viewing the Status of Dynamic Multicast Routing

To view the status of dynamic multicast routing, type:

```
show routing status multicast
```

If multicast routes have been configured, a table or list similar to the following example appears:

```
ruggedcom# show routing status multicast
                            IN           OUT
SOURCE          GROUP       INTERFACE    INTERFACE
-------------------------------------------------------
192.168.11.101  225.0.0.1   switch.0011  switch.0012 switch.0014
```

12.14.4 Configuring PIM-SM

PIM-SM can be used to establish and dynamically manage the Multicast Routing table.

To configure PIM-SM, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable PIM-SM by typing:

   ```
   routing multicast dynamic pim-sm enabled
   ```

3. Configure the following parameter(s) as required:

Parameter	Description
`default-preference { default-preference }`	**Synopsis:** An integer **Default:** 1024 Default preference value. Preferences are used by assert elections to determine upstream routers.

Parameter	Description
`default-metric { default-metric }`	**Synopsis:** An integer **Default:** 1024 Default metric value. Metric is the cost of sending data through interface.
`broken-cisco-checksum`	If your RP is a cisco and shows many PIM_REGISTER checksum errors from this router, setting this option will help.

4. If the device is to be a Rendezvous Point (RP) in a shared tree, set the device as an RP candidate. For more information, refer to "Setting the Device as an RP Candidate (Page 723)".
5. If the device is to be a Boot Strap Router (BSR), set the device as an BSR candidate. For more information, refer to "Setting the Device as an RP Candidate (Page 723)".
6. Define which multicast groups the device will handle. For more information, refer to "Adding a Multicast Group Prefix (Page 728)".
7. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.14.5 Setting the Device as a BSR Candidate

To set the device as a BSR candidate, do the following:

1. Make sure the CLI is in Configuration mode.
2. Set the device as a BSR candidate by typing:

   ```
   routing multicast dynamic pim-sm bsr-candidate
   local-address { address } priority { number }
   ```

   Where:

   - `{ address }` is the local address to be used in the Cand-BSR messages. If not specified, the largest local IP address will be used (excluding passive interfaces).
   - `{ priority }` sets the priority for the BSR. Larger values have higher priority.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.14.6 Setting the Device as an RP Candidate

To set the device as an RP candidate, do the following:

1. Make sure the CLI is in Configuration mode.

2. Set the device as an RP candidate by typing:

   ```
   routing multicast dynamic pim-sm rp-candidate
   local-address { address } timer { timer } priority
   { number }
   ```

   Where:

   - `{ address }` is the local address to be used in the Cand-RP messages. If not specified, the largest local IP address will be used (excluding passive interfaces).
   - `{ timer }` is the number of seconds to wait between advertising and Cand-RP message.
   - `{ priority }` sets the priority for this CRP. Smaller values have higher priority.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.14.7 Managing PIM-SM Interfaces

PIM-SM requires at least one interface on which to receive or transmit advertisements. The interface must be non-passive and be assigned an IP address.

12.14.7.1 Viewing a List of PIM-SM Interfaces

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***routing » multicast » dynamic » pim-sm*** and press **Enter**.
3. At the command prompt, type **`show full-configuration`** and press **Enter**.The PIM-SM interfaces information appears:

```
ruggedcom(config-pim-sm)# show full-configuration | tab

routing multicast dynamic pim-sm
 enabled
 bsr-candidate local-address 1.1.1.1
 bsr-candidate priority 1
 rp-candidate local-address 1.1.1.1
 rp-candidate priority 1
 no broken-cisco-checksum
 interface
                      IGMP
IFNAME       PASSIVE  VERSION
-------------------------------
dummy0       true     v2
fe-3-1       false    v2
fe-3-2       false    v2
fe-3-5       true     v2
fe-cm-1      true     v2
switch.0001  false    v3

 group-prefix
PREFIX
```

```
--------------
228.1.3.1/32
228.1.3.2/32

!
```

If no PIM-SM interfaces have been configured, enable interfaces as needed. For more information about enabling PIM-SM interfaces, refer to "Enabling/Disabling a PIM-SM Interface (Page 725)".

12.14.7.2 Enabling/Disabling a PIM-SM Interface

To enable or disable a PIM-SM interface, do the following:

Note
Enabling IGMPv3 on an interface also enables PIM-SSM. IGMPv3 is backwards compatible with IGMPv2.

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***routing » multicast » dynamic » PIM-SM » interface » interface-name***, where *interface-name* is the name of the interface to be enabled for PIM-SM.

   Note
   A maximum of 30 non-passive interfaces can be active for PIM-SM.

3. Configure the following parameter(s) as required:

Parameter	Description
`passive { passive }`	**Synopsis:** [true | false] **Default:** true Whether an interface is active or passive.
`igmp-version { igmp-version }`	**Synopsis:** [v2 | v3] **Default:** v2 The version of IGMP. Options include: • v2: IGMP version 2. • v3: IGMP version 3. Backwards compatible with v2.

4. Make sure the chosen interface is assigned an IP address. For more information, refer to "Managing IP Addresses for Routable Interfaces (Page 249)".
5. For VLAN interfaces only, if IGMP snooping is enabled on the interface, make sure the IGMP query interval is set to 125 seconds. For more information, refer to "Configuring IGMP Snooping (Page 346)".

   The same is required for any Layer 2 switches on the network.
6. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.14.8 Managing Static RP Addresses

A commonly used method for locating Rendezvous Points (RPs) is to target them directly by IP address, as opposed to locating them dynamically. Use static IP addresses when there are only a small number of RPs on the network and/or the RP assignment does not change often. It is important though that all static RP addresses be mirrored on all PIM-SM enabled devices in the multicast domain.

12.14.8.1 Viewing a List of Static RP Addresses

To view a list of static RP addresses, type:

```
show running-config routing multicast dynamic pim-sm rp-address
```

If addresses have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing multicast dynamic pim-sm rp-address | tab
ADDRESS         GROUP        PRIORITY
---------------------------------------
172.30.145.254  225.0.2.6/8  -
192.168.0.10    225.0.0.1/8  -

!
```

If no addresses have been configured, add addresses as needed. For more information, refer to "Adding a Static RP Address (Page 726)".

12.14.8.2 Adding a Static RP Address

To add a static RP address, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the RP address by typing:

   ```
   routing multicast dynamic pim-sm rp-address
   { static-address } { group-address } priority
   { priority }
   ```

   Where:

   - `{ static-address }` is the IP address of the RP
   - `{ group-address }` is the multicast address of the group handled by the RP
   - `{ priority }` is the the RP's priority in the election process

   Note
   A higher value means a higher rendezvous point priority.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.14.8.3 Deleting a Static RP Address

To delete a static RP address, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the chosen RP address by typing:

   ```
   no routing multicast dynamic pim-sm rp-address { static-address }
   ```

   Where `{ static-address }` is the Static RP (Rendezvous Point) address
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.14.9 Managing Multicast Group Prefixes

When nominated to a Rendezvous Point (RP), the device can serve up to 20 groups of multicast devices. The device is associated with a multicast group by defining the prefix for the group's multicast IP address (e.g. 225.1.2.0/24).

12.14.9.1 Viewing a List of Multicast Group Prefixes

To view a list of multicast group prefixes, type:

```
show running-config routing multicast dynamic pim-sm group-prefix
```

If prefixes have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config routing multicast dynamic pim-sm group-prefix
routing multicast dynamic pim-sm
 group-prefix 225.1.2.0/24
 !
!
```

If no prefixes have been configured, add prefixes as needed. For more information, refer to "Adding a Multicast Group Prefix (Page 728)".

12.14.9.2 Adding a Multicast Group Prefix

To add a multicast group prefix, do the following:

Note
A maximum of 20 group prefixes can be defined for PIM-SM.

1. Make sure the CLI is in Configuration mode.
2. Add the multicast group prefix by typing:

   ```
   routing multicast dynamic pim-sm group-prefix
   { prefix }
   ```

   Where { prefix } is the prefix for the multicast group (e.g. 225.1.2.0/24).
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.14.9.3 Deleting a Multicast Group Prefix

To delete a multicast group prefix, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the multicast group prefix by typing:

   ```
   no routing multicast dynamic pim-sm group-prefix
   { prefix }
   ```

   Where { prefix } is the chosen prefix.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

12.14.10 Example: Configuring Protocol Independent Multicast

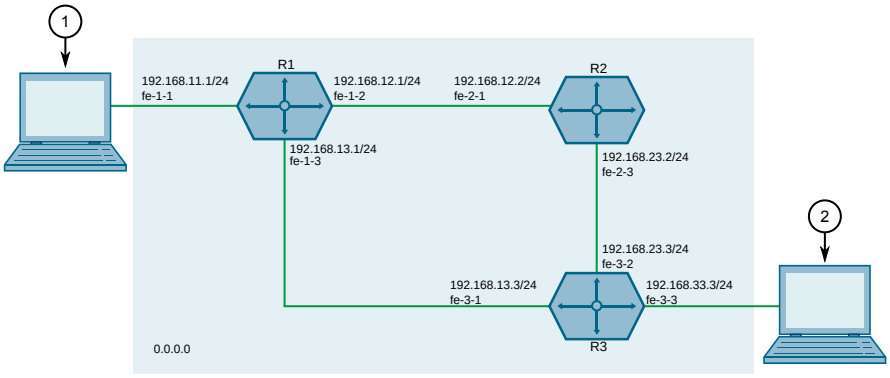
This section describes how to configure both PIM-SM and PIM-SSM using router ports in an OSPF network.

Configuring PIM-SM

The following topology depicts a scenario where PIM-SM is being deployed in a simple OSPF network. Routers R1, R2 and R3 all reside in OSPF area 0.0.0.0.

⚠ NOTICE

The values shown are specific to the provided topology. Actual values can vary based on the user's configuration.



① Producer
② Subscriber

Figure 12.15 PIM-SM Topology

To configure PIM-SM per the topology, do the following:

1. On R1, assign IP addresses to interfaces. For more information, refer to "Adding an IPv4 Address (Page 251)".

Interface	IP Address/Prefix
fe-1-1	192.168.11.1/24
fe-1-2	192.168.12.1/24
fe-1-3	192.168.13.1/24

2. On R2, assign IP addresses to interfaces. For more information, refer to "Adding an IPv4 Address (Page 251)".

Interface	IP Address/Prefix
fe-2-1	192.168.12.2/24
fe-2-3	192.168.23.2/24

3. On R3, assign IP addresses to interfaces. For more information, refer to "Adding an IPv4 Address (Page 251)".

Interface	IP Address/Prefix
fe-3-1	192.168.13.3/24
fe-3-2	192.168.23.3/24
fe-3-3	192.168.33.3/24

4. Configure OSPF. For more information, refer to "Configuring OSPF (Page 627)".
   a. Enable OSPF on routers R1, R2 and R3.
   b. Add the following areas:

Router	Area ID	IP Address/Prefix
R1	0.0.0.0	192.168.11.0/24
R1	0.0.0.0	192.168.12.0/24

Router	Area ID	IP Address/Prefix
R1	0.0.0.0	192.168.13.0/24
R2	0.0.0.0	192.168.12.0/24
R2	0.0.0.0	192.168.23.0/24
R3	0.0.0.0	192.168.13.0/24
R3	0.0.0.0	192.168.23.0/24
R3	0.0.0.0	192.168.33.0/24

c. Make sure the default value for the interfaces is active (not passive):

Router	Interface	Passive Default Value
R1	fe-1-2	False
R1	fe-1-3	False
R2	fe-2-1	False
R2	fe-2-3	False
R3	fe-3-1	False
R3	fe-3-2	False

5. Enable PIM-SM on routers R1, R2 and R3. For more information, refer to "Configuring PIM-SM (Page 722)".
6. Enable PIM-SM on all multicast path interfaces. For more information, refer to "Enabling/Disabling a PIM-SM Interface (Page 725)".
7. Configure the Rendezvous Point (RP).
   a. On R2, assign an IPv4 address to the desired interface to be used for the RP. For example, assign address is 2.2.2.2/32 to the dummy0 interface. For more information, refer to "Adding an IPv4 Address (Page 251)".
   b. Configure router R2 as the rendezvous point (RP). For example, assign static address 2.2.2.2/32, and group address 234.1.6.1/24. For more information, refer to "Adding a Static RP Address (Page 726)".
   c. On R1 and R3, add the RP address. For more information, refer to "Adding a Static RP Address (Page 726)".
8. Verify the configuration.
   a. Make sure routers R1, R2 and R3 can ping one another.
   b. Make sure the producer and subscriber can ping each other.

Final PIM-SM Configuration Example

The following configuration reflects the topology:

- **R1**

```
R1# show running-config routing multicast dynamic pim-sm
routing multicast dynamic pim-sm
 enabled
 no broken-cisco-checksum
 interface dummy0
 !
 interface fe-1-2
```

```
  no passive
 !
 interface fe-1-3
  no passive
 !
 interface fe-cm-1
 !
 interface gre-g1
  no passive
 !
 interface switch.0001
  no passive
 !
 rp-address 2.2.2.2 234.1.6.1/32
 !
!
```

- **R2**

```
R2# show running-config routing multicast dynamic pim-sm
routing multicast dynamic pim-sm
 enabled
 no broken-cisco-checksum
 interface dummy0
  no passive
 !
 interface fe-2-1
  no passive
 !
 interface fe-2-3
  no passive
 !
 interface fe-cm-1
 !
 interface switch.0001
 !
 rp-address 2.2.2.2 234.1.6.1/32
 !
 group-prefix 234.1.6.1/24
 !
!
```

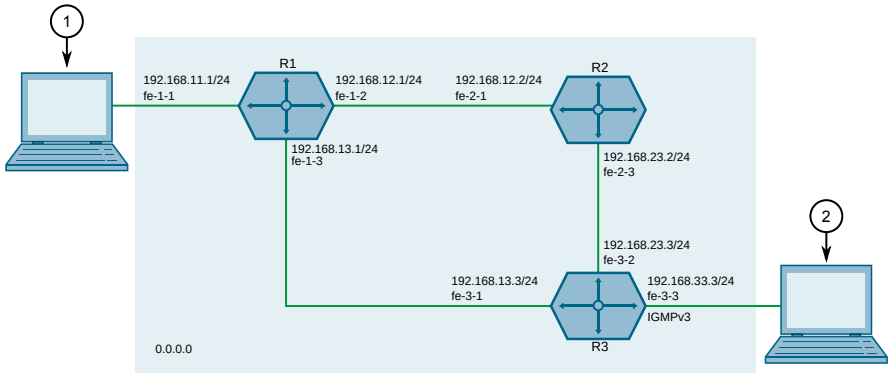
- **R3**

```
R3# show running-config routing multicast dynamic pim-sm
routing multicast dynamic pim-sm
 enabled
 no broken-cisco-checksum
 interface dummy0
  no passive
 !
 interface fe-3-1
  no passive
 !
 interface fe-3-2
  no passive
 !
 interface fe-3-5
 !
 interface fe-cm-1
 !
 interface gre-g1
  no passive
 !
 interface switch.0001
  no passive
```

```
 !
 rp-address 2.2.2.2 234.1.6.1/32
 !
!
```

Configuring PIM-SSM

PIM-SSM configuration is similar to PIM-SM configuration, however IGMPv3 must be enabled on the subscriber-facing interface.



① Producer
② Subscriber

Figure 12.16 PIM-SM Topology

To configure PIM-SSM per the topology, do the following:

1. Configure routers R1, R2 and R3 per subsection "Configuring PIM-SM".
2. On router R3, activate PIM-SSM by selecting IGMPv3 as the IGMP version on the port facing the subscriber. For more information, refer to "Enabling/Disabling a PIM-SM Interface (Page 725)".
3. Verify the configuration by making sure clients are properly registered on the subscriber (R3).
   a. Configure R3 to send IGMPv3 reports to the desired multicast groups. For example:

Multicast Group	Source IP	Virtual Interface Index
232.1.2.9	192.168.11.4	4
232.1.2.8	192.168.11.4	4
232.1.2.7	192.168.11.4	4
232.1.2.6	192.168.11.4	4
232.1.2.5	192.168.11.4	4

   For more information, refer to "Configuring IGMP Snooping (Page 346)".

b. On R1 and R3, verify the groups listed in step 3.a are registered as SSM groups. For more information, refer to "Viewing the Status of PIM-SM (Page 717)".

c. Verify the requested UDP/TCP multicast traffic is being forwarded to R3 based on the source IP and the multicast group being requested.

d. On R1, verify that only the traffic being forwarded to R3 through the best route (in this example the direct connection fe-1-3) is what is being requested and the non-requested traffic is not being forwarded.

e. Verify that R3 is receiving multicast traffic from R1 through interface fe-3-1.

Final PIM-SSM Configuration Example

The following configuration reflects the topology:

- **R1**

```
R1# show running-config routing multicast dynamic pim-sm
routing multicast dynamic pim-sm
 enabled
 no broken-cisco-checksum
 interface dummy0
 !
 interface fe-1-2
  no passive
 !
 interface fe-1-3
  no passive
 !
 interface fe-cm-1
 !
 interface gre-g1
  no passive
 !
 interface switch.0001
  no passive
 !
!
```

- **R2**

```
R2# show running-config routing multicast dynamic pim
routing multicast dynamic pim-sm
 enabled
 no broken-cisco-checksum
 interface dummy0
 !
 interface fe-2-1
  no passive
 !
 interface fe-2-3
  no passive
 !
 interface fe-cm-1
 !
 interface switch.0001
 !
!
```

- **R3**

```
R3# show running-config routing multicast dynamic pim
routing multicast dynamic pim-sm
 enabled
 no broken-cisco-checksum
 interface dummy0
 !
 interface fe-3-1
  no passive
 !
 interface fe-3-2
  no passive
 !
 interface fe-3-5
 !
 interface fe-cm-1
 !
 interface gre-g1
  no passive
 !
 interface switch.0001
  no passive
  igmp-version v3
 !
!
```

13 Network Redundancy

This chapter describes protocols and features that allow RUGGEDCOM ROX II to operate with redundancy, protecting the network from crippling service disruptions from single points of failure.

13.1 Managing VRRP

The Virtual Router Redundancy Protocol (VRRP) is a gateway redundancy protocol. It provides a gateway failover mechanism invisible to hosts and other devices that send traffic through the gateway.

VRRP eliminates a single point of failure associated with statically routed networks by providing automatic failover using alternate routers. The RUGGEDCOM ROX II VRRP daemon (keepalived) is an RFC 5798 [http://tools.ietf.org/html/rfc5798] version 2 and version 3 compliant implementation of VRRP.

Note
RFC 5798 defines the standard for VRRP version 3 on IPv4 and IPv6. Only IPv4 is supported in this release of RUGGEDCOM ROX II.

13.1.1 VRRP Concepts

This section describes some of the concepts important to the implementation of the Virtual Router Redundancy Protocol (VRRP) in RUGGEDCOM ROX II.

13.1.1.1 Static Routing vs. VRRP

Many network designs employ a statically configured default gateway in the network hosts. A static default gateway is simple to configure, requires little if any overhead to run, and is supported by virtually every IP implementation. When the Dynamic Host Configuration Protocol (DHCP) is employed, hosts may accept a configuration for only a single default gateway.

Unfortunately, this approach creates a single point of failure. Loss of the router supplying the default gateway, or the router's WAN connection, results in isolating the hosts that rely upon the default gateway.

There are a number of ways to provide redundant connections for the hosts. Some hosts can configure alternate gateways while others are intelligent enough to participate in dynamic routing protocols such as the Routing Information Protocol

(RIP) or Open Shortest Path First (OSPF) routing protocol. Even when available, these approaches are not always practical due to administrative and operation overhead.

VRRP solves the problem by allowing the establishment of a *virtual router group*, composed of a number of routers that provide one gateway IP. VRRP uses an election protocol to dynamically assign responsibility for the gateway to one of the routers in the group. This router is called the Master.

If the Master (or, optionally, a condition) fails, the alternate (or backup) routers in the group elect a new Master. The new master owns the virtual IP address and issues a gratuitous ARP to inform the network of where the gateway can be reached.

Since the host's default route and MAC address does not change, packet loss at the hosts is limited to the amount of time required to elect a new router.

13.1.1.2 VRRP Terminology

Each physical router running VRRP is known as a VRRP Router. Two or more VRRP Routers can be configured to form a *Virtual Router*. Each VRRP Router may participate in one or more Virtual Routers.

Each Virtual Router has a user-configured Virtual Router Identifier (VRID) and a Virtual IP address or set of IP addresses on the shared LAN. Hosts on the shared LAN are configured to use these addresses as the default gateway.

Each router in the Virtual Router Group has a specific priority, which is a number between 1 and 255. The router with the highest priority (or highest number) is elected the Master, while all other routers are considered Backups.

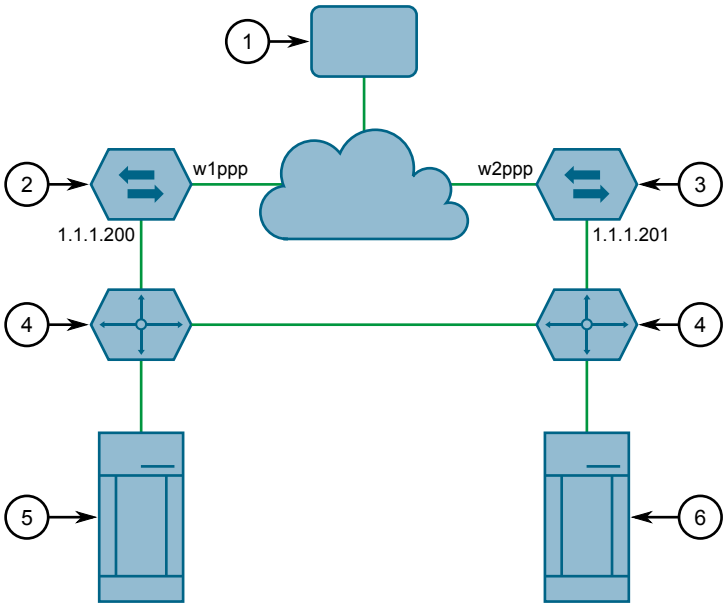
On RUGGEDCOM RX1400 devices with RUGGEDCOM ROX II v2.3 or higher installed, if the router with the highest priority is in a fault state, the backup VRRP Router can delay its transition to becoming the Master router. The length of the delay is user-defined.

VRRP can also monitor a specified interface and give up control of a gateway IP to another VRRP Router if that interface goes down.

An Example of VRRP

In the following example, host 1 uses a gateway of 1.1.1.253 and host 2 uses a gateway of 1.1.1.252. The 1.1.1.253 gateway is provided by VRID 10. In normal practice, router 1 will provide this virtual IP since its priority for VRID 10 is higher than that of router 2. If router 1 becomes inoperative or if its w1ppp link fails, it will relinquish control of gateway IP 1.1.1.253 to router 2.

In a similar fashion host 2 can use the VRID 11 gateway address of 1.1.1.252, which will normally be supplied by router 2.



① Network
② Remote Router 1
③ Remote Router 2
④ Switch
⑤ Host 1
⑥ Host 2

Figure 13.1 VRRP Example

In this example, the remote routers are configured as follows:

Remote Router 1	Remote Router 2
• VRID 10 Gateway IP: 1.1.1.253 • VRID 10 Priority: 100 • VRID 10 Monitor Interface: w1ppp • VRID 11 Gateway IP: 1.1.1.252 • VRID 11 Priority: 50	• VRID 10 Gateway IP: 1.1.1.253 • VRID 10 Priority: 50 • VRID 11 Gateway IP: 1.1.1.252 • VRID 11 Priority: 100 • VRID 11 Monitor Interface: w2ppp

Traffic from host 1 is sent through router 1, and traffic from host 2 is sent through router 2. A failure of either router or their WAN link will be recovered by the other router.

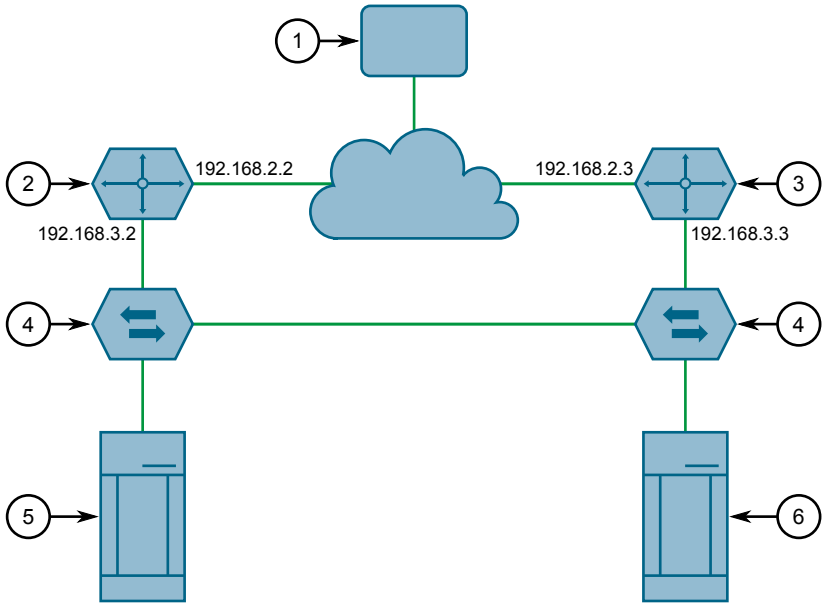
Note that both routers can always be reached by the hosts at their *real* IP addresses.

Two or more VRRP instances can be assigned to be in the same VRRP Group, in which case, they can failover together.

An Example of VRRP Groups

In the next example, both host 1 and host 2 use a gateway of 192.168.3.10. The external side can access the internal side by gateway 192.168.2.10. VRID_20 and VRID_21 are grouped together. Normally, router 1 will provide both an internal and external access gateway, as its priority is higher than those on Router 2. When either

the internal or external side of Router 1 becomes inoperative, Router 1 will remove give control of both 192.168.2.10 and 192.168.3.10 gateways to Router 2.



① Network
② Remote Router 1
③ Remote Router 2
④ Switch
⑤ Host 1
⑥ Host 2

Figure 13.2 VRRP Group Example

In this example, the remote routers are configured as follows:

Remote Router 1	Remote Router 2
• VRID_20 Gateway IP: 192.168.2.10 • VRID_20 Priority: 100 • VRID_21 Gateway IP: 192.168.3.10 • VRID_21 Priority: 100	• VRID_20 Gateway IP: 192.168.2.10 • VRID_20 Priority: 50 • VRID_21 Gateway IP: 192.168.3.10 • VRID_21 Priority: 50

Other VRRP parameters are the Advertisement Interval and Gratuitous ARP Delay. The advertisement interval is the time between which advertisements are sent. A backup router will assume the role of Master three advertisement intervals after the Master fails. If a monitored interface goes down, a Master router will immediately signal an election and allow a Backup router to assume the Master roles.

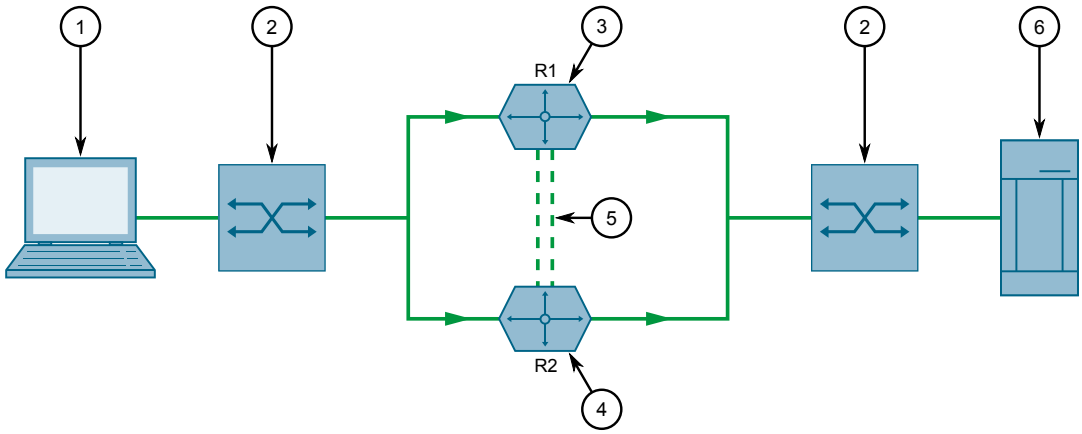
The router issues a set of gratuitous ARPs when moving between Master and Backup roles. These unsolicited ARPs teach the hosts and switches in the network of the current MAC address and port associated with the gateway. The router will issue a second set of ARPs after the time specified by the Gratuitous ARP delay.

13.1.1.3 Connection Synchronization

When failover occurs, hosts must typically either reconnect manually to the backup firewall, or wait for the connection to automatically reconnect. This can sometimes take several minutes.

When connection synchronization is enabled, stateful connections are maintained when a VRRP master router fails, resulting in a seamless failover to the VRRP backup router. This is done by synchronizing the firewall and NAT states between the master and backup routers.

In the following example, when the master router (R1) fails, the firewall connection and NAT states are initialized automatically for the backup router (R2). The backup router then becomes the new VRRP master.



① Host A
② Switch
③ Primary VRRP Firewall and Router (R1)
④ Backup VRRP Firewall and Router (R2)
⑤ Dedicated Links
⑥ Host B

Figure 13.3 Connection Synchronization Example

13.1.2 Viewing the Status of VRRP

To view the status of VRRP, type:

```
show services vrrp status
```

A table or list similar to the following example appears:

```
ruggedcom# show services vrrp status
                                                                    MONITOR
                                                    INTERFACE       INTERFACE
NAME  STATE    PRIORITY  TIME CHANGE                STATE           STATE
-------------------------------------------------------------------------------
v1    master   100       Sat Feb  2 06:30:41 EST 2013  fe-cm-1 is Up
```

This table or list provides the following information:

Parameter	Description
`{ name }`	**Synopsis:** A string The VRRP instance name.
`state`	**Synopsis:** A string The VRRP instance state.
`priority`	**Synopsis:** A string The VRRP instance priority.
`time-change`	**Synopsis:** A string The time of change to the current state.
`interface-state`	**Synopsis:** A string The VRRP interface state.
`monitor-interface-state`	**Synopsis:** A string Monitors the interface state.

13.1.3 Enabling/Disabling VRRP

To enable or disable VRRP, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable or disable VRRP by typing:

   Enabling VRRP

   ```
   services vrrp enabled
   ```

   Disabling VRRP

   ```
   no services vrrp enabled
   ```

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.1.4 Managing VRRP Trackers

VRRP trackers monitor the state/condition of a route. When the route is unavailable, VRRP will lower its priority or transition it to a fault state.

Note
The decision to increase or decrease the priority of a route must be done in coordination with any backup VRRP Routers since the priority decides whether a router becomes a Master or a Backup. For example, if Router X's priority is 150

and Router Y's priority is 145, Router X's priority must be lowered by 6 to make it a Backup router.

13.1.4.1 Viewing a List of VRRP Trackers

To view a list of VRRP trackers, type:

```
show running-config services vrrp trackers
```

If trackers have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services vrrp trackers
services
 vrrp
  trackers tracker tracker1
   network   10.0.0.0/8
   interface dummy0
   interval  1
  !
 !
!
```

If no VRRP trackers have been configured, add trackers as needed. For more information, refer to "Adding a VRRP Tracker (Page 741)".

13.1.4.2 Adding a VRRP Tracker

To add a VRRP tracker, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the tracker by typing:

   ```
   services vrrp trackers { name }
   ```

   Where:

   - `{ name }` is the name of the VRRP tracker
3. Configure the following parameter(s) as required:

Parameter	Description
`type { type }`	**Synopsis:** [route] **Default:** route The type of condition for the tracker to check.
`network { network }`	**Synopsis:** A string between 9 and 18 characters long The network to track. The tracker checks for a route to this network in the routing table.

Parameter	Description
`interface { interface }`	**Synopsis:** A string The interface to the tracked network. The tracker rises only when the route to the monitored network is through this interface.
`interval { interval }`	**Synopsis:** An integer between 1 and 120 The number of seconds between tracker queries.
`weight { weight }`	**Synopsis:** An integer between -254 and 254 The amount by which to increase or decrease the router's priority. When negative, the priority decreases by this amount when the tracker falls. When positive, the priority increases by this amount when the tracker rises. When not set, the state changes to the fault state when the tracker falls.
`rise { rise }`	**Synopsis:** An integer between 1 and 65535 The number of successful tracker queries before changing the router priority.
`fall { fall }`	**Synopsis:** An integer between 1 and 65535 The number of unsuccessful tracker queries before changing the router priority.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.1.4.3 Deleting a VRRP Tracker

To delete a VRRP tracker, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the tracker by typing:

   ```
   no services vrrp trackers { name }
   ```

   Where:

   - `{ name }` is the name of the VRRP tracker
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.1.5 Managing VRRP Groups

Two or more VRRP instances can be assigned to be in the same VRRP Group, in which case, they can failover together.

13.1.5.1 Viewing a List of VRRP Groups

To view a list of VRRP groups, type:

```
show running-config services vrrp group
```

If groups have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services vrrp group
services
 vrrp
  group group1
  !
 !
!
```

If no VRRP groups have been configured, add groups as needed. For more information, refer to "Adding a VRRP Group (Page 743)".

13.1.5.2 Adding a VRRP Group

To add a VRRP group, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the group by typing:

   ```
   services vrrp group { name }
   ```

   Where:

   - `{ name }` is the name of the VRRP group
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.1.5.3 Deleting a VRRP Group

To delete a VRRP group, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the group by typing:

   ```
   no services vrrp group { name }
   ```

   Where:

   - `{ name }` is the name of the VRRP group
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.1.6 Managing VRRP Instances

VRRP instances define the interfaces monitored by VRRP. Two or more instances can be added to the same VRRP group, which allows them to failover together.

13.1.6.1 Viewing a List of VRRP Instances

To view a list of VRRP instances, type:

```
show running-config services vrrp instance
```

If instances have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services vrrp instance
services
 vrrp
  instance vid20
   interface switch.0001
   vrid      10
   priority  100
   group     group1
   monitor fe-cm-1
   !
   track-script tracker1
   !
   vrip 192.168.0.10/24
   !
  !
 !
!
```

If no VRRP instances have been configured, add instances as needed. For more information, refer to "Adding a VRRP Instance (Page 744)".

13.1.6.2 Adding a VRRP Instance

To add a VRRP instance, do the following:

1. Make sure the CLI is in Configuration mode.
2. Make sure a VRRP group has been configured. For more information, refer to "Adding a VRRP Group (Page 743)".
3. Add the instance by typing:

   ```
   services vrrp instance { name }
   ```

   Where:

   - `{ name }` is the name of the VRRP instance. The name must not include spaces.
4. Configure the following parameter(s) as required:

⚠ NOTICE

When **use-virtual-mac** is enabled, an additional firewall interface *vrrp.{VRID}* is required, where *{VRID}* is the name of the virtual router identifier. For more information about adding a firewall interface, refer to "Adding an Interface (Page 228)".

Note

A preemption occurs when either:

- a backup VRRP router gains higher priority and transitions to the Master state
- VRRP is initiated and this router has higher priority than that of any VRRP router on the network

Parameter	Description
`vrrp-version { vrrp-version }`	**Synopsis:** An integer between 2 and 3 **Default:** 2 Configure VRRP version for this instance.
`interface { interface }`	**Synopsis:** A string The interface used by the VRRP service to communicate with other VRRP-enabled routers using the VRRP protocol. Additionally, this interface hosts the Virtual IP (VRIP) when the 'Use Virtual MAC' parameter is not enabled.
`vrid { vrid }`	**Synopsis:** An integer between 1 and 255 The Virtual Router ID. All routers supplying the same VRIP should have the same VRID.
`priority { priority }`	**Synopsis:** An integer between 0 and 255 The priority for the VRRP instance. When electing the master, the highest priority wins. The configurable range is 1 to 255. A value of zero (0) is invalid.
`advert-interval { advert-interval }`	**Synopsis:** An integer between 1 and 255 **Default:** 1 VRRP2 advertisement interval, in seconds.
`advert-interval-millisecond { advert-interval-millisecond }`	**Synopsis:** An integer between 20 and 3000 **Default:** 1000 VRRP3 advertisement interval in millisecond, must be multiple of 10.
`garp-delay { garp-delay }`	**Synopsis:** An integer between 1 and 255 **Default:** 5 Gratuitous ARP delay, in seconds. Sets the delay after the router changes state state before a second set of gratuitous ARPs are sent.

Parameter	Description
`nopreempt`	When enabled, a lower priority router maintains its role as master even if this router has a higher priority.
`preempt-delay { preempt-delay }`	**Synopsis:** An integer between 0 and 1000 **Default:** 0 The time, in seconds, after startup until preemption.
`fault-to-master-delay { fault-to-master-delay }`	**Synopsis:** An integer between 0 and 1000 **Default:** 0 The delay, in seconds, before a transition from the fault state to the master state occurs, thereby preempting the current master.
`use-virtual-mac`	When enabled, the router uses a virtual MAC address for the Virtual IP (VRIP).
`group { group }`	**Synopsis:** A string between 1 and 64 characters long Binds this VRRP instance to a VRRP group.

5. [Optional] Add one or more VRRP monitors. For more information, refer to "Adding a VRRP Monitor (Page 747)".
6. [Optional] Add one or more track scripts. For more information, refer to "Adding a Track Script (Page 749)".
7. Add one or more virtual IP addresses. For more information, refer to "Adding a Virtual IP Address (Page 750)".
8. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.1.6.3 Deleting a VRRP Instance

To delete a VRRP instance, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the instance by typing:

   ```
   no services vrrp instance { name }
   ```

   Where:

   - `{ name }` is the name of the VRRP instance
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.1.7 Managing VRRP Monitors

A VRRP monitor selects an extra interface to monitor. If the interface becomes unavailable, the router will relinquish control of the gateway IP address to another VRRP Router.

13.1.7.1 Viewing a List of VRRP Monitors

To view a list of VRRP monitors, type:

```
show running-config services vrrp instance { name } monitor
```

Where:

- `{ name }` is the name of the VRRP instance

If monitors have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services vrrp instance monitor
services
 vrrp
  instance vid20
   monitor fe-cm-1
   !
  !
 !
!
```

If no VRRP monitors have been configured, add monitors as needed. For more information, refer to "Adding a VRRP Monitor (Page 747)".

13.1.7.2 Adding a VRRP Monitor

To add a VRRP monitor, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the instance by typing:

   ```
   services vrrp instance { name } monitor { interface }
   ```

   Where:

   - `{ name }` is the name of the VRRP instance
   - `{ interface }` is the name of the extra interface to monitor
3. Configure the following parameter(s) as required:

Parameter	Description
`weight { weight }`	**Synopsis:** An integer between -254 and 254 The amount by which to increase or decrease the router's priority. When negative, the priority decreases by this amount when the interface fails. When positive, the priority increases by this amount when the interface is up. When not set, the state changes to the fault state when the interface fails.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.1.7.3 Deleting a VRRP Monitor

To delete a VRRP monitor, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the monitor by typing:

   ```
   no services vrrp instance { name } monitor { interface }
   ```

   Where:

   - `{ name }` is the name of the VRRP instance
   - `{ interface }` is the name of the extra interface to monitor
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.1.8 Managing Track Scripts

Track scripts are used to associate VRRP trackers with VRRP instances.

13.1.8.1 Viewing a List of Track Scripts

To view a list of track scripts, type:

```
show running-config services vrrp instance { name } monitor
```

Where:

- `{ name }` is the name of the VRRP instance

If track scripts have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services vrrp instance track-script
services
```

```
 vrrp
  instance vid20
   track-script tracker1
   !
  !
 !
!
```

If no track scripts have been configured, add track scripts as needed. For more information, refer to "Adding a Track Script (Page 749)".

13.1.8.2 Adding a Track Script

To add a track script, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the track script by typing:

   ```
   services vrrp instance { name } track-script
   { tracker }
   ```

   Where:

   - `{ name }` is the name of the VRRP instance
   - `{ tracker }` is the name of the tracker to use to monitor the VRRP instance
3. Configure the following parameter(s) as required:

Parameter	Description
`weight { weight }`	**Synopsis:** An integer between -254 and 254 This setting overwrites the weight setting in the tracker. If negative, the priority decreases by this amount when the tracker falls. If positive, the priority increases by this amount when the tracker rises. If not set, the weight value in the tracker will be used.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.1.8.3 Deleting a Track Script

To delete a track script, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the track script by typing:

   ```
   no services vrrp instance { name } track-script
   { tracker }
   ```

   Where:

- `{ name }` is the name of the VRRP instance
- `{ tracker }` is the name of the tracker to use to monitor the VRRP instance

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.1.9 Managing Virtual IP Addresses

Virtual IP addresses represent the default gateways used by the hosts on the shared LAN.

Note
A VRRP packet will be ignored if any virtual IP address listed in the packet is not defined on the device. A syslog message is added for every 20 ignored VRRP packets.

13.1.9.1 Viewing a List of Virtual IP Addresses

To view a list of virtual IP addresses, type:

```
show running-config services vrrp instance { name } vrip
```

Where:

- `{ name }` is the name of the VRRP instance

If addresses have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services vrrp instance vid20 vrip
services
 vrrp
  instance vid20
   vrip 192.168.0.10/24
   !
  !
 !
!
```

If no virtual IP addresses have been configured, add addresses as needed. For more information, refer to "Adding a Virtual IP Address (Page 750)".

13.1.9.2 Adding a Virtual IP Address

To add a virtual IP address, do the following:

1. Make sure the CLI is in Configuration mode.

2. Add the instance by typing:

   ```
   services vrrp instance { name } vrip { address }
   ```

   Where:

   - `{ name }` is the name of the VRRP instance
   - `{ address }` is the address and subnet

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.1.9.3 Deleting a Virtual IP Address

To delete a virtual IP address, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the virtual IP address by typing:

   ```
   no services vrrp instance { name } vrip
   { address }
   ```

   Where:

   - `{ name }` is the name of the VRRP instance
   - `{ address }` is the virtual IP address and netmask

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.1.10 Managing Connection Synchronization

This section describes how to configure connection synchronization between two VRRP-enabled routers.

13.1.10.1 Configuring Connection Synchronization

To configure connection synchronization, do the following for *each* VRRP-enabled device:

⚠ NOTICE
Well-formed stateful firewall rules are required. For more information, refer to "Stateless vs. Stateful Firewalls (Page 217)".

1. Configure a firewall with stateful firewall rules to control inbound and outbound traffic. For more information, refer to "Adding a Firewall (Page 221)".
2. Make sure the VRRP service is enabled. For more information, refer to "Enabling/Disabling VRRP (Page 740)".

3. Configure VRRP instances and groups. For more information, refer to "Adding a VRRP Instance (Page 744)" and "Adding a VRRP Group (Page 743)".
4. Define one or more dedicated links for each VRRP group. For more information, refer to "Adding a Dedicated Link (Page 753)".
5. Select a link to be the default dedicated link for any VRRP group not assigned a dedicated link. For more information, refer to "Selecting a Default Dedicated Link (Page 754)".
6. Enable the configuration synchronization service. For more information, refer to "Enabling/Disabling Connection Synchronization (Page 752)".

Once the configuration is complete, verify the status of the service on both devices. For more information, refer to "Viewing the Status of Each Dedicated Link (Page 754)".

13.1.10.2 Enabling/Disabling Connection Synchronization

To enable or disable connection synchronization, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable or disable connection synchronization by typing:

   Enabling

   ```
   services conn-sync enabled
   ```

   Disabling

   ```
   no services conn-sync enabled
   ```

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.1.10.3 Viewing a List of Dedicated LInks

To view a list of dedicated links, type:

```
show running-config services conn-sync dedicated-link | tab
```

If dedicated links have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services conn-sync dedicated-link | tab
                                                    SEND    RECV
NAME  INTERFACE  IP         MCAST IP    GROUP  BUFFER  BUFFER
-------------------------------------------------------------------
3     fe-2-3     100.0.5.1  225.0.0.51  3781   1220    1220
4     fe-2-4     100.1.5.1  225.0.0.52  3782   1220    1220

 !
!
```

If no dedicated links have been configured, add dedicated links as needed. For more information, refer to "Adding a Dedicated Link (Page 753)".

13.1.10.4 Adding a Dedicated Link

To add a dedicated link, do the following:

1. Make sure the CLI is in Configuration mode.

   Note
   RUGGEDCOM ROX II supports up to four dedicated links.

2. Add a dedicated link by typing:

   ```
   services conn-sync dedicated-link { name }
   ```

   Where { name } is the name of the dedicated link.

3. Configure the following parameter(s) as required:

Parameter	Description
`interface { interface }`	**Synopsis:** A string between 1 and 15 characters long The interface name of the dedicated link.
`ip { ip }`	**Synopsis:** A string between 7 and 15 characters long or A string between 6 and 40 characters long The IPv4 or IPv6 address of the dedicated link interface.
`mcast-ip { mcast-ip }`	**Synopsis:** A string between 7 and 15 characters long or A string between 7 and 39 characters long **Default:** 225.0.0.50 The destination IPv4 or IPv6 multicast address of the dedicated link.
`group { group }`	**Synopsis:** An integer between 1 and 65535 **Default:** 3780 The multicast group ID of the cluster.
`send-buffer { send-buffer }`	**Synopsis:** An integer between 64 and 2560 **Default:** 1220 The sending socket buffer size in kB.
`recv-buffer { recv-buffer }`	**Synopsis:** An integer between 64 and 2560 **Default:** 1220 The receiving socket buffer size in kB.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.1.10.5 Deleting a Dedicated Link

To delete a dedicated link, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the dedicated link by typing:

   `no services conn-sync dedicated-link { name }`

   Where { name } is the name of the dedicated link.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.1.10.6 Selecting a Default Dedicated Link

To select a default a dedicated link, do the following:

1. Make sure the CLI is in Configuration mode.
2. Set the default dedicated link by typing:

   `services conn-sync default-dedicated-link { link }`

   Where { link } is the name of the default dedicated link.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.1.10.7 Viewing the Status of Each Dedicated Link

To view the status of all dedicated links, do the following:

1. Make sure the CLI is in Configuration mode.
2. To view the status of all dedicated links, type the following:

   `show services conn-sync status`

   A list similar to the following example appears:

```
ruggedcom# show services conn-sync status
status fe-2-3
 state           NO-CARRIER
 role            ACTIVE
 byte sent       3614860
 byte received   0
 packet sent     114224
 packet received 0
 error sent      0
 error received  0
status fe-2-4
 state           NO-CARRIER
 role            BACKUP
 byte sent       0
 byte received   0
 packet sent     0
 packet received 0
```

```
  error sent      0
  error received  0
```

The list provides the following information:

Parameter	Description
`{ name }`	**Synopsis:** A string The conn-sync dedicated link interface name.
`state`	**Synopsis:** A string The conn-sync dedicated link status.
`role`	**Synopsis:** A string The conn-sync dedicated link role.
`byte-sent`	**Synopsis:** An integer The number of bytes sent on conn-sync dedicated link.
`byte-received`	**Synopsis:** An integer The number of bytes received on conn-sync dedicated link.
`packet-sent`	**Synopsis:** An integer The number of packets sent on conn-sync dedicated link.
`packet-received`	**Synopsis:** An integer The number of packets received on conn-sync dedicated link.
`error-sent`	**Synopsis:** An integer The number of errors sent on conn-sync dedicated link.
`error-received`	**Synopsis:** An integer The number of errors received on conn-sync dedicated link.

13.2 Managing VRRP within VRF

RUGGEDCOM ROX II supports VRRP configuration within VRF definitions, for IPv4 addresses. This allows gateway redundancy to be applied to individual VRF instances.

For more information about virtual routing and forwarding, refer to "VRF Concepts (Page 670)".

13.2.1 Configuring VRRP within VRF

To configure VRRP within a VRF, do the following:

1. Configure virtual routing and forwarding. For more information, refer to "Configuring VRF (Page 671)".
2. Enable the VRRP service for each VRF definition. For more information, refer to "Adding VRRP Service to a VRF (Page 757)".

3. [Optional] Add VRRP trackers as needed. For more information, refer to "Adding a VRRP Tracker for a VRF (Page 759)".
4. [Optional] Add VRRP groups as needed. For more information, refer to "Adding a VRRP Group for a VRF (Page 761)".
5. [Optional] Add VRRP monitors as needed. For more information, refer to "Adding a VRRP Monitor to a VRF (Page 765)".
6. [Optional] Add track scripts as needed. For more information, refer to "Adding a VRRP Track Script to a VRF (Page 766)".
7. Add a virtual IP address for the VRF. For more information, refer to "Adding a Virtual IP Address to a VRF (Page 768)".
8. Verify the network configuration.

13.2.2 Viewing the VRRP Status for a VRF

To view the VRRP status for a VRF, type:

```
show services vrrp vrf { name } status
```

Where:

- `{ name }` is the name of the VRF

IIf VRRP instances have been configured, a table or list similar to the following example appears:

```
 show services vrrp vrf vrf1 status
                                                                    MONITOR
                                                        INTERFACE   INTERFACE
NAME      STATE   PRIORITY  TIME CHANGE               STATE       STATE
-------------------------------------------------------------------------------
vrf-ins1  backup  130       Thu Jan 24 11:08:54 2019  fe-1-1 is Up
```

This table or list provides the following information:

Parameter	Description
`{ name }`	**Synopsis:** A string The VRRP instance name.
`state`	**Synopsis:** A string The VRRP instance state.
`priority`	**Synopsis:** A string The VRRP instance priority.
`time-change`	**Synopsis:** A string The time of change to the current state.
`interface-state`	**Synopsis:** A string The VRRP interface state.

Parameter	Description
monitor-interface-state	**Synopsis:** A string Monitors the interface state.

13.2.3 Configuring VRRP Service for a VRF

This section describes how to view, add and delete VRRP for a VRF.

13.2.3.1 Viewing a List of VRFs Configured with VRRP Service

To view a list of VRFs configured with VRRP service, type:

```
show running-config services vrrp vrf
```

If a VRF has been configured with VRRP service, a table or list similar to the following example appears:

```
show running-config services vrrp vrf
services
 vrrp
  vrf vrf1
   enabled
   no router-id
   group Grp-1
   !
   trackers tracker net-6
    network  6.6.6.4/30
    interval 1
   !
   instance vrf-ins1
    vrrp-version                3
    interface                   fe-1-1
    vrid                        101
    priority                    150
    advert-interval-millisecond 20
    group                       Grp-1
    vrip 100.100.100.101/24
    !
   !
```

If no VRF has been configured with VRRP service, add as needed. For more information, refer to "Adding VRRP Service to a VRF (Page 757)".

13.2.3.2 Adding VRRP Service to a VRF

To add VRRP service to a VRF, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the definition by typing:

   ```
   services vrrp vrf { name }
   ```

Where:

- `{ name }` is the name of the VRF. The name must be unique and not exceed 32 characters or contain spaces. The first character must also not be a special character. Only the following special characters are permitted in the remainder of the name: hyphen (-), underscore (_), colon (:), and period (.).

3. Configure the following parameter(s) as required:

Parameter	Description
`enabled`	Enables or disables the VRRP service.
`router-id { router-id }`	**Synopsis:** A string The router ID for VRRP logs.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.2.3.3 Deleting VRRP Service from a VRF

To delete VRRP service from a VRF, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the definition key by typing:

   ```
   no services vrrp vrf { name }
   ```

   Where:

   - `{ name }` is the name of the VRRP for VRF.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.2.4 Managing VRRP Trackers for a VRF

VRRP trackers monitor the state/condition of a route. When the route is unavailable, VRRP will lower its priority or transition it to a fault state.

Note
The decision to increase or decrease the priority of a route must be done in coordination with any backup VRRP Routers since the priority decides whether a router becomes a Master or a Backup. For example, if Router X's priority is 150 and Router Y's priority is 145, Router X's priority must be lowered by 6 to make it a Backup router.

13.2.4.1 Viewing a List of VRRP Trackers for a VRF

To view a list of VRRP trackers for a VRF, type:

```
show running-config services vrrp vrf trackers
```

If trackers have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services vrrp vrf trackers
services
 vrrp
  vrf vrf1
   trackers tracker net-6
    network  6.6.6.4/30
    interval 1
   !
  !
 !
```

If no VRRP trackers have been configured, add trackers as needed. For more information, refer to "Adding a VRRP Tracker for a VRF (Page 759)".

13.2.4.2 Adding a VRRP Tracker for a VRF

To add a VRRP tracker for a VRF, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the tracker by typing:

   ```
   services vrrp vrf trackers { name }
   ```

   Where:

   - `{ name }` is the name of the VRRP tracker
3. Configure the following parameter(s) as required:

Parameter	Description
`type { type }`	**Synopsis:** [route] **Default:** route The type of condition for the tracker to check.
`network { network }`	**Synopsis:** A string between 9 and 18 characters long The network to track. The tracker checks for a route to this network in the routing table.
`interface { interface }`	**Synopsis:** A string The interface to the tracked network. The tracker rises only when the route to the monitored network is through this interface.
`interval { interval }`	**Synopsis:** An integer between 1 and 120 The number of seconds between tracker queries.

Parameter	Description
`weight { weight }`	**Synopsis:** An integer between -254 and 254 The amount by which to increase or decrease the router's priority. When negative, the priority decreases by this amount when the tracker falls. When positive, the priority increases by this amount when the tracker rises. When not set, the state changes to the fault state when the tracker falls.
`rise { rise }`	**Synopsis:** An integer between 1 and 65535 The number of successful tracker queries before changing the router priority.
`fall { fall }`	**Synopsis:** An integer between 1 and 65535 The number of unsuccessful tracker queries before changing the router priority.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.2.4.3 Deleting a VRRP Tracker for a VRF

To delete a VRRP tracker for a VRF, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the tracker by typing:

   ```
   no services vrrp vrf trackers { name }
   ```

   Where:

   - `{ name }` is the name of the VRRP tracker
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.2.5 Managing VRRP Groups for a VRF

Two or more VRRP instances can be assigned to be in the same VRRP Group, in which case, they can failover together.

13.2.5.1 Viewing a List of VRRP Groups for a VRF

To view a list of VRRP groups, type:

```
show running-config services vrrp vrf group
```

If groups have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services vrrp vrf group
```

```
services
 vrrp
  vrf vrf1
   group Grp-1
   !
  !
 !
```

If no VRRP groups have been configured, add groups as needed. For more information, refer to "Adding a VRRP Group (Page 743)".

13.2.5.2 Adding a VRRP Group for a VRF

To add a VRRP group for a VRF, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the group by typing:

   `services vrrp vrf group { name }`

   Where:

   - `{ name }` is the name of the VRRP group
3. Configure the following parameter(s) as required:

Parameter	Description
`name { name }`	**Synopsis:** A string between 1 and 64 characters long The VRRP group name.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.2.5.3 Deleting a VRRP Group

To delete a VRRP group, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the group by typing:

   `no services vrrp vrf group { name }`

   Where:

   - `{ name }` is the name of the VRRP group
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.2.6 Managing VRRP Instances for a VRF

VRRP instances can be configured for one or more VRF definitions. This is done by by enabling VRRP for a VRF and then configuring the required VRRP parameters.

13.2.6.1 Viewing a List of VRRP Instances for a VRF

To view a list of VRF instances defined for OSPF, type:

```
show running-config services vrrp vrf instance
```

If instances have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services vrrp vrf instance
services
 vrrp
  vrf vrf1
   instance vrf-ins1
    vrrp-version                3
    interface                   fe-1-1
    vrid                        101
    priority                    220
    advert-interval-millisecond 500
    group                       Grp-1
    vrip 100.100.100.101/24
    !
   !
  !
```

If no instances have been configured for a VRF, add instances as needed. For more information, refer to "Adding a VRRP Instance for a VRF (Page 762)".

13.2.6.2 Adding a VRRP Instance for a VRF

To add a VRRP instance for a VRF, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the group by typing:

   ```
   services vrrp vrf { name } instance
   ```

   Where:

   - `{ name }` is the name of the VRF
3. Configure the following parameter(s) as required:

> **⚠ NOTICE**
>
> When **use-virtual-mac** is enabled, an additional firewall interface *vrrp.{VRID}* is required, where *{VRID}* is the name of the virtual router identifier. For more information about adding a firewall interface, refer to "Adding an Interface (Page 228)".

Parameter	Description
`vrrp-version { vrrp-version }`	**Synopsis:** An integer between 2 and 3 **Default:** 2 Configure VRRP version for this instance.
`interface { interface }`	**Synopsis:** A string The interface used by the VRRP service to communicate with other VRRP-enabled routers using the VRRP protocol. Additionally, this interface hosts the Virtual IP (VRIP) when the 'Use Virtual MAC' parameter is not enabled.
`vrid { vrid }`	**Synopsis:** An integer between 1 and 255 The Virtual Router ID. All routers supplying the same VRIP should have the same VRID.
`priority { priority }`	**Synopsis:** An integer between 0 and 255 The priority for the VRRP instance. When electing the master, the highest priority wins. The configurable range is 1 to 255. A value of zero (0) is invalid.
`advert-interval { advert-interval }`	**Synopsis:** An integer between 1 and 255 **Default:** 1 VRRP2 advertisement interval, in seconds.
`advert-interval-millisecond { advert-interval-millisecond }`	**Synopsis:** An integer between 20 and 3000 **Default:** 1000 VRRP3 advertisement interval in millisecond, must be multiple of 10.
`garp-delay { garp-delay }`	**Synopsis:** An integer between 1 and 255 **Default:** 5 Gratuitous ARP delay, in seconds. Sets the delay after the router changes state state before a second set of gratuitous ARPs are sent.
`nopreempt`	When enabled, a lower priority router maintains its role as master even if this router has a higher priority.
`preempt-delay { preempt-delay }`	**Synopsis:** An integer between 0 and 1000 **Default:** 0 The time, in seconds, after startup until preemption.
`fault-to-master-delay { fault-to-master-delay }`	**Synopsis:** An integer between 0 and 1000 **Default:** 0 The delay, in seconds, before a transition from the fault state to the master state occurs, thereby preempting the current master.
`use-virtual-mac`	When enabled, the router uses a virtual MAC address for the Virtual IP (VRIP).
`group { group }`	**Synopsis:** A string between 1 and 64 characters long Binds this VRRP instance to a VRRP group.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.2.6.3 Deleting a VRRP Instance for a VRF

To delete a VRF instance for a VRF, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the definition key by typing:

   ```
   no services vrrp vrf { name } instance
   ```

   Where:

   - `{ name }` is the name of the VRF
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.2.7 Managing VRRP Monitors for a VRF

A VRRP monitor selects an extra interface to monitor. If the interface becomes unavailable, the router will relinquish control of the gateway IP address to another VRRP Router.

13.2.7.1 Viewing a List of VRRP Monitors for a VRF

To view a list of VRRP monitors, type:

```
show running-config services vrrp vrf { vrf name }
instance { name } monitor
```

Where:

- `{ vrf name }` is the name of the VRF
- `{ name }` is the name of the VRRP instance

If monitors have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services vrrp vrf instance vrf-ins1 monitor
services
 vrrp
  vrf vrf1
   instance vrf-ins1
    monitor fe-1-1
    !
   !
  !
 !
!
```

If no monitors have been configured, add monitors as needed. For more information, refer to "Adding a VRRP Monitor to a VRF (Page 765)".

13.2.7.2 Adding a VRRP Monitor to a VRF

To add a VRRP monitor to a VRF, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the instance by typing:

   ```
   services vrrp vrf { vrf name } instance { name }
   monitor { interface }
   ```

   Where:

   - `{ vrf name }` is the name of the VRF
   - `{ name }` is the name of the VRRP instance
   - `{ interface }` is the name of the extra interface to monitor
3. Configure the following parameter(s) as required:

Parameter	Description
`weight { weight }`	**Synopsis:** An integer between -254 and 254 The amount by which to increase or decrease the router's priority. When negative, the priority decreases by this amount when the interface fails. When positive, the priority increases by this amount when the interface is up. When not set, the state changes to the fault state when the interface fails.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.2.7.3 Deleting a VRRP Monitor from a VRF

To delete a VRRP monitor, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the monitor by typing:

   ```
   no services vrrp vrf { vrf name } instance
   { name } monitor { interface }
   ```

   Where:

   - `{ vrf name }` is the name of the VRF
   - `{ name }` is the name of the VRRP instance
   - `{ interface }` is the name of the extra interface to delete
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.2.8 Managing VRRP Track Scripts for a VRF

Track scripts are used to associate VRRP trackers with VRRP instances.

13.2.8.1 Viewing a List of VRRP Track Scripts for a VRF

To view a list of track scripts, type:

```
show running-config services vrrp vrf instance
{ name } track-script
```

Where:

- `{ name }` is the name of the VRRP instance

If track scripts have been configured, a table or list similar to the following example appears:

```
show running-config services vrrp vrf instance vrf-ins1  track-script
services
 vrrp
  vrf vrf1
   instance vrf-ins1
    track-script net-6
    !
   !
  !
 !
!
```

If no track scripts have been configured, add track scripts as needed. For more information, refer to "Adding a VRRP Track Script to a VRF (Page 766)".

13.2.8.2 Adding a VRRP Track Script to a VRF

To add a track script, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the track script by typing:

   ```
   services vrrp vrf { vrf name } instance { name }
   track-script { tracker }
   ```

   Where:

   - `{ vrf name }` is the name of the VRF
   - `{ name }` is the name of the VRRP instance
   - `{ tracker }` is the name of the tracker to use to monitor the VRRP instance
3. Configure the following parameter(s) as required:

Parameter	Description
`weight { weight }`	**Synopsis:** An integer between -254 and 254 This setting overwrites the weight setting in the tracker. If negative, the priority decreases by this amount when the tracker falls. If positive, the priority increases by this amount when the tracker rises. If not set, the weight value in the tracker will be used.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.2.8.3 Deleting a VRRP Track Script from a VRF

To delete a track script, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the track script by typing:

   ```
   no services vrrp vrf { vrf name } instance
   { name } track-script { tracker }
   ```

   Where:

   - `{ vrf name }` is the name of the VRF
   - `{ name }` is the name of the VRRP instance
   - `{ tracker }` is the name of the tracker to use to monitor the VRRP instance
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.2.9 Managing Virtual IP Addresses for a VRF

Virtual IP addresses represent the default gateways used by the hosts on the shared LAN.

Note
A VRRP packet will be ignored if any virtual IP address listed in the packet is not defined on the device. A syslog message is added for every 20 ignored VRRP packets.

13.2.9.1 Viewing a List of Virtual IP Addresses

To view a list of virtual IP addresses, type:

```
show running-config services vrrp vrf { vrf name }
instance { name } vrip
```

Where:

- `{ vrf name }` is the name of the VRF
- `{ name }` is the name of the VRRP instance

If VRIPs have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services vrrp vrf vrf1 instance vrf-ins1 vrip
services
 vrrp
  vrf vrf1
   instance vrf-ins1
    vrip 100.100.100.101/24
    !
   !
  !
 !
```

If no virtual IP addresses have been configured, add addresses as needed. For more information, refer to "Adding a Virtual IP Address to a VRF (Page 768)".

13.2.9.2 Adding a Virtual IP Address to a VRF

⚠ NOTICE
At least one virtual IP address is required for each configured VRF instance.

To add a virtual IP address to a VRF, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the instance by typing:

   `services vrrp vrf { vrf name } instance { name } vrip { address }`

   Where:

   - `{ vrf name }` is the name of the VRF
   - `{ name }` is the name of the VRRP instance
   - `{ address }` is the address and subnet
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.2.9.3 Deleting a Virtual IP Address from a VRF

To delete a virtual IP address from a VRF, do the following:

1. Make sure the CLI is in Configuration mode.

2. Delete the virtual IP address by typing:

   ```
   no services vrrp vrf { vrf name } instance
   { name } vrip { address }
   ```

   Where:

   - `{ vrf name }` is the name of the VRF
   - `{ name }` is the name of the VRRP instance
   - `{ address }` is the address and subnet

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.2.10 Example: Configuring VRRP within a VRF

This example demonstrates how to configure VRRP within a VRF instance.

The following topology depicts a scenario where a PC/host is attempting to send a packet to a destination via a default gateway (VRIP) owned by the VRRP routers. If the Master router (R1) fails, a backup router (R2) is elected Master and acts as the gateway. The previous Master then transitions to a fault state or becomes a backup.

⚠ NOTICE

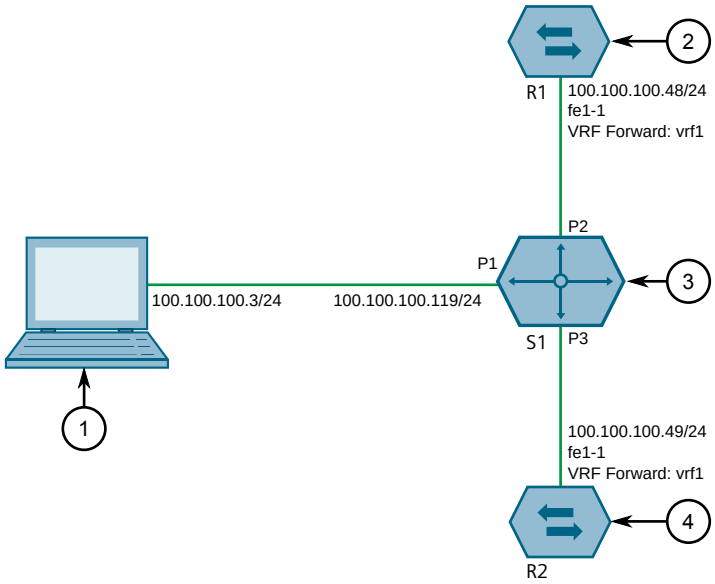
RUGGEDCOM ROX II supports VRRP within VRF for IPv4 addresses only.

⚠ NOTICE

Connection synchronization is not supported for VRRPs within a VRF. For more information about connection synchronization, refer to "Connection Synchronization (Page 739)".

⚠ NOTICE

The values shown are specific to the provided topology. Actual values can vary based on the user's configuration.



① PC
② Router R1
③ Layer 2 Switch S1
④ Router R2

Figure 13.4 Topology – VRRP within a VRF

To configure the devices per the topology, do the following:

1. Configure switch S1:

   Note
   The device may be a RUGGEDCOM ROX II device acting as Layer 2 switch, a RUGGEDCOM ROS device, or a third party Layer 2 device.

   a. Add VLAN 100. For more information, refer to "Adding a Static VLAN (Page 363)".

   b. Assign IP address *100.100.100.119* to VLAN 100. For more information, refer to "Adding an IPv4 Address (Page 251)".

   c. Assign VLAN 100 to ports 1, 2 and 3. For more information, refer to "Configuring a Switched Ethernet Port (Page 314)".

2. Connect port 1 of switch S1 to a PC.
3. Connect port 2 of switch S1 to router R1.
4. Connect port 3 of switch S1 to router R2.
5. Configure router R1:

   a. Configure a VRF definition for *vrf1* with a route distinguisher of **100:1**. For more information, refer to "Adding a VRF Definition (Page 674)".

   b. Define a route target for vrf1 of type **both** with the export community set to **100:1**. For more information, refer to "Adding a Route Target (Page 676)".

c. Make sure interface fe-1-1 is configured with the IP address 100.100.100.48/24.

d. Assign the interfaces in step 5.c to forward traffic to vrf1. For more information, refer to "Configuring a VRF Interface (Page 672)".

e. Enable VRRP Service for VRF. For more information, refer to "Adding VRRP Service to a VRF (Page 757)".

f. Configure a VRF instance with the folowing parameters:

Interface	Virtual Router ID	Priority
fe-1-1	101	150

For more information, refer to "Adding a VRRP Instance for a VRF (Page 762)".

g. Add virtual IP address 100.100.100.101/24 to the VRF. For more information, refer to "Adding a Virtual IP Address to a VRF (Page 768)".

6. Configure router R2:

a. Configure a VRF definition for *vrf1* with a route distinguisher of **`100:1`**. For more information, refer to "Adding a VRF Definition (Page 674)".

b. Define a route target for vrf1 of type **both** with the export community set to **`100:1`**. For more information, refer to "Adding a Route Target (Page 676)".

c. Make sure interface fe-1-1 is configured with the IP address 100.100.100.49/24.

d. Assign the interfaces in step 6.c to forward traffic to vrf1. For more information, refer to "Configuring a VRF Interface (Page 672)".

e. Enable VRRP Service for VRF. For more information, refer to "Adding VRRP Service to a VRF (Page 757)".

f. Configure a VRF instance with the folowing parameters:

Interface	VRID	Priority
fe-1-1	101	130

For more information, refer to "Adding a VRRP Instance for a VRF (Page 762)".

g. Add virtual IP address 100.100.100.101/24 to the VRF. For more information, refer to "Adding a Virtual IP Address to a VRF (Page 768)".

Verification

To verify the configuration, from the PC ping VRIP 100.100.100.101/24. If the configuration is successful the Master will respond.

Final Configuration Example

The following configurations reflect the topology:

```
R1# show services vrrp vrf vrf1 status
                                                                        MONITOR
                                                          INTERFACE     INTERFACE
NAME      STATE  PRIORITY  TIME CHANGE                  STATE         STATE
-------------------------------------------------------------------------------
vrf-ins1  master  150       Fri Jan 25 13:43:52 2019  fe-1-1 is Up
```

```
R2# show services vrrp vrf vrf1 status
                                                                        MONITOR
                                                          INTERFACE     INTERFACE
NAME      STATE  PRIORITY  TIME CHANGE                  STATE         STATE
-------------------------------------------------------------------------------
vrf-ins1  backup  130       Fri Jan 25 13:43:52 2019  fe-1-1 is Up
```

13.3 Managing Link Failover Protection

Link failover provides an easily configurable means of raising a backup link upon the failure of a designated main link. The main and backup links can be Ethernet and Cellular Modem.

Link failover can back up to multiple remote locations, managing multiple main-to-backup link relationships. When the backup link is a modem, many profiles of dialed numbers can exist, each serving as a distinct backup link.

Link failover can back up a permanent, high-speed WAN link to a permanent, low-speed WAN link. Use this function when OSPF cannot be employed, such as on public links.

Link failover can also be used to migrate the default route from the main link to the backup link.

The time after a main link failure to backup link startup, and the time after a main link recovery to backup link stoppage, are configurable. The link failover function also provides failover status information and a test of the failover settings.

13.3.1 Viewing the Link Failover Log

To view the link failover log, do the following:

1. Make sure the CLI is in Configuration mode.
2. Display the log by typing:

   ```
   services  link-failover   log
   ```

   A table or list similar to the following appears:

```
ruggedcom(config)# services link-failover switch.0001 log
link-backup-log /var/log/syslog:Jan 25 09:46:49 R1-RX1512 linkd[4183]: linkd initializing.
/var/log/syslog:Jan 25 09:46:49 R1-RX1512 linkd[4183]: linkd configured and started.
/var/log/syslog:Jan 25 09:46:49 R1-RX1512 linkd[4183]: linkd_interface_up: interface fe-cm-1 is up
/var/log/syslog:Jan 25 09:46:51 R1-RX1512 linkd[4183]: creating thread to monitor main=switch.0001
/var/log/syslog:Jan 25 09:46:51 R1-RX1512 linkd[4183]: setting new_backup_record
/var/log/syslog:Jan 25 09:46:51 R1-RX1512 linkd[4183]: setting new_backup_record done!
/var/log/syslog:Jan 25 09:46:51 R1-RX1512 linkd[4183]: dumping backup record:
```

```
/var/log/syslog:Jan 25 09:46:51 R1-RX1512 linkd[4183]:   main_interface = switch.0001
/var/log/syslog:Jan 25 09:46:51 R1-RX1512 linkd[4183]:     main_test_host = 10.10.10.10
/var/log/syslog:Jan 25 09:46:51 R1-RX1512 linkd[4183]:     start_delay = 180
/var/log/syslog:Jan 25 09:46:51 R1-RX1512 linkd[4183]:     main_path_down_timeout = 60
/var/log/syslog:Jan 25 09:46:51 R1-RX1512 linkd[4183]:     main_path_up_timeout = 60
/var/log/syslog:Jan 25 09:46:51 R1-RX1512 linkd[4183]:     backup_path_up_timeout = 60
/var/log/syslog:Jan 25 09:46:51 R1-RX1512 linkd[4183]:     ping_timeout = 2
/var/log/syslog:Jan 25 09:46:51 R1-RX1512 linkd[4183]:     ping_interval = 60
/var/log/syslog:Jan 25 09:46:51 R1-RX1512 linkd[4183]:     ping_retry_count = 3
/var/log/syslog:Jan 25 09:46:51 R1-RX1512 linkd[4183]:     backup_interface = fe-1-1
/var/log/syslog:Jan 25 09:46:51 R1-RX1512 linkd[4183]:       backup gateway = 192.168.1.2
/var/log/syslog:Jan 25 09:46:51 R1-RX1512 linkd[4183]:       ondemand = yes
/var/log/syslog:Jan 25 09:46:51 R1-RX1512 linkd[4183]:       distance = 1
/var/log/syslog:Jan 25 09:46:51 R1-RX1512 linkd[4183]:       transfer default route = yes
/var/log/syslog:Jan 25 09:46:51 R1-RX1512 linkd[4183]:     backup_interface = te1-2-1c01ppp
/var/log/syslog:Jan 25 09:46:51 R1-RX1512 linkd[4183]:       ondemand = yes
/var/log/syslog:Jan 25 09:46:51 R1-RX1512 linkd[4183]:       distance = 1
/var/log/syslog:Jan 25 09:46:51 R1-RX1512 linkd[4183]:       transfer default route = yes
/var/log/syslog:Jan 25 09:46:55 R1-RX1512 linkd[4183]: linkd_interface_up: interface fe-1-1 is up
/var/log/syslog:Jan 25 09:46:55 R1-RX1512 linkd[4183]: linkd_interface_down: interface fe-1-1 is down
/var/log/syslog:Jan 25 09:46:55 R1-RX1512 linkd[4183]: linkd_interface_up: interface fe-1-1 is up
/var/log/syslog:Jan 25 09:46:55 R1-RX1512 linkd[4183]: linkd_interface_down: interface fe-1-1 is down
/var/log/syslog:Jan 25 09:46:55 R1-RX1512 linkd[4183]: linkd_interface_up: interface fe-cm-1 is up
/var/log/syslog:Jan 25 09:46:55 R1-RX1512 linkd[4183]: linkd_interface_up: interface switch.0001 is up
/var/log/syslog:Jan 25 09:47:11 R1-RX1512 linkd[4183]: linkd_interface_down: interface switch.0001 is
 down
/var/log/syslog:Jan 25 09:47:14 R1-RX1512 linkd[4183]: linkd_interface_up: interface switch.0001 is up
/var/log/syslog:Jan 25 09:49:52 R1-RX1512 linkd[4183]: Start monitoring link backup set: "switch.0001"
```

13.3.2 Viewing the Link Failover Status

The Link Failover Status form displays the current link failover status. To view the link failover status, do the following:

```
show  services  link-failover  status
```

A table or list similar to the following appears:

```
ruggedcom# show services link-failover status
             MAIN    BACKUP  MAIN                                                  BACKUP
             LINK    LINK    PING  TIME OF LAST STATE                              INTERFACE
MAIN         STATUS  STATUS  TEST  CHANGE                    LINK BACKUP STATE     IN USE
-------------------------------------------------------------------------------------------
switch.0001  up      down    ok    Fri Jan 25 09:49:52 2013  Main path is active  fe-1-1
```

The table or list provides the following information:

Parameter	Description
`main-link-status`	**Synopsis:** A string The main link status.
`backup-link-status`	**Synopsis:** A string The backup link status.
`main-ping-test`	**Synopsis:** A string The results of pinging the target using the main interface.

Parameter	Description
`time-of-last-state-change`	**Synopsis:** A string The time of the last state change.
`link-backup-state`	**Synopsis:** A string The backup link state.
`backup-interface-in-use`	**Synopsis:** A string The name of the backup interface that is being used.

13.3.3 Managing Link Failover Parameters

This section describes how to manage parameter settings for link failover.

13.3.3.1 Viewing a List of Link Failover Parameters

To view a list of link failover parameters, type:

```
show running-config services link-failover
```

If parameters have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services link-failover
services
 link-failover switch.0001
  enabled
  backup fe-1-1
   transfer-default-route
   backup-gateway         192.168.1.2
  !
  backup te1-2-1c01ppp
   priority               second
   transfer-default-route
  !
  target 10.10.10.10
  !
 !
!
```

If no parameters have been configured, add parameters as needed. For more information, refer to "Adding a Link Failover Parameter (Page 774)".

13.3.3.2 Adding a Link Failover Parameter

To add a link failover parameter, do the following:

Note
The link failover feature can only be configured on a routable interface. For the link failover feature to be used on a switched port, another VLAN must be configured (for

example, switch.0002) to logically differentiate the switched port from the default PVID VLAN 1 (switch.0001).

1. Make sure the CLI is in Configuration mode.
2. Add the parameter by typing:

   ```
   services link-failover { interface }
   ```

   Where:

   - `{ interface }` is the name of the interface
3. Configure the following parameter(s) as required:

Parameter	Description
`enabled`	Enables this link backup.
`ping-timeout { ping-timeout }`	**Synopsis:** An integer between 1 and 65536 **Default:** 2 The time interval, in seconds, before immediately retrying a ping.
`ping-interval { ping-interval }`	**Synopsis:** An integer between 0 and 65536 **Default:** 60 The time interval, in seconds, between ping tests.
`ping-retry { ping-retry }`	**Synopsis:** An integer between 0 and 65536 **Default:** 3 The number of ping retries before constructing a path failure.
`start-delay { start-delay }`	**Synopsis:** An integer between 0 and 65536 **Default:** 180 The delay time, in seconds, when first starting link failover.
`main-down-timeout { main-down-timeout }`	**Synopsis:** An integer between 0 and 65536 **Default:** 60 The delay time, in seconds, that the main trunk is down before starting the backup trunk.
`main-up-timeout { main-up-timeout }`	**Synopsis:** An integer between 0 and 65536 **Default:** 60 The delay time, in seconds, to confirm that the main trunk is up (returned to service) before stopping the backup trunk.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.3.3.3 Deleting a Link Failover Parameter

To delete a link failover parameter, do the following:

1. Make sure the CLI is in Configuration mode.

2. Delete the parameter by typing:

   ```
   no services link-failover { interface }
   ```

   Where:

   - `{ interface }` is the name of the interface

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.3.4 Managing Link Failover Backup Interfaces

A backup interface is the interface to which link failover switches when the main interface is determined to be down. You can add up to three backup interfaces to each link failover configuration.

13.3.4.1 Viewing a List of Link Failover Backup Interfaces

To view a list of link failover backup interfaces, type:

```
show running-config services link-failover
{ interface } backup
```

Where:

- `{ interface }` is the name of the interface

If backup interfaces have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services link-failover switch.0001 backup
services
 link-failover switch.0001
  backup fe-1-1
   transfer-default-route
   backup-gateway         192.168.1.2
  !
  backup te1-2-1c01ppp
   priority               second
   transfer-default-route
  !
 !
!
```

If no backup interfaces have been configured, add backup interfaces as needed. For more information, refer to "Adding a Link Failover Backup Interface (Page 776)".

13.3.4.2 Adding a Link Failover Backup Interface

To set a link failover backup interface, do the following:

1. Make sure the CLI is in Configuration mode.

2. Add the backup interface by typing:

   ```
   services link-failover { interface } backup
   { backup-interface }
   ```

   Where:

   - `{ interface }` is the name of the interface
   - `{ backup-interface }` is the name of the secondary, backup interface

3. Configure the following parameter(s) as required:

   Note
   Do not configure the `backup-gateway` parameter for Point to Point (P2P) links.

   Note
   The `on-demand` parameter is set at the interface itself.

Parameter	Description
`priority { priority }`	**Synopsis:** [third | second | first] **Default:** first The priority which is applied to the backup interface when switching.
`transfer-default-route`	The transfer default gateway on the switching main and backup interface. The default route on the device must have a **distance** greater than one.
`backup-gateway { backup-gateway }`	**Synopsis:** A string 15 characters long The IP address of the backup gateway.
`on-demand`	**Synopsis:** [true | false] Displays the status of the interface's On-demand option. When enabled, link failover can set the interface to up or down as needed. The interface is down until needed by link failover. When disabled, link failover cannot set the interface to up or down. By default, the interface is always up.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.3.4.3 Deleting a Link Failover Backup Interface

To delete a link failover backup interface, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the backup interface by typing:

   ```
   no services link-failover { interface } backup
   { backup-interface }
   ```

Where:

- `{ interface }` is the name of the interface
- `{ backup-interface }` is the name of the secondary, backup interface

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.3.5 Managing Link Failover Ping Targets

A link failover ping target is an IP address that link failover pings to determine if the main link is down. The address can be a dedicated host or a dummy address on a router. Up to three link failover ping targets can be added to each link failover configuration.

13.3.5.1 Viewing a List of Link Failover Ping Targets

To view a list of link failover ping targets, type:

```
show running-config services link-failover
{ interface } target
```

Where:

- `{ interface }` is the name of the interface

If ping targets have been configured, a table or list similar to the following example appears:

```
R1-RX1512# show running-config services link-failover switch.0001 target
services
 link-failover switch.0001
  target 10.10.10.10
  !
 !
!
```

If no ping targets have been configured, add targets as needed. For more information, refer to "Adding a Link Failover Ping Target (Page 778)".

13.3.5.2 Adding a Link Failover Ping Target

To add a link failover ping target, do the following:

Note
Link failover pings each target separately. If all targets are down, the main link is considered to be down and it fails over to the backup interface. Backup links are used in the order of their Priority setting (first, second, and then third), always starting with the first priority interface. When a higher-priority interface becomes available again, the system reverts to the higher priority interface. For example, if the second

priority interface is active, the system switches back to the first priority interface when the first priority interface becomes available again.

1. Make sure the CLI is in Configuration mode.
2. Add the ping target by typing:

   ```
   services link-failover { interface } target
   { address }
   ```

   Where:

   - `{ interface }` is the name of the interface
   - `{ address }` is the IP address of the target host to verify the main path
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.3.5.3 Deleting a Link Failover Ping target

To delete a link failover ping target, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the backup interface by typing:

   ```
   no services link-failover { interface } target
   { address }
   ```

   Where:

   - `{ interface }` is the name of the interface
   - `{ address }` is the IP address of the target host to verify the main path
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.3.6 Testing Link Failover

The link failover settings can be tested to confirm that each link failover configuration works properly. To launch the test, specify for how long the system should operate on the backup interface, and for how long the system should delay before starting the test. Canceling the test returns the interfaces to their pre-test condition.

While the test is running, monitor the status of the test to observe the main and backup link status, ping test results, state change, backup state, and backup interface information. As the test progresses, this information changes as link failover switches from the main interface to the backup interface. For more information on the **Link Fail Over Status** form, refer to "Viewing the Link Failover Status (Page 773)".

To launch a link failover test, do the following:

Note
The link failover test can be canceled at any time. For more information about canceling a link failover test, refer to "Canceling a Link Failover Test (Page 780)".

Canceling the test returns the interfaces to their pre-test condition.

1. Make sure the CLI is in Configuration mode.
2. Start the test by typing:

   ```
   services link-failover { interface } start-test
   start-test-delay { delay } test-duration { duration }
   ```

   Where:

   - `{ interface }` is the name of the interface
   - `{ delay }` is the time (in seconds) to wait before running the test
   - `{ duration }` is the maximum time (in minutes) to run the test before restoring service to the main trunk

13.3.7 Canceling a Link Failover Test

To cancel a link failover test, type:

```
services link-failover { interface } cancel-test
```

Where:

- `{ interface }` is the name of the interface

13.4 Managing Spanning Tree Protocol

This section describes how to manage the Spanning Tree Protocol (STP).

13.4.1 RSTP Operation

The IEEE 802.1D Spanning Tree Protocol (STP) was developed to enable the construction of robust networks that incorporate redundancy while pruning the active topology of the network to prevent loops. While STP is effective, it requires that frame transfer halt after a link outage until all bridges in the network are guaranteed to be aware of the new topology. Using the values recommended by IEEE 802.1D, this period lasts 30 seconds.

The Rapid Spanning Tree Protocol (RSTP), first introduced by IEEE 802.1w and significantly improved in IEEE 802.12D-2004, was a further evolution of the IEEE 802.1D Spanning Tree Protocol. It replaced the settling period with an active

handshake between bridges that guarantees the rapid propagation of topology information throughout the network.

13.4.1.1 RSTP States and Roles

RSTP bridges have roles to play, either root or designated. One bridge – the Root Bridge – is the logical center of the network. All other bridges in the network are Designated bridges. RSTP also assigns each port of the bridge a state and a role. The RSTP state describes what is happening at the port in relation to address learning and frame forwarding. The RSTP role basically describes whether the port is facing the center or the edges of the network and whether it can currently be used.

State

There are three RSTP states: Discarding, Learning and Forwarding.

The discarding state is entered when the port is first put into service. The port does not learn addresses in this state and does not participate in frame transfer. The port looks for RSTP traffic in order to determine its role in the network. When it is determined that the port will play an active part in the network, the state will change to learning.

The learning state is entered when the port is preparing to play an active part in the network. The port learns addresses in this state but does not participate in frame transfer. In a network of RSTP bridges, the time spent in this state is usually quite short. RSTP bridges operating in STP compatibility mode will spend six to 40 seconds in this state.

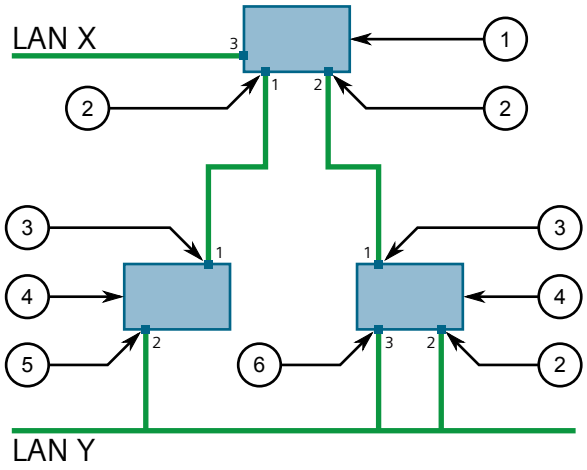
After *learning*, the bridge will place the port in the forwarding state. The port both learns addresses and participates in frame transfer while in this state.

⚠ NOTICE
Purely for purposes of management, RUGGEDCOM ROX II introduces two more states: *Disabled* and *Link Down*. The *Disabled* state refers to links for which RSTP has been disabled. The *Link Down* state refers to links for which RSTP is enabled but are currently down.

Role

There are four RSTP port roles: Root, Designated, Alternate and Backup. If the bridge is not the root bridge, it must have a single Root Port. The Root Port is the “best” (i.e. quickest) way to send traffic to the root bridge.

A port is marked as Designated if it is the best port to serve the LAN segment it is connected to. All bridges on the same LAN segment listen to each other's messages and agree on which bridge is the Designated Bridge. The ports of other bridges on the segment must become either Root, Alternate or Backup ports.



① Root Bridge
② Designated Bridge
③ Designated Port
④ Root Port
⑤ Alternate Port
⑥ Backup Port

Figure 13.5 Bridge and Port Roles

A port is alternate when it receives a better message from another bridge on the LAN segment it is connected to. The message that an Alternate Port receives is better than the port itself would generate, but not good enough to convince it to become the Root Port. The port becomes the alternate to the current Root Port and will become the new Root Port should the current Root Port fail. The Alternate Port does not participate in the network.

A port is a Backup Port when it receives a better message from the LAN segment it is connected to, originating from another port on the same bridge. The port is a backup for another port on the bridge and will become active if that port fails. The Backup Port does not participate in the network.

13.4.1.2 Edge Ports

A port may be designated as an Edge Port if it is directly connected to an end station. As such, it cannot create bridging loops in the network and can thus directly transition to forwarding, skipping the listening and learning stages.

Edge ports that receive configuration messages immediately lose their Edge Port status and become normal spanning tree ports. A loop created on an improperly connected edge port is thus quickly repaired.

Because an Edge Port services only end stations, topology change messages are not generated when its link toggles.

13.4.1.3 Point-to-Point and Multipoint Links

RSTP uses a peer-peer protocol called Proposing-Agreeing to ensure transitioning in the event of a link failure. This protocol is point-to-point and breaks down in multipoint situations, i.e. when more than two bridges operate on a shared media link.

If RSTP detects this circumstance (based upon the port's half duplex state after link up) it will switch off Proposing-Agreeing. The port must transition through the learning and forwarding states, spending one forward delay in each state.

There are circumstances in which RSTP will make an incorrect decision about the point-to-point state of the link simply by examining the half-duplex status, namely:

- The port attaches only to a single partner, but through a half-duplex link.
- The port attaches to a shared media hub through a full-duplex link. The shared media link attaches to more than one RSTP enabled bridge.

In such cases, the user may configure the bridge to override the half-duplex determination mechanism and force the link to be treated in the proper fashion.

13.4.1.4 Path and Port Costs

The STP path cost is the main metric by which root and designated ports are chosen. The path cost for a designated bridge is the sum of the individual port costs of the links between the root bridge and that designated bridge. The port with the lowest path cost is the best route to the root bridge and is chosen as the root port.

Note
In actuality the primary determinant for root port selection is the root bridge ID. Bridge ID is important mainly at network startup when the bridge with the lowest ID is elected as the root bridge. After startup (when all bridges agree on the root bridge's ID) the path cost is used to select root ports. If the path costs of candidates for the root port are the same, the ID of the peer bridge is used to select the port. Finally, if candidate root ports have the same path cost and peer bridge ID, the port ID of the peer bridge is used to select the root port. In all cases the lower ID, path cost or port ID is selected as the best.

How Port Costs Are Generated

Port costs can be generated either as a result of link auto-negotiation or manual configuration. When the link auto-negotiation method is used, the port cost is derived from the speed of the link. This method is useful when a well-connected network has been established. It can be used when the designer is not too concerned with the resultant topology as long as connectivity is assured.

Manual configuration is useful when the exact topology of the network must be predictable under all circumstances. The path cost can be used to establish the topology of the network exactly as the designer intends.

STP vs. RSTP Costs

The STP specification limits port costs to values of 1 to 65536. Designed at a time when 9600 bps links were state of the art, this method breaks down in modern use, as the method cannot represent a link speed higher than 10 Gbit/s.

To remedy this problem in future applications, the RSTP specification limits port costs to values of 1 to 20000000, and a link speed up to 10 Tbit/s can be represented with a value of 2.

13.4.1.5 Bridge Diameter

The bridge diameter is the maximum number of bridges between any two possible points of attachment of end stations to the network.

The bridge diameter reflects the realization that topology information requires time to propagate hop by hop through a network. If configuration messages take too long to propagate end to end through the network, the result will be an unstable network.

There is a relationship between the bridge diameter and the maximum age parameter.

Note
The RSTP algorithm is as follows:

- STP configuration messages contain *age* information.
- Messages transmitted by the root bridge have an age of 0. As each subsequent designated bridge transmits the configuration message it must increase the age by at least 1 second.
- When the age exceeds the value of the maximum age parameter the next bridge to receive the message immediately discards it.

To achieve extended ring sizes, Siemens's eRSTP™ uses an age increment of ¼ of a second. The value of the maximum bridge diameter is thus four times the configured maximum age parameter.

⚠ **NOTICE**
Raise the value of the maximum age parameter if implementing very large bridged networks or rings.

13.4.1.6 eRSTP

Siemens's enhanced Rapid Spanning Tree Protocol (eRSTP) improves the performance of RSTP in two ways:

- Improves the fault recovery time performance (< 5 ms per hop)
- Improves performance for large ring network topologies (up to 160 switches)

eRSTP is also compatible with standard RSTP for interoperability with commercial switches.

For example, in a network comprised of 15 RUGGEDCOM hardened Ethernet switches in a ring topology, the expected fault recovery time would be less than 75 ms (i.e. 5 ms x 15). However, with eRSTP, the worst case fault recovery time is less than 26 ms.

13.4.1.7 Fast Root Failover

Siemens's *Fast Root Failover* feature is an enhancement to RSTP that may be enabled or disabled. Fast Root Failover improves upon RSTP's handling of root bridge failures in mesh-connected networks, resulting in slightly increased failover times for some non-root bridge scenarios.

⚠ NOTICE

In networks mixing RUGGEDCOM and non-RUGGEDCOM switches, or in those mixing Fast Root Failover algorithms, RSTP Fast Root Failover will not function properly and root bridge failure will result in an unpredictable failover time. To avoid potential issues, note the following:

- When using the Robust algorithm, all switches must be RUGGEDCOM switches
- When using the Relaxed algorithm, all switches must be RUGGEDCOM switches, with the exception of the root switch
- All RUGGEDCOM switches in the network must use the same Fast Root Failover algorithm

Two Fast Root Failover algorithms are available:

- **Robust** – Guarantees a deterministic root failover time, but requires support from all switches in the network, including the root switch
- **Relaxed** – Ensures a deterministic root failover time in most network configurations, but allows the use of a standard bridge in the root role

Note

The minimum interval for root failures is one second. Multiple, near simultaneous root failures (within less than one second of each other) are not supported by Fast Root Failover.

Fast Root Failover and RSTP Performance

- Running RSTP with Fast Root Failover disabled has no impact on RSTP performance.
- Fast Root Failover has no effect on RSTP performance in the case of failures that do not involve the root bridge or one of its links.
- The extra processing introduced by Fast Root Failover significantly decreases the worst-case failover time in mesh networks, with a modest increase in the

best-case failover time. The effect on failover time in ring-connected networks, however, is only to increase it.

Recommendations On the Use of Fast Root Failover

- It is not recommended to enable Fast Root Failover in single ring network topologies
- It is strongly recommended to always connect the root bridge to each of its neighbor bridges using more than one link

13.4.2 RSTP Applications

This section describes various applications of RSTP.

13.4.2.1 RSTP in Structured Wiring Configurations

RSTP may be used to construct structured wiring systems where connectivity is maintained in the event of link failures. For example, a single link failure of any link between A and N in Figure 13.6, “Example - Structured Wiring Configuration” would leave all the ports of bridges 555 through 888 connected to the network.

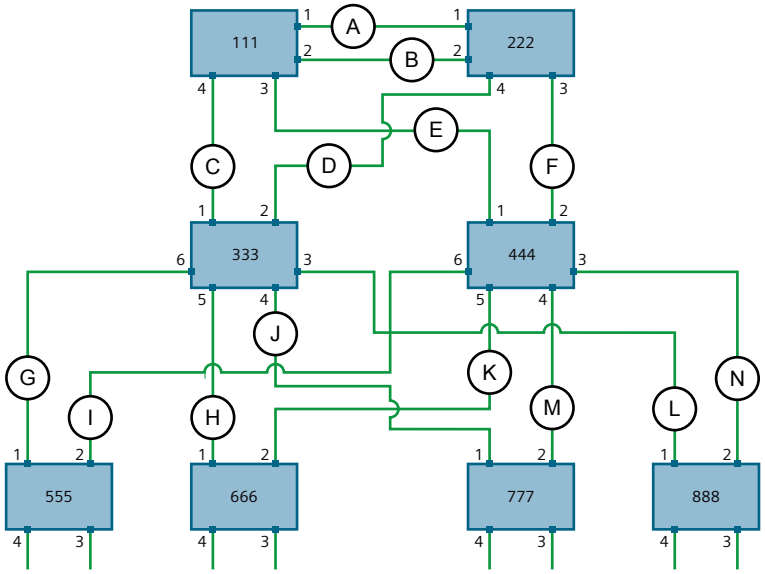


Figure 13.6 Example - Structured Wiring Configuration

To design a structured wiring configuration, do the following:

1. **Select the design parameters for the network.**

   What are the requirements for robustness and network failover/recovery times? Are there any special requirements for diverse routing to a central host computer? Are there any special port redundancy requirements?

2. **Identify required legacy support.**

   Are STP bridges used in the network? These bridges do not support rapid transitioning to forwarding. If these bridges are present, can they be re-deployed closer to the network edge?

3. **Identify edge ports and ports with half-duplex/shared media restrictions.**

   Ports that connect to host computers, IEDs and controllers may be set to edge ports in order to guarantee rapid transitioning to forwarding as well as to reduce the number of topology change notifications in the network. Ports with half-duplex/shared media restrictions require special attention in order to guarantee that they do not cause extended fail-over/recovery times.

4. **Choose the root bridge and backup root bridge carefully.**

   The root bridge should be selected to be at the concentration point of network traffic. Locate the backup root bridge adjacent to the root bridge. One strategy that may be used is to tune the bridge priority to establish the root bridge and then tune each bridge's priority to correspond to its distance from the root bridge.

5. **Identify desired steady state topology.**

   Identify the desired steady state topology taking into account link speeds, offered traffic and QOS. Examine of the effects of breaking selected links, taking into account network loading and the quality of alternate links.

6. **Decide upon a port cost calculation strategy.**

   Select whether fixed or auto-negotiated costs should be used? It is recommended to use the auto-negotiated cost style, unless it is necessary for the network design to change the auto-negotiated cost style. Select whether the STP or RSTP cost style should be used. Make sure to configure the same cost style on all devices on the network.

7. **Enable RSTP Fast Root Failover option.**

   This is a proprietary feature of Siemens. In a mesh network with only RUGGEDCOM devices in the core of the network, it is recommended to enable the RSTP Fast Root Failover option to minimize the network downtime in the event of a Root bridge failure.

8. Calculate and configure priorities and costs.
9. Implement the network and test under load.

13.4.2.2 RSTP in Ring Backbone Configurations

RSTP may be used in ring backbone configurations where rapid recovery from link failure is required. In normal operation, RSTP will block traffic on one of the links. For an example, refer to link H in Figure 13.7, "Example - Ring Backbone Configuration". In the event of a failure on link D, bridge 444 will unblock link H and bridge 333 will communicate with the network through link F.

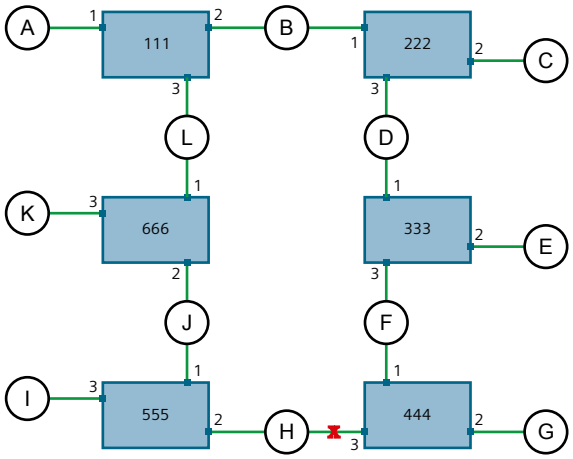


Figure 13.7 Example - Ring Backbone Configuration

To design a ring backbone configuration with RSTP, do the following:

1. **Select the design parameters for the network.**

   What are the requirements for robustness and network fail-over/recovery times? Typically, ring backbones are chosen to provide cost effective but robust network designs.

2. **Identify required legacy support and ports with half-duplex/shared media restrictions.**

   These bridges should not be used if network fail-over/recovery times are to be minimized.

3. **Identify edge ports.**

   Ports that connect to host computers, IEDs and controllers may be set to edge ports in order to guarantee rapid transitioning to forwarding as well as to reduce the number of topology change notifications in the network.

4. **Choose the root bridge.**

   The root bridge can be selected to equalize either the number of bridges, number of stations or amount of traffic on either of its legs. It is important to realize that the ring will always be broken in one spot and that traffic always flows through the root.

5. **Assign bridge priorities to the ring.**

   For more information, refer to the RUGGEDCOM White Paper " Performance of the Rapid Spanning Tree Protocol in Ring Network Topology [https://assets.new.siemens.com/siemens/assets/api/uuid:d4af5d17-728c-493f-b00a-9c4db67b23ed/RSTP-whitepaper-EN-09-2020.pdf] ".

6. **Decide upon a port cost calculation strategy.**

   It is recommended to use the auto-negotiated cost style, unless it is necessary for the network design to change the auto-negotiated cost style. Select whether

the STP or RSTP cost style should be used. Make sure to configure the same cost style on all devices on the network.

7. **Disable RSTP Fast Root Failover option.**

   This is a proprietary feature of Siemens. In RUGGEDCOM ROX II, the RSTP Fast Root Failover option is enabled by default. It is recommended to disable this feature when operating in a Ring network.

8. Implement the network and test under load.

13.4.2.3 RSTP Port Redundancy

In cases where port redundancy is essential, RSTP allows more than one bridge port to service a LAN. In the following example, if port 3 is designated to carry the network traffic of LAN A, port 4 will block traffic. Should an interface failure occur on port 3, port 4 will assume control of the LAN.

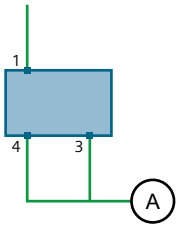


Figure 13.8 Example - Port Redundancy

13.4.3 MSTP Operation

The Multiple Spanning Tree (MST) algorithm and protocol provide greater control and flexibility than RSTP and legacy STP. MSTP (Multiple Spanning Tree Protocol) is an extension of RSTP, whereby multiple spanning trees may be maintained on the same bridged network. Data traffic is allocated to one or several spanning trees by mapping one or more VLANs to different Multiple Spanning Tree Instances (MSTIs).

The sophistication and utility of the MSTP implementation on a given bridged network is proportional to the amount of planning and design invested in configuring MSTP.

If MSTP is activated on some or all of the bridges in a network with no additional configuration, the result will be a fully and simply connected network. At best though, the result will be the same as a network using only RSTP. Taking full advantage of the features offered by MSTP requires a potentially large number of configuration variables to be derived from an analysis of data traffic on the bridged network, and from requirements for load sharing, redundancy, and path optimization. Once these parameters have all been derived, it is also critical they are consistently applied and managed across all bridges in an MST region.

By design, MSTP processing time is proportional to the number of active STP instances. This means MSTP will likely be significantly slower than RSTP. Therefore, for mission critical applications, RSTP should be considered a better network redundancy solution than MSTP.

13.4.3.1 MSTP Regions and Interoperability

In addition to supporting multiple spanning trees in a network of MSTP-capable bridges, MSTP is capable of inter-operating with bridges that support only RSTP or legacy STP, without requiring any special configuration.

An MST region may be defined as the set of interconnected bridges whose MST Region Identification is identical. The interface between MSTP bridges and non-MSTP bridges, or between MSTP bridges with different MST Region Identification information, becomes part of an MST Region boundary.

Bridges outside an MST region will see the entire region as though it were a single (R)STP bridge, with the internal detail of the MST region being hidden from the rest of the bridged network. In support of this, MSTP maintains separate *hop counters* for spanning tree information exchanged at the MST region boundary versus information propagated inside the region. For information received at the MST region boundary, the (R)STP Message Age is incremented only once. Inside the region, a separate Remaining Hop Count is maintained, one for each spanning tree instance. The external Message Age parameter is referred to the (R)STP Maximum Age Time, whereas the internal Remaining Hop Counts are compared to an MST region-wide Maximum Hops parameter.

MSTI

An MSTI (Multiple Spanning Tree Instance) is one of sixteen independent spanning tree instances that may be defined in an MST region (not including the IST). An MSTI is created by mapping a set of VLANs to a given MSTI ID. The same mapping must be configured on all bridges that are intended to be part of the MSTI. Moreover, all VLAN-to-MSTI mappings must be identical for all bridges in an MST region.

RUGGEDCOM ROX II supports 16 MSTIs in addition to the IST.

Each MSTI has a topology that is independent of others. Data traffic originating from the same source and bound to the same destination, but on different VLANs on different MSTIs, may therefore travel a different path across the network.

IST

An MST region always defines an IST (Internal Spanning Tree). The IST spans the entire MST region, and carries all data traffic that is not specifically allocated (by VLAN) to a specific MSTI. The IST is always computed and is defined to be MSTI zero.

The IST is also the extension inside the MST region of the CIST

CST

The CST (Common Spanning Tree) spans the entire bridged network, including MST regions and any connected STP or RSTP bridges. An MST region is seen by the CST as an individual bridge, with a single cost associated with its traversal.

CIST

The CIST (Common and Internal Spanning Tree) is the union of the CST and the ISTs in all MST regions. The CIST therefore spans the entire bridged network, reaching into each MST region via the latter's IST to reach every bridge on the network.

13.4.3.2 MSTP Bridge and Port Roles

MSTP supports the following bridge and port roles:

Bridge Roles

Role	Description
CIST Root	The CIST Root is the elected root bridge of the CIST (Common and Internal Spanning Tree), which spans all connected STP and RSTP bridges and MSTP regions.
CIST Regional Root	The root bridge of the IST within an MSTP region. The CIST Regional Root is the bridge within an MSTP region with the lowest cost path to the CIST Root. Note that the CIST Regional Root will be at the boundary of an MSTP region. Note also that it is possible for the CIST Regional Root to be the CIST Root.
MSTI Regional Root	The root bridge for an MSTI within an MSTP region. A root bridge is independently elected for each MSTI in an MSTP region.

Port Roles

Each port on an MSTP bridge may have more than one CIST role depending on the number and topology of spanning tree instances defined on the port.

Role	Description
CIST Port Roles	• The Root Port provides the minimum cost path from the bridge to the CIST Root via the CIST Regional Root. If the bridge itself happens to be the CIST Regional Root, the Root Port is also the Master Port for all MSTIs, and provides the minimum cost path to a CIST Root located outside the region. • A Designated Port provides the minimum cost path from an attached LAN, via the bridge to the CIST Regional Root. • Alternate and Backup Ports function the same as they do in RSTP, but relative to the CIST Regional Root.
MSTI Port Roles	For each MSTI on a bridge: • The Root Port provides the minimum cost path from the bridge to the MSTI Regional Root, if the bridge itself is not the MSTI Regional Root.

Role	Description
	• A Designated Port provides the minimum cost path from an attached LAN, via the bridge to the MSTI Regional Root. • Alternate and Backup Ports function the same as they do in RSTP, but relative to the MSTI Regional Root. The Master Port, which is unique in an MSTP region, is the CIST Root Port of the CIST Regional Root, and provides the minimum cost path to the CIST Root for all MSTIs.
Boundary Ports	A Boundary Port is a port on a bridge in an MSTP region that connects to either: a bridge belonging to a different MSTP region, or a bridge supporting only RSTP or legacy STP. A Boundary Port blocks or forwards all VLANs from all MSTIs and the CIST alike. A Boundary Port may be: • The CIST Root Port of the CIST Regional Root (and therefore also the MSTI Master Port). • A CIST Designated Port, CIST Alternate/Backup Port, or Disabled. At the MSTP region boundary, the MSTI Port Role is the same as the CIST Port Role. A Boundary Port connected to an STP bridge will send only STP BPDUs. One connected to an RSTP bridge need not refrain from sending MSTP BPDUs. This is made possible by the fact that the MSTP carries the CIST Regional Root Identifier in the field that RSTP parses as the Designated Bridge Identifier.

13.4.3.3 Benefits of MSTP

MSTP is configured by default to arrive automatically at a spanning tree solution for each configured MSTI. However, advantages may be gained from influencing the topology of MSTIs in an MST region by way of the Bridge Priority and the cost of each port.

Load Balancing

MSTP can be used to balance the data traffic load among sets of VLANs, enabling more complete utilization of a bridged network that has multiple redundant interconnections between bridges.

A bridged network controlled by a single spanning tree will block redundant links by design to avoid harmful loops. However, when using MSTP, any given link may have a different blocking state for MSTI, as maintained by MSTP. Any given link, therefore, might be in blocking state for some VLANs, and in forwarding state for other VLANs, depending on the mapping of VLANs to MSTIs.

It is possible to control the spanning tree solution for each MSTI, especially the set of active links for each tree, by manipulating per MSTI the bridge priority and the port costs of links in the network. If traffic is allocated judiciously to multiple VLANs, redundant interconnections in a bridged network, which would have gone unused when using a single spanning tree, can now be made to carry traffic.

Isolation of Spanning Tree Reconfiguration

A link failure in an MSTP region that does not affect the roles of Boundary ports will not cause the CST to be reconfigured, nor will the change affect other MSTP regions. This is due to the fact that MSTP information does not propagate past a region boundary.

MSTP versus PVST

An advantage of MSTP over the Cisco Systems Inc. proprietary Per-VLAN Spanning Tree (PVST) protocol is the ability to map multiple VLANs onto a single MSTI. Since each spanning tree requires processing and memory, the expense of keeping track of an increasing number of VLANs increases much more rapidly for PVST than for MSTP.

Compatibility with STP and RSTP

No special configuration is required for the bridges of an MST region to connect fully and simply to non-MST bridges on the same bridged network. Careful planning and configuration is, however, recommended to arrive at an optimal network design.

13.4.3.4 Implementing MSTP on a Bridged Network

The following procedure is recommended for configuring MSTP on a network. Beginning with a set of MSTP-capable Ethernet bridges, do the following for each bridge on the network:

Note
Careful network analysis and planning should inform each step of creating an MSTP network.

Note
MSTP does not need to be enabled to map a VLAN to an MSTI. However, the mapping must be identical for each bridge that belongs to the MSTP region.

1. Disable STP. For more information, refer to "Configuring STP Globally (Page 794)".
2. Configure one or more Multiple Spanning Tree Instances (MSTI), each with a unique bridge priority. For more information, refer to "Adding a Multiple Spanning Tree Instance (Page 801)".
3. Create static VLANs and map them to the MSTIs. For more information, refer to "Adding a Static VLAN (Page 363)".
4. Configure individual MSTI for each switched Ethernet port and/or Ethernet trunk interface that will transmit/receive MST BPDU (Bridge Protocol Data Unit) traffic. For more information, refer to "Managing Multiple Spanning Tree Instances Per-Port (Page 802)".

5. Set the STP protocol version to MSTP, configure the MST region identifier and revision level, and then enable STP. For more information, refer to "Configuring STP Globally (Page 794)".

13.4.4 Configuring STP Globally

To configure global settings for the Spanning Tree Protocol (STP), do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***switch » spanning-tree***.
3. Configure the basic STP settings by configuring the following parameter(s):

Parameter	Description
`enabled { enabled }`	**Synopsis:** [true | false] **Default:** true Enables STP/RSTP/MSTP for the bridge globally. Note that STP/RSTP/MSTP is enabled on a port when it is enabled globally and along with enabling per port setting.
`version { version }`	**Synopsis:** [stp | rstp | mstp] **Default:** rstp The version (either only STP or Rapid STP or Multiple STP) of the Spanning Tree Protocol (STP) to support.
`hello-time { hello-time }`	**Synopsis:** An integer between 1 and 10 **Default:** 2 The time between configuration messages issued by the root bridge. Shorter hello times result in faster detection of topology changes at the expense of moderate increases in STP traffic. (Relationship : maxAgeTime >= 2 * (helloTime + 1.0 seconds))
`max-age { max-age }`	**Synopsis:** An integer between 6 and 40 **Default:** 20 The time for which a configuration message remains valid after being issued by the root bridge. Configure this parameter with care when many tiers of bridges exist, or slow speed links (such as those used in WANs) are part of the network. (Relationship : maxAgeTime >= 2 * (helloTime + 1.0 seconds))
`tx-hold-count { tx-hold-count }`	**Synopsis:** An integer between 0 and 100 **Default:** 0 The maximum number of configuration messages on each port that may be sent in a special event, such as recovering from a failure or bringing up a new link. After the maximum number of messages is reached, Rapid Spanning Tree Protocol (RSTP) will be limited to one message per second. Larger values allow the network to recover from failed links more quickly. If RSTP is being used in a ring architecture, the transmit count should be larger than the number of switches in the ring. If a number is not defined, the value is considered unlimited.

Parameter	Description
`forward-delay { forward-delay }`	**Synopsis:** An integer between 4 and 30 **Default:** 15 The amount of time a bridge spends learning MAC addresses on a rising port before beginning to forward traffic. Lower values allow the port to reach the forwarding state more quickly, but at the expense of flooding unlearned addresses to all ports.
`max-hops { max-hops }`	**Synopsis:** An integer between 6 and 40 **Default:** 20 The maximum possible bridge diameter inside a Multiple Spanning Tree (MST) region. MST BPDUs propagating inside an MST region carry a time-to-live parameter decremented by every switch that propagates the BPDU. If the maximum number of hops inside the region exceeds the configured maximum, the BPDUs may be discarded due to their time-to-live information. This parameter is only applicable to Multiple Spanning Tree Protocol (MSTP) configurations.
`mst-region-name { mst-region-name }`	**Synopsis:** A string 32 characters long The name of the MST region. All devices in the same MST region must have the same region name configured
`mst-revision-level { mst-revision-level }`	**Synopsis:** An integer between 0 and 65535 **Default:** 0 The revision level for the MST configuration. Typically, all devices in the same MST region are configured with the same revision level. However, different revision levels can be used to create sub-regions under the same region name.

4. Configure the eRSTP settings by configuring the following parameter(s):

Parameter	Description
`max-net-diameter-multiplier { max-net-diameter-multiplier }`	**Synopsis:** [1 | 4] **Default:** 4 The Max Network Diameter as a multiplier of the MaxAgeTime value.
`bpdu-guard { bpdu-guard }`	**Synopsis:** [specify | noshutdown | untilreset] **Default:** noshutdown The Rapid Spanning Tree Protocol (RSTP) standard does not address network security. RSTP must process every received Bridge Protocol Data Unit (BPDU) and take an appropriate action. This opens a way for an attacker to influence RSTP topology by injecting RSTP BPDUs into the network. BPDU Guard is a feature that protects the network from BPDUs received by a port where RSTP-capable devices are not expected to be attached. If a BPDU is received by a port for which the 'Edge' parameter is set to 'TRUE' or RSTP is disabled, the port will be shut down for the time period specified by this parameter. • NO SHUTDOWN: BPDU Guard is disabled. • UNTIL RESET: The port will remain shut down until the port reset command is issued by the user.

Parameter	Description
	• SPECIFY: A timeout period is specified for the port using the BPDU Timeout parameter.
`bpdu-timeout { bpdu-timeout }`	**Synopsis:** An integer between 1 and 86400 The time for which a port is shutdown. Only applicable when BPDU Guard Mode is set to **specify** .
`fast-root-failover { fast-root-failover }`	**Synopsis:** [on | off | on-with-standard-root] **Default:** on The Fast Root Failover algorithm. Options include: • Off: The Fast Root Failover algorithm is disabled. As such, a root switch failure may result in excessive connectivity recovery time in a mesh network. • On: Fast Root Failover is enabled and the most robust algorithm is used, which restores network connectivity quickly in case of root bridge failure in a mesh network. • On with standard root: Fast Root Failover is enabled but a relaxed algorithm is used, allowing the use of a standard switch in the root role.
`dot1w-interop { dot1w-interop }`	**Synopsis:** [true | false] **Default:** true Enables/disables IEEE 802.1w Interoperability
`cost-style { cost-style }`	**Synopsis:** [stp | rstp] **Default:** stp The style of link costs to employ. STP uses 16-bit path costs based upon 1x10E9/link speed (4 for 1Gbps, 19 for 100 Mbps and 100 for 10 Mbps) whereas RSTP uses 32-bit costs based upon 2x10E13/link speed (20,000 for 1Gbps, 200,000 for 100 Mbps and 2,000,000 for 10 Mbps). Note that RSTP link costs are used only when the bridge version support is set to allow RSTP and the port does not migrate to the Spanning Tree Protocol (STP).

5. Configure the RSTP instance settings by configuring the following parameter(s):

Parameter	Description
`bridge-priority { bridge-priority }`	**Synopsis:** [0 | 4096 | 8192 | 12288 | 16384 | 20480 | 24576 | 28672 | 32768 | 36864 | 40960 | 45056 | 49152 | 53248 | 57344 | 61440] **Default:** 32768 The priority assigned to the RSTP/Common Bridge Instance.

6. If necessary, add Multiple Spanning Tree Instances (MSTI). For more information, refer to "Adding a Multiple Spanning Tree Instance (Page 801)".
7. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.4.5 Configuring STP for Switched Ethernet Ports and Ethernet Trunk Interfaces

To configure the Spanning Tree Protocol (STP) for a switched Ethernet port, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to:
   - **For switched Ethernet ports:**

     interface » switch » swport » {port} » spanning-tree, where *{port}* is the port number of the switched Ethernet port.
   - **For Ethernet trunk interfaces:**

     interface » trunks » {id} » spanning-tree, where *{id}* is the ID given to the interface.
3. Configure the following parameter(s):

Parameter	Description
`enabled { enabled }`	**Synopsis:** [true | false] **Default:** true Enables/disables STP/RSTP on the interface.
`admin-edge { admin-edge }`	**Synopsis:** [forceTrue | forceFalse | auto] **Default:** auto Edge ports are ports that do not participate in the spanning tree, but still send configuration messages. Edge ports transition directly to frame forwarding without any listening and learning delays. The MAC tables of edge ports do not need to be flushed when topology changes occur in the STP network. Unlike an STP-disabled port, accidentally connecting an edge port to another port in the spanning tree will result in a detectable loop. The **Edgeness** of the port will be switched off and the standard RSTP rules will apply (until the next link outage).
`admin-point-to-point { admin-point-to-point }`	**Synopsis:** [forceTrue | forceFalse | auto] **Default:** auto RSTP uses a peer-to-peer protocol that provides for rapid transitioning on point-to-point links. This protocol is automatically turned off in situations where multiple STP bridges communicate over a shared (non point-to-point) LAN. The bridge will automatically take point-to-point to be true when the link is found to be operating in full-duplex mode. The point-to-point parameter allows this behavior or overrides it, forcing point-to-point to be true or false. Force the parameter true when the port operates a point-to-point link but cannot run the link in full-duplex mode. Force the parameter false when the port operates the link in full-duplex mode, but is still not point-to-point (e.g. a full-duplex link to an unmanaged bridge that concentrates two other STP bridges).
`restricted-role`	If enabled, causes the port not to be selected as the root port for the CIST or any MSTI, even though it has the best spanning tree priority vector. This parameter should be FALSE by default.

Parameter	Description
`restricted-tcn`	If TRUE, causes the port not to propagate received topology change notifications and topology changes to other ports. This parameter should be FALSE by default. If set, it can cause a temporary loss of connectivity after changes in a spanning tree's active topology as a result of persistent, incorrectly learned station location information.
`rstp-priority { rstp-priority }`	**Synopsis:** [0 | 16 | 32 | 64 | 96 | 112 | 128 | 144 | 160 | 176 | 192 | 208 | 224 | 240] **Default:** 128 The STP port priority. Ports of the same cost that attach to a common LAN will select the port to be used based upon the port priority.
`stp-cost { stp-cost }`	**Synopsis:** [auto-cost] or An integer between 0 and 65535 **Default:** auto-cost The cost to use in cost calculations, when the cost style parameter is set to STP in the bridge RSTP parameters configuration. Setting the cost manually provides the ability to preferentially select specific ports to carry traffic over others. Leave this field set to 'auto' to use the standard STP port costs as negotiated (four for 1Gbps, 19 for 100 Mbps links and 100 for 10 Mbps links). For MSTP, this parameter applies to both external and internal path cost.
`rstp-cost { rstp-cost }`	**Synopsis:** [auto-cost] or An integer between 0 and 2147483647 **Default:** auto-cost The cost to use in cost calculations, when the cost style parameter is set to RSTP in the bridge RSTP parameters configuration. Setting the cost manually provides the ability to preferentially select specific ports to carry traffic over others. Leave this field set to 'auto' to use the standard RSTP port costs as negotiated (20,000 for 1Gbps, 200,000 for 100 Mbps links and 2,000,000 for 10 Mbps links). For MSTP, this parameter applies to both external and internal path costs.

4. If necessary, add Multiple Spanning Tree Instances (MSTI). For more information, refer to "Adding a Multiple Spanning Tree Instance (Page 801)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.4.6 Managing Multiple Spanning Tree Instances Globally

MSTP (Multiple Spanning Tree Protocol), as defined by the IEEE 802.1 standard, maps multiple VLANs to a single Spanning Tree instance, otherwise referred to as a Multiple Spanning Tree Instance (MSTI).

Each MSTI is assigned an MST ID and a bridge priority:

- The MST ID is used to associate the MSTI with a VLAN.

- The bridge priority is used by all devices in the Spanning Tree topology to determine which device among them is elected the root device or backbone. An ideal root device is one that is central to the network and not connected to end devices.

For more information about MSTP, refer to "MSTP Operation (Page 789)".

13.4.6.1 Viewing Statistics for Multiple Spanning Tree Instances

To view statistics related to Multiple Spanning Tree Instances (MSTIs), type:

```
show switch spanning-tree msti-status
```

A table or list similar to the following example appears:

```
ruggedcom# show switch spanning-tree msti-status | tab
                                                                                ROOT  ROOT  ROOT  TOTAL
INSTANCE          ROOT                          BRIDGE                        PORT  PORT  PATH  TOP
ID        STATUS  PRIORITY  ROOT MAC            PRIORITY  BRIDGE MAC          SLOT  PORT  COST  CHANGES
--------------------------------------------------------------------------------------------------------
1         none    0         00:00:00:00:00:00   0         00:00:00:00:00:00   ---   -1    0     0
2         none    0         00:00:00:00:00:00   0         00:00:00:00:00:00   ---   -1    0     0
3         none    0         00:00:00:00:00:00   0         00:00:00:00:00:00   ---   -1    0     0
4         none    0         00:00:00:00:00:00   0         00:00:00:00:00:00   ---   -1    0     0
5         none    0         00:00:00:00:00:00   0         00:00:00:00:00:00   ---   -1    0     0
6         none    0         00:00:00:00:00:00   0         00:00:00:00:00:00   ---   -1    0     0
7         none    0         00:00:00:00:00:00   0         00:00:00:00:00:00   ---   -1    0     0
8         none    0         00:00:00:00:00:00   0         00:00:00:00:00:00   ---   -1    0     0
9         none    0         00:00:00:00:00:00   0         00:00:00:00:00:00   ---   -1    0     0
10        none    0         00:00:00:00:00:00   0         00:00:00:00:00:00   ---   -1    0     0
11        none    0         00:00:00:00:00:00   0         00:00:00:00:00:00   ---   -1    0     0
12        none    0         00:00:00:00:00:00   0         00:00:00:00:00:00   ---   -1    0     0
13        none    0         00:00:00:00:00:00   0         00:00:00:00:00:00   ---   -1    0     0
14        none    0         00:00:00:00:00:00   0         00:00:00:00:00:00   ---   -1    0     0
15        none    0         00:00:00:00:00:00   0         00:00:00:00:00:00   ---   -1    0     0
16        none    0         00:00:00:00:00:00   0         00:00:00:00:00:00   ---   -1    0     0
```

This table or list provides the following information:

Parameter	Description
`{ instance-id }`	**Synopsis:** An integer between 1 and 16 The bridge identifier of this bridge.
`status`	**Synopsis:** [none | designatedBridge | notDesignatedForAnyLAN | rootBridge] The spanning tree status of the bridge. The status may be root or designated. This field may show text saying 'not designated for any LAN' if the bridge is not the designated bridge for any of its ports.
`root-priority`	**Synopsis:** An integer The bridge identifier of the root bridge.
`root-mac`	**Synopsis:** A string 17 characters long The bridge identifier of the root bridge.
`bridge-priority`	**Synopsis:** An integer The bridge identifier of this bridge.

Parameter	Description
bridge-mac	**Synopsis:** A string 17 characters long The bridge identifier of this bridge.
root-port-slot	**Synopsis:** [--- | sm | lm1 | lm2 | lm3 | lm4 | lm5 | lm6 | swport | eth | serport | celport | wlanport | trnk] If the bridge is designated, this is the slot containing the port that provides connectivity towards the root bridge of the network.
root-port-port	**Synopsis:** An integer If the bridge is designated, this is the port of the slot that provides connectivity towards the root bridge of the network.
root-path-cost	**Synopsis:** An integer The total cost of the path to the root bridge composed of the sum of the costs of each link in the path. If custom costs have not been configured, 1Gbps ports will contribute a cost of four, 100 Mbps ports will contribute 19 and 10 Mbps ports will contribute 100. For the Common and Internal Spanning Tree (CIST) instance of the Multiple Spanning Tree Protocol (MSTP), this is an external root path cost, which is the cost of the path from the Internal Spanning Tree (IST) root (i.e. regional root) bridge to the Common Spanning Tree (CST) root (i.e. network "global" root) bridge.
total-top-changes	**Synopsis:** An integer A count of topology changes in the network, as detected on this bridge through link failures or as signaled from other bridges. Excessively high or rapidly increasing counts signal network problems.

13.4.6.2 Viewing a List of Multiple Spanning Tree Instances

To view a list of Multiple Spanning Tree Instances (MSTIs), type:

```
show running-config switch spanning-tree mstp-instance
```

If instances have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config switch spanning-tree mstp-instance | tab
INSTANCE  BRIDGE
ID        PRIORITY
--------------------
1         32768
2         57344

!
```

If no MSTIs have been configured, add instances as needed. For more information, refer to "Adding a Multiple Spanning Tree Instance (Page 801)".

13.4.6.3 Adding a Multiple Spanning Tree Instance

To add a Multiple Spanning Tree Instance (MSTI), do the following:

Note
RUGGEDCOM ROX II supports up to 16 MSTIs.

1. Make sure the CLI is in Configuration mode.

   ⚠ NOTICE
   Since each MSTI acts as an independent RSTP instance, its configuration is similar to that of RSTP. However, until one or more VLANs are mapped to an MSTI, an MSTI is considered to be inactive.

2. Add the Multiple Spanning Tree Instance by typing:

   ```
   switch spanning-tree mstp-instance { id }
   ```

   Where:

   - `{ id }` is the ID for the Multiple Spanning Tree Instance

3. Configure the following parameter(s) as required:

Parameter	Description
`bridge-priority { bridge-priority }`	**Synopsis:** [0 | 4096 | 8192 | 12288 | 16384 | 20480 | 24576 | 28672 | 32768 | 36864 | 40960 | 45056 | 49152 | 53248 | 57344 | 61440] **Default:** 32768 Bridge priority provides a way to control the topology of the Spanning Tree Protocol (STP) connected network. The desired root and designated bridges can be configured for a particular topology. The bridge with the lowest priority will become the root. In the event of a failure of the root bridge, the bridge with the next lowest priority will then become the root. Designated bridges that (for redundancy purposes) service a common Local Area Network (LAN) also use priority to determine which bridge is active. In this way, careful selection of bridge priorities can establish the path of traffic flows in normal and abnormal conditions.

4. Map one or more static VLANs and map them to the MSTI. For more information, refer to "Adding a Static VLAN (Page 363)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.4.6.4 Deleting a Multiple Spanning Tree Instance

To delete a Multiple Spanning Tree Instance (MSTI), do the following:

1. Make sure the CLI is in Configuration mode.

2. Delete the multiple spanning tree instance by typing:

   `no switch spanning-tree mstp-instance { ID }`

   Where:

   - `{ ID }` is the ID of the multiple spanning tree instance

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.4.7 Managing Multiple Spanning Tree Instances Per-Port

This section describes how to configure and manage Multiple Spanning Tree Instances (MSTIs) for individual ports.

13.4.7.1 Viewing Per-Port Multiple Spanning Tree Instance Statistics

To view Multiple Spanning Tree Instance (MSTI) statistics for individual switched Ethernet ports and/or Ethernet trunk interfaces, type:

`show switch spanning-tree port-msti-id`

A table similar to the following example appears:

```
ruggedcom# show switch spanning-tree port-msti-id
                                                DESIG
INSTANCE                  STP       STP         BRIDGE
ID        SLOT    PORT    STATE     ROLE  COST  PRIORITY  DESIG BRIDGE MAC
-------------------------------------------------------------------------------
1
          swport  1       disabled  ----  0     0         00:00:00:00:00:00
          swport  2       disabled  ----  0     0         00:00:00:00:00:00
          swport  3       disabled  ----  0     0         00:00:00:00:00:00
          swport  4       disabled  ----  0     0         00:00:00:00:00:00
          swport  5       disabled  ----  0     0         00:00:00:00:00:00
          swport  6       disabled  ----  0     0         00:00:00:00:00:00
2
          swport  1       disabled  ----  0     0         00:00:00:00:00:00
          swport  2       disabled  ----  0     0         00:00:00:00:00:00
          swport  3       disabled  ----  0     0         00:00:00:00:00:00
          swport  4       disabled  ----  0     0         00:00:00:00:00:00
          swport  5       disabled  ----  0     0         00:00:00:00:00:00
          swport  6       disabled  ----  0     0         00:00:00:00:00:00
.
.
.
```

This table provides the following information:

Parameter	Description
`instance-id`	**Synopsis:** An integer between 1 and 16 The Multiple Spanning Tree Protocol (MSTP) Instance ID.

Parameter	Description
`{ slot }`	**Synopsis:** [sm | lm1 | lm2 | lm3 | lm4 | lm5 | lm6 | swport | eth | serport | celport | wlanport | trnk] The slot of the module that contains this port.
`{ port }`	**Synopsis:** An integer between 1 and 16 The port number as seen on the front plate silkscreen of the module.
`stp-state`	**Synopsis:** [disabled | blocking | listening | learning | forwarding | linkDown | discarding] The status of this interface in the spanning tree: • Disabled: The Spanning Tree Protocol (STP) is disabled on this port. • Link Down: STP is enabled on this port but the link is down. • Discarding: The link is not used in the STP topology but is standing by. • Learning: The port is learning MAC addresses in order to prevent flooding when it begins forwarding traffic. • Forwarding: The port is forwarding traffic.
`stp-role`	**Synopsis:** [---- | root | designated | alternate | backup | master] The role of this port in the spanning tree: • Designated: The port is designated for (i.e. carries traffic towards the root for) the Local Area Network (LAN) it is connected to. • Root: The single port on the bridge, which provides connectivity towards the root bridge. • Backup: The port is attached to a LAN that is serviced by another port on the bridge. It is not used but is standing by. • Alternate: The port is attached to a bridge that provides connectivity to the root bridge. It is not used but is standing by. • Master: Only exists in Multiple Spanning Tree Protocol (MSTP). The port is a Multiple Spanning Tree (MST) region boundary port and the single port on the bridge, which provides connectivity for the Multiple Spanning Tree Instance towards the Common Spanning Tree (CST) root bridge (i.e. this port is the root port for the Common Spanning Tree Instance).
`cost`	**Synopsis:** An integer The total cost of the path to the root bridge composed of the sum of the costs of each link in the path. If custom costs have not been configured, 1Gbps ports will contribute a cost of four, 100 Mbps ports will contribute 19 and 10 Mbps ports will contribute 100. For the Common and Internal Spanning Tree (CIST) instance of Multiple Spanning Tree Protocol (MSTP), this is an external root path cost, which is the cost of the path from the Internal Spanning Tree (IST) root (i.e. regional root) bridge to the Common Spanning Tree (CST) root (i.e. network "global" root) bridge.
`desig-bridge-priority`	**Synopsis:** An integer The bridge identifier of this bridge.

Parameter	Description
desig-bridge-mac	**Synopsis:** A string 17 characters long The bridge identifier of this bridge.

13.4.7.2 Viewing a List of Per-Port Multiple Spanning Tree Instances

To view a list of the Multiple Spanning Tree Instances (MSTIs) for switched Ethernet ports or Ethernet trunk interfaces, type:

- **For switched Ethernet ports:**

  `show running-config interface switch swport { port } spanning-tree msti`

  Where:

  - `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module

- **For Ethernet trunk interfaces:**

  `show running-config interface trunk { id } spanning-tree msti`

  Where:

  - `{ id }` is the ID given to the interface

If instances have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config interface trunks 1 spanning-tree msti | tab
INSTANCE  MSTP
ID        PRIORITY  STP COST   RSTP COST
----------------------------------------
1         128       auto-cost  auto-cost
2         128       auto-cost  auto-cost

 !
!
```

`show running-config interface trunk { id } spanning-tree msti`

Where:

- `{ id }` is the ID given to the interface

If MSTIs have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config interface trunks 1 spanning-tree msti | tab
INSTANCE  MSTP
ID        PRIORITY  STP COST   RSTP COST
----------------------------------------
1         128       auto-cost  auto-cost
2         128       auto-cost  auto-cost
```

```
  !
!
```

If no MSTIs have been configured, add them as needed. For more information, refer to "Adding a Port-Specific Multiple Spanning Tree Instance (Page 805)".

13.4.7.3 Adding a Port-Specific Multiple Spanning Tree Instance

To add a Multiple Spanning Tree Instance (MSTI) for a switched Ethernet port or an Ethernet trunk interface, do the following:

Note
RUGGEDCOM ROX II supports up to 16 MSTIs per port/interface.

1. Make sure the CLI is in Configuration mode.

   ⚠ NOTICE
   Since each MSTI acts as an independent RSTP instance, its configuration is similar to that of RSTP. However, until one or more VLANs are mapped to an MSTI, an MSTI is considered to be inactive.

2. Add the MSTI by typing:
   - **For switched Ethernet ports:**

     `interface switch swport { port } spanning-tree msti { id }`

     Where:
     - `{ slot }` is the name of the module location
     - `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module
     - `{ id }` is the ID for the Multiple Spanning Tree Instance
   - **For Ethernet trunk interfaces:**

     `interface trunks { id } spanning-tree msti { mstp-id }`

     Where:
     - `{ id }` is the ID given to the interface
     - `{ mstp-id }` is the ID for the Multiple Spanning Tree Instance
3. Configure the following parameter(s) as required:

Parameter	Description
`mstp-priority { mstp-priority }`	**Synopsis:** [0 | 16 | 32 | 64 | 96 | 112 | 128 | 144 | 160 | 176 | 192 | 208 | 224 | 240] **Default:** 128 The STP port priority. Ports of the same cost that attach to a common LAN will select the port to be used based upon the port priority.
`stp-cost { stp-cost }`	**Synopsis:** [auto-cost] or An integer between 0 and 65535 **Default:** auto-cost The cost to use in cost calculations, when the cost style parameter is set to STP in the bridge RSTP parameter configuration. Setting the cost manually provides the ability to preferentially select specific ports to carry traffic over others. Leave this field set to 'auto' to use the standard STP port costs as negotiated (four for 1Gbps, 19 for 100 Mbps links and 100 for 10 Mbps links). For MSTP, this parameter applies to both external and internal path costs.
`rstp-cost { rstp-cost }`	**Synopsis:** [auto-cost] or An integer between 0 and 2147483647 **Default:** auto-cost The cost to use in cost calculations, when the cost style parameter is set to RSTP in the bridge RSTP parameter configuration. Setting the cost manually provides the ability to preferentially select specific ports to carry traffic over others. Leave this field set to 'auto' to use the standard RSTP port costs as negotiated (20,000 for 1Gbps, 200,000 for 100 Mbps links and 2,000,000 for 10 Mbps links). For MSTP, this parameter applies to both external and internal path costs.

4. Map one or more static VLANs and map them to the MSTI. For more information, refer to "Adding a Static VLAN (Page 363)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.4.7.4 Deleting a Port-Specific Multiple Spanning Tree Instances

To delete a Multiple Spanning Tree Instance (MSTI) for a switched Ethernet port or an Ethernet trunk interface, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the MSTI by typing:
   - **For switched Ethernet ports:**

     ```
     no interface switch swport { port } spanning-tree msti { id }
     ```

     Where:

     - `{ slot }` is the name of the module location

- `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module
- `{ id }` is the ID for the Multiple Spanning Tree Instance

- **For Ethernet trunk interfaces:**

  ```
  no interface trunks { id } spanning-tree msti { mstp-id }
  ```

  Where:

  - `{ id }` is the ID given to the interface
  - `{ mstp-id }` is the ID for the Multiple Spanning Tree Instance

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.4.8 Viewing the Status of RSTP

To view the status of the RSTP network, type:

```
show switch spanning-tree rstp-status
```

A list similar to the following appears:

```
ruggedcom# show switch spanning-tree rstp-status
rstp-status
 status                  notDesignatedForAnyLAN
 bridge priority         32768
 bridge mac              00:0a:dc:f6:c6:ff
 root priority           32768
 root mac                00:0a:dc:00:71:57
 regional root priority  32768
 regional root mac       00:0a:dc:f6:c6:ff
 root port slot          swport
 root port port          1
 root path cost          38
 regional root path cost 0
 configured hello time   2
 learned hello time      2
 configured forward delay 15
 learned forward delay   15
 configured max age      20
 learned max age         20
 total top changes       5
```

This list provides the following information:

Parameter	Description
`status`	**Synopsis:** [none | designatedBridge | notDesignatedForAnyLAN | rootBridge] The spanning tree status of the bridge. The status may be root or designated. This field may show text saying 'not designated for any LAN' if the bridge is not the designated bridge for any of its ports.

Parameter	Description
bridge-priority	**Synopsis:** An integer The bridge identifier of this bridge.
bridge-mac	**Synopsis:** A string 17 characters long The bridge identifier of this bridge.
root-priority	**Synopsis:** An integer The ports to which the multicast group traffic is forwarded.
root-mac	**Synopsis:** A string 17 characters long The ports to which the multicast group traffic is forwarded.
regional-root-priority	**Synopsis:** An integer The bridge identifier of the Internal Spanning Tree (IST) regional root bridge for the Multiple Spanning Tree (MST) region this device belongs to.
regional-root-mac	**Synopsis:** A string 17 characters long The bridge identifier of the Internal Spanning Tree (IST) regional root bridge for the Multiple Spanning Tree (MST) region this device belongs to.
root-port-slot	**Synopsis:** [--- | sm | lm1 | lm2 | lm3 | lm4 | lm5 | lm6 | swport | eth | serport | celport | wlanport | trnk] If the bridge is designated, this is the slot containing the port that provides connectivity towards the root bridge of the network.
root-port-port	**Synopsis:** An integer If the bridge is designated, this is the port of the slot that provides connectivity towards the root bridge of the network.
root-path-cost	**Synopsis:** An integer The total cost of the path to the root bridge, composed of the sum of the costs of each link in the path. If custom costs have not been configured. 1Gbps ports will contribute a cost of four, 100 Mbps ports will contribute 19 and 10 Mbps ports will contribute 100. For the Common and Internal Spanning Tree (CIST) instance of the Multiple Spanning Tree Protocol (MSTP), this is an external root path cost, which is the cost of the path from the Internal Spanning Tree (IST) root (i.e. regional root) bridge to the Common Spanning Tree (CST) root (i.e. network "global" root) bridge.
regional-root-path-cost	**Synopsis:** An integer For the Common and Internal Spanning Tree (CIST) instance of the Multiple Spanning Tree Protocol (MSTP), this is the cost of the path to the Internal Spanning Tree (IST) root (i.e. regional root) bridge
configured-hello-time	**Synopsis:** An integer The configured hello time from the Bridge RSTP Parameters menu.
learned-hello-time	**Synopsis:** An integer The actual hello time provided by the root bridge as learned in configuration messages. This time is used in designated bridges.

Parameter	Description
`configured-forward-delay`	**Synopsis:** An integer The configured forward delay time from the Bridge RSTP Parameters menu.
`learned-forward-delay`	**Synopsis:** An integer The actual forward delay time provided by the root bridge as learned in configuration messages. This time is used in designated bridges.
`configured-max-age`	**Synopsis:** An integer The configured maximum age time from the Bridge RSTP Parameters menu.
`learned-max-age`	**Synopsis:** An integer The actual maximum age time provided by the root bridge as learned in configuration messages. This time is used in designated bridges.
`total-top-changes`	**Synopsis:** An integer A count of topology changes in the network, as detected on this bridge through link failures or as signaled from other bridges. Excessively high or rapidly increasing counts signal network problems.

13.4.9 Viewing RSTP Per-Port Statistics

To view Rapid Spanning Tree Protocol (RSTP) statistics for each port, type:

```
show switch spanning-tree port-rstp-stats
```

A table or list similar to the following example appears:

```
ruggedcom# show switch spanning-tree port-rstp-stats
port-rstp-stats swport 4
 stp state            forwarding
 stp role             designated
 cost                 19
 desg bridge priority 0
 desg bridge mac      00:00:00:00:00:00
 oper edge            true
 rx rsts              0
 tx rsts              43086
 rx configs           0
 tx configs           0
 rx tcns              0
 tx tcns              0
```

This table or list provides the following information:

Parameter	Description
`{ slot }`	**Synopsis:** [sm | lm1 | lm2 | lm3 | lm4 | lm5 | lm6 | swport | eth | serport | celport | wlanport | trnk] The slot of the module that contains this port.

Parameter	Description
`{ port }`	**Synopsis:** An integer between 1 and 16 The port number as seen on the front plate silkscreen of the module.
`stp-state`	**Synopsis:** [disabled | blocking | listening | learning | forwarding | linkDown | discarding] Describes the status of this interface in the spanning tree: • Disabled: Spanning Tree Protocol (STP) is disabled on this port. • Link Down: STP is enabled on this port but the link is down. • Discarding: The link is not used in the STP topology but is standing by. • Learning: The port is learning MAC addresses in order to prevent flooding when it begins forwarding traffic. • Forwarding : The port is forwarding traffic.
`stp-role`	**Synopsis:** [---- | root | designated | alternate | backup | master] The role of this port in the spanning tree: • Designated: The port is designated for (i.e. carries traffic towards the root for) the Local Area Network (LAN) it is connected to. • Root: The single port on the bridge, which provides connectivity towards the root bridge. • Backup: The port is attached to a LAN that is serviced by another port on the bridge. It is not used but is standing by. • Alternate: The port is attached to a bridge that provides connectivity to the root bridge. It is not used but is standing by. • Master: Only exists in Multiple Spanning Tree Protocol (MSTP). The port is a Multiple Spanning Tree (MST) region boundary port and the single port on the bridge, which provides connectivity for the Multiple Spanning Tree Instance (MSTI) towards the Common Spanning Tree (CST) root bridge (i.e. this port is the root port for the Common Spanning Tree Instance).
`cost`	**Synopsis:** An integer The cost offered by this port. If the Bridge RSTP Parameters Cost Style is set to STP, 1Gbps ports will contribute a cost of four, 100 Mbps ports will contribute 19 and 10 Mbps ports contribute 100. If the Cost Style is set to RSTP, 1Gbps will contribute 20,000, 100 Mbps ports will contribute a cost of 200,000 and 10 Mbps ports contribute a cost of 2,000,000. Note that even if the Cost style is set to RSTP, a port that migrates to STP will have its cost limited to a maximum of 65535.
`desg-bridge-priority`	**Synopsis:** An integer between 0 and 65535 Provided on the root ports of the designated bridges, the bridge identifier of the bridge this port is connected to.
`desg-bridge-mac`	**Synopsis:** A string 17 characters long Provided on the root ports of the designated bridges, the bridge identifier of the bridge this port is connected to.

Parameter	Description
`oper-edge`	**Synopsis:** [true | false] Whether or not the port is operating as an edge port.
`rx-rsts`	**Synopsis:** An integer The number of Rapid Spanning Tree Protocol (RSTP) configuration messages received on this port.
`tx-rsts`	**Synopsis:** An integer The number of Rapid Spanning Tree Protocol (RSTP) configuration messages transmitted on this port.
`rx-configs`	**Synopsis:** An integer The number of Spanning Tree Protocol (STP) configuration messages received on this port.
`tx-configs`	**Synopsis:** An integer The number of Spanning Tree Protocol (STP) configuration messages transmitted on this port.
`rx-tcns`	**Synopsis:** An integer The number of configuration change notification messages received on this port. Excessively high or rapidly increasing counts signal network problems.
`tx-tcns`	**Synopsis:** An integer The number of configuration messages transmitted from this port.

13.4.10 Clearing Spanning Tree Protocol Statistics

To clear all Spanning Tree Protocol statistics, type:

```
switch  spanning-tree  clear-stp-stats
```

13.5 Managing the Media Redundancy Protocol (MRP)

RUGGEDCOM ROX II supports the Media Redundancy Protocol (MRP), a network redundancy protocol for mission-critical applications.

13.5.1 Understanding MRP

The Media Redundancy Protocol (MRP) is a networking protocol designed to implement redundancy and recovery in a ring topology of up to 50 devices. It allows rings of Ethernet switches to quickly overcome any single failure of an inter-switch link or switch in the MRP ring or interconnection topology.

MRP operates at the MAC layer of Ethernet switches and uses the functions of ISO/IEC/IEEE 8802-3 (IEEE 802.3) and IEEE 802.1Q, including the Filtering Database (FDB).

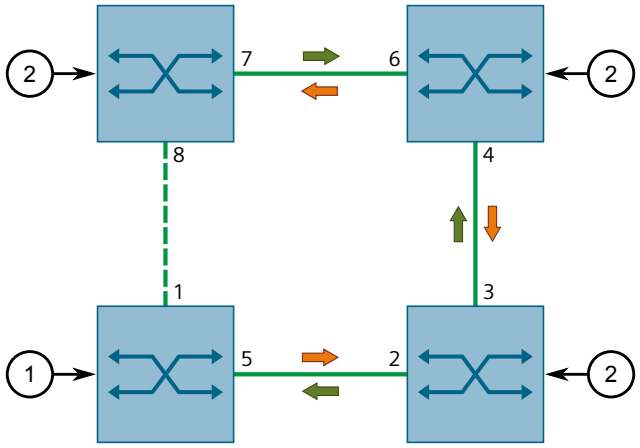
MRP is standardized by the International Electrotechnical Commission as IEC 62439-2.

13.5.1.1 MRP Operation

An MRP ring consists of a single switch known as the Media Redundancy Manager (MRM). All other switches in the ring are Media Redundancy Clients (MRC).

Each MRM and MRC designates two ports to participate in the MRP ring.

In normal operation, an MRP ring operates in a **ring-closed** state. In this state, one of the ring ports on the MRM is blocked, while the other forwards traffic to the MRP ring. For MRCs, both ring ports are in the **forwarding** state.

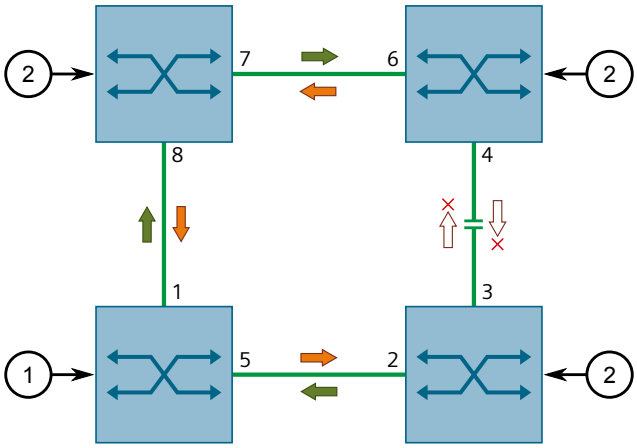


① MRM
② MRC

Figure 13.9 MRP Ring-Closed State

When a network failure (i.e. failed link between two switches) occurs, MRCs adjacent to the failure signal the fault to the MRM and the ring moves to a **ring-open** state. The following occurs in this state:

- For the MRM, the previously blocked ring port begins forwarding traffic along with the other ring port
- For MRCs adjacent to the network failure, the ring port connected to the broken link is disabled, while the other ring port continues to forward traffic
- Ring ports on all other MRCs continue to forward traffic



① MRM
② MRC

Figure 13.10 MRP Ring-Open State

Note
Frames will be lost when transitioning between ring states.

13.5.1.2 MRA

The MRM for an MRP ring can be chosen manually by setting the role for a switch to **manager**, or it can be decided automatically by one or more Media Redundancy Manager/Auto (MRA) switches.

An MRA decides or negotiates with other MRAs in the ring through an election process on which switch in the ring will be the MRM. Once an MRM is chosen, all MRAs in the ring automatically change to MRCs.

The MRM is chosen based on the priority defined for each switch.

Note
A switch cannot be an MRA if an MRM exists on the same MRP ring.

13.5.1.3 MRP Instances

An MRM can support up to four MRP rings, or instances. Each instance requires a unique domain ID and a dedicated pair of ring ports. The device must also be the MRM (or ring manager) in all instances.

MRCs belonging to an MRP instance must have the same domain ID as the MRM.

13.5.1.4 Requirements and Restrictions

Note the following requiremens and restriction before deploying MRP:

- A switch acting as an MRM can support up to four MRP rings (or instances).
- Up to 50 MRCs are supported per MRP ring.
- MRP ring ports cannot be trunk or link aggregated ports.
- The same port cannot be used for more than one MRP ring.
- Only switchports can be chosen as ring ports in an MRP ring. Routable ports are not supported.
- RSTP must be disabled on any port used as an MRP ring port.

13.5.2 Configuring MRP Globally

To configure the Media Redundancy Protocol globally, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***switch » media-redundancy***.
3. Configure the following parameter(s) as required:

Parameter	Description
`enabled { enabled }`	**Synopsis:** [true | false] **Default:** false Enables MRP globally.
`auto-generate-uuid { auto-generate-uuid }`	**Synopsis:** [true | false] **Default:** true Enables or disables the automatic generation of the MRP Universal Unique Identifier (UUID).

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.5.3 Enabling/Disabling SNMP Traps for MRP

The following proprietary SNMP traps are available to indicate when MRP rings are open or closed:

- rcMrpManagerRingClosed
- rcMrpManagerRingOpen

For more information, refer to "Proprietary SNMP Traps (Page 1007)".

These traps can be enabled or disabled as needed.

To enable/disable these SNMP traps, do the following:

1. Make sure the CLI is in Configuration mode.

2. Enable or disable SNMP traps for the desired MRP instance by typing one of the following commands:

   Enable

   ```
   switch media-redundancy mrp-instance { instance-id } ring-alarms
   ```

   Where { instance-id } is a number between 1 and 4.

   Disable

   ```
   no switch media-redundancy mrp-instance { instance-id } ring-alarms
   ```

   Where { instance-id } is a number between 1 and 4.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.5.4 Viewing the List of MRP Instances

To view the status of MRP instances, type:

```
show running-config switch media-redundancy mrp-instance
```

If MRP instances have been configured, a table or list similar to the following example appears:

```
switch media-redundancy
 mrp-instance 1
  ring-ports primary-slot lm1
  ring-ports primary-port 5
  ring-ports secondary-slot lm1
  ring-ports secondary-port 6
 !
!
```

If no MRP instances have been configured, add them. For more information, refer to "Adding an MRP Instance (Page 815)".

13.5.5 Adding an MRP Instance

To configure an MRP instance, do the following:

⚠ NOTICE
Configuration hazard – risk of communication disruption
RUGGEDCOM ROX II only allows multiple MRP instances if the device is the ring manager in each instance. A device can have up to four ring manager instances.

⚠ NOTICE

Configuration hazard – risk of communication disruption

MRMs or MRAs acting as a ring manager must be either physically disconnected or have their primary ring port disabled (i.e. MRP ring open) before the MRM instance configuration can be changed.

For more information about configuring ports, refer to "Configuring a Switched Ethernet Port (Page 314)".

For more information about open and closed MRP rings, refer to "MRP Operation (Page 812)".

Note

When using port security in an MRP ring, the MAC addresses of devices in the ring must be configured to allow communication between them. Also, the MRM's ring port must be configured in the **Static MAC Addresses** table for the ring to remain in a closed state.

For more information, refer to "Static MAC Address-Based Authentication in an MRP Ring (Page 157)".

1. Make sure the CLI is in Configuration mode.
2. Add the MRP instance by typing:

   ```
   switch media-redundancy mrp-instance { instance-id }
   ```

   Where { instance-id } is a number between 1 and 4.
3. Configure the following parameters to define the MRP instance:

Parameter	Description
`name { name }`	**Synopsis:** A string between 1 and 24 characters long **Default:** default-mrpdomain The name of the MRP domain/ring. All MRP instances belonging to the same ring must have the same domain name.
`role { role }`	**Synopsis:** [Disabled | Client | Manager | ManagerAuto] **Default:** Client The role assigned to this MRP instance. • Disabled – No role is assigned. The MRP instance is disabled. • Client – The device operates as a Media Redundancy Client (MRC). • Manager – The device operates as a Media Redundancy Manager (MRM). • ManagerAuto – The MRP instance automatically determines the role of the device.

Parameter	Description
`priority { priority }`	**Synopsis:** A string 4 characters long **Default:** 8000 The priority assigned to the MRP instance. This is used when negotiating with other MRP devices to determine which is the MRP Manager. • 0000 - Highest priority (Manager) • 1000-7000 -High priority (Manager) • 8000 - Default priority (Manager) • 9000-E000 - Low priority (ManagerAuto) • F000 - Lowest priority (ManagerAuto)
`domain-id { domain-id }`	**Synopsis:** A string 32 characters long **Default:** FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF A 128-bit domain UUID unique to a domain/ring. All MRP instances belonging to the same ring must have the same domain ID. If the Auto Generate UUID parameter is enabled, the system automatically generates the domain ID as an MD5 hash of the domain name. In this case, the domain ID cannot be modified. If the Auto Generate UUID parameter is disabled, the domain ID can be modified.
`ring-alarms { ring-alarms }`	**Synopsis:** [true | false] **Default:** true Enables/disables SNMP traps that indicate the status of the MRP ring. Only applies to the specific MRP instance and when the device is the Media Redundancy Manager (MRM). Traps will only be sent when enabled.

4. Enter `ring-ports` and then configure the following parameters to select the primary and secondary ring ports:

Parameter	Description
`primary-slot { primary-slot }`	**Synopsis:** [sm | lm1 | lm2 | lm3 | lm4 | lm5 | lm6 | swport | eth | serport | celport | wlanport] MRP ring primary slot number.
`primary-port { primary-port }`	**Synopsis:** An integer between 1 and 16 MRP ring primary port number.
`secondary-slot { secondary-slot }`	**Synopsis:** [sm | lm1 | lm2 | lm3 | lm4 | lm5 | lm6 | swport | eth | serport | celport | wlanport] MRP ring secondary slot number.
`secondary-port { secondary-port }`	**Synopsis:** An integer between 1 and 16 MRP ring secondary port number.

5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.5.6 Deleting an MRP Instance

To delete an MRP instance, do the following:

1. Make sure the CLI is in Configuration mode.
2. If the device is an MRM or MRA acting as a ring manager, open the MRP ring before deleting the MRP instance.

   This can be done by either disabling the primary and secondary ring ports via RUGGEDCOM ROX II, or physically disconnecting them.

   For more information about disabling the ports, refer to "Configuring a Switched Ethernet Port (Page 314)".
3. Delete the desired MRP instance by typing:

   ```
   no switch media-redundancy mrp-instance { instance-id }
   ```

   Where { instance-id } is a number between 1 and 4.
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

13.5.7 Viewing the Status of MRP Instances

To view the status of MRP instances, type:

```
show switch media-redundancy mrp-status
```

If MRP instances have been configured, a table or list similar to the following example appears:

```
ruggedcom# show switch media-redundancy mrp-status
mrp-status 1
 name             default-mrpdomain
 role             manager
 ring status      closed
 prm port         lm1-2
 prm port state   FORWARD
 sec port         lm1-5
 sec port state   BLOCKED
 multi mrm err    false
 one side rx err false
```

This table or list provides the following information per instance:

Parameter	Description
`{ instance-id }`	**Synopsis:** An integer between 1 and 4 The Media Redundancy Protocol (MRP) instance
`name`	**Synopsis:** A string The name of the MRP domain/ring. All MRP instances belonging to the same ring must have the same domain name.

Parameter	Description
`role`	**Synopsis:** [disable | client | manager | managerAuto] The role assigned to this MRP instance. • Disabled – No role is assigned. The MRP instance is disabled. • Client – The device operates as a Media Redundancy Client (MRC). • Manager – The device operates as a Media Redundancy Manager (MRM). • ManagerAuto – The MRP instance automatically determines the role of the device.
`ring-status`	**Synopsis:** [unknown | open | closed] The status of the MRP ring. • Unknown - The status of the ring is unknown. This is displayed when the device is an MRC • Open - The MRP ring is open. Both ring ports are forwarding packets. • Closed - The MRP ring is closed. One ring port is forwarding packets, while the other is blocking packets.
`prm-port`	**Synopsis:** A string The MRP primary port of the MRP ring port.
`prm-port-state`	**Synopsis:** [OFF | DOWN | BLOCKED | FORWARD | UNKNOWN] The status of the primary ring port. Possible values include: • OFF - MRP is not running • DOWN - The MRP ring port is down • BLOCKED - The MRP ring port is blocking packets • FORWARD - The MRP ring port is forwarding packets • UNKNOWN - The MRP ring port is Unknown
`sec-port`	**Synopsis:** A string The MRP secondary port of the MRP ring port.
`sec-port-state`	**Synopsis:** [OFF | DOWN | BLOCKED | FORWARD | UNKNOWN] The status of the secondary ring port. Possible values include: • OFF - MRP is not running • DOWN - The MRP ring port is down • BLOCKED - The MRP ring port is blocking packets • FORWARD - The MRP ring port is forwarding packets • UNKNOWN - The MRP ring port is Unknown
`multi-mrm-err`	**Synopsis:** [true | false] Error indicated by an MRM when more than one MRM are active in the MRP ring.
`one-side-rx-err`	**Synopsis:** [true | false] Error indicated by an MRM when the test frames of an MRM has been seen, but only on one ring port.

If no MRP instances have been configured, add them. For more information, refer to "Adding an MRP Instance (Page 815)".

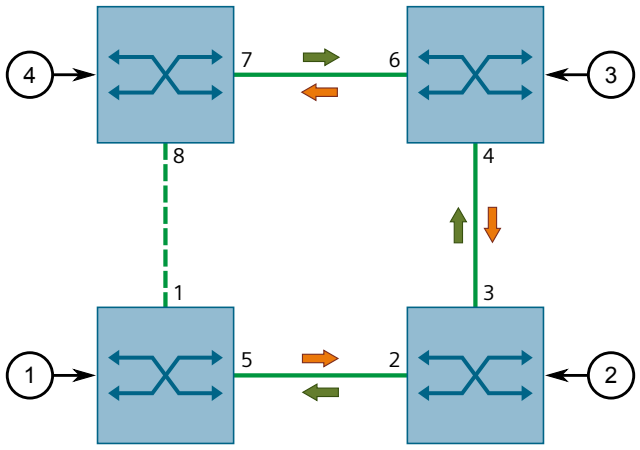
13.5.8 Example: Configuring an MRP Ring

This example demonstrates how to configure an MRP ring using four RUGGEDCOM ROX II devices.

In the following topology, the MRP ring is operating in the ring-closed state.

⚠ NOTICE

Values shown are specific to the provided topology. Actual values can vary based on the user's configuration.



① MRM
② MRC 1
③ MRC 2
④ MRC 3

Figure 13.11 Topology – MRP Ring

To configure an MRP ring per the topology, do the following:

1. Make sure RSTP is disabled either globally or for each port participating in the MRP ring.

   For more information about disabling RSTP globally, refer to "Configuring STP Globally (Page 794)".

   For more information about disabling RSTP per port, refer to "Configuring a Switched Ethernet Port (Page 314)".

2. Enable MRP on the MRM and all MRCs.

   For more information, refer to "Configuring MRP Globally (Page 814)".

3. Configure an MRP instance for the MRM as follows:

Parameter	Value
Name	{ name }
Role	`manager`
PRM Port	`5`
SEC Port	`1`
Priority	`1000`

For more information about configuring MRP instances, refer to "Adding an MRP Instance (Page 815)".

4. Configure an MRP instance for each MRC as follows:

Parameter	Value		
	MRC 1	**MRC 2**	**MRC 3**
Name	MRC1	MRC2	MRC3
Role	`client`	`client`	`client`
PRM Port	`2`	`4`	`7`
SEC Port	`3`	`6`	`8`
Priority	`A000`	`A000`	`A000`

For more information about configuring MRP instances, refer to "Adding an MRP Instance (Page 815)".

5. To verify the configuration, make sure the MRP Instance ID is generated automatically on the MRM and each MRC.

   For more information about the MRP Instance ID, refer to "Adding an MRP Instance (Page 815)".

14 Network Discovery and Management

RUGGEDCOM ROX II supports the following protocols for automatic network discovery, monitoring and device management:

- **Link Layer Device Protocol (LLDP)**

  Use LLDP to broadcast the device's network capabilities and configuration to other devices on the network, as well as receive broadcasts from other devices.

- **Simple Network Management Protocol (SNMP)**

  Use SNMP to notify select users or groups of certain events that happen during the operation of the device, such as changes to network topology, link state, spanning tree root, etc.

- **Network Configuration Protocol (NETCONF)**

  Use NETCONF to remotely download, upload, change, and delete configuration data on the device.

14.1 Managing LLDP

RUGGEDCOM ROX II supports the Link Layer Discovery Protocol (LLDP), a Layer 2 protocol for automated network discovery.

LLDP is an IEEE standard protocol (IEEE 802.11AB) that allows a networked device to advertise its own basic networking capabilities and configuration. It can simplify the troubleshooting of complex networks and can be used by Network Management Systems (NMS) to obtain and monitor detailed information about a network's topology. LLDP data are made available via SNMP (through support of LLDP-MIB).

LLDP allows a networked device to discover its neighbors across connected network links using a standard mechanism. Devices that support LLDP are able to advertise information about themselves, including their capabilities, configuration, interconnections, and identifying information.

LLDP agent operation is typically implemented as two modules: the LLDP transmit module and LLDP receive module. The LLDP transmit module, when enabled, sends the local device's information at regular intervals, in 802.1AB standard format. Whenever the transmit module is disabled, it transmits an LLDPDU (LLDP data unit) with a time-to-live (TTL) TLV containing *0* in the information field. This enables remote devices to remove the information associated with the local device in their databases. The LLDP receive module, when enabled, receives information about remote devices and updates its LLDP database of remote systems. When new or updated information is received, the receive module initiates a timer for the valid duration indicated by the TTL TLV in the received LLDPDU. A remote system's

information is removed from the database when an LLDPDU is received from it with TTL TLV containing *0* in its information field.

⚠ NOTICE

Security hazard – risk of unauthorized access and/or exploitation

LLDP is not secure by definition. Avoid enabling LLDP on devices connected to external networks. Siemens recommends using LLDP only in secure environments operating within a security perimeter.

Note
LLDP is implemented to keep a record of only one device per Ethernet port. Therefore, if there are multiple devices sending LLDP information to a switch port on which LLDP is enabled, information about the neighbor on that port will change constantly.

14.1.1 Configuring LLDP

To configure the Link Layer Discovery Protocol (LLDP), do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***switch » net-discovery » lldp*** and configure the following parameter(s) as required:

Parameter	Description
`enabled { enabled }`	**Synopsis:** [true | false] **Default:** true Enables LLDP, making the device an LLDP agent.
`tx-interval { tx-interval }`	**Synopsis:** An integer between 5 and 32768 **Default:** 30 The time in seconds (s) between each subsequent transmission of an LLDP frame.
`tx-hold { tx-hold }`	**Synopsis:** An integer between 2 and 10 **Default:** 4 The multiplier used to determine the time-to-live (TTL) value in an LLDP frame. The TTL value indicates the time in seconds (s) for which the information in an LLDP frame will be considered valid. The TTL value is equal to the value of the **Transmission Hold (tx-hold)** parameter multiplied by the value of the **Transmission Interval (tx-interval)** parameter.
`reinit-delay { reinit-delay }`	**Synopsis:** An integer between 1 and 10 **Default:** 2 The time in seconds (s) the LLDP agent will wait before attempting to re-enable LLDP on a port where it has been previously disabled.

Parameter	Description
`tx-delay { tx-delay }`	**Synopsis:** An integer between 1 and 8192 **Default:** 2 The time in seconds (s) the LLDP agent will wait before transmitting a new LLDP frame after the configuration of the device is changed. The value of the **Transmission Delay (tx-parameter)** should be no more than one quarter of the value of the **Transmission Interval (tx-interval)** parameter.
`notification-interval { notification-interval }`	**Synopsis:** An integer between 5 and 3600 **Default:** 5 The time in seconds (s) between each subsequent transmission of an SNMP trap for LLDP. SNMP traps provide the network manager with updates about LLDP functions.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

14.1.2 Viewing Global Statistics and Advertised System Information

To view global statistics for LLDP, type:

```
show switch net-discovery lldp global-statistics
```

A table or list similar to the following appears:

```
ruggedcom# show switch net-discovery lldp global-statistics
global-statistics
 inserts          21
 deletes          20
 drops            0
 ageouts          8
 last change time 3D14m19s
```

This table or list displays the following information:

Parameter	Description
`inserts`	**Synopsis:** An integer between 0 and 4294967295 The total number of new hosts added to the LLDP Neighbor Information Table.
`deletes`	**Synopsis:** An integer between 0 and 4294967295 The total number of hosts deleted from the LLDP Neighbor Information Table.
`drops`	**Synopsis:** An integer between 0 and 4294967295 The total number of hosts detected that could not be added to the LLDP Neighbor Information Table.

Parameter	Description
`ageouts`	**Synopsis:** An integer between 0 and 4294967295 The number of times that an LLDP neighbor has been dropped because its time-to-live (TTL) value was exhausted. TTL values are specified in the LLDP frames sent from the neighbor to the device.
`last-change-time`	**Synopsis:** A string The timestamp at which the LLDP Global Statistics were last updated. Timestamps represent the amount of time elapsed since the device was powered on. Values are expressed in durations of years, months, weeks, days, hours, minutes, and/or seconds in ISO 8601 format (e.g. P1Y1M2W3DT2H3M30S represents 1 year, 1 month, 2 weeks, 3 days, 2 hours, 3 minutes, and 30 seconds).

To view the system information that is advertised to neighbors, type:

```
show switch net-discovery lldp local-system
```

A table or list similar to the following appears:

```
ruggedcom#  show switch net-discovery lldp local-system
local-system
 local chassis subtype     macAddress
 local chassis id          00:0a:dc:ff:9a:00
 local system name         R12.localdomain
 local system desc         RX5000-R-MNT-HI-HI-SM61-CM01-L3SEC-16TX01-XX-XX-XX-4FG50-
XX
 local system caps         bridge,router
 local system caps enabled bridge,router
```

This table or list displays the following information:

Parameter	Description
`local-chassis-subtype`	**Synopsis:** [chassisComponent | interfaceAlias | portComponent | macAddress | networkAddress | interfaceName | local] The source of the **Local Chassis ID (local-chassis-id)** parameter. Options include: • chassisComponent - The **Local Chassis ID (local-chassis-id)** corresponds with the alias for a chassis component (entPhysicalAlias) in the ENTITY-MIB file • interfaceAlias - The **Local Chassis ID (local-chassis-id)** corresponds with the alias for an interface (ifAlias) in the IF-MIB file • portComponent - The **Local Chassis ID (local-chassis-id)** corresponds with the alias for a port or backplane component (entPhysicalAlias) in the ENTITY-MIB file • macAddress - The **Local Chassis ID (local-chassis-id)** is a MAC address associated with the device • networkAddress - The **Local Chassis ID (local-chassis-id)** is an IP address associated with the device • interfaceName - The **Local Chassis ID (local-chassis-id)** corresponds with the default name for an interface (ifName) in the IF-MIB file

Parameter	Description
	• local - The **Local Chassis ID (local-chassis-id)** is a locally defined value
`local-chassis-id`	**Synopsis:** A string 17 characters long The type-length-value (TLV) used to identify the device to LLDP neighbors. The value of the **Local Chassis ID (local-chassis-id)** parameter is categorized by the **Local Chassis Subtype (local-chassis-subtype)** parameter.
`local-system-name`	**Synopsis:** A string 255 characters long An administratively assigned name, often the fully qualified domain name (FQDN), for the device. The **Local System Name (local-system-name)** parameter corresponds with the sysName object in the SNMPv2-MIB.
`local-system-desc`	**Synopsis:** A string 255 characters long The default system description of the device, which includes the full name and version ID of its hardware, operating system, and networking software. The **Local System Description (local-system-desc)** parameter corresponds with the sysDescr object in the SNMPv2-MIB.
`local-system-caps`	**Synopsis:** [other | repeater | bridge | wlanAccessPoint | router | telephone | docsisCableDevice | stationOnly] The network functions the device can serve. Options include: • other - The device can serve other, unspecified functions • repeater - The device can receive and regenerate IP packets within a single network • bridge - The device can join two or more networks into a single network • wlanAccessPoint - The device can forward network traffic to/from a WLAN • router - The device can forward IP packets from one wired network to another • telephone - The device can forward IP packets to/from a telephone network • docsisCableDevice - The device can forward IP packets to a Cable TV system • stationOnly - The device can only receive network traffic
`local-system-caps-enabled`	**Synopsis:** [other | repeater | bridge | wlanAccessPoint | router | telephone | docsisCableDevice | stationOnly] The network functions the device currently serves. Options include: • other - The device serves other, unspecified functions • repeater - The device receives and regenerates IP packets within a single network • bridge - The device joins two or more networks into a single network • wlanAccessPoint - The device forwards network traffic to/from a WLAN

Parameter	Description
	• router - The device forwards IP packets from one wired network to another • telephone - The device forwards IP packets to/from a telephone network • docsisCableDevice - The device forwards IP packets to a Cable TV system • stationOnly - The device only receives network traffic

14.1.3 Viewing Statistics for LLDP Neighbors

To view statistics for LLDP neighbors, type:

```
show switch net-discovery lldp port-lldp-neighbors
```

A table or list similar to the following appears:

```
ruggedcom# show switch net-discovery lldp port-lldp-neighbors
port-lldp-neighbors swport 1
 chassis id              ""
 port id                 ""
 system name             ""
 system desc             ""
 port desc               ""
 man address             ""
 man address if id       0
 system caps             ""
 system caps enabled     ""
 chassis subtype         macAddress
 port subtype            interfaceName
 man address subtype     other
 man address if subtype unknown
 last update             0s
```

This table or list displays the following information:

Parameter	Description
`chassis-id`	**Synopsis:** A string 17 characters long The type-length-value (TLV) used to identify the LLDP neighbor. The value of the **Chassis ID (chassis-id)** parameter is categorized by the **Chassis Subtype (chassis-subtype)** parameter.
`port-id`	**Synopsis:** A string 17 characters long The remote port from which the LLDP neighbor sends LLDP frames to the device. The value of the **Port ID (port-id)** parameter is categorized by the **Port Subtype (port-subtype)** parameter.
`system-name`	**Synopsis:** A string 255 characters long An administratively assigned name, often the fully qualified domain name (FQDN), for the LLDP neighbor.

Parameter	Description
	The **System Name (system-name)** parameter corresponds with the sysName object in the SNMPv2-MIB associated with the LLDP neighbor.
`system-desc`	**Synopsis:** A string 255 characters long The default system description of the LLDP neighbor, which includes the full name and version ID of its hardware, operating system, and networking software. The **System Description (system-desc)** parameter corresponds with the sysDescr object in the SNMPv2-MIB associated with the LLDP neighbor.
`port-desc`	**Synopsis:** A string 255 characters long The default description of the port from which the LLDP neighbor sends LLDP frames to the device. The port description includes the manufacturer, the product name, and the version of the port. The **Port Description (port-desc)** parameter corresponds with the ifDescr object in the IF-MIB associated with the LLDP neighbor.
`man-address`	**Synopsis:** A string 31 characters long An address associated with the LLDP neighbor that can be used to access information about the neighbor host. The value of the **Management Address (man-address)** parameter is categorized by the **Management Address Subtype (man-address-subtype)** parameter.
`man-address-if-id`	**Synopsis:** An integer The interface with which the **Management Address (man-address)** of the LLDP neighbor is associated. The value of the **Management Address Interface ID (man-address-if-id)** parameter is categorized by the **Management Address Interface Subtype (man-address-if-subtype)** parameter.
`system-caps`	**Synopsis:** [other | repeater | bridge | wlanAccessPoint | router | telephone | docsisCableDevice | stationOnly] The network functions the LLDP neighbor can serve. Possible values include: • other - The neighbor host can serve other, unspecified functions • repeater - The neighbor host can receive and regenerate IP packets within a single network • bridge - The neighbor host can join two or more networks into a single network • wlanAccessPoint - The neighbor host can forward network traffic to/from a WLAN • router - The neighbor host can forward IP packets from one wired network to another • telephone - The neighbor host can forward IP packets to/from a telephone network • docsisCableDevice - The neighbor host can forward IP packets to a Cable TV system • stationOnly - The neighbor host can only receive network traffic

Parameter	Description
	The network functions that the LLDP neighbor currently serves are specified by the **System Capabilities Enabled (system-caps-enabled)** parameter.
`system-caps-enabled`	**Synopsis:** [other | repeater | bridge | wlanAccessPoint | router | telephone | docsisCableDevice | stationOnly] The network functions that the LLDP neighbor currently serves. Possible values include: • other - The neighbor host serves other, unspecified functions • repeater - The neighbor host receives and regenerates IP packets within a single network • bridge - The neighbor host joins two or more networks into a single network • wlanAccessPoint - The neighbor host forwards network traffic to/from a WLAN • router - The neighbor host forwards IP packets from one wired network to another • telephone - The neighbor host forwards IP packets to/from a telephone network • docsisCableDevice - The neighbor host forwards IP packets to a Cable TV system • stationOnly - The neighbor host only receives network traffic In addition to the network functions that the LLDP neighbor currently serves, the network functions that the LLDP neighbor can serve are specified by the **System Capabilities (system-caps)** parameter.
`chassis-subtype`	**Synopsis:** [chassisComponent | interfaceAlias | portComponent | macAddress | networkAddress | interfaceName | local] The source of the **Chassis ID (chassis-id)** parameter as advertised by LLDP neighbor. Possible values include: • chassisComponent - The **Chassis ID (chassis-id)** corresponds with the alias for a chassis component (entPhysicalAlias) in the ENTITY-MIB file • interfaceAlias - The **Chassis ID (chassis-id)** corresponds with the alias for an interface (ifAlias) in the IF-MIB file • portComponent - The **Chassis ID (chassis-id)** corresponds with the alias for a port or backplane component (entPhysicalAlias) in the ENTITY-MIB file • macAddress - The **Chassis ID (chassis-id)** is a MAC address associated with the LLDP neighbor • networkAddress - The **Chassis ID (chassis-id)** is an IP address associated with the LLDP neighbor • interfaceName - The **Chassis ID (chassis-id)** corresponds with the default name for an interface (ifName) in the IF-MIB file • local - The **Chassis ID (chassis-id)** is a value defined locally by the LLDP neighbor

Parameter	Description
`port-subtype`	**Synopsis:** [interfaceAlias | portComponent | macAddress | networkAddress | interfaceName | agentCircuitId | local] The source of the **Port ID (port-id)** parameter as advertised by LLDP neighbor. Possible values include: • interfaceAlias - The **Port ID (port-id)** corresponds with the alias for an interface (ifAlias) in the IF-MIB file • portComponent - The **Port ID (port-id)** corresponds with the alias for a port component (entPhysicalAlias) in the ENTITY-MIB file • macAddress - The **Port ID (port-id)** is a MAC address associated with a remote port • networkAddress - The **Port ID (port-id)** is an IP address associated with a remote port • interfaceName - The **Port ID (port-id)** corresponds with the default name for a port (ifName) in the IF-MIB file • agentCircuitId - The **Port ID (port-id)** corresponds with the Circuit ID for a port as defined by the DHCP agent • local - The **Port ID (port-id)** is a value defined locally by the LLDP neighbor
`man-address-subtype`	**Synopsis:** [other | ipV4 | ipV6 | nsap | hdlc | bbn1822 | all802 | e163 | e164 | f69 | x121 | ipx | appleTalk | decnetIV | banyanVines | e164withNsap | dns | distinguishedName | asNumber | xtpOverIpv4 | xtpOverIpv6 | xtpNativeModeXTP | fibreChannelWWPN | fibreChannelWWNN | gwid | afi | reserved] The source of the **Management Address (man-address)** parameter as advertised by LLDP neighbor. Possible values include: • other - The **Management Address (man-address)** is another, unspecified type of address • ipv4 - The **Management Address (man-address)** is an IPv4 address • ipv6 - The **Management Address (man-address)** is an IPv6 address • nsap - The **Management Address (man-address)** is an Network Service Access Point (NSAP) address • hdlc - The **Management Address (man-address)** is a High-level Link Control (HDLC) address • bbn1822 - The **Management Address (man-address)** is a numeric host address to be used in IMP-host exchanges • all802 - The **Management Address (man-address)** is an IEEE 802 address • e163 - The **Management Address (man-address)** is an E.163 telephone number • e164 - The **Management Address (man-address)** is an E.164 telephone number • f69 - The **Management Address (man-address)** is an F.69 telex number • x121 - The **Management Address (man-address)** is an X.121 address

Parameter	Description
	• ipx - The **Management Address (man-address)** is an IPX address • appleTalk - The **Management Address (man-address)** is an AppleTalk address • decnetIV - The **Management Address (man-address)** is a DECnet Phase IV address • banyanVines - The **Management Address (man-address)** is a VINES network address • e164withNsap - The **Management Address (man-address)** is a Network Service Access Point (NSAP)-encoded E.164 telephone number • dns - The **Management Address (man-address)** is a Domain Name Server (DNS) server • distinguishedName - The **Management Address (man-address)** is a Distinguished Name (DN) address • asNumber - The **Management Address (man-address)** is an Autonomous System Number (ASN) • xtpOverIpv4 - The **Management Address (man-address)** is an IPv4 address that uses Xpress Transport Protocol (XTP) instead of TCP • xtpOverIpv6 - The **Management Address (man-address)** is an IPv6 address that uses Xpress Transport Protocol (XTP) instead of TCP • xtpNativeModeXTP - The **Management Address (man-address)** is an Xpress Transport Protocol (XTP) address segment • fibreChannelWWPN - The **Management Address (man-address)** is an World Wide Port Name (WWPN) • fibreChannelWWNN - The **Management Address (man-address)** is an World Wide Node Name (WWNN) • gwid - The **Management Address (man-address)** is a Gateway Identifier (GWID) • afi - The **Management Address (man-address)** is an Authority and Format Identifier (AFI) • reserved - The **Management Address (man-address)** is a reserved IPv4 or IPv6 address
`man-address-if-subtype`	**Synopsis:** [unknown | ifIndex | systemPortNumber] The source of the **Management Address Interface ID (man-address-if-id)** parameter as advertised by the LLDP neighbor. Possible values include: • unknown - The **Management Address Interface ID (man-address-if-id)** is not known • ifIndex - The **Management Address Interface ID (man-address-if-id)** corresponds with the indexed name for an interface (ifIndex) in the IF-MIB file • systemPortNumber - The **Management Address Interface ID (man-address-if-id)** corresponds with a locally defined port number

Parameter	Description
last-update	**Synopsis:** A string The time at which the statistics for LLDP neighbors were last updated. Timestamps represent the amount of time elapsed since the device was powered on. Values are expressed in durations of years, months, weeks, days, hours, minutes, and/or seconds in ISO 8601 format (e.g. P1Y1M2W3DT2H3M30S represents 1 year, 1 month, 2 weeks, 3 days, 2 hours, 3 minutes, and 30 seconds).

14.1.4 Viewing Statistics for LLDP Ports

To view statistics for LLDP ports, type:

```
show switch net-discovery lldp port-lldp-stats
```

A table or list similar to the following appears:

```
ruggedcom# show switch net-discovery lldp port-lldp-stats
                FRM  ERR  FRM  FRM           TLVS  TLVS
SLOT    PORT    DRP  FRM  IN   OUT  AGEOUTS  DROP  UNKNOWN
-------------------------------------------------------------
swport  1       0    0    0    0    0        0     0
swport  2       0    0    0    0    0        0     0
swport  3       0    0    0    0    0        0     0
swport  4       0    0    208  209  0        0     0
swport  5       0    0    0    0    0        0     0
swport  6       0    0    0    0    0        0     0
```

This table or list displays the following information:

Parameter	Description
{ slot }	**Synopsis:** [--- | pm1 | pm2 | main | sm | lm1 | lm2 | lm3 | lm4 | lm5 | lm6 | swport | eth | serport | celport | wlanport | cm | em | trnk] The slot number of the module that contains the port specified by the **Port (port)** parameter.
{ port }	**Synopsis:** An integer between 1 and 16 The port number as indicated on the front plate silkscreen of the module. The port is contained in the slot module specified by the **Slot (slot)** parameter.
frm-drp	**Synopsis:** An integer between 0 and 4294967295 The total number of incoming LLDP frames dropped by the port.
err-frm	**Synopsis:** An integer between 0 and 4294967295 The total number of incoming LLDP frames received on the port with detectable errors.
frm-in	**Synopsis:** An integer between 0 and 4294967295 The total number of incoming LLDP frames received on the port.

Parameter	Description
`frm-out`	**Synopsis:** An integer between 0 and 4294967295 The total number of outgoing LLDP frames broadcast on the port.
`ageouts`	**Synopsis:** An integer between 0 and 4294967295 The number of times that an LLDP neighbor has been dropped on the port because its time-to-live (TTL) value had been exhausted. TTL values are specified in the LLDP frames sent from the neighbor to the port.
`tlvs-drop`	**Synopsis:** An integer between 0 and 4294967295 The total number of TLVs discarded from LLDP frames received on the port.
`tlvs-unknown`	**Synopsis:** An integer between 0 and 4294967295 The total number of unrecognized TLVs in LLDP frames received on the port.

14.2 Managing SNMP

The Simple Network Management Protocol (SNMP) is used by network management systems and the devices they manage. It is used to report alarm conditions and other events that occur on the devices it manages.

In addition to SNMPv1 and SNMPv2, RUGGEDCOM ROX II also supports SNMPv3, which offers the following features:

- Provides the ability to send a notification of an event via *traps*. Traps are unacknowledged UDP messages and may be lost in transit.
- Provides the ability to notify via *informs*. Informs simply add acknowledgement to the trap process, resending the trap if it is not acknowledged in a timely fashion.
- Encrypts all data transmitted by scrambling the contents of each packet to prevent it from being seen by an unauthorized source. The AES CFB 128 and DES3 encryption protocols are supported.
- Authenticates all messages to verify they are from a valid source.
- Verifies the integrity of each message by making sure each packet has not been tampered with in-transit.

SNMPv3 also provides security models and security levels. A security model is an authentication strategy that is set up for a user and the group in which the user resides. A security level is a permitted level of security within a security model. A combination of a security model and security level will determine which security mechanism is employed when handling an SNMP packet.

Before configuring SNMP, note the following:

- each user belongs to a group
- a group defines the access policy for a set of users

- an access policy defines what SNMP objects can be accessed for: reading, writing and creating notifications
- a group determines the list of notifications its users can receive
- a group also defines the security model and security level for its users

For a list of supported SNMP MIBs, refer to "Supported MIBs (Page 945)".

For a list of supported SNMP traps, refer to "Standard SNMP Traps (Page 1005)" and "Proprietary SNMP Traps (Page 1007)".

14.2.1 Enabling and Configuring SNMP Sessions

To enable and configure SNMP sessions, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***admin » snmp*** and configure the following parameter(s) as required:

⚠ NOTICE

To generate all SNMP traffic for a specific interface, make sure the IP address for the desired interface is set for both the **Listen IP** and **Source IP for Traps** parameters.

⚠ NOTICE

The **auth-failure-trap-notify** parameter is used to notify users of authentication failures when the **authen-traps-enabled** is enabled. For more information about SNMP notifications, refer to "Standard SNMP Traps (Page 1005)" and "Proprietary SNMP Traps (Page 1007)".

Parameter	Description
`enabled { enabled }`	**Synopsis:** [true | false] **Default:** false Enables SNMP, making the device an SNMP agent.
`listen-ip { listen-ip }`	**Synopsis:** A string **Default:** 0.0.0.0 The IPv4 or IPv6 address to which SNMP requests are sent. The default value (i.e. 0.0.0.0) enables the device to receive SNMP requests via any IP address associated with the device.
`port { port }`	**Synopsis:** An integer between 0 and 65535 **Default:** 161 The default port on which the SNMP agent will listen for SNMP requests. The port corresponds with the IP address specified by the **Listen IP (listen-ip)** parameter.

Parameter	Description
`extra-ip-ports { extra-ip-ports }`	**Synopsis:** A string Additional IPv4 or IPv6 addresses and their associated ports on which the SNMP agent will listen for SNMP requests. IPv4 addresses and port numbers must be separated by a colon (e.g. 192.168.0.2:1). IPv6 addresses and port numbers must be separated by square brackets and a colon (e.g. [2001:db8:2728::2200]:[1]). If the **Listen IP (listen-ip)** parameter is set to a value other than 0.0.0.0, the port specified by the **Listen Port (port** parameter must not be associated with any additional addresses.
`max-sessions { max-sessions }`	**Synopsis:** An integer **Default:** 30 The maximum number of concurrent SNMP sessions.
`snmp-engine-id { snmp-engine-id }`	**Synopsis:** A string The unique SNMP engine ID assigned to the SNMP agent. Engine IDs consist of 5 to 32 colon-separated octets (e.g. nn:nn:nn:nn:nn). Each octet is a 2-digit hexadecimal number. The default ID is the enterprise number of the device followed by its MAC address. The value of **Local SNMP Engine ID (snmp-engine-id).** must correspond with the value of **User SNMP Engine ID (id)** .
`source-ip { source-ip }`	**Synopsis:** A string The source IP address for all notifications sent from the SNMP agent. The address may or may not belong to the device.
`auth-failure-trap-notify { auth-failure-trap-notify }`	**Synopsis:** [none | snmpv1_trap | snmpv2_trap | snmpv2_inform | snmpv3_trap | snmpv3_inform] **Default:** none The security model and notification type of the authenticationFailure notification, which the agent sends out when authentication fails. Options include: • none - The authenticationFailure notification is delivered to all management targets • snmpv1_trap - The authenticationFailure notification is delivered to management targets configured to receive SNMPv1 trap notifications • snmpv2_trap - The authenticationFailure notification is delivered to management targets configured to receive SNMPv2 trap notifications • snmpv2_inform - The authenticationFailure notification is delivered to management targets configured to receive SNMPv2 **inform** notifications • snmpv3_trap - The authenticationFailure notification is delivered to management targets configured to receive SNMPv3 **trap** notifications • snmpv3_inform - The authenticationFailure notification is delivered to management targets configured to receive SNMPv3 **inform** notifications

Parameter	Description
`authen-traps-enabled { authen-traps-enabled }`	**Synopsis:** [true | false] **Default:** false Enables/disables the SNMP to send generic authentication traps.
`rox-authentication-trap-enabled { rox-authentication-trap-enabled }`	**Synopsis:** [true | false] **Default:** false Enables/disables the SNMP to send detailed traps related to user authentication and password management.
`dscp { dscp }`	**Synopsis:** An integer between 0 and 63 **Default:** 0 The priority level for traffic sent by the SNMP agent. Values must correspond with Differentiated Services Code Points (DSCPs), as described in RFC 2475.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

14.2.2 Viewing Statistics for SNMP

To view the statistics collected for SNMP, type:

```
show admin snmp statistics
```

If statistics are available, a table or list similar to the following example appears:

```
ruggedcom# show admin snmp statistics
statistics
 unsupported sec levels 1
 not in time windows    1
 unknown user names     1
 unknown engine ids     4
 wrong digests          1
 decryption errors      1
```

This table or list provides the following information:

Parameter	Description
`unsupported-sec-levels`	**Synopsis:** An integer The total number of incoming SNMP packets dropped because they requested an unknown or unavailable security level.
`not-in-time-windows`	**Synopsis:** An integer The total number of incoming SNMP packets dropped because they were received after the authoritative SNMP engine's time out period expired.
`unknown-user-names`	**Synopsis:** An integer The total number of incoming SNMP packets dropped because they referenced an unknown user.

Parameter	Description
unknown-engine-ids	**Synopsis:** An integer The total number of incoming SNMP packets dropped because they referenced an unknown SNMP Engine ID.
wrong-digests	**Synopsis:** An integer The total number of incoming SNMP packets dropped because they contained an unexpected digest value (i.e. authentication key).
decryption-errors	**Synopsis:** An integer The total number of incoming SNMP packets dropped because they could not be decrypted.

14.2.3 Discovering SNMP Engine IDs

To discover an ID of a remote SNMP protocol engine, do the following:

1. At the prompt, type the following command:

   ```
   admin snmp snmp-discover
   ```

2. When prompted, type the IP address of the remote SNMP protocol engine.

   ```
   ruggedcom# admin snmp snmp-discover
   Value for 'address' (&amp;lt;string, min: 7 chars, max: 15 chars&amp;gt;):
    { ip-address }
   ```

Once discovered, the ID is displayed. For example:

```
snmp-discover-return-string 80:00:3A:9C:03:94:B8:C5:FF:F6:00
```

14.2.4 Managing SNMP Communities

This section describes how to manage SNMP communities.

14.2.4.1 Viewing a List of SNMP Communities

To view a list of SNMP communities configured on the device, type:

```
show running-config admin snmp snmp-community
{ name }
```

If communities have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config admin snmp snmp-community | tab
COMMUNITY  USER
NAME       NAME
------------------
```

```
private     oper
public      guest

 !
!
```

By default, private and public communities are pre-configured. If additional communities are required, add them as needed. For more information, refer to "Adding an SNMP Community (Page 839)".

14.2.4.2 Adding an SNMP Community

To add an SNMP community, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the SNMP community by typing:

   `admin snmp snmp-community { name }`

   Where:

   - `{ name }` is the name of the community
3. Configure the following parameter(s) as required:

Parameter	Description
`user-name { user-name }`	**Synopsis:** A string between 1 and 128 characters long The user name associated with the community string.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

14.2.4.3 Deleting an SNMP Community

To delete an SNMP community, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the SNMP community by typing:

   `no admin snmp snmp-community { name }`

   Where:

   - `{ name }` is the name of the community
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

14.2.5 Managing SNMP Target Addresses

This section describes how to manage SNMP target addresses.

14.2.5.1 Viewing a List of SNMP Target Addresses

To view a list of SNMP target addresses configured on the device, type:

```
show running-config admin snmp snmp-target-address
```

If target addresses have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config admin snmp snmp-target-address | tab
                              TARGET          TRAP  SECURITY  USER   SECURITY
TARGET NAME          ENABLED  ADDRESS         PORT  MODEL     NAME   LEVEL
-------------------------------------------------------------------------------
127.0.0.1 v1         true     127.0.0.1       162   v1        oper   noAuthNoPriv
127.0.0.1 v2         true     127.0.0.1       162   v2c       oper   noAuthNoPriv
127.0.0.1 v3.guest   true     127.0.0.1       162   v3        admin  noAuthNoPriv
127.0.0.1 v3.inform  true     127.0.0.1       162   v3        admin  authPriv
127.0.0.1 v3.trap    true     127.0.0.1       162   v3        admin  authNoPriv
target               true     192.168.0.111   162   v2c       admin  noAuthNoPriv

 !
!
```

If no SNMP target addresses have been configured, add target addresses as needed. For more information, refer to "Adding an SNMP Target Address (Page 840)".

14.2.5.2 Adding an SNMP Target Address

To add an SNMP target address, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***admin » snmp » snmp-target-address*** and configure the following parameter(s) as required:

Parameter	Description
`{ target-name }`	**Synopsis:** A string between 1 and 32 characters long The unique name for the SNMP target.
`enabled { enabled }`	**Synopsis:** [true | false] **Default:** true Enables/disables the SNMP agent to send traps to the SNMP target.
`target-address { target-address }`	**Synopsis:** A string The IPv4 or IPv6 address for the SNMP target.
`trap-port { trap-port }`	**Synopsis:** An integer between 0 and 65535 **Default:** 162 The UDP port on which the target will receive notifications. The trap port corresponds with the IP address specified by **Target Address (target-address).**

Parameter	Description
`security-model { security-model }`	**Synopsis:** [v1 | v2c | v3] **Default:** v2c The recognized security model of SNMP packets sent from the target. Options include: • snmpv1 - Packets sent from the target use the SNMPv1 community-based security model. • snmpv2c - Packets sent from the target use the SNMPv2c community-based security model • snmpv3 - Packets sent from the target use the SNMPv3 user-based security model
`user-name { user-name }`	**Synopsis:** A string between 1 and 128 characters long The recognized user name. Only this user name is permitted to exchange SNMP packets with the target.
`security-level { security-level }`	**Synopsis:** [noAuthNoPriv | authNoPriv | authPriv] **Default:** noAuthNoPriv The security level of SNMPv3 packets sent to or from the target. Options include: • authPriv - Users must be authenticated with a password in order to receive SNMPv3 packets sent from the target • authNoPriv - Users must be authenticated in order to receive SNMPv3 packets sent from the target. No password is required. • noAuthnoPriv - Users do not need to be authenticated to receive SNMPv3 packets sent from the target. No password is required. **Security Model (security-model)** must be set to **snmpv3** .
`control-community { control-community }`	**Synopsis:** A string between 1 and 32 characters long Incoming SNMP requests from the specified community will be blocked. Values must correspond with preconfigured SNMPv1/v2c community names.
`tag-list { tag-list }`	**Synopsis:** [snmpv1_trap | snmpv2_trap | snmpv2_inform | snmpv3_trap | snmpv3_inform] **Default:** snmpv2_trap The types of notifications the target may receive. Options include: • snmpv1_trap - The target will receive **trap** notifications from SNMPv1 agents • snmpv2_trap - The target will receive **trap** notifications from SNMPv2c agents • snmpv2_inform - The target will receive and acknowledge **inform** notifications from SNMPv2c agents • snmpv3_trap - The target will receive **trap** notifications from SNMPv3 agents • snmpv3_inform - The target will receive and acknowledge **inform** notifications from SNMPv3 agents

Parameter	Description
	Note Multiple options can be selected.
`inform-timeout { inform-timeout }`	**Synopsis:** An integer between 0 and 2147483647 **Default:** 6000 The time in hectoseconds (hs or 100 s) the SNMP agent will wait for the target to acknowledge an inform notification. When this time expires, the SNMP agent will resend the notification until it is acknowledged. The maximum number of attempts is defined by **Maximum Retries (inform-retries)** .
`inform-retries { inform-retries }`	**Synopsis:** An integer between 0 and 255 **Default:** 3 The maximum number of times the agent will resend an unacknowledged inform notification. After this value is exceeded the SNMP session fails.
`target-engine-id { target-engine-id }`	**Synopsis:** A string The SNMP engine ID of the SNMP target. Engine IDs consist of 5 to 32 colon-separated octets (e.g. nn:nn:nn:nn:nn). Each octet is a 2-digit hexadecimal number.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

14.2.5.3 Deleting an SNMP Target Address

To delete an SNMP target address, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the SNMP target address by typing:

   ```
   no admin snmp snmp-target-address { target-name }
   ```

   Where:

   - `{ target-name }` is a descriptive name for the target (e.g. *Corporate NMS*)
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

14.2.6 Managing SNMP Users

This section describes how to manage SNMP users.

14.2.6.1 Viewing a List of SNMP Users

To view a list of SNMP users configured on the device, type:

```
show running-config admin snmp snmp-user
```

If users have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config admin snmp snmp-user | tab
                                 USER   AUTH
USER ENGINE ID                   NAME   PROTOCOL  AUTH KEY
------------------------------------------------------------------------------
80:00:3a:9c:03:00:0a:dc:ff:9a:00 oper   sha1      $4$kNxlPIYMx2xJhYYI0d4IDw==
80:00:3a:9c:03:00:0a:dc:ff:9a:00 admin  none      -
80:00:3a:9c:03:00:0a:dc:ff:9a:00 guest  md5       $4$kNxlPIYMx2xJhYYI0d4IDw==

 !
!
```

If no SNMP users have been configured, add users as needed. For more information, refer to "Adding an SNMP User (Page 843)".

14.2.6.2 Adding an SNMP User

To add an SNMP user, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the SNMP user by typing:

   ```
   admin snmp snmp-user { id } { name }
   ```

   Where:

   - `{ id }` is the ID for the user
   - `{ name }` is the name of the user

   ⚠ NOTICE

   Security hazard – risk of unauthorized access and/or exploitation

   Use only strong passwords when configuring SNMP users that consist of at least:

   - One lower case character
   - One upper case character
   - One number
   - One special character (i.e. !@#$%^&*()_+-={}[];:',<.>/?\|`~)

   Avoid weak passwords (e.g. *password1*, *123456789*, *abcdefgh*) or repeated characters (e.g. *abcabc*).

3. Configure the following parameter(s) as required:

Parameter	Description
`auth-protocol { auth-protocol }`	**Synopsis:** [none | md5 | sha1] **Default:** none The authentication method used for exchanges between the user and the SNMP engine. Options include: • none - Exchanges are not authenticated • md5 - The server uses the MD5 algorithm to authenticate exchanges • sha1 - The server uses the SHA-1 hash function to authenticate exchanges When md5 or sha1 is selected, **Authentication Key (auth-key)** must be defined.
`auth-key { auth-key }`	**Synopsis:** A string The passphrase required to authenticate messages from the SNMP engine. The passphrase must be at least 8 characters long. **Authentication Protocol (auth-protocol)** must be set to either md5 or sha1.
`privacy-protocol { privacy-protocol }`	**Synopsis:** [none | des3cbc | aescfb128] **Default:** none The data encryption and decryption method for exchanges between the user and the SNMP engine. Options include: • none - Exchanges are not encrypted and decrypted • des3cbc - The server uses the 3DES-CBC algorithm to encrypt and decrypt exchanges • aescfb128 - The server uses the AES-CFB algorithm to encrypt and decrypt exchanges When des3cbc or aescfb128 is selected, **Privacy Key (privacy-key)** must be defined.
`privacy-key { privacy-key }`	**Synopsis:** A string The privacy passphrase required to encrypt message to and decrypt messages from the SNMP engine. The passphrase must be at least 8 characters long. **Privacy Protocol (privacy-protocol)** must be set to either des3cbc or aescfb128.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

14.2.6.3 Deleting an SNMP User

To delete an SNMP user, do the following:

1. Make sure the CLI is in Configuration mode.

2. Delete the SNMP user by typing:

   `no admin snmp snmp-user { id } { name }`

   Where:

   - `{ id }` is the ID for the user
   - `{ name }` is the name of the user

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

14.2.7 Managing SNMP Security Model Mapping

This section describes how to manage the mapping of SNMP security models.

14.2.7.1 Viewing a List of SNMP Security Models

To view a list of SNMP security models configured on the device, type:

`show running-config admin snmp snmp-security-to-group`

If target addresses have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config admin snmp snmp-security-to-group | tab
SECURITY  USER
MODEL     NAME   GROUP
----------------------------
v1        oper   all-rights
v1        guest  all-rights
v2c       oper   all-rights
v2c       admin  testgroup
v2c       guest  all-rights
v3        admin  initial

 !
!
```

If no SNMP security models have been configured, add security models as needed. For more information, refer to "Adding an SNMP Security Model (Page 845)".

14.2.7.2 Adding an SNMP Security Model

To add an SNMP security model, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the SNMP security model by typing:

   `admin snmp snmp-security-to-group { model } { name } { group | { group } }`

Where:

- `{ model }` is the security model. Options include **range**, **v1**, **v2c** and **v3**.
- `{ name }` is the name of the associated user profile. Options include **admin**, **guest** and **oper**.
- `{ group }` is the name of the associated SNMP group. If a group is not defined, the user is granted all access rights by default.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

14.2.7.3 Deleting an SNMP Security Model

To delete an SNMP security model, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the SNMP security model by typing:

   ```
   no admin snmp snmp-security-to-group { model } { name }
   ```

   Where:

   - `{ model }` is the security model
   - `{ name }` is the name of the associated user profile

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

14.2.8 Managing SNMP Group Access

This section describes how to manage access for SNMP groups.

14.2.8.1 Viewing a List of SNMP Groups

To view a list of SNMP groups configured on the device, type:

```
show running-config admin snmp snmp-access
```

If groups have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config admin snmp snmp-access | tab
            SECURITY  SECURITY      READ VIEW   WRITE VIEW  NOTIFY
GROUP       MODEL     LEVEL         NAME        NAME        VIEW NAME
-------------------------------------------------------------------------
initial     any       noAuthNoPriv  all-of-mib  all-of-mib  all-of-mib
initial     any       authNoPriv    all-of-mib  all-of-mib  all-of-mib
initial     any       authPriv      all-of-mib  all-of-mib  all-of-mib
testgroup   v2c       noAuthNoPriv  all-of-mib  all-of-mib  all-of-mib
```

```
all-rights  any       noAuthNoPriv  all-of-mib  all-of-mib  all-of-mib

 !
!
```

If no SNMP groups have been configured, add groups as needed. For more information, refer to "Adding an SNMP Group (Page 847)".

14.2.8.2 Adding an SNMP Group

To add an SNMP group, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the SNMP group by typing:

   ```
   admin snmp snmp-access { group } { model } { level }
   ```

   Where:

   - `{ group }` is the name of the group.
   - `{ model }` is the security model for the group. Options include: **any**, **v1**, **v2c**, or **v3**.
   - `{ level }` is the security level for the group. Options include:
     - **authPriv** – Communication with authentication and privacy.
     - **authNoPriv** – Communication with authentication and without privacy.
     - **noAuthnoPriv** – Communication without authentication and privacy.
3. Configure the following parameter(s) as required:

Parameter	Description
`read-view-name { read-view-name }`	**Synopsis:** [no-view | v1-mib | restricted | all-of-mib] **Default:** all-of-mib The read view to which members of the SNMP group have access. Options include: • all-of-mib - Group members can view all objects in the MIB • restricted - Group members can view only the system, snmp, snmpEngine, snmpMPDStats, and usmStats subtrees in the MIB • v1-mib - Group members can view only SNMPv1 objects in the MIB • no-view - Group members cannot view any object in the MIB
`write-view-name { write-view-name }`	**Synopsis:** [no-view | v1-mib | restricted | all-of-mib] **Default:** all-of-mib The write view to which members of the SNMP group have access. Options include:

Parameter	Description
	• all-of-mib - Group members can make changes to all objects in the MIB • restricted - Group members can make changes to only the system, snmp, snmpEngine, snmpMPDStats, and usmStats subtrees in the MIB • v1-mib - Group members can make changes to only SNMPv1 objects in the MIB • no-view - Group members cannot make changes to any object in the MIB
`notify-view-name { notify-view-name }`	**Synopsis:** [no-view | v1-mib | restricted | all-of-mib] **Default:** all-of-mib The notify view to which members of the SNMP group have access. Options include: • all-of-mib - Group members receive notifications from all objects in the MIB • restricted - Group members receive notifications from only the system, snmp, snmpEngine, snmpMPDStats, and usmStats subtrees in the MIB • v1-mib - Group members receive notifications from only SNMPv1 objects in the MIB • no-view - Group members do not receive any notifications from the MIB

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

14.2.8.3 Deleting an SNMP Group

To delete an SNMP group, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the SNMP group by typing:

   ```
   no admin snmp snmp-access { group } { model } { level }
   ```

   Where:

   - `{ group }` is the name of the group
   - `{ model }` is the security model for the group
   - `{ level }` is the security level for the group
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

14.3 Managing NETCONF

The Network Configuration Protocol (NETCONF) is a network configuration protocol developed by the Internet Engineering Task Force (IETF). NETCONF provides functions to download, upload, change, and delete the configuration data on network devices. RUGGEDCOM ROX II devices also support the ability to collect data and perform direct actions on the device, such as rebooting the device, clearing statistics, and restarting services.

Note
For more information about NETCONF and its use, refer to the "NETCONF Reference Guide for RUGGEDCOM ROX II v2.15 ".

14.3.1 Enabling and Configuring NETCONF Sessions

To enable and configure NETCONF sessions, do the following:

1. Make sure the CLI is in Configuration mode.

⚠ NOTICE

Security hazard – risk of unauthorized access/exploitation

Configure an idle timeout period for NETCONF to prevent unauthorized access (e.g. a user leaves their station unprotected) or denial of access (e.g. a guest user blocks an admin user by opening the maximum number of NETCONF sessions).

Note
Before configuring an idle timeout on a device managed by RUGGEDCOM NMS, make sure NMS is configured to support a timeout period for NETCONF sessions.

2. Navigate to ***admin » netconf*** and configure the following parameter(s) as required:

Parameter	Description
`enabled { enabled }`	**Synopsis:** [true | false] **Default:** true Enables NETCONF on the device, allowing it to receive and respond to NETCONF requests.
`listen-ip { listen-ip }`	**Synopsis:** A string **Default:** 0.0.0.0 The IPv4 or IPv6 address on which the device will listen for NETCONF requests. The default value (i.e. 0.0.0.0) enables the device to receive NETCONF requests via any IP address associated with the device.

Parameter	Description
`port { port }`	**Synopsis:** An integer between 0 and 65535 **Default:** 830 The default port on which the device will listen for NETCONF requests. The port corresponds with the IP address specified by the **Listen IP (listen-ip)** parameter.
`extra-ip-ports { extra-ip-ports }`	**Synopsis:** A string Additional IPv4 or IPv6 addresses and their associated ports on which the device will listen for NETCONF requests. IPv4 addresses and port numbers must be separated by a colon (e.g. 192.168.0.2:19343). IPv6 addresses and port numbers must be separated by square brackets and a colon (e.g. [2001:db8:2728::2200]:[19343]). If the **Listen IP (listen-ip)** parameter is set to a value other than "0.0.0.0," the port specified by the **Listen Port (port)** parameter must not be associated with any additional addresses.
`max-sessions { max-sessions }`	**Synopsis:** An integer **Default:** 10 The maximum number of concurrent NETCONF sessions.
`idle-timeout { idle-timeout }`	**Synopsis:** A string **Default:** PT0S The maximum period of time a NETCONF session will remain idle before being terminated. Values are expressed in durations of years, months, weeks, days, hours, minutes, and/or seconds in ISO 8601 format (e.g. P1Y1M2W3DT2H3M30S represents 1 year, 1 month, 2 weeks, 3 days, 2 hours, 3 minutes, and 30 seconds). If the value is set to 0, a NETCONF session will never time out. A session is not considered idle if the NETCONF server is waiting for notifications or if commits are pending. If the value of this parameter is changed during a session, the change will not take effect until the next session

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.
4. [Optional] Enable the NETCONF summary log (saved under **/var/log/netconf.log**) to record all NETCONF protocol transactions. For more information, refer to "Enabling/Disabling the NETCONF Summary Log (Page 96)".
5. [Optional] Enable the NETCONF trace log (saved under **/var/log/netconf-trace.log**) to record the text of each NETCONF XML message received by and sent by the device. For more information, refer to "Enabling/Disabling the NETCONF Trace Log (Page 97)".

14.3.2 Viewing NETCONF Statistics

To view NETCONF related statistics, type:

```
show admin netconf
```

A table or list similar to the following example appears:

```
ruggedcom# show admin netconf
netconf
 statistics
  in bad hellos     0
  in sessions       0
  dropped sessions  0
  in rpcs           0
  in bad rpcs       0
  out rpc errors    0
  out notifications 0
```

This table or list provides the following information:

Parameter	Description
`in-bad-hellos`	**Synopsis:** An integer The total number of NETCONF sessions dropped because the device received an invalid hello message. Errors in nested elements and/or attributes can invalidate a hello message.
`in-sessions`	**Synopsis:** An integer The total number of NETCONF sessions initiated on the device.
`dropped-sessions`	**Synopsis:** An integer The total number of NETCONF sessions dropped on the device.
`in-rpcs`	**Synopsis:** An integer The total number of NETCONF requests (i.e. rpc messages) received.
`in-bad-rpcs`	**Synopsis:** An integer The total number of NETCONF requests (i.e. rpc messages) dropped because they contained non-conformant XML.
`out-rpc-errors`	**Synopsis:** An integer The total number of NETCONF replies (i.e. rpc-reply messages) sent with a nested rpc-error element. The rpc-error element indicates to a client that one or more errors occurred in processing its NETCONF request (i.e. rpc message).
`out-notifications`	**Synopsis:** An integer The total number of notification messages sent.

14.4 Managing IPv4 Neighbors

RUGGEDCOM ROX II supports Address Resolution Protocol (ARP) tables for individual Layer 3 interfaces.

14.4.1 IPv4 Neighbor Concepts

An IPv4 neighbor is any host on the same local area network connected to the device via Ethernet cables or network swiches. For the device to forward traffic to an IPv4 neighbor, it must know the host's IP address and physical address, or Media Access Control (MAC) address.

This information is collected separately for each Layer 3 interface in a dedicated ARP table (or cache) for quick IP address resolution.

Hosts communicate their IP and MAC addresses through ARP request and ARP response messages. When an interface has traffic to forward and the destination cannot be found in the ARP table, the device broadcasts an ARP reqeust message to hosts on its local network. The host that matches the request responds with an ARP response message, which includes its MAC address and IP address. This information is then added to the interface's ARP table for future reference.

Host information is retained for each Layer 3 interface, unless explicitly cleared. Users have the option to clear select entries per interface.

14.4.2 Viewing IPv4 Neighbors

An ARP table (or cache) of IPv4 neighbor information is available for a Layer 3 interface if IPv4 neighbors are discovered.

IPv4 Neighbor Information

The ARP table details the following for each entry:

Parameter	Description
`{ neigh-ipaddress }`	**Synopsis:** A string The IP address of the neighbor.
`neigh-macaddress`	**Synopsis:** A string The MAC address of the neighbor.
`neigh-state`	**Synopsis:** A string The state of the neighbor. Possible values include: • **permanent** – The entry is valid and permanent. Entries in this state must be cleared by a user. • **noarp** – The entry is valid, but no attempt to validate the entry will be made. It can be removed when its lifetime has expired. • **reachable** – The entry is valid until the reachability timeout expires. • **stale** – The entry is valid, but suspicious. • **incomplete** – The entry is not yet validated/resolved. • **delay** – Validation of the entry is delayed. • **probe** – The neighbor is being probed.

Parameter	Description
	• **failed** – The maximum number of probes has been exceeded and neighbor verification has failed.

Viewing the State of All IPv4 Neighbors

To view the state of all IPv4 neighbors for all Layer 3 interfaces, type:

```
show ip ipv4 neighbors
```

For example:

```
ruggedcom# show ip ipv4 neighbors
             NEIGH                              NEIGH
IFNAME       IPADDRESS       NEIGH MACADDRESS   STATE
-------------------------------------------------------------
dummy0
fe-cm-1
             172.30.141.141  none               incomplete
             172.30.141.164  00:0a:cd:27:e2:80  stale
             172.30.128.12   00:1a:64:23:9b:d8  stale
             192.168.1.111   00:1b:21:a2:fe:4d  stale
             172.30.128.1    94:b8:c5:34:ac:3f  reachable
             172.30.128.8    00:1a:64:d4:4d:1e  stale
             172.30.141.49   00:13:46:30:2f:b5  stale
switch.0001
```

Viewing the State of IPv4 Neighbors for Specific Interfaces

To view the state of IPv4 neighbors for a specific Layer 3 interface, type:

```
show ip { interface } ipv4 neighbors
```

Where { interface } is the name of the Layer 3 interface.

For example:

```
ruggedcom# show ip fe-cm-1 ipv4 neighbors
NEIGH                            NEIGH
IPADDRESS       NEIGH MACADDRESS   STATE
-----------------------------------------------
172.30.141.164  00:0a:cd:27:e2:80  stale
172.30.128.12   00:1a:64:23:9b:d8  stale
192.168.1.111   00:1b:21:a2:fe:4d  stale
172.30.128.1    94:b8:c5:34:ac:3f  reachable
172.30.128.8    00:1a:64:d4:4d:1e  stale
172.30.141.49   00:13:46:30:2f:b5  stale
```

Viewing the State of a Specific IPv4 Neighbor

To view the state of a specific IPv4 neighbor in an ARP table, type:

```
show ip { interface } ipv4 neighbors status
{ neighbor }
```

Where:

- { interface } is the name of the Layer 3 interface

- { neighbor } is the IP address of the IPv4 neighbor

For example:

```
ruggedcom# show ip fe-cm-1 ipv4 neighbors status 172.30.128.1
NEIGH                          NEIGH
IPADDRESS     NEIGH MACADDRESS   STATE
-------------------------------------------
172.30.128.1  94:b8:c5:34:ac:3f  reachable
```

14.4.3 Clearing IPv4 Neighbors

Select IPv4 neighbors can be cleared from the ARP tables.

To clear an entry from the cache for a Layer 3 interface, type:

```
ip { interface } ipv4 neighbors status { neighbor } clear
```

Where:

- { interface } is the name of the Layer 3 interface
- { neighbor } is the IP address of the IPv4 neighbor

15 Traffic Control and Classification

Use the traffic control and classification subsystems to control the flow of data packets to connected network interfaces. RUGGEDCOM ROX II also features tools for traffic analysis and characterization.

15.1 Managing Port Mirroring

Port mirroring is a troubleshooting tool that copies, or mirrors, all traffic received or transmitted on a designated port to another mirror port. If a protocol analyzer were attached to the target port, the traffic stream of valid frames on any source port is made available for analysis.

Select a target port that has a higher speed than the source port. Mirroring a 100 Mbps port onto a 10 Mbps port may result in an improperly mirrored stream.

Frames will be dropped if the full-duplex rate of frames on the source port exceeds the transmission speed of the target port. Since both transmitted and received frames on the source port are mirrored to the target port, frames will be discarded if the sum traffic exceeds the target port's transmission rate. This problem reaches its extreme in the case where traffic on a 100 Mbps full-duplex port is mirrored onto a 10 Mbps half-duplex port.

Invalid frames received on the source port will not be mirrored. These include CRC errors, oversized and undersized packets, fragments, jabbers, collisions, late collisions and dropped events).

Note
Port mirroring has the following limitations:

- The target port may sometimes incorrectly show the VLAN tagged/untagged format of the mirrored frames.
- Network management frames (such as RSTP, GVRP, etc.) may not be mirrored.
- Switch management frames generated by the switch (such as Telnet, HTTP, SNMP, etc.) may not be mirrored.

15.1.1 Configuring Port Mirroring

To configure port mirroring, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***switch » port-mirroring***.

Note
Mirror ports allow bidirectional traffic (i.e. the device will not block incoming traffic to the mirror port or ports). This can lead to traffic being forwarded to unintended ports. For increased security, configure ingress filtering to control traffic flow when port mirroring is enabled.

For information about configuing the device to control traffic flow when port mirroring is enabled, refer to the FAQ "How to Control Bidirectional Traffic when Using Port Mirroring" (https://support.industry.siemens.com/cs/ww/en/view/109759351).

For more information about enabling ingress filtering, refer to "Enabling/Disabling Ingress Filtering (Page 361)".

3. Configure port mirroring for a specific port by typing:

   ```
   switch port-mirroring enabled target-slot swport target-port { port } egress-src { egress } ingress-src { ingress }
   ```

   Where:

   - `{ port }` is the port number (or a list of ports, if aggregated in a port trunk)
   - `{ egress }` is the port number for the outgoing port
   - `{ ingress }` is the port number for the the incoming port

4. Add egress and ingress source ports. For more information, refer to "Adding an Egress Source Port (Page 857)" and "Adding an Ingress Source Port (Page 858)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.1.2 Managing Egress Source Ports

This section describes how to configure and manage egress source ports for port mirroring.

15.1.2.1 Viewing a List of Egress Source Ports

To view a list of egress source port for port mirroring, type:

```
show running-config switch port-mirroring egress-src
```

If egress source ports have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config switch port-mirroring egress-src
```

```
switch port-mirroring
 egress-src swport 1
 !
!
```

If no egress source ports have been configured, add egress source ports as needed. For more information, refer to "Adding an Egress Source Port (Page 857)".

15.1.2.2 Adding an Egress Source Port

To add an egress source port for port mirroring, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the egress source port by typing:

   `switch port-mirroring egress-src swport { port }`

   Where:

   - `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.1.2.3 Deleting an Egress Source Port

To delete an egress source port for port mirroring, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the address by typing:

   `no switch port-mirroring egress-src swport { port }`

   Where:

   - `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.1.3 Managing Ingress Source Ports

This section describes how to configure and manage ingress source ports for port mirroring.

15.1.3.1 Viewing a List of Ingress Source Ports

To view a list of ingress source port for port mirroring, type:

```
show running-config switch port-mirroring ingress-src
```

If ingress source ports have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config switch port-mirroring ingress-src
switch port-mirroring
 ingress-src swport 1
 !
!
```

If no ingress source ports have been configured, add ingress source ports as needed. For more information, refer to "Adding an Ingress Source Port (Page 858)".

15.1.3.2 Adding an Ingress Source Port

To add an ingress source port for port mirroring, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the ingress source port by typing:

   ```
   switch port-mirroring ingress-src swport { port }
   ```

   Where:

   - `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.1.3.3 Deleting an Ingress Source Port

To delete an ingress source port for port mirroring, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the address by typing:

   ```
   no switch port-mirroring ingress-src swport
   { port }
   ```

   Where:

   - `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.2 Managing Traffic Control

Traffic control is a firewall subsystem that manages the amount of bandwidth for each network interface that different types of traffic are permitted to use. For a traffic control configuration to work, a firewall must be configured.

Note
For more information about firewalls, refer to "Managing Firewalls (Page 217)".

RUGGEDCOM ROX II allows up to four different firewall configurations, enabling users to quickly change between configurations. Users can quickly assess different configurations without needing to save and reload any part of the configuration. In contrast, there is only one traffic control configuration.

When enabled, a traffic control configuration is used with the current firewall configuration. A current firewall configuration is defined as one that is specified in either work-config and/or active-config. It does not have to be enabled to be validated.

Note
Traffic control is not available for Ethernet traffic on any line module when Layer 3 hardware acceleration is enabled. It is intended to be used only on WAN interfaces.

15.2.1 Enabling and Configuring Traffic Control

Traffic control functions are divided into two modes:

- **Basic Mode**

  Basic mode offers a limited set of options and parameters. Use this mode to set the outgoing bandwidth for an interface, the interface priority (high, medium or low), and some simple traffic control characteristics. Basic traffic shaping affects traffic identified by protocol, port number, address and interface. Note that some of these options are mutually exclusive. Refer to the information given for each option.

  In basic mode, a packet is categorized based on the contents of its Type of Service (ToS) field if it does not match any of the defined classes.

- **Advanced Mode**

  In advanced mode, each interface to be managed is assigned a total bandwidth for incoming and outgoing traffic. Classes are then defined for each interface, each with its own minimum assured bandwidth and a maximum permitted bandwidth. The combined minimum of the classes on an interface must be no more than the total outbound bandwidth specified for the interface. Each class is also assigned a priority, and any bandwidth left over after each class has received its minimum allocation (if needed) will be allocated to the lowest priority class up until it reaches its maximum bandwidth, after which the next priority is allocated more bandwidth. When the specified total bandwidth for the interface is reached, no further packets are sent, and any further packets may be dropped if the interface queues are full.

Packets are assigned to classes on the outbound interface based on either a mark assigned to the packet, or the Type of Service (ToS) field in the IP header. If the ToS field matches a defined class, the packet is allocated to that class. Otherwise, it is allocated to any class that matches the mark assigned to the packet. If no class matches the mark, the packet is assigned to the default class.

Marks are assigned to packets by traffic control rules that are based on a number of parameters, such as IP address, port number, protocol, packet length, and more.

The two modes cannot be accessed simultaneously. Only the mode that is currently configured can be accessed.

To enable and configure traffic control, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***qos » traffic-control***.
3. Configure the following parameter(s) as required:

Parameter	Description
`enabled`	Enables/disables traffic control (TC) for the current firewall configuration. The current firewall configuration is the one that is committed. When an active configuration is committed to the system, then an **enabled** TC configuration will be included. When a work configuration is committed, the **enabled** TC configuration will be included in the work configuration. **A TC configuration needs a firewall configuration to operate** .
`mode-choice { mode-choice }`	**Synopsis:** [basic | advanced] **Default:** basic Choose to use either 'simple' or 'advanced' configuration modes. Click again on traffic-control after making a choice.

4. If basic mode is enabled, do the following:
   a. Add traffic control interfaces. For more information, refer to "Adding a Traffic Control Interface (Page 861)".
   b. Add traffic control priorities. For more information, refer to "Adding a Traffic Control Priority (Page 864)".
5. If advanced mode is enabled, do the following:
   a. Add traffic control classes. For more information, refer to "Adding a Traffic Control Class (Page 866)".
   b. Add traffic control devices. For more information, refer to "Adding a Traffic Control Device (Page 868)".
   c. Add traffic control rules. For more information, refer to "Adding a Traffic Control Rule (Page 870)".
6. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.2.2 Managing Traffic Control Interfaces

Traffic control interfaces define interfaces used for traffic shaping, mainly for outbound bandwidth and the outgoing device.

Note
Traffic control interfaces can only be configured in basic mode. For more information about setting the traffic control mode, refer to "Enabling and Configuring Traffic Control (Page 859)".

15.2.2.1 Viewing a List of Traffic Control Interfaces

To view a list of traffic control interfaces, type:

```
show running-config qos traffic-control basic-configuration tcinterfaces
```

If interfaces have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config qos traffic-control basic-configuration tcinterfaces
qos
 traffic-control
  basic-configuration
   tcinterfaces te1-2-1c01ppp
    type         external
    inbandwidth  1500
    in-unit      kilobits
    outbandwidth 1500
    out-unit     kilobits
    description  "TC on T1 Link"
   !
  !
 !
!
```

If no interfaces have been configured, add interfaces as needed. For more information, refer to "Adding a Traffic Control Interface (Page 861)".

15.2.2.2 Adding a Traffic Control Interface

To add a new traffic control interface, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the interface by typing:

   ```
   qos traffic-control basic-configuration tcinterfaces { interface }
   ```

   Where:

   - { interface } is the name of the traffic control interface
3. Configure the following parameter(s) as required:

Parameter	Description
`iptype { iptype }`	**Synopsis:** [ipv4 | ipv6 | ipv4ipv6] **Default:** ipv4 The type of traffic accepted by the interface. Traffic not accepted will be routed to another interface. Select 'ipv4ipv6' to accept all traffic regardless of IP type.
`type { type }`	**Synopsis:** [internal | external | none] **Default:** none (optional) 'external' (facing toward the Internet) or 'internal' (facing toward a local network). 'external' causes the traffic generated by each unique source IP address to be treated as a single flow. 'internal' causes the traffic generated by each unique destination IP address to be treated as a single flow. Internal interfaces seldom benefit from simple traffic shaping.
`inbandwidth { inbandwidth }`	**Synopsis:** An integer (optional) The incoming bandwidth of this interface. If incoming traffic exceeds the given rate, received packets are dropped randomly. When unspecified, maximum speed is assumed. Specify only the number here. The unit (kilobits, megabits) is specified in the in-unit.
`in-unit { in-unit }`	**Synopsis:** [none | kilobits | megabits] **Default:** none The unit for inbandwidth, per second.
`outbandwidth { outbandwidth }`	**Synopsis:** An integer The outgoing bandwidth for this interface. Specify only the number here. The unit (kilobits, megabits) is specified in the out-unit.
`out-unit { out-unit }`	**Synopsis:** [kilobits | megabits] **Default:** megabits The unit for outgoing bandwidth, per second.
`description { description }`	**Synopsis:** A string A description for this configuration item.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.2.2.3 Deleting a Traffic Control Interface

To delete a traffic control interface, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the traffic control interface by typing:

```
no qos traffic-control basic-configuration
tcinterfaces { interface }
```

Where:

- `{ interface }` is the name of the traffic control interface

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.2.3 Managing Traffic Control Priorities

Traffic control priorities define priorities used for traffic shaping.

Note
Traffic control priorities can only be configured in basic mode. For more information about setting the traffic control mode, refer to "Enabling and Configuring Traffic Control (Page 859)".

15.2.3.1 Viewing a List of Traffic Control Priorities

To view a list of traffic control priorities, type:

```
show running-config qos traffic-control basic-configuration tcpriorities
```

If priorities have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config qos traffic-control basic-configuration tcpriorities
qos
 traffic-control
  basic-configuration
   tcpriorities high
    band        high
    protocol    tcp
    port        80
    description "High priority traffic"
   !
   tcpriorities medium
    protocol    udp
    port        1500
    description "Medium priority traffic"
   !
   tcpriorities low
    band        low
    protocol    icmp
    description "Low priority traffic"
   !
  !
 !
!
```

If no priorities have been configured, add priorities as needed. For more information, refer to "Adding a Traffic Control Priority (Page 864)".

15.2.3.2 Adding a Traffic Control Priority

To add a new traffic control priority, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the static MAC address by typing:

   ```
   qos traffic-control basic-configuration tcpriority
   { name }
   ```

   Where:

   - `{ name }` is the name of the traffic control priority entry
3. Configure the following parameter(s) as required:

Parameter	Description
`iptype { iptype }`	**Synopsis:** [ipv4 | ipv6 | ipv4ipv6] **Default:** ipv4 Internet protocol type - use both when no addresses are used, otherwise define IPv4 and IPv6 rules for each type of addresses used.
`band { band }`	**Synopsis:** [high | medium | low] **Default:** medium Priority (band) : high, medium, low... **High band includes:** Minimize Delay (md) (0x10), md + Minimize Monetary Cost (mmc) (0x12), md + Maximize Reliability (mr) (0x14), mmc+md +mr (0x16). **Medium band includes:** Normal Service (0x0), mr (0x04), mmc+mr (0x06), md + Maximize Throughput (mt) (0x18), mmc+mt+md (0x1a), mr+mt+md (0x1c), mmc+mr+mt +md (0x1e). **Low band includes:** mmc (0x02), mt (0x08), mmc+mt (0x0a), mr+mt (0x0c), mmc+mr+mt (0x0e).
`protocol { protocol }`	**Synopsis:** A string or [tcp | udp | icmp | all] (choice) A targeted protocol.
`port { port }`	**Synopsis:** A string (choice) Source port - can be specified **only if** protocol is TCP, UDP, DCCP, SCTP or UDPlite
`address { address }`	**Synopsis:** A string (choice) The source address. This can be specified **only if** the protocol, port and interface are not defined.
`interface { interface }`	**Synopsis:** A string between 1 and 15 characters long (choice) The source interface. This can be specified **only if** the protocol, port and address are not defined. Lowercase alphanumerical as well as '.' and '-' characters are allowed.
`description { description }`	**Synopsis:** A string (optional) A description for this configuration.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.2.3.3 Deleting a Traffic Control Priority

To delete a traffic control priority, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the traffic control priority by typing:

   ```
   no qos traffic-control basic-configuration
   tcpriority { name }
   ```

   Where:

   - `{ name }` is the name of the traffic control priority entry
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.2.4 Managing Traffic Control Classes

Traffic control classes define classes for traffic shaping. Optionally, they can also define parameters for Type of Service (ToS), which is an eight-bit field in the IPv4 header. Traffic control can inspect the ToS value of an incoming IP frame and classify traffic to provide preferential service in the outgoing queue. Traffic classification is done based on the ToS value and the ToS options defined for each traffic control class and traffic control rule. IP Traffic matching with the ToS options takes precedence over the mark rules.

Note
One traffic control class must be added for each network interface.

Note
Type of Service (ToS) is defined by the Internet Engineering Task Force (IETF). For more information about ToS, refer to RFC 1349 [http://tools.ietf.org/html/rfc1349].

15.2.4.1 Viewing a List of Traffic Control Classes

To view a list of traffic control classes, type:

```
show running-config qos traffic-control advanced-
configuration tcclasses
```

If classes have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config qos traffic-control advanced-configuration tcclasses
qos
 traffic-control
  advanced-configuration
   tcclasses TCP
    interface     te1-2-1c01ppp
    mark          1
    min-bandwidth full/2
```

```
    max-bandwidth full
    priority      1
   !
  !
 !
!
```

If no classes have been configured, add classes as needed. For more information, refer to "Adding a Traffic Control Class (Page 866)".

15.2.4.2 Adding a Traffic Control Class

To add a new traffic control class, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the static MAC address by typing:

   ```
   qos traffic-control advanced-configuration tcclasses
   { name }
   ```

   Where:

   - `{ name }` is the name of the traffic control class entry
3. Configure the following parameter(s) as required:

Parameter	Description
`iptype { iptype }`	**Synopsis:** [ipv4 | ipv6 | ipv4ipv6] **Default:** ipv4 Internet protocol type - use both when no addresses are used, otherwise define IPv4 and IPv6 rules for each type of addresses used.
`interface { interface }`	**Synopsis:** A string The interface to which this class applies. Each interface must be listed only once. Lowercase alphanumerical as well as '.' and '-' characters are allowed.
`mark { mark }`	**Synopsis:** An integer between 1 and 255 A mark that identifies traffic belonging to this class. This is a unique integer between 1-255. Each class must have its own unique mark.
`min-bandwidth { min-bandwidth }`	**Synopsis:** A string The minimum bandwidth this class should have when the traffic load rises. This can be either a numeric value or a calculated expression based on the bandwidth of the interface. A fixed numerical value must only be a number - its unit is specified in Minbw-unit. A calculated expression is based on a fraction of the 'full' bandwidth, such as: 1. 'full/3' for a third of the bandwidth and 2. 'full*9/10' for nine tenths of the bandwidth. In such a case, do not specify any minbw-unit.

Parameter	Description
`minbw-unit { minbw-unit }`	**Synopsis:** [none | kilobits | megabits] **Default:** none (per second) Only if the minimum bandwidth is a single numerical value
`max-bandwidth { max-bandwidth }`	**Synopsis:** A string The maximum bandwidth this class is allowed to use when the link is idle. This can be either a numeric value or a calculated expression based on the bandwidth of the interface. A fixed numerical value must only be a number - its unit is specified in Maxbw-unit. A calculated expression is based on a fraction of the 'full' bandwidth, such as: 1. 'full/3' for a third of the bandwidth and 2. 'full*9/10' for nine tenths of the bandwidth. In such a case, do not specify any maxbw-unit.
`maxbw-unit { maxbw-unit }`	**Synopsis:** [none | kilobits | megabits] **Default:** none (per second) only if max-bandwidth is a **single numerical value**
`priority { priority }`	**Synopsis:** An integer between 0 and 7 **Default:** 0 The priority in which classes will be serviced. Higher priority classes will experience less delay since they are serviced first. Priority values are serviced in ascending order (e.g. 0 is higher priority than 1. Minimum: 7).
`description { description }`	**Synopsis:** A string A description for this configuration item.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.2.4.3 Deleting a Traffic Control Class

To delete a traffic control class, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the traffic control class by typing:

   ```
   no qos traffic-control advanced-configuration tcclasses { name }
   ```

   Where:

   - `{ name }` is the name of the traffic control class entry

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.2.5 Managing Traffic Control Devices

Traffic control devices define devices used for traffic shaping.

Note
Traffic control devices can only be configured in advanced mode. For more information about setting the traffic control mode, refer to "Enabling and Configuring Traffic Control (Page 859)".

15.2.5.1 Viewing a List of Traffic Control Devices

To view a list of traffic control devices, type:

```
show running-config qos traffic-control advanced-configuration tcdevices
```

If devices have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config qos traffic-control advanced-configuration tcdevices
qos
 traffic-control
  advanced-configuration
   tcdevices te1-2-1c01ppp
    inbandwidth  1500
    in-unit      kilobits
    outbandwidth 1500
    out-unit     kilobits
   !
  !
 !
!
```

If no devices have been configured, add devices as needed. For more information, refer to "Adding a Traffic Control Device (Page 868)".

15.2.5.2 Adding a Traffic Control Device

To add a new traffic control device, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the traffic control device by typing:

   ```
   qos traffic-control advanced-configuration tcdevices { name }
   ```

   Where:

- `{ name }` is the name of the interface to which traffic shaping will apply. Lowercase alphanumerical as well as '.' and '-' characters are allowed.

3. Configure the following parameter(s) as required:

Parameter	Description
`iptype { iptype }`	**Synopsis:** [ipv4 | ipv6 | ipv4ipv6] **Default:** ipv4 Internet protocol type - use both when no addresses are used, otherwise define IPv4 and IPv6 rules for each type of addresses used.
`inbandwidth { inbandwidth }`	**Synopsis:** An integer **Default:** 0 Incoming bandwidth. Default: 0 = ignore ingress. Defines the maximum traffic allowed for this interface in total. If the rate is exceeded, the packets are dropped.
`in-unit { in-unit }`	**Synopsis:** [none | kilobits | megabits] **Default:** none Unit for inbandwidth, per second.
`outbandwidth { outbandwidth }`	**Synopsis:** An integer Maximum outgoing bandwidth... This is the maximum speed that can be handled. Additional packets will be dropped. This is the bandwidth that can be refrred-to as 'full' when defining classes.
`out-unit { out-unit }`	**Synopsis:** [kilobits | megabits] **Default:** megabits Unit for outgoing bandwidth, per second.
`description { description }`	**Synopsis:** A string A description for this configuration item.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.2.5.3 Deleting a Traffic Control Device

To delete a traffic control device, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the traffic control device by typing:

```
no qos traffic-control advanced-configuration tcdevices { name }
```

Where:

- `{ name }` is the name of the interface to which traffic shaping will apply.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.2.6 Managing Traffic Control Rules

Traffic control rules define rules for packet marking.

Note
Traffic control rules can only be configured in advanced mode. For more information about setting the traffic control mode, refer to "Enabling and Configuring Traffic Control (Page 859)".

15.2.6.1 Viewing a List of Traffic Control Rules

To view a list of traffic control rules, type:

```
show running-config qos traffic-control advanced-configuration tcrules
```

If rules have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config qos traffic-control advanced-configuration tcrules
qos
 traffic-control
  advanced-configuration
   tcrules rule1
    mark-choice set
     mark 1
    !
    source       all
    destination  all
    protocol     tcp
    source-ports 80
   !
  !
 !
!
```

If no rules have been configured, add rules as needed. For more information, refer to "Adding a Traffic Control Rule (Page 870)".

15.2.6.2 Adding a Traffic Control Rule

To add a new traffic control rule, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the traffic control rule by typing:

   ```
   qos traffic-control advanced-configuration tcrule { name }
   ```

Where:

- `{ name }` is the name of the traffic control rule entry.

3. Configure the following parameter(s) as required:

Parameter	Description
`iptype { iptype }`	**Synopsis:** [ipv4 | ipv6 | ipv4ipv6] **Default:** ipv4 Internet protocol type - use both when no addresses are used, otherwise define IPv4 and IPv6 rules for each type of addresses used.
`source { source }`	**Synopsis:** A string IF name, comma-separated list of hosts or IPs, MAC addresses, or 'all'. When using MAC addresses, use '~' as prefix and '-' as separator. Ex.: ~00-1a-6b-4a-72-34,~00-1a-6b-4a-71-42
`destination { destination }`	**Synopsis:** A string IF name, comma-separated list of hosts or IPs, or 'all'.
`protocol { protocol }`	**Synopsis:** A string or [tcp | udp | icmp | all] **Default:** all The protocol to match.
`destination-ports { destination-ports }`	**Synopsis:** A string (Optional) A comma-separated list of port names, port numbers or port ranges.
`source-ports { source-ports }`	**Synopsis:** A string (Optional) A comma- separated list of port names, port numbers or port ranges.
`test { test }`	**Synopsis:** A string Defines the test criteria for an existing packet or connection mark. The rule will match only if the test returns true. Define the test as follows: [!]{ value }[/ { mask }][:C] ! - Reverses the test value - The value of the packet or connection mark mask - A mask to be applied to the mark before testing :C - Designates a connection mark. If not present, the test is applied by default to a packet mark. Example: !0:C
`length { length }`	**Synopsis:** A string (Optional) Matches the length of a packet against a specific value or range of values... Greater than and lesser than, as well as ranges are supported in the form of min:max. Ex.: Equal to 64 **64** Greater or equal to 65 **65:** Lesser or equal to 65 **:65** In-between 64 and 768 **64:768**

Parameter	Description
`tos { tos }`	**Synopsis:** A string or [minimize-delay | maximize-throughput | maximize-reliability | minimize-cost | normal-service] (Optional) Type of Service . A pre-defined ToS value or a numerical value. The numerical value is hexadecimal. Ex.: 0x38
`description { description }`	**Synopsis:** A string A description for this configuration item.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.2.6.3 Configuring QoS Marking

Quality of Service (QoS) marking applies a mark to important data packets that should receive preferential treatment as they travel through the network. Only one QoS mark is allowed for each traffic control rule. Options include:

- **Set** – Determines whether the packet or the connection is assigned the QoS mark.
- **Modify** – Changes the QoS mark value using an AND or OR argument.
- **Save/Restore** – Replaces the connection's QoS mark value with an assigned value.
- **Continue** – If the packet matches, no more traffic control rules are checked and the packet is automatically forwarded to the specified chain.
- **DSCP Marking:** Determines whether the packet is assigned the DSCP mark.

To configure the QoS mark for a traffic control rule, do the following:

Configuring a Set Mark

1. Make sure the CLI is in Configuration mode.
2. Select the Set option by typing:

   ```
   qos traffic-control advanced-configuration tcrules
   { name } mark-choice set
   ```

   Where:

   - `{ name }` is the name of the traffic control rule
3. Configure the following parameter(s):

Note
The `chain-options` parameter specifies the chain in which the rule will be processed.

- **Pre-Routing - Mark the connection in the PREROUTING chain**

  This can be used with DNAT, SNAT and Masquerading rules in the firewall. An example of such a rule is *Source.IP:192.168.2.101, Chain-option: preroute or default*, but the actual Source.NAT address is 2.2.2.2.

- **Post-Routing - Mark the connection in the POSTROUTING chain**

  This can be used with DNAT, SNAT and Masquerading rules in the firewall. An example of such rule is *Destination.IP:192.168.3.101, Chain-option:preroute or default*. In this case, the actual destination address is 192.168.3.101, but it will be translated to 192.168.3.33 by DNAT. Another example of a traffic control rule is *Destination.IP:192.168.3.33, Chain-option:postrouting*.

- **Forward - Mark the connection in the FORWARD chain**

  This is the default chain option and it can be used for normal IP traffic without any address or port translation.

Parameter	Description
`object { object }`	**Synopsis:** [packet | connection] **Default:** packet Sets the mark on either a packet or a connection.
`mark { mark }`	**Synopsis:** A string A mark that corresponds to a class mark (decimal value).
`mask { mask }`	**Synopsis:** A string (optional) A mask to determine which mark bits will be set.
`chain-options { chain-options }`	**Synopsis:** [forward | postrouting | prerouting] **Default:** forward A chain where the set operation will take place.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

Configuring a Modify Mark

1. Make sure the CLI is in Configuration mode.
2. Select the Modify option by typing:

   ```
   qos traffic-control advanced-configuration tcrules
   { name } mark-choice modify
   ```

   Where:

   - `{ name }` is the name of the traffic control rule

3. Configure the following parameter(s):

Parameter	Description
`logic-op { logic-op }`	**Synopsis:** [and | or] A logical operation to perform on the current mark: AND/OR.
`mark-value { mark-value }`	**Synopsis:** A string A mark to perform the operation with (decimal value).
`modify-chain { modify-chain }`	**Synopsis:** [forward | postrouting | prerouting] **Default:** forward A chain in which the operation will take place.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

Configuring a Save Mark

1. Make sure the CLI is in Configuration mode.
2. Configure the Save option by typing:

   ```
   qos traffic-control advanced-configuration tcrules { name } mark-choice save
   ```

   Where:

   - `{ name }` is the name of the traffic control rule
3. Configure the following parameter(s):

Parameter	Description
`value-mask { value-mask }`	**Synopsis:** A string Mask to process the mark with
`op-chain { op-chain }`	**Synopsis:** [forward | prerouting] **Default:** forward A chain in which the operation will take place.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

Configuring a Restore Mark

1. Make sure the CLI is in Configuration mode.
2. Select the Restore option by typing:

   ```
   qos traffic-control advanced-configuration tcrules { name } mark-choice restore
   ```

   Where:

   - `{ name }` is the name of the traffic control rule

3. Configure the following parameter(s):

Parameter	Description
`value-mask { value-mask }`	**Synopsis:** A string A mask to process the mark with.
`op-chain { op-chain }`	**Synopsis:** [forward | prerouting] **Default:** forward A chain in which the operation will take place.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

Configuring a Continue Mark

1. Make sure the CLI is in Configuration mode.
2. Select the Continue option by typing:

   ```
   qos traffic-control advanced-configuration tcrules
   { name } mark-choice continue
   ```

   Where:

   - `{ name }` is the name of the traffic control rule
3. Configure the following parameter(s):

Parameter	Description
`continue-chain { continue-chain }`	**Synopsis:** [forward | prerouting] **Default:** forward A chain in which the operation will take place.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

Configuring a DSCP Mark

1. Make sure the CLI is in Configuration mode.
2. Select the DSCP Marking option by typing:

   ```
   qos traffic-control advanced-configuration tcrules
   { name } mark-choice dscpmarking
   ```

   Where:

   - `{ name }` is the name of the traffic control rule
3. Configure the following parameter(s):

Parameter	Description
`dscp-mark { dscp-mark }`	**Synopsis:** [BE | AF11 | AF12 | AF13 | AF21 | AF22 | AF23 | AF31 | AF32 | AF33 | AF41 | AF42 | AF43 | CS1 | CS2 | CS3 | CS4 | CS5 | CS6 | CS7 | EF] A DSCP class value chosen amongst the given list.
`dscpchain { dscpchain }`	**Synopsis:** [forward | postrouting | prerouting] **Default:** forward A chain where the DSCP marking will take place.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.2.6.4 Deleting aTraffic Control Rule

To delete a traffic control rule, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the traffic control rule by typing:

   ```
   no qos traffic-control advanced-configuration tcrule { name }
   ```

   Where:

   - `{ name }` is the name of the traffic control rule entry
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.2.7 Managing QoS Mapping for VLANs

Quality of Service (QoS) mapping is used to map QoS traffic. It assigns a traffic control mark to incoming IP traffic based on the priority value of a tagged frame. The incoming traffic is then classified and placed in the priority queues according to the traffic control rules specified for the marked rule. In addition, traffic control can assign the same priority or a different priority value when a frame needs to be egressed with a VLAN tag through a traffic control interface.

QoS maps can be configured for VLAN connections on virtual switches.

15.2.7.1 Viewing a List of QoS Maps for VLANs

To view a list of QoS maps for a VLAN connection, type:

- **For Switched Ethernet Ports**

  ```
  show running-config switch { vlans } { all-vlans } { id } qosmap
  ```

  Where:

  - `{ id }` is the ID given to the VLAN

- **For Virtual Switches**

  ```
  show running-config interface virtualswitch { id } vlan { vlan-id } qosmap
  ```

  Where:

  - `{ id }` is the ID of the virtual switch
  - `{ vlan-id }` is the ID given to the VLAN

If QoS maps have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config interface virtualswitch vlan 100 qosmap
interface
 virtualswitch 1
  vlan 100
   qosmap 2
    ingress 10
   !
  !
 !
!
```

If no QoS maps have been configured, add maps as needed. For more information, refer to "Adding a QoS Map (Page 877)".

15.2.7.2 Adding a QoS Map

To add a QoS map for a VLAN connection, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the QoS map by typing:
   - **For Switched Ethernet Ports**

     ```
     switch { vlans } { all-vlans } { id } qosmap { priority }
     ```

     Where:

     - `{ id }` is the ID given to the VLAN
     - `{ priority }` is the priority assigned to the QoS map

- **For Virtual Switches**

  ```
  interface virtualswitch { id } vlan { vlan-id }
  qosmap { priority }
  ```

  Where:

  - `{ id }` is the ID of the virtual switch
  - `{ vlan-id }` is the ID given to the VLAN
  - `{ priority }` is the priority assigned to the QoS map

3. Configure the following parameter(s) as required:

Parameter	Description
`ingress { ingress }`	**Synopsis:** An integer between 0 and 255 Map ingress to mark.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.2.7.3 Deleting a QoS Map

To delete a QoS map for a VLAN connection, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the QoS map for the VLAN connection by typing:
   - **For Switched Ethernet Ports**

     ```
     no switch { vlans } { all-vlans } { id } qosmap
     { priority }
     ```

     Where:

     - `{ id }` is the ID given to the VLAN
     - `{ priority }` is the priority assigned to the QoS map

   - **For Virtual Switches**

     ```
     no interface virtualswitch { id } vlan { vlan-
     id } qosmap { priority }
     ```

     Where:

     - `{ id }` is the ID of the virtual switch
     - `{ vlan-id }` is the ID given to the VLAN
     - `{ priority }` is the priority assigned to the QoS map

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.2.8 Managing Egress Markers for QoS Maps

Egress markers for QoS maps are used to assign priority to traffic that shares the same mark as one of the egress marks configured for the device.

15.2.8.1 Viewing a List of Egress Marks

To view a list of egress marks for a QoS map, type:

- **For Switched Ethernet Ports**

  ```
  show running-config interface switch { vlans }
  { all-vlans } { id } qosmap { priority } egress
  ```

  Where:

  - `{ id }` is the ID given to the VLAN
  - `{ priority }` is the priority assigned to the QoS map

- **For Virtual Switches**

  ```
  show running-config interface virtualswitch { id }
  vlan { vlan-id } qosmap { priority } egress
  ```

  Where:

  - `{ slot }` is the name of the module location
  - `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module
  - `{ id }` is the ID given to the VLAN
  - `{ priority }` is the priority assigned to the QoS map

If egress marks have been configured, a table or list similar to the following example appears:

```
show running-config interface virtualswitch vs1 vlan 100 qosmap 2 egress
interface
 virtualswitch vs1
  vlan 100
   qosmap 2
    egress 11
    !
   !
  !
 !
!
```

If no egress marks have been configured, add egress marks as needed. For more information, refer to "Adding an Egress Mark (Page 880)".

15.2.8.2 Adding an Egress Mark

To add an egress mark for a QoS Map, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the QoS map by typing:
   - **For Switched Ethernet Ports**

     ```
     switch { vlans } { all-vlans } { id } qosmap
     { priority } egress { mark }
     ```

     Where:
     - `{ id }` is the ID given to the VLAN
     - `{ priority }` is the priority assigned to the QoS map
     - `{ mark }` is the value of the egress mark
   - **For Virtual Switches**

     ```
     interface virtualswitch { id } vlan { vlan-id }
     qosmap { priority } egress { mark }
     ```

     Where:
     - `{ slot }` is the name of the module location
     - `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module
     - `{ id }` is the ID given to the VLAN
     - `{ priority }` is the priority assigned to the QoS map
     - `{ mark }` is the value of the egress mark
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.2.8.3 Deleting an Egress Mark

To delete an egress mark for a QoS map, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the QoS map for the VLAN connection by typing:
   - **For Switched Ethernet Ports**

     ```
     no switch { vlans } { all-vlans } { id } qosmap
     { priority } egress { mark }
     ```

     Where:
     - `{ id }` is the ID given to the VLAN
     - `{ priority }` is the priority assigned to the QoS map
     - `{ mark }` is the value of the egress mark

- **For Virtual Switches**

  ```
  no interface virtualswitch { id } vlan { vlan-id } qosmap { priority } egress { mark }
  ```

  Where:

  - `{ slot }` is the name of the module location
  - `{ port }` is the port number (or a list of ports, if aggregated in a port trunk) for the module
  - `{ id }` is the ID given to the VLAN
  - `{ priority }` is the priority assigned to the QoS map
  - `{ mark }` is the value of the egress mark

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.2.9 Viewing QoS Statistics

RUGGEDCOM ROX II provides statistics for traffic going through each class that has been configured. Packets are assigned to classes on the outbound interface based on rules. If a packet matches the specified criteria, it is considered to be a member of the class and is forwarded to that class. If the packet does not match any rule, it is forwarded to the default class.

For more information about traffic control classes, refer to "Managing Traffic Control Classes (Page 865)".

Note
Statistics are only available when traffic control is enabled in advanced mode. For more information about enabling traffic control, refer to "Enabling and Configuring Traffic Control (Page 859)".

To view the QoS statistics, type:

```
show qos statistics
```

A table or list similar to the following example appears:

```
ruggedcom# show qos statistics | tab
           MIN        MAX
CLASSNAME  BANDWIDTH  BANDWIDTH  SENTBYTES  SENTPACKETS  DROPPEDPACKETS  RATE       AVERAGE
-------------------------------------------------------------------------------------------
High       1200Kbit   1500Kbit   4956594    9953         0               446104bit  112pps
Default    300000bit  1500Kbit   3029832    6084         3869            270088bit  68pps
```

This table provides the following information:

Parameter	Description
`min-bandwidth`	**Synopsis:** A string The minimum guaranteed bandwidth. This is based on the device's defined characteristics.
`max-bandwidth`	**Synopsis:** A string The maximum guaranteed bandwidth in absence of any higher prioritized traffic. This is based on the device's defined characteristics.
`sentbytes`	**Synopsis:** A string The number of bytes that were sent through this class.
`sentpackets`	**Synopsis:** A string The number of packets that were sent through this class.
`droppedpackets`	**Synopsis:** A string The number of packets that were dropped in this class.
`rate`	**Synopsis:** A string Based on a 10-second average.
`average`	**Synopsis:** A string Based on a 10-second average.

15.3 Managing Classes of Service

Classes of Service (CoS) provides the ability to expedite the transmission of certain frames and port traffic over others. The CoS of a frame can be set to Normal, Medium, High or Critical. By default, RUGGEDCOM ROX II enforces Normal CoS for all traffic.

⚠ NOTICE

Use the highest supported CoS with caution, as it is always used by the switch for handling network management traffic, such as RSTP BPDUs.

If this CoS is used for regular network traffic, upon traffic bursts, it may result in the loss of some network management frames, which in turn may result in the loss of connectivity over the network.

The process of controlling traffic based on CoS occurs over two phases:

- **Inspection Phase**

  In the inspection phase, the CoS priority of a received frame is determined from:

  - A specific CoS based upon the source and destination MAC address (as set in the Static MAC Address Table)
  - The priority field in 802.1Q tags
  - The Differentiated Services Code Point (DSCP) component of the Type Of Service (TOS) field, if the frame is IP

- The default CoS for the port

Each frame's CoS will be determined once the first examined parameter is found in the frame.

Received frames are first examined to determine if their destination or source MAC address is found in the Static MAC Address Table. If they are, the CoS configured for the static MAC address is used. If neither destination or source MAC address is in the Static MAC Address Table, the frame is then examined for 802.1Q tags and the priority field is mapped to a CoS. If a tag is not present, the frame is examined to determine if it is an IP frame. If the frame is IP and inspecting TOS is enabled, the CoS is determined from the DSCP field. If the frame is not IP or inspecting TOS is disabled, the default CoS for the port is used.

After inspection, the frame is forwarded to the egress port for transmission.

- **Forwarding Phase**

  Once the CoS of the frame is determined, the frame is forwarded to the egress port, where it is collected into one of the priority queues according to the assigned CoS.

  CoS weighting selects the degree of preferential treatment that is attached to different priority queues. The ratio of the number of higher CoS to lower CoS frames transmitted can be configured. If desired, the user can configure lower CoS frames to be transmitted only after all higher CoS frames have been serviced.

15.3.1 Configuring Classes of Service

To configure Classes of Service, do the following:

1. Make sure the CLI is in Configuration mode.
2. Configure the CoS weighting by typing:

   ```
   switch classes-of-service cos-weighting { weighting }
   ```

   Where:

   - `{ weighting }` is the weighting algorithm for transmitting different priority CoS frames. During traffic bursts, frames queued in the switch pending transmission on a port may have different CoS priorities.
3. If necessary, configure CoS mapping based on either the IEEE 802.1p priority or Differentiated Services (DS) field set in the IP header for each packet. For more information, refer to "Adding a Priority-to-CoS Mapping Entry (Page 884)" or "Adding a DSCP-to-CoS Mapping Entry (Page 886)".
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.3.2 Managing Priority-to-CoS Mapping

Assigning CoS to different IEEE 802.1p priority values in the frame is done by defining priority-to-CoS mapping table entries.

15.3.2.1 Viewing a List of Priority-to-CoS Mapping Entries

To view a list of priority-to-CoS mapping entries, type:

```
show running-config switch class-of-service priority-to-cos
```

If entries have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config switch class-of-service priority-to-cos | tab
PRIORITY  COS
------------------
0         normal
1         normal
2         normal
3         medium
4         medium
5         medium
6         high
7         high

!
```

If no entries have been configured, add entries as needed. For more information, refer to "Adding a Priority-to-CoS Mapping Entry (Page 884)".

15.3.2.2 Adding a Priority-to-CoS Mapping Entry

To add a priority-to-CoS mapping entry, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the entry by typing:

   ```
   switch class-of-service priority-to-cos { priority }
   ```

   Where:

   - `{ priority }` is the value of the IEEE 802.1p priority
3. Configure the following parameter(s) as required:

Parameter	Description
`cos { cos }`	**Synopsis:** [N/A | normal | medium | high | crit] **Default:** normal The Class of Service (CoS) assigned to received tagged frames with the specified IEEE 802.1p priority value.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.3.2.3 Deleting a Priority-to-CoS Mapping Entry

To delete a priority-to-CoS mapping entry, do the following:

Note
Deleting an entry sets the CoS to Normal.

1. Make sure the CLI is in Configuration mode.
2. Delete the entry by typing:

   ```
   no switch class-of-service priority-to-cos
   { priority }
   ```

   Where:

   - `{ priority }` is the value of the IEEE 802.1p priority
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.3.3 Managing DSCP-to-CoS Mapping

Assigning CoS to different values of the Differentiated Services Code Point (DSCP) field in the IP header of received packets is done by defining DSCP-to-CoS mapping table entries.

15.3.3.1 Viewing a List of DSCP-to-CoS Mapping Entries

To view a list of priorites, type:

```
show running-config switch class-of-service dscp-to-cos
```

If entries have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config switch class-of-service dscp-to-cos | tab
DSCP  COS
--------------
1     normal
3     high
4     medium
6     normal
7     normal

!
```

If no entries have been configured, add entries as needed. For more information, refer to "Adding a DSCP-to-CoS Mapping Entry (Page 886)".

15.3.3.2 Adding a DSCP-to-CoS Mapping Entry

To add a DSCP-to-CoS mapping entry, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the entry by typing:

   ```
   switch class-of-service dscp-to-cos { dscp }
   ```

   Where:

   - `{ dscp }` is the value of the 6 bit DiffServ field in the Type-Of-Service (TOS) field of the IP header
3. Configure the following parameter(s) as required:

Parameter	Description
`cos { cos }`	**Synopsis:** [N/A | normal | medium | high | crit] **Default:** normal The Class of Service (CoS) assigned to the received frames with the specified DSCP.

4. Configure the CoS parameters on select switched Ethernet ports and/or trunk interfaces as needed. For more information, refer to "Configuring a Switched Ethernet Port (Page 314)" and/or "Adding an Ethernet Trunk Interface (Page 329)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.3.3.3 Deleting a DSCP-to-CoS Mapping Entry

To delete a DSCP-to-CoS mapping entry, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the entry by typing:

   ```
   no switch class-of-service dscp-to-cos { dscp }
   ```

   Where:

   - `{ dscp }` is the value of the 6 bit DiffServ field in the Type-Of-Service (TOS) field of the IP header
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.4 Managing NetFlow Data Export

RUGGEDCOM ROX II supports the collection and forwarding of flow records to NetFlow-enabled servers, or NetFlow Collectors.

⚠ NOTICE

NetFlow requires additional memory and CPU resources, which may affect device performance when network traffic is high. When enabled, general performance should be monitored to make sure traffic is processed optimally. If needed, NetFlow's resource requirements can be minimized by reducing the NetFlow cache. For more information, refer to "Controlling the NetFlow Cache (Page 890)".

15.4.1 Understanding NetFlow Data Export

NetFlow is a traffic analysis tool developed by Cisco that allows network operators to characterize traffic flows across their networks. It provides information that allows operators to identify security vulnerabilities, assess network productivity and resource utilization, determine the causes of congestion, and more.

A basic NetFlow monitoring setup consists of the following components

- **Flow Exporter**

  The exporter aggregates data packets into flows, which are forwarded to one or more flow collectors.

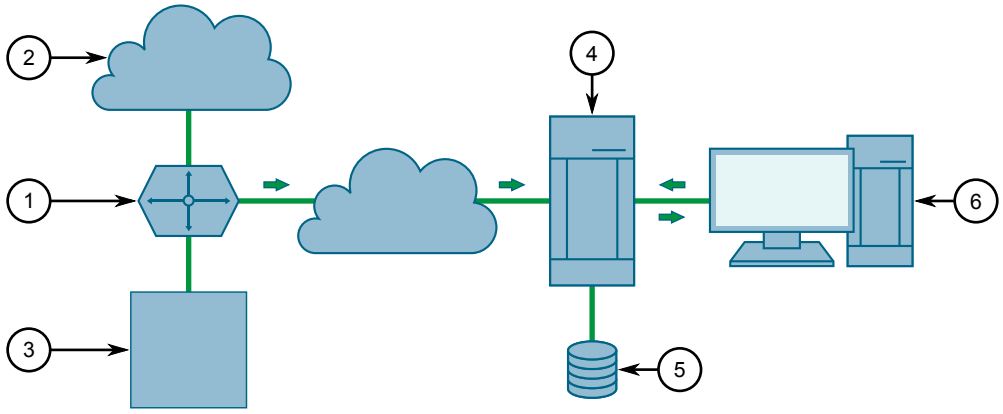
- **Flow Collector**

  The collector receives, stores and pre-processes flow data received from one or more flow exporters.

- **Flow Analyzer**

  The flow analyzer queries one or more flow collectors for flow data and then analyzes the data with a focus on intrusion detection and traffic profiling.

RUGGEDCOM ROX II acts as a *flow exporter*, collecting data from ingress (incoming) and/or egress (outgoing) packets and then forwarding them as flow records to one or more collectors.



① NetFlow Exporter (RUGGEDCOM ROX II)
② WAN
③ LAN

④ NetFlow Collector
⑤ Flow Storage
⑥ Analysis Console

Figure 15.1 NetFlow

Note
RUGGEDCOM ROX II supports NetFlow version 5.

15.4.1.1 Flow Records

A flow record, as defined by the Cisco standard, is a unidirectional sequence of packets that share the same:

- Ingress interface
- Source and destination IP address
- IP protocol
- Source and destination port for TCP and UDP
- Type of Service (ToS)

Each flow record is exported using the User Datagram Protocol (UDP), which requires each packet to include the IP address of the target NetFlow collector and its designated UDP port.

A flow record is considered ready to export when either of the following conditions are met:

- The flow has been inactive (e.g. no new packets) for a specific period of time
- The flow has been active for longer than allowed by the configuration
- A TCP flag indicates the flow has been terminated

RUGGEDCOM ROX II includes user-configurable timers for inactive and active flows.

Note
RUGGEDCOM ROX II does not retain a record of flows sent. Therefore, any NetFlow packets dropped due to congestion or packet corruption will be lost permanently.

15.4.2 Configuring NetFlow Data Export

To configure the device to send flows to a NetFlow collector, do the following:

1. Change the mode to **Edit Private** or **Edit Exclusive**.

⚠ **NOTICE**
NetFlow does not support Layer 3 switching functions. Layer 3 switching must be disabled before NetFlow is enabled.

2. Enable the NetFlow service. For more information, refer to "Enabling/Disabling NetFlow (Page 889)".
3. [Optional] Set the engine ID that is assigned to each flow record. For more information, refer to "Setting the NetFlow Engine ID (Page 889)".
4. [Optional] Set the maximum number of active flows tracked by the device. This can help improve performance in some scenarios. For more information, refer to "Controlling the NetFlow Cache (Page 890)".
5. [Optional] Control how RUGGEDCOM ROX II manages active and inactive flows. For more information, refer to "Controlling Active/Inactive Flows (Page 890)".
6. Define one or more interfaces from which to monitor traffic. For more information, refer to "Adding a NetFlow Interface (Page 891)".
7. Define one or more NetFlow collectors to which RUGGEDCOM ROX II can send flows. For more information, refer to "Adding a NetFlow Collector (Page 892)".

15.4.3 Enabling/Disabling NetFlow

To enable or disable NetFlow, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable or disable NetFlow by typing:

   Enabling NetFlow

   ```
   services netflow enabled
   ```

   Disabling NetFlow

   ```
   no services netflow enabled
   ```

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.4.4 Setting the NetFlow Engine ID

An engine ID can be assigned to flow records to uniquely link them to the device from which they were sent. This can be useful information to network analysts wishing to further categorize NetFlow data by device, region, etc.

The engine ID is defined in the header of the data export.

To set an engine ID for the device, do the following:

1. Make sure the CLI is in Configuration mode.
2. Set the engine ID by typing:

   ```
   services netflow engine-id { number }
   ```

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.4.5 Controlling the NetFlow Cache

NetFlow consumes memory and CPU resources during operation, which may affect the performance of the device during times of high traffic. To reduce NetFlow's effect on performance, consider reducing the number of active flows tracked by NetFlow. This will reduce the cache and free resources for other processes.

To control the NetFlow cache, do the following:

1. Make sure the CLI is in Configuration mode.
2. Configure the maximum number of active flows tracked by NetFlow by typing:

   ```
   services netflow maxflows { number }
   ```

   Where { number } is the number of active flows. The default value is 16384, but the value can be set anywhere between 0 and 65535.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.4.6 Controlling Active/Inactive Flows

NetFlow considers a flow to be ready for export when it has been inactive for a specific period of time or the flow has been active (long lived) for too long. By default, a flow is considered inactive if no new packets have been received for 15 seconds. An active flow is considered ready if it has received packets for longer than 30 minutes. Both durations can be adjusted to reduce or increase either the size of the NetFlow packets and/or the speed at which they are delivered.

To control how RUGGEDCOM ROX II manages active and inactive flows, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***services » netflow » timeouts*** and configure the following parameters:

Parameter	Description
`active-timeout { active-timeout }`	**Synopsis:** An integer **Default:** 1800 The time in seconds (s) an active flow remains active.
`inactive-timeout { inactive-timeout }`	**Synopsis:** An integer **Default:** 15 The time in seconds (s) an inactive flow remains in the cache before it is deleted.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.4.7 Managing NetFlow Interfaces

RUGGEDCOM ROX II requires an interface from which to collect NetFlow data, but can be configured to monitor multiple interfaces if needed. Each interface can be configured to monitor packets entering (ingress) and/or exiting (egress).

Note
RUGGEDCOM ROX II does not support Netflow data collection on hardware-accelerated interfaces.

15.4.7.1 Viewing a List of NetFlow Interfaces

To view a list of interfaces configured to monitor traffic for NetFlow, type:

```
show running-config services netflow interface
```

If interfaces have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services netflow interface | tab
NAME         DIRECTION  TYPE
------------------------------
switch.0001  both       ipv4

 !
!
```

If no interfaces have been configured, add interfaces as needed. For more information, refer to "Adding a NetFlow Interface (Page 891)".

15.4.7.2 Adding a NetFlow Interface

To add a NetFlow interface, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the interface by typing:

   ```
   services netflow interface { interface } direction
   { direction }
   ```

   Where:

   - { interface } is the desired interface
   - { direction } is the direction of traffic to be monitored. Options include:
     - **ingress** – Only traffic entering through the interface is monitored
     - **egress** – Only traffic exiting through the interface is monitored
     - **both** – All traffic traversing the interface is monitored
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.4.7.3 Deleting a NetFlow Interface

To delete a NetFlow interface, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the interface by typing:

   `no services netflow interface { interface }`

   Where { interface } is the desired interface.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.4.8 Managing NetFlow Collectors

RUGGEDCOM ROX II can be configured to forward flows to up to four NetFlow collectors.

15.4.8.1 Viewing a List of NetFlow Collectors

To view a list of NetFlow collectors the device can send flows, type:

`show running-config services netflow collector`

If collectors have been configured, a table or list similar to the following example appears:

```
show running-config services netflow collector | tab
IP ADDRESS      PORT  ENABLED
-------------------------------
172.30.142.224  6030  true

 !
!
```

If no collectors have been configured, add collectors as needed. For more information, refer to "Adding a NetFlow Collector (Page 892)".

15.4.8.2 Adding a NetFlow Collector

To define a NetFlow collector to which RUGGEDCOM ROX II will send flows, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the collector by typing:

Note
A single server can host multiple NetFlow collectors, each monitoring a specific UDP port.

```
services netflow collector { address } { port }
```

Where:

- { address } is the IPv4 address of the NetFlow collector
- { port } is the UDP port used by the NetFlow Collector to receive messages

3. [Optional] Enable the collector so RUGGEDCOM ROX II can forward NetFlow packets to it. For more information, refer to "Enabling/Disabling a NetFlow Collector (Page 893)".
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.4.8.3 Enabling/Disabling a NetFlow Collector

To enable or disable a NetFlow collector defined in RUGGEDCOM ROX II, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable or disable the collector by typing:

   Enabling

   ```
   services netflow collector { address } { port } enable
   ```

   Disabling

   ```
   no services netflow collector { address } { port } enable
   ```

   Where:

   - { address } is the IPv4 address of the NetFlow collector
   - { port } is the UDP port used by the NetFlow collector to receive messages
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.4.8.4 Deleting a NetFlow Collector

To delete a NetFlow collector, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the collector by typing:

   Note
   A single server can host multiple NetFlow collectors, each monitoring a specific UDP port. It is important to specify both the IP address and port number when deleting a NetFlow collector.

```
no services netflow collector { address } { port }
```

Where:

- { address } is the IPv4 address of the NetFlow collector
- { port } is the UDP port used by the NetFlow Collector to receive messages

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

15.4.9 Viewing the Status of NetFlow

To view the status of NetFlow, type:

```
show services netflow status
```

For example:

```
ruggedcom# show services netflow status
status
 flow-status
  active flows 2
 rate-status
  bits sec     19311176
  pkts sec     2399
  bits sec min 19009225
  pkts sec min 2358
```

The following information is displayed:

Parameter	Description
`bits-sec`	**Synopsis:** An integer The current rate in bits/s.
`pkts-sec`	**Synopsis:** An integer The current rate in packets/s.
`bits-sec-min`	**Synopsis:** An integer The average rate in bits/s over a minute.
`pkts-sec-min`	**Synopsis:** An integer The average rate in packets/s over a minute.

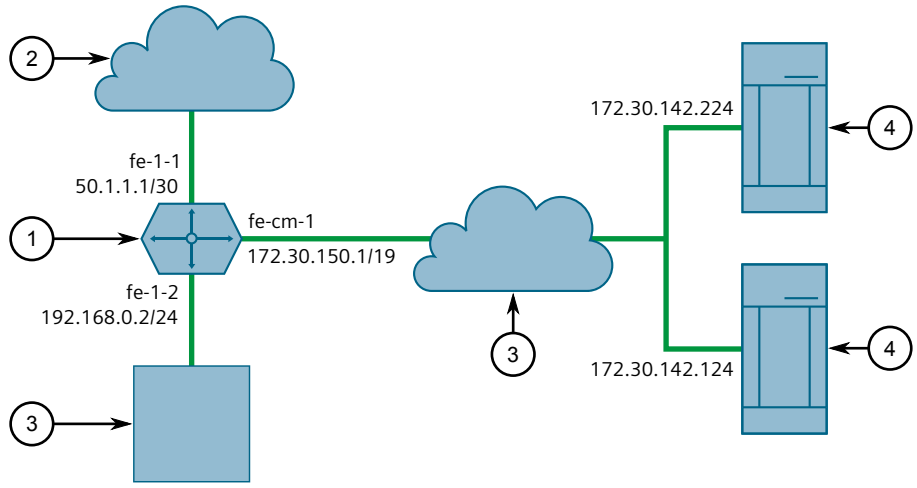
15.4.10 Example: Exporting Flows to Multiple Collectors

This example describes how to configure RUGGEDCOM ROX II to forward NetFlow data to two NetFlow collectors.

In the following topology, the NetFlow exporter (RUGGEDCOM ROX II) is collecting data on packets traversing two interfaces. Packets sharing the same characteristics (i.e. source, destination, port, etc.) are placed into flows. When each flow is either

deemed inactive, has exceeded the active timer, or is flagged as terminated, the exporter forwards the flow to the specified collectors.

Note
The values shown are specific to the provided topology. Actual values can vary based on the user's configuration.



① NetFlow Exporter (RUGGEDCOM ROX II)
② WAN
③ LAN
④ NetFlow Collector

Figure 15.2 Topology – Exporting Data to Multiple Collectors

Configuration

To configure RUGGEDCOM ROX II to export NetFlow packets to two NetFlow collectors, do the following:

1. Enable NetFlow. For more information, refer to "Enabling/Disabling NetFlow (Page 889)".
2. Define two NetFlow collectors and make sure they are both enabled. For more information, refer to "Adding a NetFlow Collector (Page 892)".
3. Define the interface that will be monitored by NetFlow. For more information, refer to "Adding a NetFlow Interface (Page 891)".
4. Send traffic to the interface monitored by RUGGEDCOM ROX II.
5. Verify the NetFlow collectors are receiving flows from the device.

Final Configuration Example

```
services
 netflow
  enabled
```

```
   engine-id 10
   timeouts active-timeout 1800
   timeouts inactive-timeout 15
   collector 172.30.142.124 2
    enabled
   !
   collector 172.30.142.224 1
    enabled
   !
   interface fe-1-1
   !
  !
!
```

15.5 Managing Port Rate Limiting

This section describes how to manage port rate limiting.

15.5.1 Understanding Port Rate Limiting

Rate limiting restricts the bandwidth for a specific interface. The restriction can be applied to ingress and/or egress traffic, and to a specific type of traffic (e.g. unicast, multicast, broadcast, etc.). In some applications, controlling bandwidth may be required to maintain quality of service.

Rate limiting also provides a layer of defense against Denial of Service (DoS) and Distributed Denial of Service (DDos) attacks. These attacks exhaust network resources by flooding a device with requests.

15.5.2 Configuring Port Rate Limiting

To configure port rate limiting, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***interface » switch » swport » {port}***, where *{port}* is the switched Ethernet port.
3. Configuring the rate Limiting settings by configuring the following parameter(s) as required:

Parameter	Description
`ingress-limit { ingress-limit }`	**Synopsis:** An integer between 62 and 256000 or [disabled] **Default:** 1000 The data rate in kbps at which received frames (of the type described by the ingress frames parameter) will start to be discarded by the switch. The valid range is 62 to 256000 kbps. The default value is 1000 kbps. If not set(cleared), this feature is disabled.

Parameter	Description
`ingress-frames { ingress-frames }`	**Synopsis:** [broadcast | multicast | mcast-flood-ucast | all] **Default:** broadcast This parameter specifies the types of frames to rate-limit on this port. It applies only to received frames: • BROADCAST : only broadcast frames will be limited. • MULTICAST : all multicast frames (including broadcast) will be limited. • MCAST-FLOOD-UCAST : all multicast frames (including broadcast) will be limited. Unicast will not be limited. • ALL : all frames (both multicast and unicast) will be limited.
`egress-limit { egress-limit }`	**Synopsis:** [disabled] or An integer between 62 and 256000 **Default:** disabled The maximum data rate in kbps at which the switch will transmit (multicast, broadcast and unicast) frames on this port. The switch will discard frames in order to meet this rate if required. The valid range is 62 to 256000 Kbps. If not set, this feature is disabled.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

16 Time Services

RUGGEDCOM ROX II offers the following time-keeping and time synchronization features:

- Local hardware time keeping and time zone management
- NTP (Network Time Protocol) client and server

16.1 Configuring the Time Synchronization Settings

To configure the time synchronization settings, do the following:

1. Configure the system time and date. For more information, refer to "Configuring the System Time and Date (Page 900)".
2. Configure the system time zone. For more information, refer to "Configuring the System Time Zone (Page 900)".
3. Configure the local time settings. For more information, refer to "Configuring the Local Time Settings (Page 900)".
4. If multicast addresses will be configured for the NTP server, enable and configure the NTP multicast client. For more information, refer to "Enabling and Configuring NTP Multicast Clients (Page 911)".
5. If broadcast addresses will be configured for the NTP server, enable and configure the NTP broadcast client. For more information, refer to "Enabling and Configuring NTP Broadcast Clients (Page 912)".
6. Add remote NTP servers. For more information, refer to "Adding an NTP Server (Page 906)".
7. Add broadcast/mutlicast addresses for the NTP server. For more information, refer to "Adding a Broadcast/Multicast Address (Page 913)".
8. If required, add server authentication keys. For more information, refer to "Adding a Server Key (Page 908)".
9. Add restrictions for the remote NTP servers. For more information, refer to "Adding a Server Restriction (Page 909)".
10. Enable and configure the NTP service. For more information, refer to "Enabling and Configuring the NTP Service (Page 901)".
11. View the status of the NTP service. For more information, refer to "Viewing the NTP Service Status (Page 902)".

16.2 Configuring the System Time and Date

To configure the system time and date, do the following:

1. Make sure the CLI is in Configuration mode.
2. Set the system time and date by typing:

   ```
   admin set-system-clock time { time-date }
   ```

   Where:

   - `{ time-date }` is the date time in the format YYYY-MM-DD HH:MM:SS
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

16.3 Configuring the System Time Zone

To configure the system time zone, do the following:

1. Make sure the CLI is in Configuration mode.
2. Set the system time zone by typing:

   Note
   The Etc/GMT time zones conform to the POSIX style and have their signs reversed from common usage. In POSIX style, zones west of Greenwich Mean Time (GMT) have a positive sign, while zones east of GMT have a negative sign.

   ```
   admin timezone category { category } zone { zone }
   ```

   Where:

   - `{ category }` is the time zone category
   - `{ zone }` is the time zone
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

16.4 Configuring the Local Time Settings

The local time settings configure the local clock on the device as the NTP time source.

To configure the local NTP time settings, do the following:

1. Make sure the CLI is in Configuration mode.
2. Enable and configure the local NTP time settings by typing:

   ```
   services ntp local-clock enable stratum { number }
   ```

   Where:

- `{ number }` is the stratum number of the local clock

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

16.5 Enabling and Configuring the NTP Service

To enable and configure the NTP service, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***services » ntp*** and configure the following parameters:

Note
RUGGEDCOM ROX II supports both IPv4 and IPv6 addresses.

Note
Only a bind interface or a bind IP address can be selected/defined for NTP.

Parameter	Description
`enabled { enabled }`	**Synopsis:** [true | false] **Default:** false Enables NTP service.
`bind-interface { bindinterface }`	**Synopsis:** A string Sets the primary/first IP address for the selected interface as the source IP address for outgoing NTP messages. Make sure an IP address is first assigned to the selected interface. The dummy0 interface should be used, unless required otherwise. If the bind interface is down, the source IP address for traffic transmitted by NTP will be the IP address of another egress interface.
`bind-ip-address { bind-ip-address }`	**Synopsis:** A string between 7 and 15 characters long The defined IP address is used as the source IP address for all outgoing NTP messages. Make sure the IP address is statically defined for an interface. If the IP address is not assigned to an interface, the source IP address for traffic transmitted by NTP will be the IP address of the egress interface.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

16.6 Viewing the NTP Service Status

To view the status of the NTP service, do the following:

1. Make sure the NTP service is enabled. For more information, refer to "Enabling and Configuring the NTP Service (Page 901)".
2. Display the NTP service status by typing:

   ```
   services ntp ntp-status
   ```

   A table similar to the following example appears:

```
ruggedcom# services ntp ntp-status
 ntp-status
   remote           refid      st t when poll reach   delay   offset  jitter
 ==============================================================================
 *142.3.100.2     .GPS.          1 u  937 1024  377   38.104   -0.273   0.802
  172.30.149.45   .INIT.        16 u    - 1024    0    0.000    0.000   0.000
 +206.186.255.226 128.138.140.44   2 u  413 1024  377   58.578    0.143  27.963
 x206.186.255.227 CHU_AUDIO(1)     3 u  927 1024  377   58.034  10846.0  30.289
 +209.87.233.53   209.87.233.52    2 u  449 1024  377   27.060   -1.132   3.153
```

This table provides the following information:

Parameter	Description
`{ remote }`	**Synopsis:** A string 40 characters long Remote address.
`reference-id`	**Synopsis:** A string 40 characters long The identification of the reference clock.
`stratum`	**Synopsis:** A string 32 characters long The stratum number of the reference clock.
`address-type`	**Synopsis:** A string 32 characters long The address type of the remote machine.
`when`	**Synopsis:** A string 32 characters long The number of seconds since the last poll of the reference clock.
`poll`	**Synopsis:** A string 32 characters long The polling interval in seconds.
`reach`	**Synopsis:** A string 32 characters long An 8-bit left-rotating register. Any 1 bit means that a time packet was received.
`delay`	**Synopsis:** A string 32 characters long The time delay (in milliseconds) to communicate with the reference clock.
`offset`	**Synopsis:** A string 32 characters long The offset (in milliseconds) between our time and that of the reference clock.

Parameter	Description
`jitter`	**Synopsis:** A string 32 characters long The observed jitter (in milliseconds).

A character before an address is referred to as a tally code. Tally codes indicate the fate of the peer in the clock selection process. The following describes the meaning of each tally code:

Tally Code	Description
blank	A blank tally code indicates the peer has been discarded either because it is unreachable, it is synchronized to the same server (synch loop) or the synchronization distance is too far.
x	This tally code indicates the peer has been discarded because its clock is not correct. This is referred to as a *falseticker*.
.	This tally code indicates the peer has been discarded because its synchronization distance is too poor to be considered a candidate.
-	This tally code indicates the peer has been discarded because its offset is too a significant compared to the other peers. This is referred to as an *outlier*.
+	This tally code indicates the peer is considered a candidate.
#	This tally code indicates the peer is considered a candidate, but it is not among the top six sorted by synchronization distance. If the association is short-lived, it may be demobilized to conserve resources.
*	This tally code indicates the peer is the system peer.
o	This tally code indicates the peer is the system peer, but the synchronization distance is derived from a Pulse-Per-Second (PPS) signal.

16.7 Viewing the Status of Reference Clocks

To view the status of reference clocks, type:

```
show services ntp status
```

A table similar to the following example appears:

```
ruggedcom# show services ntp status reference-clock
                                 REFERENCE           ADDRESS
ADDRESS          STATE           ID         STRATUM  TYPE     WHEN  POLL  REACH  DELAY  OFFSET
 JITTER
-------------------------------------------------------------------------------------------------------
127.127.1.0      System peer     .LOCL.  10       l        2     64    377    0.000  0.000   0.000
206.186.255.227  Not synchronized .INIT.  16       -        -     1024  0      0.000  0.000   0.000
206.186.255.226  Not synchronized .INIT.  16       -        -     1024  0      0.000  0.000   0.000
142.3.100.2      Not synchronized .INIT.  16       -        -     1024  0      0.000  0.000   0.000
```

This table provides the following information:

Parameter	Description
`{ address }`	**Synopsis:** A string 40 characters long The IP address of the reference clock.

Parameter	Description
`state`	**Synopsis:** A string 32 characters long The state of the clock.
`reference-id`	**Synopsis:** A string 40 characters long The identification of the reference clock.
`stratum`	**Synopsis:** A string 32 characters long The stratum number of the reference clock.
`address-type`	**Synopsis:** A string 32 characters long The address type of the remote machine.
`when`	**Synopsis:** A string 32 characters long The number of seconds since the last poll of the reference clock.
`poll`	**Synopsis:** A string 32 characters long The polling interval in seconds.
`reach`	**Synopsis:** A string 32 characters long An 8-bit left-rotating register. Any 1 bit means that a time packet was received.
`delay`	**Synopsis:** A string 32 characters long The time delay (in milliseconds) to communicate with the reference clock.
`offset`	**Synopsis:** A string 32 characters long The offset (in milliseconds) between our time and that of the reference clock.
`jitter`	**Synopsis:** A string 32 characters long The observed jitter (in milliseconds).

16.8 Managing NTP Servers

RUGGEDCOM ROX II can periodically refer to a remote NTP server to correct any accumulated drift in the onboard clock. RUGGEDCOM ROX II can also serve time via SNTP (Simple Network Time Protocol) to hosts that request it.

NTP servers can be added with or without authentication keys. To associate an authentication key with an NTP server, first define a server key. For information about adding server keys, refer to "Adding a Server Key (Page 908)".

16.8.1 Viewing a List of NTP Servers

To view a list of NTP servers configured on the device, type:

```
show running-config services ntp server
```

If servers have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services ntp server | tab
                                                                  NTP
NAME             ENABLED  PEER  MINPOLL  MAXPOLL  IBURST  VERSION  PREFER  KEY
-------------------------------------------------------------------------------
142.3.100.2      X        -     6        10       -       -        X       -
206.186.255.226  X        -     6        10       -       -        -       -
206.186.255.227  X        -     6        10       -       -        -       -

!
!
```

If no servers have been configured, add servers as needed. For more information, refer to "Adding an NTP Server (Page 906)".

16.8.2 Monitoring Subscribers

RUGGEDCOM ROX II monitors the subscriptions of up to 600 hosts (e.g. clients, servers and peers) that are connected to the NTP server.

To view the list of subscriber hosts, type:

```
show services ntp status monitor-list
```

If hosts are detected, a table or list similar to the following example appears:

```
ruggedcom# show services ntp status monitor-list | tab
                                                                    AVERAGE   LAST
 REMOTE         PORT  COUNT  MODE  VERSION  RESTRICT                  INTERVAL  INTERVAL
 ------------------------------------------------------------------------------------------
 192.168.0.1    123   2      3     4        [ nomodify nopeer noquery notrap ]  447       887
 192.168.0.2    123   1      3     4        [ nomodify nopeer noquery notrap ]  885       885
 192.168.0.3    123   1      3     4        [ nomodify nopeer noquery notrap ]  883       883
 192.168.0.4    123   1      3     4        [ nomodify nopeer noquery notrap ]  881       881
 192.168.1.1    123   1      3     4        [ nomodify nopeer noquery notrap ]  862       862
 192.168.1.3    123   1      3     4        [ nomodify nopeer noquery notrap ]  854       854
 192.168.1.8    123   1      3     4        [ nomodify nopeer noquery notrap ]  850       850
 192.168.2.1    123   1      4     4        [ nomodify nopeer noquery notrap ]  837       837
 192.168.2.4    123   1      4     4        [ nomodify nopeer noquery notrap ]  834       834
 192.168.2.10   123   1      4     4        [ nomodify nopeer noquery notrap ]  830       830
 192.168.3.3    123   1      1     4        [ nomodify nopeer noquery notrap ]  823       823
 192.168.3.7    123   1      1     4        [ nomodify nopeer noquery notrap ]  816       816
 192.168.3.9    123   1      1     4        [ nomodify nopeer noquery notrap ]  813       813
```

The table/list provides the following information:

Parameter	Description
`port`	**Synopsis:** An integer UDP port number.
`count`	**Synopsis:** An integer Number of packets received.
`mode`	**Synopsis:** An integer Mode of last packet.

Parameter	Description
`version`	**Synopsis:** An integer Version of last packet.
`restrict`	**Synopsis:** [ignore | kod | limited | lowpriotrap | nomodify | nopeer | noquery | noserve | notrap | notrust | ntpport | version] Restrict flags.
`average-interval`	**Synopsis:** An integer Average interval (in seconds) between packets from this address.
`last-interval`	**Synopsis:** An integer Interval (in seconds) between the receipt of the most recent packet from this address and the completion of the retrieval of the status.

16.8.3 Adding an NTP Server

To configure an NTP server on the device, do the following:

1. Make sure the CLI is in Configuration mode.
2. [Optional] If the communications with the server are to be authenticated, add a server authentication key or make sure the required key has been configured. For more information, refer to "Managing Server Keys (Page 907)".
3. Add the NTP server by typing:

   Note
   RUGGEDCOM ROX II supports both IPv4 and IPv6 addresses.

   ```
   services ntp server { IP Address }
   ```

   Where:

   - `{ IP Address }` is the address of the remote NTP server
4. Configure the following parameter(s) as required:

Parameter	Description
`enabled`	Turns on the NTP interface to this server.
`peer`	Allows you to enter and edit peers. Peers are NTP servers of the same stratum as the router, and are useful when contact is lost with the hosts in the NTP servers menu.
`minpoll { minpoll }`	**Synopsis:** An integer between 4 and 17 **Default:** 6 The minimum poll interval for NTP messages, in seconds as a power of two.

Parameter	Description
`maxpoll { maxpoll }`	**Synopsis:** An integer between 4 and 17 **Default:** 10 The maximum poll interval for NTP messages, in seconds as a power of two.
`iburst`	When the server is unreachable and at each poll interval, a burst of eight packets is sent instead of one.
`ntp-version { ntp-version }`	**Synopsis:** An integer between 1 and 4 The version of the NTP protocol used to communicate with this host. Change this only if it is known that the host requires a version other than 4.
`prefer`	Marks this server as preferred.
`key { key }`	**Synopsis:** An integer An authentication key associated with this host.

5. [Optional] Set restrictions to control which NTP services can be accessed on the server. For more information, refer to "Adding a Server Restriction (Page 909)".
6. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

16.8.4 Deleting an NTP Server

To delete an NTP server configured on the device, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete the NTP server by typing:

   ```
   no services ntp server { IP Address }
   ```

   Where:

   - `{ IP Address }` is the internal address of the remote NTP server.
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

16.8.5 Managing Server Keys

Server keys are used to authenticate NTP communications and prevent tampering with NTP timestamps. When using authentication, both the local and remote servers must share the same key and key identifier. Packets sent to and received from the server/peer include authentication fields encrypted using the key.

16.8.5.1 Viewing a List of Server Keys

To view a list of server keys, type:

```
show running-config services ntp key
```

If keys have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services ntp key
services
 ntp
  key 1
   value   $4$87sRT/Z+sxs9hYYI0d4IDw==
   trusted
  !
 !
!
```

If no server keys have been configured, add keys as needed. For more information, refer to "Adding a Server Key (Page 908)".

16.8.5.2 Adding a Server Key

To add a server key, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the key by typing:

   ```
   services ntp key { id }
   ```

   Where:

   - `{ id }` is the ID assigned to the key
3. Configure the following parameter(s) as required:

Parameter	Description
`value { value }`	**Synopsis:** A string between 1 and 1024 characters long The key.
`trusted`	Mark this key as trusted for the purposes of authenticating peers with symmetric key cryptography. The authentication procedures require that both the local and remote servers share the same key and key identifier.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

16.8.5.3 Deleting a Server Key

To delete a server key, do the following:

1. Make sure the CLI is in Configuration mode.

2. Delete the chosen key by typing:

   ```
   no services ntp key { id }
   ```

   Where:

   - `{ id }` is the ID assigned to the key
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

16.8.6 Managing Server Restrictions

Server restrictions control access to the NTP servers.

16.8.6.1 Viewing a List of Server Restrictions

To view a list of NTP server restrictions, type:

```
show running-config services ntp restrict
```

If restrictions have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services ntp restrict | tab
NAME       MASK     FLAGS
---------------------------
127.0.0.1  default  -

 !
!
```

If no server restrictions have been configured, add restrictions as needed. For more information, refer to "Adding a Server Restriction (Page 909)".

16.8.6.2 Adding a Server Restriction

To add an NTP server restriction, do the following:

1. Make sure the CLI is in Configuration mode.
2. Add the restriction by typing:

   ```
   services ntp restrict { address } { mask }
   ```

   Where:

   - `{ address }` is the IP address to match. The address can be a host or network IP address, or a valid host DNS name.
   - `{ mask }` is the mask used to match the address. A value of 255.255.255.255 indicates the address is treated as the address of an individual host.

3. Configure the following parameter(s) as required:

⚠ NOTICE

Security hazard – risk of unauthorized access and/or exploitation

It is recommended to restrict queries via ntpdc and ntpq, unless the queries come from a localhost, or to disable this feature entirely if not required. This prevents DDoS (Distributed Denial of Service) reflection/amplification attacks. To set this restriction, configure the following flags: **kod**, **nomodify**, **nopeer**, **noquery** and **notrap**.

Parameter	Description
`flags { flags }`	**Synopsis:** [ignore | kod | limited | lowpriotrap | nomodify | nopeer | noquery | noserve | notrap | notrust | ntpport | version] Flags restrict access to NTP services. An entry with no flags allows free access to the NTP server. • Version: Denies packets that do not match the current NTP version. • ntpport: Matches only if the source port in the packet is the standard NTP UDP port (123). • notrust: Denies service unless the packet is cryptographically authenticated. • notrap: Declines to to provide mode 6 control message trap service to matching hosts. • noserve: Denies all packets except ntpq(8) and ntpdc(8) queries. • noquery: Denies ntpq(8) and ntpdc(8) queries. • nopeer: Denies packets which result in mobilizing a new association. • nomodify: Denies ntpq(8) and ntpdc(8) queries attempting to modify the state of the server; queries returning information are permitted. • lowpriotrap: Declares traps set by matching hosts to be low priority. • limited: Denies service if the packet spacing violates the lower limits specified in the NTP discard setting. • kod: Sends a Kiss-o'-Death (KoD) packet when an access violation occurs. • ignore: Denies all packets.

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

16.8.6.3 Deleting a Server Restriction

To delete an NTP server restriction, do the following:

1. Make sure the CLI is in Configuration mode.

2. Delete the restriction by typing:

   `no services ntp restrict { address } { mask }`

   Where:

   - `{ address }` is the IP address to match. The address can be a host or network IP address, or a valid host DNS name.
   - `{ mask }` is the mask used to match the address. A value of 255.255.255.255 indicates the address is treated as the address of an individual host.

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

16.9 Managing NTP Broadcast/Multicast Clients

Set the device to NTP broadcast or multicast client mode if the NTP server issues regular time-of-day advertisements.

16.9.1 Enabling and Configuring NTP Multicast Clients

The NTP multicast client enables the NTP server to receive advertisements from other NTP servers.

To enable and configure the NTP multicast client, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***services » ntp » multicastclient*** and configure the following parameter(s) as required:

Parameter	Description
`enabled`	Enables the multicast message mode.
`address { address }`	**Synopsis:** A string between 1 and 253 characters long **Default:** 224.0.1.1 The multicast address on which the NTP client listens for NTP messages.

3. Add a multicast address for a known NTP server. For more information, refer to "Adding a Broadcast/Multicast Address (Page 913)".
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

16.9.2 Enabling and Configuring NTP Broadcast Clients

The NTP broadcast client enables the NTP server to receive advertisements from other NTP servers and send advertisements of its own.

To enable and configure the NTP broadcast client, do the following:

1. Make sure the CLI is in Configuration mode.
2. Navigate to ***services » time » ntp***.
3. Configure the following parameters as required:

Parameter	Description
`broadcastclient`	Enables/disables the broadcast client.

4. Add a broadcast address for a known NTP server. For more information, refer to "Adding a Broadcast/Multicast Address (Page 913)".
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

16.9.3 Managing NTP Broadcast/Multicast Addresses

When broadcast or multicast addresses for known NTP servers are configured, the NTP daemon monitors advertisements from each address and chooses the server with the lowest stratum to use as the NTP host. This is opposed to manually configuring a list of servers or peers.

16.9.3.1 Viewing a List of Broadcast/Multicast Addresses

To view a list of broadcast/multicast addresses, type:

```
show running-config services ntp broadcast
```

If addresses have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services ntp broadcast
services
 ntp
  broadcast 224.0.0.1
   no enabled
   key 1
   no ntp-version
  !
 !
!
```

If no broadcast/multicast addresses have been configured, add addresses as needed. For more information, refer to "Adding a Broadcast/Multicast Address (Page 913)".

16.9.3.2 Adding a Broadcast/Multicast Address

To add a broadcast/multicast address for an NTP server, do the following:

⚠ NOTICE

It is strongly recommended to enable NTP authentication, unless all hosts on the network are trusted.

1. Make sure a server key has been configured with the broadcast/multicast setting to enable NTP authentication. For more information, refer to "Adding a Server Key (Page 908)".
2. Make sure the CLI is in Configuration mode.
3. Add the address by typing:

   ⚠ NOTICE

   The broadcast/multicast address must be the same as the address for the NTP multicast client.

   ```
   services ntp broadcast { address }
   ```

   Where:

   - `{ address }` is the broadcast or multicast address
4. Configure the following parameter(s) as required:

Parameter	Description
`enabled`	Enables sending broadcast or multicast NTP messages to this address.
`key { key }`	**Synopsis:** An integer Authentication key.
`ntp-version { ntp-version }`	**Synopsis:** An integer between 1 and 4 The version of the NTP protocol used to communicate with this host. Change this only if it is known that the host requires a version other than 4.
`ttl { ttl }`	**Synopsis:** An integer between 1 and 127 **Default:** 1 Time to live.

5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

16.9.3.3 Deleting a Broadcast/Multicast Address

To delete a broadcast/multicast address for an NTP server, do the following:

1. Make sure the CLI is in Configuration mode.

2. Delete the restriction by typing:

   ```
   no services ntp broadcast { address }
   ```

   Where:

   - `{ address }` is the broadcast or multicast address

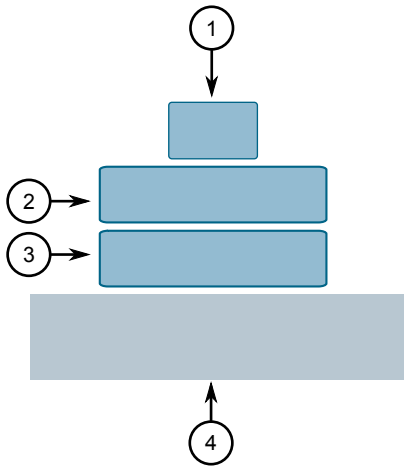
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

17 Virtualization

RUGGEDCOM ROX II supports kernel-based virtualization systems on the RUGGEDCOM RX1400.

The Virtual Processing Engine (VPE) provides a Linux-based platform for third-party applications to use, without impacting RUGGEDCOM RX1400 core services running on the system. Virtualization allows a full Linux image (with dedicated storage media and I/O ports) to run in parallel with the RUGGEDCOM ROX II, using a KVM (Kernel Virtual Machine) based solution.

A front-end management interface is added for the deployment and configuration of virtual machines. Once installed and configured, users can launch a Linux-based guest operating system and install third party applications on top of the image. Third-party applications will have access to network and serial interfaces on the system, based on the configuration.



① Apps
② Guest Linux Kernel
③ QEMU
④ ROXII Linux Kernel ARM

Figure 17.1 System Block Diagram

⚠ NOTICE

A separate VPE feature key (VIRTUALM) must be installed before enabling the virtualization service. For more information about obtaining this feature key, contact a Siemens Sales representative or Customer Support.

⚠ NOTICE
Virtual machine images must be run from the microSD/microSDHC drive. For more information, refer to "Features and Benefits (Page 1)".

Note
Multiple virtual machines can be installed, but only one virtual machine can be run at a time.

To aid in the deployment of large virtual machine images, setup of the VPE requires the Linux OS and applications to be compressed in a tar archive. This file is transferred to a microSD card, which is then installed in the RUGGEDCOM RX1400. The RUGGEDCOM ROX II virtualization service will mount the microSD card, extract the image file, and use it as the file system for the Linux OS and applications.

17.1 Configuring Virtualization

To configure a virtual machine on the RUGGEDCOM RX1400, perform the following basic steps:

1. Obtain and install the VPE feature key (VIRTUALM).
2. Enable the RUGGEDCOM ROX II virtualization service.
3. Configure the global settings for the virtualization service.
4. Add and extract the virtual machine image.
5. Configure the network interface.
6. Start the virtual machine image.

Once the virtual machine is started, it can be accessed for the first time via the virtual machine console using the `vm-console` command. Once logged in via console, standard Linux commands can be used to set up networking and other configuration parameters.

17.2 Enabling/Disabling the Virtualization Service

To enable or disable the virtualization service, do the following:

Note
A pre-built virtual machine image for Debian Linux is available upon request from Siemens. For more information, refer to Siemens Customer Support.

1. Insert the microSD/microSDHC drive containing the virtual machine image into the microSD/microSDHC drive slot. For more information, refer to the " RUGGEDCOM RX1400 Installation Manual".
2. Make sure the CLI is in Configuration mode.

3. Enable or disable the virtualization service by typing:

   ```
   services virtualization enabled [ true | false ]
   ```

   Where:

   - `{ true }` enables the virtualization service
   - `{ false }` disables the virtualization service

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

17.3 Configuring Global Settings

To configure the global settings, do the following:

1. Make sure the CLI is in Configuration mode.
2. Configure the global settings by typing:

   ```
   services virtualization virtual-machines basic-
   parameters cpu { cpu } vpe-boot-partition
   { parition } machine { machine } memory { memory }
   auto-start { auto-start }
   ```

   Where:

   - `{ cpu }` is the CPU type to emulate.
   - `{ partition }` is the primary virtual disk partition that VPE will boot from. The value can be any number between 1 and 4. The default value is 1.
   - `{ machine }` is the machine type to emulate.
   - `{ memory }` is the memory allocation in MB. The allocation can be any value between 200 and 512 MB.
   - `{ auto-start }` is the name of the virtual machine to start on system restart.

3. Assign one or more serial ports to the virtualization service. For more information, refer to "Assigning a Serial Port (Page 925)".
4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

17.4 Issuing VM Commands

To issue a virtual machine command, do the following:

1. Issue a virtual machine command by typing:

   ```
   services virtualization vm-command cmd [ kill |
   quit | status | stop ]
   ```

Where:

- `kill` forcefully terminates the virtual machine process
- `quit` systematically terminates the process from the host
- `status` queries the status of the Quick Emulator
- `stop` pauses the virtual machine

2. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

17.5 Assigning a Network Interface

The network configuration is divided into two sections: the network interface configuration on the guest, and the back end interface on the host side. The available network interfaces on the guest are *eth0*, *eth1*, and *eth2*. Network interfaces are bridged to the external network via a Linux kernel virtual bridge.

To assign a network interface to the virtual machine, do the following:

1. Make sure the CLI is in Configuration mode.

Note
Any VLAN interface or dedicated port can be assigned to the virtual switch.

2. Add a virtual machine. For more information, refer to "Adding a Virtual Machine (Page 922)".
3. Make sure the VPE Network Interface for the virtual machine is enabled. For more information, refer to "Enabling/Disabling the VPE Network Interface (Page 927)".

Note
Up to three network interfaces can be added for each VPE.

4. Add one or more network interfaces. For more information, refer to "Adding a Virtual Interface (Page 927)".
5. Configure a virtual switch for the virtualization service. For more information, refer to "Adding a Virtual Switch (Page 446)".
6. Start the virtual machine. For more information, refer to "Starting a Virtual Machine (Page 924)".
7. Access the virtual machine console window. For more information, refer to "Accessing the Active Virtual Machine (Page 919)".
8. Log in to the virtual machine.
9. Navigate to ***etc » network » interfaces***.

10. Add an entry for the desired interface by typing an appropriate Linux command, such as:

    Note
    IP addresses can be assigned either manually or via DHCP. The following example uses DHCP.

    ```
    allow-hotplug  { interface }
    iface  { interface }  inet  dhcp
    ```

    Where:

    - { interface } is the interface to be used. Options include **eth0**, **eth1**, **eth2**.

11. Activate the network interface by typing:

    ```
    ifup  { interface }
    ```

    Where:

    - { interface } is the interface to be used. Options include **eth0**, **eth1**, **eth2**.

17.6 Accessing the Active Virtual Machine

The CLI includes a built-in Command Line Interface (CLI) for accessing and interacting with the active virtual machine. To access the active virtual machine, type:

```
vm-console
```

The prompt for the virtual machine appears. For example:

```
ruggedcom# vm-console
Trying 127.0.0.1...
Connected to ruggedcom.localdomain.
Escape character is '^]'.

ruggedcom login:
```

17.7 Querying the Device Serial Number

To query the serial number of the RUGGEDCOM RX1400 using SNMP, do the following:

1. Log in to the active virtual machine. For more information, refer to "Accessing the Active Virtual Machine (Page 919)".
2. Make sure the SNMP utility is installed on the virtual machine. If it is not, install the utility by typing:

   ```
   apt-get  install snmp
   ```

⚠ NOTICE

The appropriate community string or password configured for the RUGGEDCOM RX1400 must be used.

3. Query the OID of the serial number by typing:

```
snmpget -v { version } -c { id } -u { user }
{ address } 1.3.6.1.4.1.15004.4.2.3.1.0
```

Where:

- { version } is the SNMP version to be used. Options include **1**, **2c**, **3**
- { id } is the name of the community string configured for the device
- { user } is the name of the ROX user
- { address } is the IP address of the RUGGEDCOM ROX II device

The following is an example of a successful query output:

```
1.3.6.1.4.1.15004.4.2.3.1.0 = STRING: RUMED22080400
```

17.8 Managing Virtual Machines

This section describes how to configure and manage virtual machines.

17.8.1 Building/Obtaining a Virtual Machine Image

Detailed instructions for creating the Linux image .tar.gz file are described in the Building a Linux-Based Virtual Machine Image [https://support.industry.siemens.com/cs/ww/en/view/109482423].

Alternatively, Siemens has sample Debian Linux images available on request from the support portal, in both 1 GB and 3.5 GB file system sizes. Either of these images can be successfully extracted onto a FAT32 formatted SD card, allowing transfer via a Windows PC. If a larger image is created, and the extracted image size is > 4 GB, an EXT4 formatted card is required, and will require a Linux PC to format and transfer.

17.8.2 Determining the Active Virtual Machine

To determine which virtual machine is active, type:

```
show services virtualization status
```

If a virtual machine has been activated, a list similar to the following example appears:

```
ruggedcom# show services virtualization status
status
 active-guest
  name   linux1
  pid    28579
  state  Started
  status Normal
```

Note
The active virtual machine is referred to as the **active guest** .

This list displays the following information:

Parameter	Description
`name`	**Synopsis:** A string between 1 and 64 characters long The name of the active guest.
`pid`	**Synopsis:** A string The Process ID (PID) associated with the active guest.
`state`	**Synopsis:** A string The state of the active guest. Possible values include started, stopped, failed or no reply.
`status`	**Synopsis:** A string The status of the active guest.

17.8.3 Viewing a List of Virtual Machine Names

To view a list of installed virtual machines, type:

```
show running-config services virtualization virtual-machines
```

If virtual machines have been configured, a table or list similar to the following example appears:

```
ruggedcom# show running-config services virtualization virtual-machines
services
 virtualization
  virtual-machines basic-parameters auto-start lnx1
  virtual-machines basic-parameters network-interfaces vma.0001
  !
  virtual-machines basic-parameters network-interfaces vma.0002
  !
  virtual-machines basic-parameters network-interfaces vma.0003
  !
  virtual-machines linux-guests lnx1
   linux-image   linux.img
   linux-kernel  vmlinuz-4.9.0-11-armmp.knl
   device-tree   vexpress-v2p-ca15-tc1.dtb
   init-ram-disk initrd.img-4.9.0-11-armmp.ird
  !
 !
!
```

If no virtual machines have been configured, add images as needed. For more information, refer to "Adding a Virtual Machine (Page 922)".

17.8.4 Adding a Virtual Machine

Users can add a virtual machine to RUGGEDCOM ROX II using a micoSD card containing the virtual machine image.

⚠ NOTICE

When preparing a virtual machine image, note the following requirements:

- At least one user profile and password must be configured when building the virtual machine image. This is required to access the virtual machine via RUGGEDCOM ROX II. For more information about accessing the virtual machine once installed and activated, refer to "Accessing the Active Virtual Machine (Page 919)".
- Each virtual machine image must be compressed into one of the following tar archive file formats: *.tar, *.tar.gz or *.tar.bz2
- Each virtual machine archive must consist of the following files: the initial RAM disk (initrd) file (if required by the image), a Linux image file (*.img), a Linux kernel file (*.knl), a device tree file (*.dtb) and a manifest file (*vmconfig.txt).

To add a virtual machine, do the following:

1. Make sure the virtual machine image is installed on the device. For more information, refer to "Installing Files (Page 88)".
2. Make sure the CLI is in Configuration mode.
3. Add the virtual machine by typing:

   ```
   services virtualization virtual-machines linux-guests { name }
   ```

   Where:

   - `{ name }` is the name of the virtual machine to be added

   Note
   If an image with the same name already exists in the file system, the user will be prompted to either overwrite the image in the file system or load the existing image. For more information, refer to either "Extracting a Virtual Machine Archive (Page 923)" or "Loading an Existing Virtual Machine Image (Page 923)".

4. Type `commit` and press **Enter** to save the changes.

17.8.5 Extracting a Virtual Machine Archive

Note
The extraction process can take several minutes to complete.

⚠ NOTICE

Do not extract an archive for the active virtual machine.

To extract a virtual machine archive, do the following:

1. Make sure the CLI is in Configuration mode.
2. Determine which virtual machine is active. For more information, refer to "Determining the Active Virtual Machine (Page 920)".
3. If the virtual machine is active, stop the machine. For more information, refer to "Stopping a Virtual Machine (Page 925)".
4. Extract a virtual machine archive by typing:

   ```
   services virtualization vm-extract-archive vm-name
   { name } archive-name { archive }
   ```

   Where:

   - `{ name }` is the name of the virtual machine
   - `{ archive }` is the name of the archive file to extract
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

17.8.6 Loading an Existing Virtual Machine Image

A user may load an existing virtual machine image from the file system.

To load an existing virtual machine image, do the following:

1. Make sure the CLI is in Configuration mode.
2. Load a virtual machine image by typing:

   ```
   services virtualization vm-load-image vm-name
   { name }
   ```

   Where:

   - `{ name }` is the name of the virtual machine
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

17.8.7 Deleting a Virtual Machine

To delete a virtual machine, do the following:

⚠ NOTICE

Deleting a virtual machine removes the image from RUGGEDCOM ROX II and the microSD/microSDHC drive.

1. Make sure the CLI is in Configuration mode.
2. Determine which virtual machine is active. For more information, refer to "Determining the Active Virtual Machine (Page 920)".
3. If the virtual machine is active, stop the machine. For more information, refer to "Stopping a Virtual Machine (Page 925)".
4. Delete the virtual machine by typing:

   ```
   no services virtualization virtual-machines linux-guests { name }
   ```

   Where:

   - `{ name }` is the name of the virtual machine to be deleted
5. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

17.8.8 Deleting a Virtual Machine Archive

To delete a virtual machine archive, do the following:

1. Make sure the CLI is in Configuration mode.
2. Delete a virtual machine archive by typing:

   ```
   services virtualization vm-delete-archive archive-name { name }
   ```

   Where:

   - `{ name }` is the name of the archive file to delete
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

17.8.9 Starting a Virtual Machine

To start a virtual machine, do the following:

1. Start a virtual machine by typing:

   ```
   services virtualization vm-start { name } console-wait [ true | false ]
   ```

Where:

- `{ name }` is the name of the virtual machine
- `{ console-wait }` is an optional parameter. When set to true, the virtual machine waits for a console connection before starting. The default value is false.

2. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

17.8.10 Stopping a Virtual Machine

To stop a virtual machine, do the following:

1. Log in to the active virtual machine. For more information, refer to "Accessing the Active Virtual Machine (Page 919)".
2. Shut down the active virtual machine by typing an appropriate Linux command (e.g. *poweroff*).

17.9 Managing Serial Port Assignments

This section describes how to assign serial ports to the virtual machine, as well as how to unassign them.

The serial ports are mapped within the virtual machine as follows:

- Port 1: /dev/ttyAMA1
- Port 2: /dev/ttyAMA2

17.9.1 Assigning a Serial Port

To assign a serial port to the virtual machine service, do the following:

⚠ NOTICE
When serial ports are assigned to the virtual machine service, they are dedicated to the service and cannot be used for any other purpose by RUGGEDCOM ROX II.

1. Make sure the CLI is in Configuration mode.
2. Set the serial port protocol to **vmserial** for the desired serial port. For more information, refer to "Adding a Serial Port Protocol (Page 378)".
3. Assign a serial port, type:

```
services virtualization virtual-machines basic-
parameters serials { serial-port }
```

Where:

- `{ serial-port }` is the host serial interface port, redirected to the virtual machine

4. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

17.9.2 Unassigning a Serial Port

To unassign a serial port, do the following:

1. Make sure the CLI is in Configuration mode.
2. Unassign the chosen serial port by typing:

   ```
   no services virtualization virtual-machines basic-parameters serials { serial-port }
   ```

   Where:

   - `{ serial-port }` the host serial interface port, mapped to the ttyAMA device

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

17.10 Managing Virtual Interfaces

This section describes how to configure and manage virtual interfaces for the virtual machine.

17.10.1 Viewing a List of Virtual Interfaces

To view a list of available virtual interfaces, type:

```
show running-config services virtualization virtual-machines basic-parameters network-interfaces
```

A table or list similar to the following appears:

```
ruggedcom# show running-config services virtualization virtual-machines basic-
parameters network-interfaces | tab
IFNAME
----------
vma.0001

 !
!
```

If a virtual interface is not listed, configure one. For more information, refer to "Adding a Virtual Interface (Page 927)".

17.10.2 Adding a Virtual Interface

Users can add up to three network interfaces to support the virtual processing engine.

To add a virtual interface, do the following:

1. Make sure the virtual machine image is installed on the device. For more information, refer to "Installing Files (Page 88)".
2. Make sure the CLI is in Configuration mode.
3. Add the virtual interface by typing:

   ```
   services virtualization virtual-machines basic-parameters network-interfaces { name }
   ```

   Where:

   - `{ name }` is the name of the interface to be added. Options include vma.0001, vma.0002, vma.0003.
4. Type `commit` and press **Enter** to save the changes.

17.10.3 Enabling/Disabling the VPE Network Interface

The VPE Network Interface must be enabled to allow network access for virtual machines.

1. Make sure the CLI is in Configuration mode.
2. Enable or disable the VPE Network Interface by typing the following commands:

   Enable

   ```
   interface VPE { name } enabled
   ```

   Where:

   - `{ name }` is the name of the emulated network interface

   Disable

   ```
   no interface VPE { name } enabled
   ```

   Where:

   - `{ name }` is the name of the emulated network interface
3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

17.10.4 Deleting a Virtual Interface

To delete a virtual interface, do the following:

1. Make sure the CLI is in Configuration mode.

2. Delete the virtual interface by typing:

   ```
   no services virtualization virtual-machines basic-parameters network-parameters { name }
   ```

   Where:

   - `{ name }` is the name of the interface to be deleted

3. Type `commit` and press **Enter** to save the changes, or type `revert` and press **Enter** to abort.

17.11 Managing VPE Adapters

This section describes how to configure and manage VPE adaptors within the virtual machine image from the RUGGEDCOM ROX II CLI.

17.11.1 Viewing the Status of the VPE Adapter

To view the current status and configuration settings of a VPE adapter, do the following:

1. Exit all vm-console sessions via the CLI.
2. View the stats of the VPE adapter by typing:

   ```
   services virtualization vm-network-query adaptor [ eth0 | eth1 | eth2 ] user { username } password { password }
   ```

   Where:

   - { username } is the username required to access the VPE adapter.
   - { password } is the password associated with the VPE username.

   A table or list similar to the following appears:

Note
A blank field indicates the associated parameter is not configured.

```
ruggedcom# services virtualization vm-networking-query adaptor eth0 password
 admin user root
 vm-adaptor-status   UP
 vm-ipv4-source   static
 vm-ipv4-address   172.30.143.173/19    172.30.142.173/19
 vm-ipv4-gateway   172.30.128.1
 vm-ipv6-source
 vm-ipv6-address   fe80::96b8:c5ff:fe24:849b/64
 vm-ipv6-gateway
 vm-dns-nameservers   172.30.128.8    172.30.128.12
```

17.11.2 Configuring a VPE Adapter

To configure a VPE adapter in the virtual machine image, do the following:

1. [Optional] Review the current configuration of the VPE adapter. For more information, refer to "Viewing the Status of the VPE Adapter (Page 928)".
2. Exit all vm-console sessions.
3. Enter `services virtualization vm-networking-set` and then define the following settings:

Parameter	Description
`adaptor { adaptor }`	**Synopsis:** [eth0 | eth1 | eth2] The interface used by the VPE adapter.
`ipv4-src { ipv4-src }`	**Synopsis:** [none | static | dhcp] The source of the virtual machine's IPv4 address. Options include • none - The source is not configured • static - The IP address is static • dhcp - The IP address is obtained from a DHCP server
`ipv4 { ipv4 }`	**Synopsis:** A string between 9 and 18 characters long or A string 0 characters long The virtual machine's IPv4 address, including the subnet (i.e. 172.30.10.12/19).
`ipv4-gateway { ipv4-gateway }`	**Synopsis:** A string between 7 and 15 characters long or A string 0 characters long The virtual machine's IPv4 gateway.
`ipv6-src { ipv6-src }`	**Synopsis:** [none | static | auto] The source of the virtual machine's IPv6 address. Options include: • none - The source is not configured • static - The IP address is static • auto - The source is selected automatically by the virtual machine
`ipv6 { ipv6 }`	**Synopsis:** A string between 4 and 43 characters long or A string 0 characters long The virtual machine's IPv6 address, including the subnet (i.e. fe80::96b8:c5ff:fe24:849b/64
`ipv6-gateway { ipv6-gateway }`	**Synopsis:** A string between 6 and 40 characters long or A string 0 characters long The virtual machine's IPv6 gateway
`dns-nameserver-1 { dns-nameserver-1 }`	**Synopsis:** A string between 7 and 15 characters long or A string between 6 and 40 characters long or A string 0 characters long The IP address of the primary DNS server.

Parameter	Description
`dns-nameserver-2 { dns-nameserver-2 }`	**Synopsis:** A string between 7 and 15 characters long or A string between 6 and 40 characters long or A string 0 characters long The IP address of the secondary DNS server
`user { user }`	**Synopsis:** A string between 1 and 128 characters long **Default:** root The name of the VPE user.
`password { password }`	**Synopsis:** A string between 1 and 128 characters long **Default:** admin The password associated with the VPE user.

4. Press **Enter**.
5. To verify the configuration, query the VPE adapter to view its current settings. For more information, refer to "Viewing the Status of the VPE Adapter (Page 928)".

17.11.3 Starting/Stopping a VPE Adapter

To stop or start a VPE adapter, do the following:

1. Exit all vm-console sessions.
2. Start or stop the VPE adapter by typing:

```
services virtualization vm-networking-state adaptor
[ eth0 | eth1 | eth2 ] state [ start | stop ]
user { username } password { password }
```

Where:

- { username } is the username required to access the VPE adapter.
- { password } is the password associated with the VPE username.

17.12 Example: Enabling a Virtual Machine to Access a WLAN via a WLAN Client Interface

This example demonstrates how to enable a virtual machine to access a TCP/IP WLAN. This is necessary if a virtual machine hosts an application that either requires access to the Internet or is a resource that other hosts on the network can access.

⚠ NOTICE

The values shown are specific to the provided topology. Actual values can vary based on the user's configuration.

The following topology consists of two networks:

- The first network (**192.168.1.0/24**) connects a VPE's *eth* interface to a router's (R1) virtual machine interface (vma.0001).
- The second network (**192.168.2.0/24**) is a WLAN that connects a router's (R2) *wlan-cl1* interface to a wireless access point (R2) and Linux host.

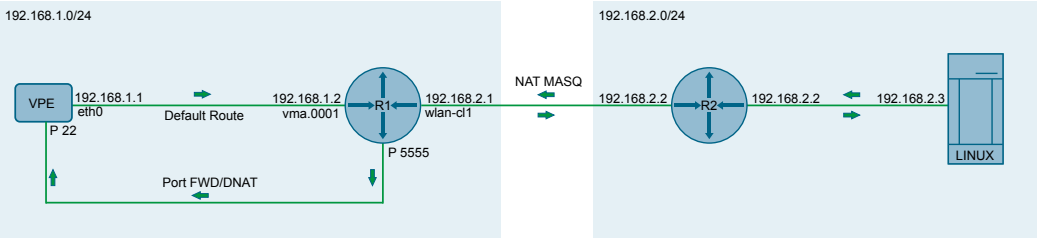


Figure 17.2 Virtual Machine to WLAN Topology

The following components exist in this topology:

- The **VPE** is a Linux guest that uses an ETH interface to access a host. In this scenario, the host is *R1*.
- **R1** is a RUGGEDCOM RX1400 running a virtual machine interface (vma.0001).
- **R2** is a RUGGEDCOM RX1400 acting as an access point.

In the topology, the default route forwards packets from the *eth* interface. This allows packets from the VPE to be sent to the *vma.0001* interface, where they can enter the RUGGEDCOM RX1400 routing system. Once in the routing system, any packets destined for the WLAN are forwarded to the *wlan-cl1* interface.

The masquerading NAT on *wlan-cl1* allows the VPE to initiate communications with a host on the WLAN and to receive replies from this host without requiring the WLAN to have a route to the VPE. The NAT does this by performing the following operations on packets passing through *wlan-cl1*:

- For packets egressing from the VPE (192.168.1.1), the masquerading NAT replaces the source IP address with the address of wlan-cl1 (192.168.2.1).
- For reply packets from the WLAN and destined to address 192.168.2.1, the masquerading NAT replaces the destination address with the IP address of the VPE (192.168.1.1). The packet is then forwarded to the VPE.

To enable hosts on the WLAN to communicate with the VPE, a Destination Network Address Translation (DNAT)/port forward is configured on the firewall to map port 5555 on *wlan-cl1* (192.168.2.1:5555) to port 22 on the VPE's *eth* interface (192.168.1.1:22). Port forwarding/DNAT allows hosts on the WLAN to initiate communications with the VPE without requiring the WLAN to have an access route. In this scenario, the DNAT/port forward configuration enables WLAN hosts to start an SSH session with the VPE.

To replicate the topology, do the following:

Step 1: Configuring the Access Point (R2)

1. Enable the WLAN interface.
2. Set the SSID to **RX1400-WLAN**.
3. Assign the IP address **192.168.2.2/24** to the access point's interface. For more information, refer to "Adding an IPv4 Address (Page 251)".

Step 2: Configuring the Linux Host

1. Connect the PC running the Linux host to the access point.
2. Assign the IP address **192.168.2.3/24** to the PC.

Step 3: Configuring the (R1)

1. Enable the WLAN interface.
2. Enable the virtualization service. For more information, refer to "Enabling/Disabling the Virtualization Service (Page 916)".
3. Add a virtual machine and name it *vm1*. For more information, refer to "Adding a Virtual Machine (Page 922)".
4. Select *vma.0001* as the virtual interface. For more information, refer to "Adding a Virtual Interface (Page 927)".
5. Set the virtual machine to start automatically to make sure the source interface for the NAT masquerade (vma.001) is enabled before the firewall rules are applied. For more information, refer to "Configuring Global Settings (Page 917)".
6. Start the virtual machine. For more information, refer to "Starting a Virtual Machine (Page 924)".
7. Assign the IP address **192.168.1.2** to the virtual machine (vma.0001). For more information, refer to "Adding an IPv4 Address (Page 251)".
8. Access the virtual machine via the virtual console using the following command:

   ```
   telnet  localhost  4444
   ```

   For more information, refer to "Accessing the Active Virtual Machine (Page 919)".
9. Enter the following command to bring up eth0:

   ```
   ip link set eth0 up # set eth0 up
   ```
10. Enter the following to assign the IP address **192.168.1.1/24** to eth0:

    ```
    ip addr add 192.168.1.1/24 dev eth0
    ```
11. Enter the following to set a default route through vma.0001:

    ```
    ip route add default via 192.168.1.2
    ```

12. Exit the virtual console.

Step 4: Configuring the WLAN Client

1. Add a WLAN client, making sure to select the access point. The IP address source must also be set to **static**. For more information, refer to "Adding a WLAN Client (Page 413)".
2. Assign the IP address **192.168.2.1/24** to the WLAN client. For more information, refer to "Adding an IPv4 Address (Page 251)".

Step 5: Configuring the Firewall

1. Create a firewall configuration named *wlan-vpe*.
2. Add the following zones:
   - *wlan*
   - *fw*
   - *vpe*

   For information about adding a zone, refer to "Adding a Zone (Page 226)".
3. Add an interface named *wlan-cl1* and select **wlan** as the predefined zone. For more information, refer to "Adding an Interface (Page 228)" and "Associating an Interface with a Zone (Page 229)".
4. Add an interface named *vma.0001* and select **vpe** as the predefined zone. For more information, refer to "Adding an Interface (Page 228)" and "Associating an Interface with a Zone (Page 229)".
5. Add a policy named *allow* and configure it as follows:

Policy	Accept
Source Zone	All
Destination Zone	All

   This policy disables the firewall's packet filtering capabilities by allow the firewall to accept all packets from any interface.

   For more information, refer to:
   - "Adding a Policy (Page 234)"
   - "Configuring the Source Zone (Page 235)"
   - "Configuring the Destination Zone (Page 235)"
6. Add a rule named *dnat* and configure it as follows:

Action	dnat
Destination Zone Hosts	192.168.1.1:22
Protocol	tcp
Destination Port	5555

Source Zone	wlan
Destination Zone	vpe

This rule forwards any TCP packets arriving on *wlan-cl1* with source IP address **192.168.2.1:5555** to **192.168.1.1:22** via *vma.0001*. This allows hosts on the WLAN to SSH to the Linux guest.

Note
To provide access to other services hosted by the Linux guest, add other DNAT rules with a destination port and protocol to match the service.

For more information, refer to:

- "Adding a Rule (Page 241)"
- "Configuring the Source Zone (Page 243)"
- "Configuring the Destination Zone (Page 244)"

7. Add a masquerade rule named *masq* and configure it as follows:

Outgoing Interface List	wlan-cli
Source Hosts	vma.0001

This rule replaces the source address of any packet forwarded via *wlan-cl1* with the IP address of *wlan-cl1* and replaces the destination address of reply packets with the IP address of *vma.0001*. This rule allows the WLAN to send reply packets to the Linux guest without a gateway.

For more information, refer to "Adding Masquerade or SNAT Settings (Page 239)".

8. Set *wlan-vpe* as the working configuration and validate the settings. For more information, refer to "Validating a Firewall Configuration (Page 245)".
9. Set *wlan-vpe* as the active configuration. For more information, refer to "Working with Multiple Firewall Configurations (Page 222)".
10. Enable the active firewall configuration. For more information, refer to "Enabling/Disabling a Firewall (Page 245)".

Step 4: Verifying the Configuration

1. To test the NAT, make sure the VPE can ping **192.168.2.3** (the Linux host).
2. To test the DNAT, make sure the Linux host can ssh into the VPE via R1 by typing the following:

```
ssh -p5555 192.168.2.1
```

Final Configuration Example

Access Point Configuration

```
ruggedcom# show running-config interface wlan wlanport 1 access-point
interface
 wlan wlanport 1
  access-point ssids RX1400-WLAN
   enabled
   interface  wlan-ap1
   channel    6
   passphrase $4$wIw1bIIIw2BwhYYI0d4IDw==
  !
 !
!
```

Virtual Machine (VM) Configuration

```
ruggedcom# show running-config services virtualization
services
 virtualization
  enabled true
  virtual-machines basic-parameters auto-start vm1
  virtual-machines basic-parameters network-interfaces vma.0001
  !
  virtual-machines linux-guests vm1
   linux-image   linux.img
   linux-kernel  vmlinuz-3.16.0-4-armmp.knl
   device-tree   vexpress-v2p-ca15-tc1.dtb
   init-ram-disk initrd.img-3.16.0-4-armmp.ird
  !
 !
!
```

WLAN Client Configuration

```
Interface
 wlan wlanport 1
  client wireless-lans rx1400-wlan
   enabled
   ssid-security    RX1400-WLAN--WPA2
   password         $4$wIw1bIIIw2BwhYYI0d4IDw==
   ip-address-src   static
   ipv6-address-src static
  !
 !
!
```

Firewall Configuration

```
Security
 firewall
  enable
  work-config   wlan-vpe
  active-config wlan-vpe
  fwconfig wlan-vpe
   fwzone wlan
    no description
   !
   fwzone fw
    type firewall
    no description
   !
   fwzone vpe
    no description
   !
   fwinterface wlan-cl1
```

```
    zone wlan
    no description
   !
   fwinterface vma.0001
    zone vpe
    no description
   !
   fwpolicy allow
    source-zone all
    destination-zone all
    policy accept
    no description
   !
   fwrule dnat
    action                dnat
    source-zone wlan
    destination-zone vpe
    destination-zone-hosts 192.168.1.1:22
    protocol              tcp
    destination-ports     5555
    no description
   !
   fwmasq masq
    out-interface wlan-cl1
    no out-interface-specifics
    no ipalias
    source-hosts  vma.0001
    no address
    no description
   !
  !
 !
!
```

18 Applications

Applications are special add-ons that extend the functionality of RUGGEDCOM ROX II, such as enhanced support for other RUGGEDCOM products (e.g. RUGGEDCOM CROSSBOW). They are installed and upgraded the same as the RUGGEDCOM ROX II operating system, in that they are first installed on the inactive partition and are only activated after a reboot. This makes it possible to decline or undo the installation if the application creates undesirable results. The currently active partition is also unaffected when an application is being installed or upgraded.

All RUGGEDCOM ROX II applications are released as repositories and must be hosted by an upgrade server. For more information about configuring an upgrade server, refer to "Configuring the Upgrade Server (Page 109)".

Note
Some applications are only compatible with specific versions of RUGGEDCOM ROX II. Check the application's requirements before installing, or before upgrading/downgrading RUGGEDCOM ROX II.

18.1 Viewing a List of Installed Applications

To view a list of RUGGEDCOM ROX II applications installed on the device, type:

```
show apps installed-apps
```

If applications have been installed, a table or list similar to the following example appears:

```
ruggedcom# show apps installed-apps
APP NAME  VERSION
------------------
crossbow  4.1.2
```

If no applications have been installed, install applications as needed. For more information, refer to "Installing an Application (Page 937)".

18.2 Installing an Application

To install an application, do the following:

1. Make sure the CLI is in Configuration mode.
2. Install the application by typing:

   ```
   admin rox-imaging apps install-app url { URL }
   ```

Where:

- `{ URL }` is the URL of the desired application

18.3 Upgrading an Application

To upgrade an application, do the following:

1. Make sure the CLI is in Configuration mode.
2. Install the application by typing:

   ```
   admin rox-imaging apps upgrade-app url { URL }
   ```

   Where:

   - `{ URL }` is the URL of the desired application

18.4 Uninstalling an Application

To uninstall an application, do the following:

1. Make sure the CLI is in Configuration mode.
2. Uninstall the application by typing:

   ```
   admin rox-imaging apps uninstall-app app-name
   { name }
   ```

   Where:

   - `{ name }` is the name of the application to uninstall as it appears in the repository configuration.

19 Troubleshooting

This chapter describes troubleshooting steps for common issues that may be encountered when using RUGGEDCOM ROX II or designing a network. It describes the following tasks:

For further assistance, contact Siemens Customer Support.

Note
For a description of pre-configured alarms, refer to "Pre-Configured Alarms (Page 132)".

19.1 Ethernet Ports

The following describes common problems related to Ethernet ports.

Problem	Solution
A link seems fine when traffic levels are low, but fails as traffic rates increase OR a link can be pinged but has problems with FTP/SQL/HTTP/etc.	A possible cause of intermittent operation is that of a *duplex mismatch*. If one end of the link is fixed to full-duplex and the peer auto-negotiates, the auto-negotiating end falls back to half-duplex operation. At lower traffic volumes, the link may display few if any errors. As the traffic volume rises, the fixed negotiation side will begin to experience dropped packets while the auto-negotiating side will experience collisions. Ultimately, as traffic loads approach 100%, the link will become entirely unusable. The ping command with flood options is a useful tool for testing commissioned links. The command `ping 192.168.0.1 500 2` can be used to issue 500 pings each separated by two milliseconds to the next switch. If the link used is of high quality, then no pings should be lost and the average round trip time should be small.
Links are inaccessible, even when using the Link Fault Indication (LFI) protection feature.	Make sure LFI is not enabled on the peer as well. If both sides of the link have LFI enabled, then both sides will withhold link signal generation from each other.

19.2 Multicast Filtering

The following describes common problems related to multicast filtering.

Problem	Solution
When started, a multicast traffic feed is always distributed to all members of the VLAN.	Is IGMP enabled for the VLAN? Multicasts will be distributed to all members of the VLAN unless IGMP is enabled.

Problem	Solution
Computers connected to the switch receive multicast traffic, but not when they are connected to a router.	Is the port used to connect the router included in the Router Ports list? To determine whether the multicast stream is being delivered to the router, view the statistics collected for switched Ethernet ports. For more information, refer to "Viewing Switched Ethernet Port Statistics (Page 320)". Verify the traffic count transmitted to the router is the same as the traffic count received from the multicasting source.
The video stream at an end station is of poor quality.	Video serving is a resource-intensive application. Because it uses isochronous workload, data must be fed at a prescribed rate or end users will see glitches in the video. Networks that carry data from the server to the client must be engineered to handle this heavy, isochronous workload. Video streams can consume large amounts of bandwidth. Features and capacity of both server and network (including routers, bridges, switches and interfaces) impact the streams. Do not exceed 60% of the maximum interface bandwidth. For example, if using a 10 Mbps Ethernet, run a single multicasting source at no more than 6 Mbps, or two sources at 3 Mbps. It is important to consider these ports in the network design, as router ports will carry the traffic of all multicast groups. **Note** Multicasting will introduce latency in all traffic on the network. Plan the network carefully to account for capacity and latency concerns.
Multicast streams of some groups are not forwarded properly. Some segments without subscribers receive the traffic, while some segments with subscribers do not.	Make sure different multicast groups do not have multicast IP addresses that map to the same multicast MAC address. The switch forwarding operation is MAC address-based and will not work properly for several groups mapping to the same MAC address.
Computers on the switch issue join requests, but do not receive multicast streams from a router.	Is the multicast route running IGMP version 2? It must run IGMP version 2 in order for IGMP Snooping to operate properly.
Unable to connect or disconnect some switch ports, and multicast goes everywhere. Is IGMP broken?	IGMP is not broken. This may in fact be proper switch behavior. When the switch detects a change in the network topology through RSTP, it acts to avoid loss of multicast traffic. If configured to do so, it starts forwarding all multicast traffic to all ports that are not RSTP Edge ports (because they may potentially link to routers). This may result in some undesired flooding of multicast traffic, which will stop after a few minutes. However, it guarantees that all devices interested in the traffic will keep receiving it without interruption. The same behavior will be observed when the switch resets or when IGMP Snooping is being disabled for the VLAN.

19.3 Spanning Tree

The following describes common problems related to the Spanning Tree Protocol (STP).

Problem	Solution
The network locks up when a new port is connected and the port status LEDs are flashing rapidly.	Is it possible that one of the switches in the network or one of the ports on a switch in the network has STP disabled and accidentally connects to another switch? If this has occurred, then a traffic loop has been formed.
Occasionally, the ports seem to experience significant flooding for a brief period of time.	If the problem appears to be transient in nature, it is possible that ports that are part of the spanning tree have been configured as edge ports. After the link layers have come up on edge ports, STP will directly transition them (perhaps improperly) to the forwarding state. If an RSTP configuration message is then received, the port will be returned to blocking. A traffic loop may be formed for the length of time the port was in forwarding. If one of the switches appears to flip the root from one port to another, the problem may be one of traffic prioritization. For more information refer to The network becomes unstable when a specific application is started (Page 942). Another possible cause of intermittent operation is that of an auto-negotiation mismatch. If one end of the link is fixed to full-duplex mode and the peer auto-negotiates, the auto-negotiating end will fall back to half-duplex operation. At lower traffic, the volumes the link may display few if any errors. As the traffic volume rises, the fixed negotiation side will begin to experience dropped packets while the auto-negotiating side will experience collisions. Ultimately, as traffic loads approach 100%, the link will become entirely unusable. At this point, RSTP will not be able to transmit configuration messages over the link and the spanning tree topology will break down. If an alternate trunk exists, RSTP will activate it in the place of the congested port. Since activation of the alternate port often relieves the congested port of its traffic, the congested port will once again become reliable. RSTP will promptly enter it back into service, beginning the cycle once again. The root port will flip back and forth between two ports on the switch.
A switch displays a strange behavior where the root port hops back and forth between two switch ports and never settles down.	
A computer or device is connected to a switch. After the switch is reset, it takes a long time for it to come up.	Is it possible that the RSTP edge setting for this port is set to false? If Edge is set to false, the bridge will make the port go through two forward delay times before the port can send or receive frames. If Edge is set to true, the bridge will transition the port directly to forwarding upon link up. Another possible explanation is that some links in the network run in half-duplex mode. RSTP uses a peer-to-peer protocol called Proposal-Agreement to ensure transitioning in the event of a link failure. This protocol requires full-duplex operation. When RSTP detects a non-full duplex port, it cannot rely on Proposal-Agreement protocol and must make the port transition the slow (i.e. STP) way. If possible, configure the port for full-duplex operation. Otherwise, configure the port's point-to-point setting to true. Either one will allow the Proposal-Agreement protocol to be used.
When the switch is tested by deliberately breaking a link, it takes a long time before devices beyond the switch can be polled.	Is it possible that some ports participating in the topology have been configured to STP mode or that the port's point-to-point parameter is set to false? STP and multi-point ports converge slowly after failures occur. Is it possible that the port has migrated to STP? If the port is connected to the LAN segment by shared media and STP bridges are connected to that media, then convergence after link failure will be slow.

Problem	Solution
	Delays on the order of tens or hundreds of milliseconds can result in circumstances where the link broken is the sole link to the root bridge and the secondary root bridge is poorly chosen. The worst of all possible designs occurs when the secondary root bridge is located at the farthest edge of the network from the root. In this case, a configuration message will have to propagate out to the edge and then back in order to reestablish the topology.
The network is composed of a ring of bridges, of which two (connected to each other) are managed and the rest are unmanaged. Why does the RSTP protocol work quickly when a link is broken between the managed bridges, but not in the unmanaged bridge part of the ring?	A properly operating unmanaged bridge is transparent to STP configuration messages. The managed bridges will exchange configuration messages through the unmanaged bridge part of the ring as if it is non-existent. When a link in the unmanaged part of the ring fails however, the managed bridges will only be able to detect the failure through timing out of hello messages. Full connectivity will require three hello times plus two forwarding times to be restored.
The network becomes unstable when a specific application is started. The network returns to normal when the application is stopped.	RSTP sends its configuration messages using the highest possible priority level. If CoS is configured to allow traffic flows at the highest priority level and these traffic flows burst continuously to 100% of the line bandwidth, STP may be disrupted. It is therefore advised not to use the highest CoS.
When a new port is brought up, the root moves on to that port instead of the port it should move to or stay on.	Is it possible that the port cost is incorrectly programmed or that auto-negotiation derives an undesired value? Inspect the port and path costs with each port active as root.
An IED/controller does not work with the device.	Certain low CPU bandwidth controllers have been found to behave less than perfectly when they receive unexpected traffic. Try disabling STP for the port. If the controller fails around the time of a link outage, there is the remote possibility that frame disordering or duplication may be the cause of the problem. Try setting the root port of the failing controller's bridge to STP.
Polls to other devices are occasionally lost.	Review the network statistics to determine whether the root bridge is receiving TCNs around the time of observed frame loss. It may be possible there are problems with intermittent links in the network.
The root is receiving a number of TCNs. Where are they coming from?	Examine the RSTP port statistics to determine the port from which the TCNs are arriving. Sign-on to the switch at the other end of the link attached to that port. Repeat this step until the switch generating the TCNs is found (i.e. the switch that is itself not receiving a large number of TCNs). Determine the problem at that switch.

19.4 VLANs

The following describes common problems related to the VLANs.

Problem	Solution
VLANs are not needed on the network. Can they be turned off?	Yes. Simply leave all ports set to type *edge* and leave the native VLAN set to 1. This is the default configuration for the switch.
Two VLANs were created and a number of ports were made	If the devices need to communicate at the physical address layer, they must be members of the same VLAN. If they can communicate

Problem	Solution
members of them. Now some of the devices in one VLAN need to send messages to devices in the other VLAN.	in a Layer 3 fashion (i.e. using a protocol such as IP or IPX), use a router. The router will treat each VLAN as a separate interface, which will have its own associated IP address space.

19.5 Firmware Updates

The following describes common errors and possible solutions related to firmware updates. If further assistance is needed, contact Siemens Customer Support.

Error Message	Solution
unknown firmware image file	The firmware image is not valid for the modem installed in the device, or the firmware download is accidentally interrupted. Check the connectivity between the device and the remote server. Make sure the connectivity is reliable.
mis-matched carrier	The new firmware is not targeted to the modem currently installed in the device. Check the firmware file name in the version information file. Make sure the file name has PRI ID of modem installed in the device. Manually download the firmware to the device, then execute qmi-firware-update command to determine what carrier the firmware is targeting. See command and option in (*).
url connection/downloading failure	The device is not able to reach the remote host server based on the URL configuration. Or, the version information file or firmware file is not found on the remote server. Check the URL configuration, and make sure the remote server is reachable. Check the path of the URL configuration. Make sure the new firmware file is in the correct location in the remote server.
invalid firmware information	The version information file name or firmware file name does not exist in server. Check the existence of the version information file name and firmware file name in remote server.
Unspecified error.	Check the syslog for more details.

20 Reference

This chapter provides additional information that may be required to understand and/or configure related features in RUGGEDCOM ROX II.

20.1 Supported MIBs

The current MIB files supported by RUGGEDCOM ROX II can be downloaded from the https://www.siemens.com.

RUGGEDCOM ROX II supports the following MIBs:

⚠ NOTICE

This section lists all MIBs supported by RUGGEDCOM ROX II, and is intended for reference purposes only. Individual device support may vary.

- **BRIDGE-MIB**

  For more information, refer to "BRIDGE-MIB".
- **IF-MIB**

  For more information, refer to "IF-MIB".
- **IP-MIB**

  For more information, refer to "IP-MIB".
- **TCP-MIB**

  For more information, refer to "TCP-MIB".
- **UDP-MIB**

  For more information, refer to "UDP-MIB".
- **LLDP-MIB**

  For more information, refer to "LLDP-MIB".
- **Q-BRIDGE-MIB**

  For more information, refer to "Q-BRIDGE-MIB".
- **RUGGEDCOM-SYS-INFO-MIB**

  For more information, refer to "RUGGEDCOM-SYS-INFO-MIB".
- **SNMP-FRAMEWORK-MIB**

  For more information, refer to "SNMP-FRAMEWORK-MIB".

- **SNMP-USER-BASED-SM-MIB**

  For more information, refer to "SNMP-USER-BASED-SM-MIB".
- **SNMPv2-MIB**

  For more information, refer to "SNMPv2-MIB".
- **SNMP-VIEW-BASED-ACM-MIB**

  For more information, refer to "SNMP-VIEW-BASED-ACM-MIB".
- **BGP4-MIB**

  For more information, refer to "BGP4-MIB".
- **IP-FORWARD-MIB**

  For more information, refer to "IP-FORWARD-MIB".
- **RFC1213-MIB**

  For more information, refer to "RFC1213-MIB".
- **PIM-STD-MIB**

  For more information, refer to "PIM-STD-MIB".
- **MPLS-LDP-STD-MIB**

  For more information, refer to "MPLS-LDP-STD-MIB".
- **MPLS-LDP-GENERIC-STD-MIB**

  For more information, refer to "MPLS-LDP-GENERIC-STD-MIB".
- **IEC-62439-2-MIB**

  For more information, refer to "IEC-62439-2-MIB".

BRIDGE-MIB

Object	Description
dot1dBaseBridgeAddress	**Syntax:** Hex-String **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.1.1 **Description:** The MAC address used by this bridge when it must be referred to in a unique fashion. It is recommended that this be the numerically smallest MAC address of all ports that belong to this bridge. However, it is only required to be unique. When concatenated with dot1dStpPriority, a unique BridgeIdentifier is formed, which is used in the Spanning Tree Protocol.
dot1dBaseNumPorts	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.1.2 **Description:** The number of ports controlled by this bridging entity.
dot1dBaseType	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.1.3

Object	Description
	Description: Indicates what type of bridging this bridge can perform. If a bridge is actually performing a certain type of bridging, this will be indicated by entries in the port table for the given type.
dot1dBasePort	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.1.4.1.1 **Description:** The port number of the port for which this entry contains bridge management information.
dot1dBasePortIfIndex	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.1.4.1.2 **Description:** The value of the instance of the ifIndex object, defined in IF-MIB, for the interface corresponding to this port.
dot1dBasePortCircuit	**Syntax:** OID **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.1.4.1.3 **Description:** For a port that (potentially) has the same value of dot1dBasePortIfIndex as another port on the same bridge. This object contains the name of an object instance unique to this port. For example, in the case where multiple ports correspond one-to-one with multiple X.25 virtual circuits, this value might identify an (e.g., the first) object instance associated with the X.25 virtual circuit corresponding to this port. For a port which has a unique value of dot1dBasePortIfIndex, this object can have the value { 0 0 }.
dot1dBasePortDelayExceededDiscards	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.1.4.1.4 **Description:** The number of frames discarded by this port due to excessive transit delay through the bridge. It is incremented by both transparent and source route bridges.
dot1dBasePortMtuExceededDiscards	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.1.4.1.5 **Description:** The number of frames discarded by this port due to an excessive size. It is incremented by both transparent and source route bridges.
dot1dStpProtocolSpecification	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.2.1 **Description:** An indication of what version of the Spanning Tree Protocol is being run. The value 'decLb100(2)' indicates the DEC LANbridge 100 Spanning Tree protocol. IEEE 802.1D implementations will return 'ieee8021d(3)'. If future versions of the IEEE Spanning Tree Protocol that are incompatible with the current version are released a new value will be defined.
dot1dStpPriority	**Syntax:** Integer **Access:** Read-Write

Object	Description
	OID: .1.3.6.1.2.1.17.2.2 **Description:** The value of the write-able portion of the Bridge ID (i.e., the first two octets of the (8 octet long) Bridge ID). The other (last) 6 octets of the Bridge ID are given by the value of dot1dBaseBridgeAddress. On bridges supporting IEEE 802.1t or IEEE 802.1w, permissible values are 0-61440, in steps of 4096.
dot1dStpTimeSinceTopologyChange	**Syntax:** Timeticks **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.2.3 **Description:** The time (in hundredths of a second) since the last time a topology change was detected by the bridge entity. For RSTP, this reports the time since the tcWhile timer for any port on this Bridge was nonzero.
dot1dStpTopChanges	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.2.4 **Description:** The total number of topology changes detected by this bridge since the management entity was last reset or initialized.
dot1dStpDesignatedRoot	**Syntax:** Hex-String **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.2.5 **Description:** The bridge identifier of the root of the spanning tree, as determined by the Spanning Tree Protocol, as executed by this node. This value is used as the Root Identifier parameter in all Configuration Bridge PDUs originated by this node.
dot1dStpRootCost	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.2.6 **Description:** The cost of the path to the root as seen from this bridge.
dot1dStpRootPort	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.2.7 **Description:** The port number of the port that offers the lowest cost path from this bridge to the root bridge.
dot1dStpMaxAge	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.2.8 **Description:** The maximum age of Spanning Tree Protocol information learned from the network on any port before it is discarded, in units of hundredths of a second. This is the actual value that this bridge is currently using.
dot1dStpHelloTime	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.2.9 **Description:** The amount of time between the transmission of Configuration bridge PDUs by this node on any port when it is the root of the spanning

Object	Description
	tree, or trying to become so, in units of hundredths of a second. This is the actual value that this bridge is currently using.
dot1dStpHoldTime	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.2.10 **Description:** This time value determines the interval length during which no more than two Configuration bridge PDUs shall be transmitted by this node, in units of hundredths of a second.
dot1dStpForwardDelay	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.2.11 **Description:** This time value, measured in units of hundredths of a second, controls how fast a port changes its spanning state when moving towards the Forwarding state. The value determines how long the port stays in each of the Listening and Learning states, which precede the Forwarding state. This value is also used when a topology change has been detected and is underway, to age all dynamic entries in the Forwarding Database. Note that this value is the one that this bridge is currently using, in contrast to dot1dStpBridgeForwardDelay, which is the value that this bridge and all others would start using if/when this bridge were to become the root.
dot1dStpBridgeMaxAge	**Syntax:** Integer **Access:** Read-Write **OID:** .1.3.6.1.2.1.17.2.12 **Description:** The value that all bridges use for MaxAge when this bridge is acting as the root. Note that 802.1D-1998 specifies that the range for this parameter is related to the value of dot1dStpBridgeHelloTime. The granularity of this timer is specified by 802.1D-1998 to be 1 second. An agent may return a badValue error if a set is attempted to a value that is not a whole number of seconds.
dot1dStpBridgeHelloTime	**Syntax:** Integer **Access:** Read-Write **OID:** .1.3.6.1.2.1.17.2.13 **Description:** The value that all bridges use for HelloTime when this bridge is acting as the root. The granularity of this timer is specified by 802.1D-1998 to be 1 second. An agent may return a badValue error if a set is attempted to a value that is not a whole number of seconds.
dot1dStpBridgeForwardDelay	**Syntax:** Integer **Access:** Read-Write **OID:** .1.3.6.1.2.1.17.2.14 **Description:** The value that all bridges use for ForwardDelay when this bridge is acting as the root. Note that 802.1D-1998 specifies that the range for this parameter is related to the value of dot1dStpBridgeMaxAge. The granularity of this timer is specified by 802.1D-1998 to be 1 second. An agent may return a badValue error if a set is attempted to a value that is not a whole number of seconds.
dot1dStpPort	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.2.15.1.1

Object	Description
	Description: The port number of the port for which this entry contains Spanning Tree Protocol management information.
dot1dStpPortPriority	**Syntax:** Integer **Access:** Read-Write **OID:** .1.3.6.1.2.1.17.2.15.1.2 **Description:** The value of the priority field that is contained in the first (in network byte order) octet of the (2 octet long) Port ID. The other octet of the Port ID is given by the value of dot1dStpPort. On bridges supporting IEEE 802.1t or IEEE 802.1w, permissible values are 0-240, in steps of 16.
dot1dStpPortState	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.2.15.1.3 **Description:** The port's current state, as defined by application of the Spanning Tree Protocol. This state controls what action a port takes on reception of a frame. If the bridge has detected a port that is malfunctioning, it will place that port into the broken(6) state. For ports that are disabled (see dot1dStpPortEnable), this object will have a value of disabled(1).
dot1dStpPortEnable	**Syntax:** Integer **Access:** Read-Write **OID:** .1.3.6.1.2.1.17.2.15.1.4 **Description:** The enabled/disabled status of the port.
dot1dStpPortPathCost	**Syntax:** Integer **Access:** Read-Write **OID:** .1.3.6.1.2.1.17.2.15.1.5 **Description:** The contribution of this port to the path cost of paths towards the spanning tree root which include this port. 802.1D-1998 recommends that the default value of this parameter be in inverse proportion to the speed of the attached LAN. New implementations should support dot1dStpPortPathCost32. If the port path costs exceeds the maximum value of this object then this object should report the maximum value, namely 65535. Applications should try to read the dot1dStpPortPathCost32 object if this object reports the maximum value.
dot1dStpPortDesignatedRoot	**Syntax:** Hex-String **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.2.15.1.6 **Description:** The unique Bridge Identifier of the Bridge recorded as the Root in the Configuration BPDUs transmitted by the Designated Bridge for the segment to which the port is attached.
dot1dStpPortDesignatedCost	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.2.15.1.7 **Description:** The path cost of the Designated Port of the segment connected to this port. This value is compared to the Root Path Cost field in received bridge PDUs.
dot1dStpPortDesignatedBridge	**Syntax:** Hex-String **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.2.15.1.8

Object	Description
	Description: The Bridge Identifier of the bridge that this port considers to be the Designated Bridge for this port's segment.
dot1dStpPortDesignatedPort	**Syntax:** Hex-String **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.2.15.1.9 **Description:** The Port Identifier of the port on the Designated Bridge for this port's segment.
dot1dStpPortForwardTransitions	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.2.15.1.10 **Description:** The number of times this port has transitioned from the Learning state to the Forwarding state.
dot1dTpLearnedEntryDiscards	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.4.1 **Description:** The contribution of this port to the path cost of paths towards the spanning tree root which include this port. 802.1D-1998 recommends that the default value of this parameter be in inverse proportion to the speed of the attached LAN. This object replaces dot1dStpPortPathCost to support IEEE 802.1t.
dot1dTpAgingTime	**Syntax:** Integer **Access:** Read-Write **OID:** .1.3.6.1.2.1.17.4.2 **Description:** The timeout period in seconds for aging out dynamically-learned forwarding information. 802.1D-1998 recommends a default of 300 seconds.
dot1dTpFdbAddress	**Syntax:** Hex-String **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.4.3.1.1 **Description:** A unicast MAC address for which the bridge has forwarding and/or filtering information.
dot1dTpFdbPort	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.4.3.1.2 **Description:** Either the value '0', or the port number of the port on which a frame having a source address equal to the value of the corresponding instance of dot1dTpFdbAddress has been seen. A value of '0' indicates that the port number has not been learned, but that the bridge does have some forwarding/filtering information about this address (e.g., in the dot1dStaticTable). Implementors are encouraged to assign the port value to this object whenever it is learned, even for addresses for which the corresponding value of dot1dTpFdbStatus is not learned(3).
dot1dTpFdbStatus	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.4.3.1.3 **Description:** The status of this entry. The meanings of the values are:

Object	Description
	• other(1) - none of the following. This would include the case where some other MIB object (not the corresponding instance of dot1dTpFdbPort, nor an entry in the dot1dStaticTable) is being used to determine if and how frames addressed to the value of the corresponding instance of dot1dTpFdbAddress are being forwarded. • invalid(2) - this entry is no longer valid (e.g., it was learned but has since aged out), but has not yet been flushed from the table. • learned(3) - the value of the corresponding instance of dot1dTpFdbPort was learned, and is being used. • self(4) - the value of the corresponding instance of dot1dTpFdbAddress represents one of the bridge's addresses. The corresponding instance of dot1dTpFdbPort indicates which of the bridge's ports has this address. • mgmt(5) - the value of the corresponding instance of dot1dTpFdbAddress is also the value of an existing instance of dot1dStaticAddress.
dot1dTpPort	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.4.4.1.1 **Description:** The port number of the port for which this entry contains Transparent bridging management information.
dot1dTpPortMaxInfo	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.4.4.1.2 **Description:** The maximum size of the INFO (non-MAC) field that this port will receive or transmit.
dot1dTpPortInFrames	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.4.4.1.3 **Description:** The number of frames that have been received by this port from its segment. Note that a frame received on the interface corresponding to this port is only counted by this object if and only if it is for a protocol being processed by the local bridging function, including bridge management frames.
dot1dTpPortOutFrames	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.4.4.1.4 **Description:** The number of frames that have been transmitted by this port to its segment. Note that a frame transmitted on the interface corresponding to this port is only counted by this object if and only if it is for a protocol being processed by the local bridging function, including bridge management frames.
dot1dTpPortInDiscards	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.4.4.1.5 **Description:** Count of received valid frames that were discarded (i.e., filtered) by the Forwarding Process.

IF-MIB

Object	Description
ifIndex	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.2.2.1.1 **Description:** A unique value, greater than zero, for each interface. It is recommended that values are assigned contiguously starting from 1. The value for each interface sub-layer must remain constant at least from one re-initialization of the entity's network management system to the next re-initialization.
ifDescr	**Syntax:** String **Access:** Read-Only **OID:** .1.3.6.1.2.1.2.2.1.2 **Description:** A textual string containing information about the interface. This string should include the name of the manufacturer, the product name and the version of the interface hardware/software.
ifType	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.2.2.1.3 **Description:** The type of interface. Additional values for ifType are assigned by the Internet Assigned Numbers Authority (IANA), through updating the syntax of the IANAifType textual convention.
ifSpeed	**Syntax:** Gauge32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.2.2.1.5 **Description:** An estimate of the interface's current bandwidth in bits per second. For interfaces which do not vary in bandwidth or for those where no accurate estimation can be made, this object should contain the nominal bandwidth. If the bandwidth of the interface is greater than the maximum value reportable by this object then this object should report its maximum value (4,294,967,295) and ifHighSpeed must be used to report the interace's speed. For a sub-layer which has no concept of bandwidth, this object should be zero.
ifAdminStatus	**Syntax:** Integer **Access:** Read-Write **OID:** .1.3.6.1.2.1.2.2.1.7 **Description:** The desired state of the interface. The testing(3) state indicates that no operational packets can be passed. When a managed system initializes, all interfaces start with ifAdminStatus in the down(2) state. As a result of either explicit management action or per configuration information retained by the managed system, ifAdminStatus is then changed to either the up(1) or testing(3) states (or remains in the down(2) state).
ifOperStatus	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.2.2.1.8 **Description:** The current operational state of the interface. The testing(3) state indicates that no operational packets can be passed. If ifAdminStatus is down(2) then ifOperStatus should be down(2). If ifAdminStatus is changed to up(1) then ifOperStatus should change to up(1) if the interface is ready

Object	Description
	to transmit and receive network traffic; it should change to dormant(5) if the interface is waiting for external actions (such as a serial line waiting for an incoming connection); it should remain in the down(2) state if and only if there is a fault that prevents it from going to the up(1) state; it should remain in the notPresent(6) state if the interface has missing (typically, hardware) components.
ifLastChange	**Syntax:** Timeticks **Access:** Read-Only **OID:** .1.3.6.1.2.1.2.2.1.9 **Description:** The value of sysUpTime at the time the interface entered its current operational state. If the current state was entered prior to the last re-initialization of the local network management subsystem, then this object contains a zero value.
ifLinkUpDownTrapEnable	**Syntax:** Integer **Access:** Read-Write **OID:** .1.3.6.1.2.1.31.1.1.1.14 **Description:** Indicates whether linkUp/linkDown traps should be generated for this interface. By default, this object should have the value enabled(1) for interfaces which do not operate on 'top' of any other interface (as defined in the ifStackTable), and disabled(2) otherwise.
ifConnectorPresent	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.31.1.1.1.17 **Description:** This object has the value 'true(1)' if the interface sublayer has a physical connector and the value 'false(2)' otherwise.
ifHighSpeed	**Syntax:** Gauge32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.31.1.1.1.15 **Description:** An estimate of the interface's current bandwidth in units of 1,000,000 bits per second. If this object reports a value of `n' then the speed of the interface is somewhere in the range of `n-500,000' to `n +499,999'. For interfaces which do not vary in bandwidth or for those where no accurate estimation can be made, this object should contain the nominal bandwidth. For a sub-layer which has no concept of bandwidth, this object should be zero.
ifName	**Syntax:** String **Access:** Read-Only **OID:** .1.3.6.1.2.1.31.1.1.1.1 **Description:** The textual name of the interface. The value of this object should be the name of the interface as assigned by the local device and should be suitable for use in commands entered at the device's `console'. This might be a text name, such as `le0' or a simple port number, such as `1', depending on the interface naming syntax of the device. If several entries in the ifTable together represent a single interface as named by the device, then each will have the same value of ifName. Note that for an agent which responds to SNMP queries concerning an interface on some other (proxied) device, then the value of ifName for such an interface is the proxied device's local name for it. If there is no local name, or this object is otherwise not applicable, then this object contains a zero-length string.
ifNumber	**Syntax:** Integer

Object	Description
	Access: Read-Only **OID:** .1.3.6.1.2.1.2.1 **Description:** The number of network interfaces (regardless of their current state) present on this system.
ifAlias	**Syntax:** String **Access:** Read-Only **OID:** .1.3.6.1.2.1.31.1.1.1.18 **Description:** This object is an 'alias' name for the interface as specified by a network manager, and provides a non-volatile 'handle' for the interface. On the first instantiation of an interface, the value of ifAlias associated with that interface is the zero-length string. As and when a value is written into an instance of ifAlias through a network management set operation, then the agent must retain the supplied value in the ifAlias instance associated with the same interface for as long as that interface remains instantiated, including across all re- initializations/reboots of the network management system, including those which result in a change of the interface's ifIndex value. An example of the value which a network manager might store in this object for a WAN interface is the (Telco's) circuit number/identifier of the interface. Some agents may support write-access only for interfaces having particular values of ifType. An agent which supports write access to this object is required to keep the value in non-volatile storage, but it may limit the length of new values depending on how much storage is already occupied by the current values for other interfaces.
ifTableLastChange	**Syntax:** Timeticks **Access:** Read-Only **OID:** .1.3.6.1.2.1.31.1.5 **Description:** The value of sysUpTime at the time of the last creation or deletion of an entry in the ifTable. If the number of entries has been unchanged since the last re-initialization of the local network management subsystem, then this object contains a zero value.
ifHCInUcastPkts	**Syntax:** Counter64 **Access:** Read-Only **OID:** .1.3.6.1.2.1.31.1.1.1.7 **Description:** The number of packets, delivered by this sub-layer to a higher (sub-)layer, which were not addressed to a multicast or broadcast address at this sub-layer. This object is a 64-bit version of ifInUcastPkts. Discontinuities in the value of this counter can occur at re-initialization of the management system, and at other times as indicated by the value of ifCounterDiscontinuityTime.
ifHCInBroadcastPkts	**Syntax:** Counter64 **Access:** Read-Only **OID:** .1.3.6.1.2.1.31.1.1.1.9 **Description:** The number of packets, delivered by this sub-layer to a higher (sub-)layer, which were addressed to a broadcast address at this sub-layer. This object is a 64-bit version of ifInBroadcastPkts. Discontinuities in the value of this counter can occur at re-initialization of the management system, and at other times as indicated by the value of ifCounterDiscontinuityTime.
ifHCOutMulticastPkts	**Syntax:** Counter64 **Access:** Read-Only

Object	Description
	OID: .1.3.6.1.2.1.31.1.1.1.12 **Description:** The number of packets, delivered by this sub-layer to a higher (sub-)layer, which were addressed to a multicast address at this sub-layer. For a MAC layer protocol, this includes both Group and Functional addresses. This object is a 64-bit version of ifInMulticastPkts. Discontinuities in the value of this counter can occur at re-initialization of the management system, and at other times as indicated by the value of ifCounterDiscontinuityTime.
ifHCInOctets	**Syntax:** Counter64 **Access:** Read-Only **OID:** .1.3.6.1.2.1.31.1.1.1.6 **Description:** The total number of octets received on the interface, including framing characters. This object is a 64-bit version of ifInOctets. Discontinuities in the value of this counter can occur at re-initialization of the management system, and at other times as indicated by the value of ifCounterDiscontinuityTime.
ifInOctets	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.2.2.1.10 **Description:** The total number of octets received on the interface, including framing characters. Discontinuities in the value of this counter can occur at re-initialization of the management system, and at other times as indicated by the value of ifCounterDiscontinuityTime.
ifInErrors	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.2.2.1.14 **Description:** For packet-oriented interfaces, the number of inbound packets that contained errors preventing them from being deliverable to a higher-layer protocol. For character- oriented or fixed-length interfaces, the number of inbound transmission units that contained errors preventing them from being deliverable to a higher-layer protocol. Discontinuities in the value of this counter can occur at re-initialization of the management system, and at other times as indicated by the value of ifCounterDiscontinuityTime.
ifMtu	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.2.2.1.4 **Description:** The size of the largest packet which can be sent/received on the interface, specified in octets. For interfaces that are used for transmitting network datagrams, this is the size of the largest network datagram that can be sent on the interface.
ifInBroadcastPkts	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.31.1.1.1.3 **Description:** The number of packets, delivered by this sub-layer to a higher (sub-)layer, which were addressed to a broadcast address at this sub-layer. Discontinuities in the value of this counter can occur at re-initialization of the management system, and at other times as indicated by the value of ifCounterDiscontinuityTime.
ifOutUcastPkts	**Syntax:** Counter32 **Access:** Read-Only

Object	Description
	OID: .1.3.6.1.2.1.2.2.1.17 **Description:** The total number of packets that higher-level protocols requested be transmitted, and which were not addressed to a multicast or broadcast address at this sub-layer, including those that were discarded or not sent. Discontinuities in the value of this counter can occur at re-initialization of the management system, and at other times as indicated by the value of ifCounterDiscontinuityTime.
ifOutBroadcastPkts	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.31.1.1.1.5 **Description:** The total number of packets that higher-level protocols requested be transmitted, and which were addressed to a broadcast address at this sub-layer, including those that were discarded or not sent. Discontinuities in the value of this counter can occur at re-initialization of the management system, and at other times as indicated by the value of ifCounterDiscontinuityTime.
ifPromiscuousMode	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.31.1.1.1.16 **Description:** This object has a value of false(2) if this interface only accepts packets/frames that are addressed to this station. This object has a value of true(1) when the station accepts all packets/frames transmitted on the media. The value true(1) is only legal on certain types of media. If legal, setting this object to a value of true(1) may require the interface to be reset before becoming effective. The value of ifPromiscuousMode does not affect the reception of broadcast and multicast packets/frames by the interface.
ifHCInMulticastPkts	**Syntax:** Counter64 **Access:** Read-Only **OID:** .1.3.6.1.2.1.31.1.1.1.8 **Description:** The number of packets, delivered by this sub-layer to a higher (sub-)layer, which were addressed to a multicast address at this sub-layer. For a MAC layer protocol, this includes both Group and Functional addresses. This object is a 64-bit version of ifInMulticastPkts. Discontinuities in the value of this counter can occur at re-initialization of the management system, and at other times as indicated by the value of ifCounterDiscontinuityTime.
ifHCOutUcastPkts	**Syntax:** Counter64 **Access:** Read-Only **OID:** .1.3.6.1.2.1.31.1.1.1.11 **Description:** The total number of packets that higher-level protocols requested be transmitted, and which were not addressed to a multicast or broadcast address at this sub-layer, including those that were discarded or not sent. This object is a 64-bit version of ifOutUcastPkts. Discontinuities in the value of this counter can occur at re-initialization of the management system, and at other times as indicated by the value of ifCounterDiscontinuityTime.
ifHCOutBroadcastPkts	**Syntax:** Counter64 **Access:** Read-Only **OID:** .1.3.6.1.2.1.31.1.1.1.13 **Description:**The total number of packets that higher-level protocols requested be transmitted, and which were addressed to a broadcast address

Object	Description
	at this sub-layer, including those that were discarded or not sent. This object is a 64-bit version of ifOutBroadcastPkts. Discontinuities in the value of this counter can occur at re-initialization of the management system, and at other times as indicated by the value of ifCounterDiscontinuityTime.
ifHCOutOctets	**Syntax:** Counter64 **Access:** Read-Only **OID:** .1.3.6.1.2.1.31.1.1.1.10 **Description:** The total number of octets transmitted out of the interface, including framing characters. This object is a 64-bit version of ifOutOctets. Discontinuities in the value of this counter can occur at re-initialization of the management system, and at other times as indicated by the value of ifCounterDiscontinuityTime.
ifOutOctets	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.2.2.1.16 **Description:** The total number of octets transmitted out of the interface, including framing characters. Discontinuities in the value of this counter can occur at re-initialization of the management system, and at other times as indicated by the value of ifCounterDiscontinuityTime.
ifOutErrors	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.2.2.1.20 **Description:** For packet-oriented interfaces, the number of outbound packets that could not be transmitted because of errors. For character-oriented or fixed-length interfaces, the number of outbound transmission units that could not be transmitted because of errors. Discontinuities in the value of this counter can occur at re-initialization of the management system, and at other times as indicated by the value of ifCounterDiscontinuityTime.
ifInUcastPkts	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.2.2.1.11 **Description:** The number of packets, delivered by this sub-layer to a higher (sub-)layer, which were not addressed to a multicast or broadcast address at this sub-layer. Discontinuities in the value of this counter can occur at re-initialization of the management system, and at other times as indicated by the value of ifCounterDiscontinuityTime.
ifInDiscards	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.2.2.1.13 **Description:** The number of inbound packets which were chosen to be discarded even though no errors had been detected to prevent their being deliverable to a higher-layer protocol. One possible reason for discarding such a packet could be to free up buffer space. Discontinuities in the value of this counter can occur at re-initialization of the management system, and at other times as indicated by the value of ifCounterDiscontinuityTime.
ifOutMulticastPkts	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.31.1.1.1.4

Object	Description
	Description: The total number of packets that higher-level protocols requested be transmitted, and which were addressed to a multicast address at this sub-layer, including those that were discarded or not sent. For a MAC layer protocol, this includes both Group and Functional addresses. Discontinuities in the value of this counter can occur at re-initialization of the management system, and at other times as indicated by the value of ifCounterDiscontinuityTime.
ifOutDiscards	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.2.2.1.19 **Description:** The number of outbound packets which were chosen to be discarded even though no errors had been detected to prevent their being transmitted. One possible reason for discarding such a packet could be to free up buffer space. Discontinuities in the value of this counter can occur at re-initialization of the management system, and at other times as indicated by the value of ifCounterDiscontinuityTime.
ifInUnknownProtos	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.2.2.1.15 **Description:** For packet-oriented interfaces, the number of packets received via the interface which were discarded because of an unknown or unsupported protocol. For character-oriented or fixed-length interfaces that support protocol multiplexing the number of transmission units received via the interface which were discarded because of an unknown or unsupported protocol. For any interface that does not support protocol multiplexing, this counter will always be 0. Discontinuities in the value of this counter can occur at re-initialization of the management system, and at other times as indicated by the value of ifCounterDiscontinuityTime.
ifInMulticastPkts	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.31.1.1.1.2 **Description:** The number of packets, delivered by this sub-layer to a higher (sub-)layer, which were addressed to a multicast address at this sub-layer. For a MAC layer protocol, this includes both Group and Functional addresses. Discontinuities in the value of this counter can occur at re-initialization of the management system, and at other times as indicated by the value of ifCounterDiscontinuityTime.
ifCounterDiscontinuityTime	**Syntax:** Timeticks **Access:** Read-Only **OID:** .1.3.6.1.2.1.31.1.1.1.19 **Description:** The value of sysUpTime on the most recent occasion at which any one or more of this interface's counters suffered a discontinuity. The relevant counters are the specific instances associated with this interface of any Counter32 or Counter64 object contained in the ifTable or ifXTable. If no such discontinuities have occurred since the last re- initialization of the local management subsystem, then this object contains a zero value.
linkUp	**OID:** .1.3.6.1.6.3.1.1.5.4
linkDown	**OID:** .1.3.6.1.6.3.1.1.5.3

IP-MIB

Object	Description
ipForwarding	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.4.1 **Description:** The indication of whether this entity is acting as an IPv4 router in respect to the forwarding of datagrams received by, but not addressed to, this entity. IPv4 routers forward datagrams. IPv4 hosts do not (except those source-routed via the host). When this object is written, the entity should save the change to non-volatile storage and restore the object from non-volatile storage upon re-initialization of the system. Note: a stronger requirement is not used because this object was previously defined.
ipInHdrErrors	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.4.4 **Description:** The number of input datagrams discarded due to errors in their IPv4 headers, including bad checksums, version number mismatch, other format errors, time-to-live exceeded, errors discovered in processing their IPv4 options, etc. This object has been deprecated as a new IP version-neutral table has been added. It is loosely replaced by ipSystemStatsInHdrErrors.
ipForwDatagrams	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.4.6 **Description:** The number of input datagrams for which this entity was not their final IPv4 destination, as a result of which an attempt was made to find a route to forward them to that final destination. In entities which do not act as IPv4 routers, this counter will include only those packets which were Source-Routed via this entity, and the Source-Route option processing was successful. This object has been deprecated, as a new IP version-neutral table has been added. It is loosely replaced by ipSystemStatsInForwDatagrams.
ipInDiscards	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.4.8 **Description:** The number of input IPv4 datagrams for which no problems were encountered to prevent their continued processing, but which were discarded (e.g., for lack of buffer space). Note that this counter does not include any datagrams discarded while awaiting re-assembly. This object has been deprecated, as a new IP version-neutral table has been added. It is loosely replaced by ipSystemStatsInDiscards.
ipOutDiscards	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.4.11 **Description:** The number of output IPv4 datagrams for which no problem was encountered to prevent their transmission to their destination, but which were discarded (e.g., for lack of buffer space). Note that this counter would include datagrams counted in ipForwDatagrams if any such packets met this (discretionary) discard criterion. This object has been deprecated, as a new IP version-neutral table has been added. It is loosely replaced by ipSystemStatsOutDiscards.

Object	Description
ipReasmTimeout	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.4.13 **Description:** The maximum number of seconds that received fragments are held while they are awaiting reassembly at this entity.
ipReasmFails	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.4.16 **Description:** The number of failures detected by the IPv4 re-assembly algorithm (for whatever reason: timed out, errors, etc). Note that this is not necessarily a count of discarded IPv4 fragments since some algorithms (notably the algorithm in RFC 815) can lose track of the number of fragments by combining them as they are received. This object has been deprecated, as a new IP version-neutral table has been added. It is loosely replaced by ipSystemStatsReasmFails.
ipFragFails	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.4.18 **Description:** The number of IPv4 datagrams that have been discarded because they needed to be fragmented at this entity but could not be, e.g., because their Don't Fragment flag was set. This object has been deprecated, as a new IP version-neutral table has been added. It is loosely replaced by ipSystemStatsOutFragFails.
ipAdEntAddr	**Syntax:** IpAddress **Access:** Read-Only **OID:** .1.3.6.1.2.1.4.20.1.1 **Description:** The IPv4 address to which this entry's addressing information pertains.
ipAdEntBcastAddr	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.4.20.1.4 **Description:** The value of the least-significant bit in the IPv4 broadcast address used for sending datagrams on the (logical) interface associated with the IPv4 address of this entry. For example, when the Internet standard all-ones broadcast address is used, the value will be 1. This value applies to both the subnet and network broadcast addresses used by the entity on this (logical) interface.
ipNetToMediaIfIndex	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.4.22.1.1 **Description:** The interface on which this entry's equivalence is effective. The interface identified by a particular value of this index is the same interface as identified by the same value of the IF-MIB's ifIndex. This object predates the rule limiting index objects to a max access value of 'not-accessible' and so continues to use a value of 'read-create'.
ipNetToMediaNetAddress	**Syntax:** IpAddress **Access:** Read-Only **OID:** .1.3.6.1.2.1.4.22.1.3

Object	Description
	Description: The IpAddress corresponding to the media-dependent `physical' address. This object predates the rule limiting index objects to a max access value of 'not-accessible' and so continues to use a value of 'read-create'.
ipRoutingDiscards	**OID:** .1.3.6.1.2.1.4.23
ipDefaultTTL	**Syntax:** Integer **Access:** Read-Write **OID:** .1.3.6.1.2.1.4.2 **Description:** The number of routing entries which were chosen to be discarded even though they are valid. One possible reason for discarding such an entry could be to free-up buffer space for other routing entries. This object was defined in pre-IPv6 versions of the IP MIB. It was implicitly IPv4 only, but the original specifications did not indicate this protocol restriction. In order to clarify the specifications, this object has been deprecated and a similar, but more thoroughly clarified, object has been added to the IP-FORWARD-MIB.
ipInAddrErrors	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.4.5 **Description:** The number of input datagrams discarded because the IPv4 address in their IPv4 header's destination field was not a valid address to be received at this entity. This count includes invalid addresses (e.g., 0.0.0.0) and addresses of unsupported Classes (e.g., Class E). For entities which are not IPv4 routers, and therefore do not forward datagrams, this counter includes datagrams discarded because the destination address was not a local address. This object has been deprecated, as a new IP version-neutral table has been added. It is loosely replaced by ipSystemStatsInAddrErrors.
ipInUnknownProtos	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.4.7 **Description:** The number of locally-addressed datagrams received successfully but discarded because of an unknown or unsupported protocol. This object has been deprecated, as a new IP version-neutral table has been added. It is loosely replaced by ipSystemStatsInUnknownProtos.
ipInDelivers	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.4.9 **Description:** The total number of input datagrams successfully delivered to IPv4 user-protocols (including ICMP). This object has been deprecated as a new IP version neutral table has been added. It is loosely replaced by ipSystemStatsIndelivers.
ipOutNoRoutes	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.4.12 **Description:** The number of IPv4 datagrams discarded because no route could be found to transmit them to their destination. Note that this counter includes any packets counted in ipForwDatagrams which meet this `no-route' criterion. Note that this includes any datagrams which a host cannot route because all of its default routers are down. This object has been

Object	Description
	deprecated, as a new IP version-neutral table has been added. It is loosely replaced by ipSystemStatsOutNoRoutes.
ipReasmReqds	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.4.14 **Description:** The number of IPv4 fragments received which needed to be reassembled at this entity. This object has been deprecated, as a new IP version-neutral table has been added. It is loosely replaced by ipSystemStatsReasmReqds.
ipFragOKs	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.4.17 **Description:** The number of IPv4 datagrams that have been successfully fragmented at this entity. This object has been deprecated, as a new IP version-neutral table has been added. It is loosely replaced by ipSystemStatsOutFragOKs.
ipFragCreates	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.4.19 **Description:** The number of IPv4 datagram fragments that have been generated as a result of fragmentation at this entity. This object has been deprecated as a new IP version neutral table has been added. It is loosely replaced by ipSystemStatsOutFragCreates.
ipAdEntIfIndex	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.4.20.1.2 **Description:** The index value which uniquely identifies the interface to which this entry is applicable. The interface identified by a particular value of this index is the same interface as identified by the same value of the IF-MIB's ifIndex.
ipAdEntReasmMaxSize	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.4.20.1.5 **Description:** The size of the largest IPv4 datagram which this entity can re-assemble from incoming IPv4 fragmented datagrams received on this interface.
ipNetToMediaPhysAddress	**Syntax:** String **Access:** Read-Only **OID:** .1.3.6.1.2.1.4.22.1.2 **Description:** The media-dependent `physical' address. This object should return 0 when this entry is in the 'incomplete' state. As the entries in this table are typically not persistent when this object is written the entity should not save the change to non-volatile storage. Note: a stronger requirement is not used because this object was previously defined.
ipNetToMediaType	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.4.22.1.4

Object	Description
	Description: The type of mapping. Setting this object to the value invalid(2) has the effect of invalidating the corresponding entry in the ipNetToMediaTable. That is, it effectively dis-associates the interface identified with said entry from the mapping identified with said entry. It is an implementation- specific matter as to whether the agent removes an invalidated entry from the table. Accordingly, management stations must be prepared to receive tabular information from agents that corresponds to entries not currently in use. Proper interpretation of such entries requires examination of the relevant ipNetToMediaType object. As the entries in this table are typically not persistent when this object is written the entity should not save the change to non-volatile storage. Note: a stronger requirement is not used because this object was previously defined.
ipInReceives	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.4.3 **Description:** The total number of input datagrams received from interfaces, including those received in error. This object has been deprecated, as a new IP version-neutral table has been added. It is loosely replaced by ipSystemStatsInRecieves.
ipOutRequests	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.4.10 **Description:** The total number of IPv4 datagrams which local IPv4 user protocols (including ICMP) supplied to IPv4 in requests for transmission. Note that this counter does not include any datagrams counted in ipForwDatagrams. This object has been deprecated, as a new IP version-neutral table has been added. It is loosely replaced by ipSystemStatsOutRequests.
ipReasmOKs	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.4.15 **Description:** The number of IPv4 datagrams successfully re-assembled. This object has been deprecated, as a new IP version-neutral table has been added. It is loosely replaced by ipSystemStatsReasmOKs.
ipAdEntNetMask	**Syntax:** IpAddress **Access:** Read-Only **OID:** .1.3.6.1.2.1.4.20.1.3 **Description:** The subnet mask associated with the IPv4 address of this entry. The value of the mask is an IPv4 address with all the network bits set to 1 and all the hosts bits set to 0.

TCP-MIB

Object	Description
tcpRtoAlgorithm	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.6.1 **Description:** The algorithm used to determine the timeout value used for retransmitting unacknowledged octets.

Object	Description
tcpRtoMin	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.6.2 **Description:** The minimum value permitted by a TCP implementation for the retransmission timeout, measured in milliseconds. More refined semantics for objects of this type depend on the algorithm used to determine the retransmission timeout; in particular, the IETF standard algorithm rfc2988(5) provides a minimum value.
tcpMaxConn	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.6.4 **Description:** The limit on the total number of TCP connections the entity can support. In entities where the maximum number of connections is dynamic, this object should contain the value -1.
tcpPassiveOpens	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.6.6 **Description:** The number of times TCP connections have made a direct transition to the SYN-RCVD state from the LISTEN state. Discontinuities in the value of this counter are indicated via discontinuities in the value of sysUpTime.
tcpEstabResets	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.6.8 **Description:** The number of times that TCP connections have made a direct transition to the CLOSED state from either the ESTABLISHED state or the CLOSE-WAIT state. Discontinuities in the value of this counter are indicated via discontinuities in the value of sysUpTime.
tcpOutSegs	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.6.11 **Description:** The total number of segments sent, including those on current connections but excluding those containing only retransmitted octets. Discontinuities in the value of this counter are indicated via discontinuities in the value of sysUpTime.
tcpConnLocalAddress	**Syntax:** IpAddress **Access:** Read-Only **OID:** .1.3.6.1.2.1.6.13.1.2 **Description:** The local IP address for this TCP connection. In the case of a connection in the listen state willing to accept connections for any IP interface associated with the node, the value 0.0.0.0 is used.
tcpConnRemAddress	**Syntax:** IpAddress **Access:** Read-Only **OID:** .1.3.6.1.2.1.6.13.1.4 **Description:** The remote IP address for this TCP connection.
tcpInErrs	**Syntax:** Counter32

Object	Description
	Access: Read-Only **OID:** .1.3.6.1.2.1.6.14 **Description:** The total number of segments received in error (e.g., bad TCP checksums). Discontinuities in the value of this counter are indicated via discontinuities in the value of sysUpTime.
tcpRtoMax	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.6.3 **Description:** The maximum value permitted by a TCP implementation for the retransmission timeout, measured in milliseconds. More refined semantics for objects of this type depend on the algorithm used to determine the retransmission timeout; in particular, the IETF standard algorithm rfc2988(5) provides an upper bound (as part of an adaptive backoff algorithm).
tcpActiveOpens	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.6.5 **Description:** The number of times that TCP connections have made a direct transition to the SYN-SENT state from the CLOSED state. Discontinuities in the value of this counter are indicated via discontinuities in the value of sysUpTime.
tcpAttemptFails	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.6.7 **Description:** The number of times that TCP connections have made a direct transition to the CLOSED state from either the SYN-SENT state or the SYN-RCVD state, plus the number of times that TCP connections have made a direct transition to the LISTEN state from the SYN-RCVD state. Discontinuities in the value of this counter are indicated via discontinuities in the value of sysUpTime.
tcpCurrEstab	**Syntax:** Gauge32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.6.9 **Description:** The number of TCP connections for which the current state is either ESTABLISHED or CLOSE-WAIT.
tcpRetransSegs	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.6.12 **Description:** The total number of segments retransmitted; that is, the number of TCP segments transmitted containing one or more previously transmitted octets. Discontinuities in the value of this counter are indicated via discontinuities in the value of sysUpTime.
tcpConnLocalPort	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.6.13.1.3 **Description:** The local port number for this TCP connection.
tcpConnRemPort	**Syntax:** Integer **Access:** Read-Only

Object	Description
	OID: .1.3.6.1.2.1.6.13.1.5 **Description:** The remote port number for this TCP connection.
tcpOutRsts	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.6.15 **Description:** The number of TCP segments sent containing the RST flag. Discontinuities in the value of this counter are indicated via discontinuities in the value of sysUpTime.
tcpInSegs	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.6.17 **Description:** The total number of segments received, including those received in error. This count includes segments received on currently established connections. Discontinuities in the value of this counter are indicated via discontinuities in the value of sysUpTime.
tcpConnState	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.6.13.1.1 **Description:** The state of this TCP connection. The only value that may be set by a management station is deleteTCB(12). Accordingly, it is appropriate for an agent to return a `badValue' response if a management station attempts to set this object to any other value. If a management station sets this object to the value deleteTCB(12), then the TCB (as defined in [RFC793]) of the corresponding connection on the managed node is deleted, resulting in immediate termination of the connection. As an implementation-specific option, a RST segment may be sent from the managed node to the other TCP endpoint (note, however, that RST segments are not sent reliably).

UDP-MIB

Object	Description
udpInDatagrams	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.7.1 **Description:** The total number of UDP datagrams delivered to UDP users. Discontinuities in the value of this counter can occur at re-initialization of the management system, and at other times as indicated by discontinuities in the value of sysUpTime.
udpNoPorts	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.7.2 **Description:** The total number of received UDP datagrams for which there was no application at the destination port. Discontinuities in the value of this counter can occur at re-initialization of the management system, and at other times as indicated by discontinuities in the value of sysUpTime.
udpInErrors	**Syntax:** Counter32 **Access:** Read-Only

Object	Description
	OID: .1.3.6.1.2.1.7.3 **Description:** The number of received UDP datagrams that could not be delivered for reasons other than the lack of an application at the destination port. Discontinuities in the value of this counter can occur at re-initialization of the management system, and at other times as indicated by discontinuities in the value of sysUpTime.
udpLocalAddress	**Syntax:** IpAddress **Access:** Read-Only **OID:** .1.3.6.1.2.1.7.5.1.1 **Description:** The local IP address for this UDP listener. In the case of a UDP listener that is willing to accept datagrams for any IP interface associated with the node, the value 0.0.0.0 is used.
udpOutDatagrams	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.7.4 **Description:** The total number of UDP datagrams sent from this entity. Discontinuities in the value of this counter can occur at re-initialization of the management system, and at other times as indicated by discontinuities in the value of sysUpTime.
udpLocalPort	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.7.5.1.2 **Description:** The local port number for this UDP listener.

LLDP-MIB

Object	Description
lldpPortConfigAdminStatus	**Syntax:** Integer **Access:** Read-Write **OID:** .1.0.8802.1.1.2.1.1.6.1.2 **Description:** The administratively desired status of the local LLDP agent. If the associated lldpPortConfigAdminStatus object has a value of 'txOnly(1)', then LLDP agent will transmit LLDP frames on this port and it will not store any information about the remote systems connected. If the associated lldpPortConfigAdminStatus object has a value of 'rxOnly(2)', then the LLDP agent will receive, but it will not transmit LLDP frames on this port. If the associated lldpPortConfigAdminStatus object has a value of 'txAndRx(3)', then the LLDP agent will transmit and receive LLDP frames on this port. If the associated lldpPortConfigAdminStatus object has a value of 'disabled(4)', then LLDP agent will not transmit or receive LLDP frames on this port. If there is remote systems information which is received on this port and stored in other tables, before the port's lldpPortConfigAdminStatus becomes disabled, then the information will naturally age out.
lldpNotificationInterval	**Syntax:** Integer **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.1.5 **Description:** This object controls the transmission of LLDP notifications. the agent must not generate more than one lldpRemTablesChange notification-event in the indicated period, where a 'notification-event' is

Object	Description
	the transmission of a single notification PDU type to a list of notification destinations. If additional changes in lldpRemoteSystemsData object groups occur within the indicated throttling period, then these trap-events must be suppressed by the agent. An NMS should periodically check the value of lldpStatsRemTableLastChangeTime to detect any missed lldpRemTablesChange notification-events, e.g. due to throttling or transmission loss. If notification transmission is enabled for particular ports, the suggested default throttling period is 5 seconds. The value of this object must be restored from non-volatile storage after a re-initialization of the management system.
lldpPortConfigNotificationEnable	**Syntax:** Integer **Access:** Read-Write **OID:** .1.0.8802.1.1.2.1.1.6.1.3 **Description:** The lldpPortConfigNotificationEnable controls, on a per port basis, whether or not notifications from the agent are enabled. The value true(1) means that notifications are enabled; the value false(2) means that they are not.
lldpMessageTxInterval	**Syntax:** Integer **Access:** Read-Write **OID:** .1.0.8802.1.1.2.1.1.1 **Description:** The interval at which LLDP frames are transmitted on behalf of this LLDP agent. The default value for lldpMessageTxInterval object is 30 seconds. The value of this object must be restored from non-volatile storage after a re-initialization of the management system.
lldpMessageTxHoldMultiplier	**Syntax:** Integer **Access:** Read-Write **OID:** .1.0.8802.1.1.2.1.1.2 **Description:** The time-to-live value expressed as a multiple of the lldpMessageTxInterval object. The actual time-to-live value used in LLDP frames, transmitted on behalf of this LLDP agent, can be expressed by the following formula: TTL = min(65535, (lldpMessageTxInterval * lldpMessageTxHoldMultiplier)) For example, if the value of lldpMessageTxInterval is '30', and the value of lldpMessageTxHoldMultiplier is '4', then the value '120' is encoded in the TTL field in the LLDP header. The default value for lldpMessageTxHoldMultiplier object is 4. The value of this object must be restored from non-volatile storage after a re-initialization of the management system.
lldpReinitDelay	**Syntax:** Integer **Access:** Read-Write **OID:** .1.0.8802.1.1.2.1.1.3 **Description:** The lldpReinitDelay indicates the delay (in units of seconds) from when lldpPortConfigAdminStatus object of a particular port becomes 'disabled' until re-initialization will be attempted. The default value for lldpReintDelay object is two seconds. The value of this object must be restored from non-volatile storage after a re-initialization of the management system.
lldpTxDelay	**Syntax:** Integer **Access:** Read-Write **OID:** .1.0.8802.1.1.2.1.1.4

Object	Description
	Description: The lldpTxDelay indicates the delay (in units of seconds) between successive LLDP frame transmissions initiated by value/status changes in the LLDP local systems MIB. The recommended value for the lldpTxDelay is set by the following formula: `1 <= lldpTxDelay <= (0.25 * lldpMessageTxInterval)` The default value for lldpTxDelay object is two seconds. The value of this object must be restored from non-volatile storage after a re-initialization of the management system.
lldpPortConfigTLVsTxEnable	**Syntax:** Hex-String **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.1.6.1.4 **Description:** The index value used to identify the port component (contained in the local chassis with the LLDP agent) associated with this entry. The value of this object is used as a port index to the lldpPortConfigTable.
lldpConfigManAddrPortsTxEnable	**Syntax:** Hex-String **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.1.7.1.1 **Description:** A set of ports that are identified by a PortList, in which each port is represented as a bit. The corresponding local system management address instance will be transmitted on the member ports of the lldpManAddrPortsTxEnable. The default value for lldpConfigManAddrPortsTxEnable object is empty binary string, which means no ports are specified for advertising indicated management address instance.
lldpStatsRemTablesLastChangeTime	**Syntax:** Timeticks **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.2.1 **Description:** The value of sysUpTime object (defined in IETF RFC 3418) at the time an entry is created, modified, or deleted in the in tables associated with the lldpRemoteSystemsData objects and all LLDP extension objects associated with remote systems. An NMS can use this object to reduce polling of the lldpRemoteSystemsData objects.
lldpStatsRemTablesInserts	**Syntax:** Gauge32 **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.2.2 **Description:** The number of times the complete set of information advertised by a particular MSAP has been inserted into tables contained in lldpRemoteSystemsData and lldpExtensions objects. The complete set of information received from a particular MSAP should be inserted into related tables. If partial information cannot be inserted for a reason such as lack of resources, all of the complete set of information should be removed. This counter should be incremented only once after the complete set of information is successfully recorded in all related tables. Any failures during inserting information set which result in deletion of previously inserted information should not trigger any changes in lldpStatsRemTablesInserts since the insert is not completed yet or or in lldpStatsRemTablesDeletes, since the deletion would only be a partial deletion. If the failure was the

Object	Description
	result of lack of resources, the lldpStatsRemTablesDrops counter should be incremented once.
lldpStatsRemTablesDeletes	**Syntax:** Gauge32 **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.2.3 **Description:** The number of times the complete set of information advertised by a particular MSAP has been deleted from tables contained in lldpRemoteSystemsData and lldpExtensions objects. This counter should be incremented only once when the complete set of information is completely deleted from all related tables. Partial deletions, such as deletion of rows associated with a particular MSAP from some tables, but not from all tables are not allowed, thus should not change the value of this counter.
lldpStatsRemTablesDrops	**Syntax:** Gauge32 **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.2.4 **Description:** The number of times the complete set of information advertised by a particular MSAP could not be entered into tables contained in lldpRemoteSystemsData and lldpExtensions objects because of insufficient resources.
lldpStatsRemTablesAgeouts	**Syntax:** Gauge32 **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.2.5 **Description:** The number of times the complete set of information advertised by a particular MSAP has been deleted from tables contained in lldpRemoteSystemsData and lldpExtensions objects because the information timeliness interval has expired. This counter should be incremented only once when the complete set of information is completely invalidated (aged out) from all related tables. Partial aging, similar to deletion case, is not allowed, and thus, should not change the value of this counter.
lldpStatsRxPortFramesDiscardedTotal	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.2.7.1.2 **Description:** The number of LLDP frames received by this LLDP agent on the indicated port, and then discarded for any reason. This counter can provide an indication that LLDP header formating problems may exist with the local LLDP agent in the sending system or that LLDPDU validation problems may exist with the local LLDP agent in the receiving system.
lldpStatsRxPortFramesErrors	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.2.7.1.3 **Description:** The number of invalid LLDP frames received by this LLDP agent on the indicated port, while this LLDP agent is enabled.
lldpStatsRxPortFramesTotal	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.2.7.1.4 **Description:** The number of valid LLDP frames received by this LLDP agent on the indicated port, while this LLDP agent is enabled.
lldpStatsRxPortTLVsDiscardedTotal	**Syntax:** Counter32

Object	Description
	Access: Read-Only **OID:** .1.0.8802.1.1.2.1.2.7.1.5 **Description:** The number of LLDP TLVs discarded for any reason by this LLDP agent on the indicated port.
lldpStatsRxPortTLVsUnrecognizedTotal	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.2.7.1.6 **Description:** The number of LLDP TLVs received on the given port that are not recognized by this LLDP agent on the indicated port. An unrecognized TLV is referred to as the TLV whose type value is in the range of reserved TLV types (000 1001 - 111 1110) in Table 9.1 of IEEE Std 802.1AB-2005. An unrecognized TLV may be a basic management TLV from a later LLDP version.
lldpStatsRxPortAgeoutsTotal	**Syntax:** Gauge32 **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.2.7.1.7 **Description:** The counter that represents the number of age-outs that occurred on a given port. An age-out is the number of times the complete set of information advertised by a particular MSAP has been deleted from tables contained in lldpRemoteSystemsData and lldpExtensions objects because the information timeliness interval has expired. This counter is similar to lldpStatsRemTablesAgeouts, except that the counter is on a per port basis. This enables NMS to poll tables associated with the lldpRemoteSystemsData objects and all LLDP extension objects associated with remote systems on the indicated port only. This counter should be set to zero during agent initialization and its value should not be saved in non-volatile storage. When a port's admin status changes from 'disabled' to 'rxOnly', 'txOnly' or 'txAndRx', the counter associated with the same port should reset to 0. The agent should also flush all remote system information associated with the same port. This counter should be incremented only once when the complete set of information is invalidated (aged out) from all related tables on a particular port. Partial aging is not allowed, and thus, should not change the value of this counter.
lldpStatsTxPortFramesTotal	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.2.6.1.2 **Description:** The collection of objects which are used to represent LLDP transmission statistics. This group is mandatory for agents which implement the LLDP and have the capability of transmitting LLDP frames.
lldpLocChassisIdSubtype	**Syntax:** Integer **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.3.1 **Description:** The type of encoding used to identify the chassis associated with the local system.
lldpLocChassisId	**Syntax:** Hex-String **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.3.2 **Description:** The string value used to identify the chassis component associated with the local system.

Object	Description
lldpLocPortIdSubtype	**Syntax:** Integer **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.3.7.1.2 **Description:** The type of port identifier encoding used in the associated 'lldpLocPortId' object.
lldpLocPortId	**Syntax:** String **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.3.7.1.3 **Description:** The string value used to identify the port component associated with a given port in the local system.
lldpLocPortDesc	**Syntax:** String **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.3.7.1.4 **Description:** The string value used to identify the 802 LAN station's port description associated with the local system. If the local agent supports IETF RFC 2863, lldpLocPortDesc object should have the same value of ifDescr object.
lldpLocSysDesc	**Syntax:** String **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.3.4 **Description:** The string value used to identify the system description of the local system. If the local agent supports IETF RFC 3418, lldpLocSysDesc object should have the same value of sysDesc object.
lldpLocSysName	**Syntax:** String **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.3.3 **Description:** The string value used to identify the system name of the local system. If the local agent supports IETF RFC 3418, lldpLocSysName object should have the same value of sysName object.
lldpLocSysCapSupported	**Syntax:** Hex-String **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.3.5 **Description:** The bitmap value used to identify which system capabilities are supported on the local system.
lldpLocSysCapEnabled	**Syntax:** Hex-String **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.3.6 **Description:** The bitmap value used to identify which system capabilities are enabled on the local system.
lldpLocManAddrLen	**Syntax:** Integer **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.3.8.1.3 **Description:** The total length of the management address subtype and the management address fields in LLDPDUs transmitted by the local LLDP agent. The management address length field is needed so that the receiving systems that do not implement SNMP will not be required to implement an

Object	Description
	iana family numbers/address length equivalency table in order to decode the management adress.
lldpLocManAddrIfSubtype	**Syntax:** Integer **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.3.8.1.4 **Description:** The enumeration value that identifies the interface numbering method used for defining the interface number, associated with the local system.
lldpLocManAddrIfId	**Syntax:** Integer **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.3.8.1.5 **Description:** The integer value used to identify the interface number regarding the management address component associated with the local system.
lldpLocManAddrOID	**Syntax:** OID **Access:** Read-Only **OID:** 1.0.8802.1.1.2.1.3.8.1.6 **Description:** The OID value used to identify the type of hardware component or protocol entity associated with the management address advertised by the local system agent.
lldpRemChassisIdSubtype	**Syntax:** Integer **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.4.1.1.4 **Description:** The type of encoding used to identify the chassis associated with the remote system.
lldpRemChassisId	**Syntax:** Hex-String **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.4.1.1.5 **Description:** The string value used to identify the chassis component associated with the remote system.
lldpRemPortIdSubtype	**Syntax:** Integer **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.4.1.1.6 **Description:** The type of port identifier encoding used in the associated 'lldpRemPortId' object.
lldpRemPortId	**Syntax:** String **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.4.1.1.7 **Description:** The string value used to identify the port component associated with the remote system.
lldpRemPortDesc	**Syntax:** String **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.4.1.1.8 **Description:** The string value used to identify the description of the given port associated with the remote system.

Object	Description
lldpRemSysName	**Syntax:** String **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.4.1.1.9 **Description:** The string value used to identify the system name of the remote system.
lldpRemSysDesc	**Syntax:** String **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.4.1.1.10 **Description:** The string value used to identify the system description of the remote system.
lldpRemSysCapSupported	**Syntax:** Hex-String **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.4.1.1.11 **Description:** The bitmap value used to identify which system capabilities are supported on the remote system.
lldpRemSysCapEnabled	**Syntax:** Hex-String **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.4.1.1.12 **Description:** The bitmap value used to identify which system capabilities are enabled on the remote system.
lldpRemManAddrIfSubtype	**Syntax:** Integer **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.4.2.1.3 **Description:** The enumeration value that identifies the interface numbering method used for defining the interface number, associated with the remote system.
lldpRemManAddrIfId	**Syntax:** Integer **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.4.2.1.4 **Description:** The integer value used to identify the interface number regarding the management address component associated with the remote system.
lldpRemManAddrOID	**Syntax:** OID **Access:** Read-Only **OID:** .1.0.8802.1.1.2.1.4.2.1.5 **Description:** The OID value used to identify the type of hardware component or protocol entity associated with the management address advertised by the remote system agent.
lldpRemUnknownTLVInfo	**OID:** .1.0.8802.1.1.2.1.4.3.1.2
lldpRemOrgDefInfo	**OID:** .1.0.8802.1.1.2.1.4.4.1.4

Q-BRIDGE-MIB

Object	Description
dot1qVlanVersionNumber	**Syntax:** Integer

Object	Description
	Access: Read-Only **OID:** .1.3.6.1.2.1.17.7.1.1.1 **Description:** The version number of IEEE 802.1Q that this device supports.
dot1qMaxVlanId	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.7.1.1.2 **Description:** The maximum IEEE 802.1Q VLAN-ID that this device supports.
dot1qMaxSupportedVlans	**Syntax:** Gauge32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.7.1.1.3 **Description:** The maximum number of IEEE 802.1Q VLANs that this device supports.
dot1qNumVlans	**Syntax:** Gauge32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.7.1.1.4 **Description:** The current number of IEEE 802.1Q VLANs that are configured in this device.
dot1qGvrpStatus	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.7.1.1.5 **Description:** The administrative status requested by management for GVRP. The value enabled(1) indicates that GVRP should be enabled on this device, on all ports for which it has not been specifically disabled. When disabled(2), GVRP is disabled on all ports, and all GVRP packets will be forwarded transparently. This object affects all GVRP Applicant and Registrar state machines. A transition from disabled(2) to enabled(1) will cause a reset of all GVRP state machines on all ports. The value of this object MUST be retained across reinitializations of the management system.
dot1qVlanNumDeletes	**OID:** .1.3.6.1.2.1.17.7.1.4.1
dot1qVlanFdbId	**Syntax:** Gauge32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.7.1.4.2.1.3 **Description:** The number of times a VLAN entry has been deleted from the dot1qVlanCurrentTable (for any reason). If an entry is deleted, then inserted, and then deleted, this counter will be incremented by 2.
dot1qVlanCurrentEgressPorts	**Syntax:** Hex-String **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.7.1.4.2.1.4 **Description:** The set of ports that are transmitting traffic for this VLAN as either tagged or untagged frames.
dot1qVlanCurrentUntaggedPorts	**Syntax:** Hex-String **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.7.1.4.2.1.5 **Description:** The set of ports that are transmitting traffic for this VLAN as untagged frames.

Object	Description
dot1qVlanStatus	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.7.1.4.2.1.6 **Description:** This object indicates the status of this entry. other(1) - this entry is currently in use, but the conditions under which it will remain so differ from the following values. permanent(2) - this entry, corresponding to an entry in dot1qVlanStaticTable, is currently in use and will remain so after the next reset of the device. The port lists for this entry include ports from the equivalent dot1qVlanStaticTable entry and ports learned dynamically. dynamicGvrp(3) - this entry is currently in use and will remain so until removed by GVRP. There is no static entry for this VLAN, and it will be removed when the last port leaves the VLAN.
dot1qVlanCreationTime	**Syntax:** Timeticks **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.7.1.4.2.1.7 **Description:** The value of sysUpTime when this VLAN was created.
dot1qVlanStaticName	**Syntax:** String **Access:** Read-Write **OID:** .1.3.6.1.2.1.17.7.1.4.3.1.1 **Description:** An administratively assigned string, which may be used to identify the VLAN.
dot1qVlanStaticEgressPorts	**Syntax:** Hex-String **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.7.1.4.3.1.2 **Description:** The set of ports that are permanently assigned to the egress list for this VLAN by management. Changes to a bit in this object affect the per-port, per-VLAN Registrar control for Registration Fixed for the relevant GVRP state machine on each port. A port may not be added in this set if it is already a member of the set of ports in dot1qVlanForbiddenEgressPorts. The default value of this object is a string of zeros of appropriate length, indicating not fixed.
dot1qVlanForbiddenEgressPorts	**Syntax:** Hex-String **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.7.1.4.3.1.3 **Description:** The set of ports that are prohibited by management from being included in the egress list for this VLAN. Changes to this object that cause a port to be included or excluded affect the per-port, per-VLAN Registrar control for Registration Forbidden for the relevant GVRP state machine on each port. A port may not be added in this set if it is already a member of the set of ports in dot1qVlanStaticEgressPorts. The default value of this object is a string of zeros of appropriate length, excluding all ports from the forbidden set.
dot1qVlanStaticUntaggedPorts	**Syntax:** Hex-String **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.7.1.4.3.1.4 **Description:** The set of ports that should transmit egress packets for this VLAN as untagged. The default value of this object for the default VLAN (dot1qVlanIndex = 1) is a string of appropriate length including all ports. There is no specified default for other VLANs. If a device agent cannot

Object	Description
	support the set of ports being set, then it will reject the set operation with an error. For example, a manager might attempt to set more than one VLAN to be untagged on egress where the device does not support this IEEE 802.1Q option.
dot1qVlanStaticRowStatus	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.7.1.4.3.1.5 **Description:** This object indicates the status of this entry.
dot1qNextFreeLocalVlanIndex	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.7.1.4.4 **Description:** The next available value for dot1qVlanIndex of a local VLAN entry in dot1qVlanStaticTable. This will report values >=4096 if a new Local VLAN may be created or else the value 0 if this is not possible. A row creation operation in this table for an entry with a local VlanIndex value may fail if the current value of this object is not used as the index. Even if the value read is used, there is no guarantee that it will still be the valid index when the create operation is attempted; another manager may have already got in during the intervening time interval. In this case, dot1qNextFreeLocalVlanIndex should be re-read and the creation re-tried with the new value. This value will automatically change when the current value is used to create a new row.
dot1qPvid	**Syntax:** Gauge32 **Access:** Read-Write **OID:** .1.3.6.1.2.1.17.7.1.4.5.1.1 **Description:** The PVID, the VLAN-ID assigned to untagged frames or Priority-Tagged frames received on this port. The value of this object MUST be retained across reinitializations of the management system.
dot1qPortAcceptableFrameTypes	**Syntax:** Integer **Access:** Read-Write **OID:** .1.3.6.1.2.1.17.7.1.4.5.1.2 **Description:** When this is admitOnlyVlanTagged(2), the device will discard untagged frames or Priority-Tagged frames received on this port. When admitAll(1), untagged frames or Priority-Tagged frames received on this port will be accepted and assigned to a VID based on the PVID and VID Set for this port. This control does not affect VLAN-independent Bridge Protocol Data Unit (BPDU) frames, such as GVRP and Spanning Tree Protocol (STP). It does affect VLAN- dependent BPDU frames, such as GMRP. The value of this object MUST be retained across reinitializations of the management system.
dot1qPortIngressFiltering	**Syntax:** Integer **Access:** Read-Write **OID:** .1.3.6.1.2.1.17.7.1.4.5.1.3 **Description:** When this is true(1), the device will discard incoming frames for VLANs that do not include this Port in its Member set. When false(2), the port will accept all incoming frames. This control does not affect VLAN-independent BPDU frames, such as GVRP and STP. It does affect VLAN-dependent BPDU frames, such as GMRP. The value of this object MUST be retained across reinitializations of the management system.
dot1qPortGvrpStatus	**Syntax:** Integer **Access:** Read-Only

Object	Description
	OID: .1.3.6.1.2.1.17.7.1.4.5.1.4 **Description:** The state of GVRP operation on this port. The value enabled(1) indicates that GVRP is enabled on this port, as long as dot1qGvrpStatus is also enabled for this device. When disabled(2) but dot1qGvrpStatus is still enabled for the device, GVRP is disabled on this port: any GVRP packets received will be silently discarded, and no GVRP registrations will be propagated from other ports. This object affects all GVRP Applicant and Registrar state machines on this port. A transition from disabled(2) to enabled(1) will cause a reset of all GVRP state machines on this port. The value of this object MUST be retained across reinitializations of the management system.
dot1qFdbDynamicCount	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.7.1.2.1.1.2 **Description:** A collection of objects providing information about all unicast addresses, learned dynamically or statically configured by management, in each Filtering Database.
dot1qTpFdbPort	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.7.1.2.2.1.2 **Description:** Either the value '0', or the port number of the port on which a frame having a source address equal to the value of the corresponding instance of dot1qTpFdbAddress has been seen. A value of '0' indicates that the port number has not been learned but that the device does have some forwarding/filtering information about this address (e.g., in the dot1qStaticUnicastTable). Implementors are encouraged to assign the port value to this object whenever it is learned, even for addresses for which the corresponding value of dot1qTpFdbStatus is not learned(3).
dot1qTpFdbStatus	**Syntax:** Integer **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.7.1.2.2.1.3 **Description:** The status of this entry. The meanings of the values are: • other(1) - none of the following. This may include the case where some other MIB object (not the corresponding instance of dot1qTpFdbPort, nor an entry in the dot1qStaticUnicastTable) is being used to determine if and how frames addressed to the value of the corresponding instance of dot1qTpFdbAddress are being forwarded. • invalid(2) - this entry is no longer valid (e.g., it was learned but has since aged out), but has not yet been flushed from the table. • learned(3) - the value of the corresponding instance of dot1qTpFdbPort was learned and is being used. • self(4) - the value of the corresponding instance of dot1qTpFdbAddress represents one of the device's addresses. The corresponding instance of dot1qTpFdbPort indicates which of the device's ports has this address. • mgmt(5) - the value of the corresponding instance of dot1qTpFdbAddress is also the value of an existing instance of dot1qStaticAddress.
dot1qTpGroupEgressPorts	**OID:** .1.3.6.1.2.1.17.7.1.2.3.1.2 **Description:** The complete set of ports, in this VLAN, to which frames destined for this Group MAC address are currently being explicitly forwarded.

Object	Description
	This does not include ports for which this address is only implicitly forwarded, in the dot1qForwardAllPorts list.
dot1qTpGroupLearnt	**OID:** .1.3.6.1.2.1.17.7.1.2.3.1.3 **Description:** The subset of ports in dot1qTpGroupEgressPorts that were learned by GMRP or some other dynamic mechanism, in this Filtering database.
dot1qForwardAllPorts	**Syntax:** Hex-String **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.7.1.2.4.1.1 **Description:** The complete set of ports in this VLAN to which all multicast group-addressed frames are to be forwarded. This includes ports for which this need has been determined dynamically by GMRP, or configured statically by management.
dot1qForwardAllStaticPorts	**Syntax:** Hex-String **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.7.1.2.4.1.2 **Description:** The set of ports configured by management in this VLAN to which all multicast group-addressed frames are to be forwarded. Ports entered in this list will also appear in the complete set shown by dot1qForwardAllPorts. This value will be restored after the device is reset. This only applies to ports that are members of the VLAN, defined by dot1qVlanCurrentEgressPorts. A port may not be added in this set if it is already a member of the set of ports in dot1qForwardAllForbiddenPorts. The default value is a string of ones of appropriate length, to indicate the standard behaviour of using basic filtering services, i.e., forward all multicasts to all ports. The value of this object MUST be retained across reinitializations of the management system.
dot1qForwardAllForbiddenPorts	**Syntax:** Hex-String **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.7.1.2.4.1.3 **Description:** The set of ports configured by management in this VLAN for which the Service Requirement attribute Forward All Multicast Groups may not be dynamically registered by GMRP. This value will be restored after the device is reset. A port may not be added in this set if it is already a member of the set of ports in dot1qForwardAllStaticPorts. The default value is a string of zeros of appropriate length. The value of this object MUST be retained across reinitializations of the management system.
dot1qForwardUnregisteredPorts	**Syntax:** Hex-String **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.7.1.2.5.1.1 **Description:** The complete set of ports in this VLAN to which multicast group-addressed frames for which there is no more specific forwarding information will be forwarded. This includes ports for which this need has been determined dynamically by GMRP, or configured statically by management.
dot1qForwardUnregisteredStaticPorts	**Syntax:** Hex-String **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.7.1.2.5.1.2 **Description:** The set of ports configured by management, in this VLAN, to which multicast group-addressed frames for which there is no more specific

Object	Description
	forwarding information are to be forwarded. Ports entered in this list will also appear in the complete set shown by dot1qForwardUnregisteredPorts. This value will be restored after the device is reset. A port may not be added in this set if it is already a member of the set of ports in dot1qForwardUnregisteredForbiddenPorts. The default value is a string of zeros of appropriate length, although this has no effect with the default value of dot1qForwardAllStaticPorts. The value of this object MUST be retained across reinitializations of the management system.
dot1qForwardUnregisteredForbiddenPorts	**Syntax:** Hex-String **Access:** Read-Only **OID:** .1.3.6.1.2.1.17.7.1.2.5.1.3 **Description:** The set of ports configured by management in this VLAN for which the Service Requirement attribute Forward Unregistered Multicast Groups may not be dynamically registered by GMRP. This value will be restored after the device is reset. A port may not be added in this set if it is already a member of the set of ports in dot1qForwardUnregisteredStaticPorts. The default value is a string of zeros of appropriate length. The value of this object MUST be retained across reinitializations of the management system.

RUGGEDCOM-SYS-INFO-MIB

Object	Description
rcDeviceErrBootupError	**Syntax:** String **Access:** Read-Only **OID:** 1.3.6.1.4.1.15004.4.2.1.1 **Description:** The error discovered during bootup process. If there was no error during device bootup, zero length string will be retreived.
rcDeviceErrWatchdogReset	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.4.1.15004.4.2.1.2 **Description:** Indicates whether the last device reboot was caused by wachdog.
rcDeviceErrConfigurationFailure	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.4.1.15004.4.2.1.3 **Description:** Indicates whether errors were detected while applying configuration settings from configuration file. Configuration is updated from the configureation file at bootup time when file is loaded from nonvolatile memory, or when new file is downloaded to the device. Whenever the value of this object changes from false(2) to true(1), the device will generate genericTrap notification.
rcDeviceErrCrashLogCreated	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.4.1.15004.4.2.1.4 **Description:** Indicates whether the device error that caused creation of an entry in crashlog.txt file was detected. Whenever the value of this object changes from false(2) to true(1), the device will generate genericTrap notification.

Object	Description
rcDeviceErrStackOverflow	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.4.1.15004.4.2.1.5 **Description:** Indicates whether the stack of any of the system tasks is used over the system threshold. Whenever the value of this object changes from false(2) to true(1), the device will generate genericTrap notification.
rcDeviceErrHeapError	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.4.1.15004.4.2.1.6 **Description:** Indicates whether the system memory corruption was detected. Whenever the value of this object changes from false(2) to true(1), the device will generate genericTrap notification.
rcDeviceErrDateAndTimeSetFailed	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.4.1.15004.4.2.1.7 **Description:** Indicates whether the date and time setting in the device falied. Whenever the value of this object changes from false(2) to true(1), the device will generate genericTrap notification.
rcDeviceErrNtpServerUnreachable	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.4.1.15004.4.2.1.8 **Description:** Indicates whether the NTP server (if required) can be reached. Whenever the value of this object changes from false(2) to true(1), the device will generate genericTrap notification.
rcDeviceErrBootPTftpTrFailed	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.4.1.15004.4.2.1.9 **Description:** Indicates whether the the file was transfered properly after obtaining IP address from the BootP server. Whenever the value of this object changes from false(2) to true(1), the device will generate genericTrap notification.
rcDeviceErrRadiusServerUnreachable	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.4.1.15004.4.2.1.10 **Description:** Indicates whether the RADIUS server (if required) can be reached. Whenever the value of this object changes from false(2) to true(1), the device will generate genericTrap notification.
rcDeviceErrTacacsServerUnreachable	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.4.1.15004.4.2.1.11 **Description:** Indicates whether the TACACS+ server (if required) can be reached. Whenever the value of this object changes from false(2) to true(1), the device will generate genericTrap notification.
rcDeviceStsTemperature	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.4.1.15004.4.2.2.3

Object	Description
	Description: The temperature measured in the device.
rcDeviceStsPowerSupply1	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.4.1.15004.4.2.2.4 **Description:** Indicates the status of Power Supply Module 1. Whenever the value of this object changes from functional(2) to notFunctional(3), or from notFunctionl(3) to functional(2), the device will generate powerSupplyTrap notification.
rcDeviceStsPowerSupply2	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.4.1.15004.4.2.2.5 **Description:** Indicates the status of Power Supply Module 2. Whenever the value of this object changes from functional(2) to notFunctional(3), or from notFunctionl(3) to functional(2), the device will generate powerSupplyTrap notification.
rcDeviceInfoMainBoardType	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.4.1.15004.4.2.3.4 **Description:** The identification code of the device main board.
rcDeviceInfoTotalRam	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.4.1.15004.4.2.3.5 **Description:** The total number of bytes of RAM in the system control CPU.
rcDeviceInfoBootSwVersion	**Syntax:** String **Access:** Read-Only **OID:** 1.3.6.1.4.1.15004.4.2.3.2 **Description:** The version and the build date of the boot loader software that has been loaded to the device and is pending reboot. Whenever the value of this object changes from zero-length string to any string of non-zero length, the device will generate swUpgradeTrap notification.
rcDeviceInfoMainSwVersion	**Syntax:** String **Access:** Read-Only **OID:** 1.3.6.1.4.1.15004.4.2.3.3 **Description:** The version and the build date of the main operating system software that has been loaded to the device and is pending reboot. Whenever the value of this object changes from zero-length string to any string of non-zero length, the device will generate swUpgradeTrap notification.
rcDeviceInfoPendingBootSwVersion	**Syntax:** String **Access:** Read-Only **OID:** 1.3.6.1.4.1.15004.4.2.3.6 **Description:** The version and the build date of the boot loader software that has been loaded to the device and is pending reboot. Whenever the value of this object changes from zero-length string to any string of non-zero length, the device will generate swUpgradeTrap notification.
rcDeviceInfoPendingMainSwVersion	**Syntax:** String

Object	Description
	Access: Read-Only **OID:** 1.3.6.1.4.1.15004.4.2.3.7 **Description:** The version and the build date of the main operating system software that has been loaded to the device and is pending reboot. Whenever the value of this object changes from zero-length string to any string of non-zero length, the device will generate swUpgradeTrap notification.
rcDeviceInfoCfgRevision	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.4.1.15004.4.2.3.8 **Description:** The configuration file revision. The revision number will be updated whenever file is saved to the flash memory. This number is recorded in config.csv at the time file is uploaded from the device. Whenever the value of this object changes the device will generate cfgChangeTrap notification.
rcDeviceInfoSerialNumber	**Syntax:** String **Access:** Read-Only **OID:** 1.3.6.1.4.1.15004.4.2.3.1 **Description:** The manufacturing serial number of the device.
rcDeviceCommReset	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.4.1.15004.4.2.4.1 **Description:** Setting the value of this object to 'true(1)' will cause device to reboot. As a result of Read request the agent will return value 'false(2)'.
rcDeviceCommLoadDefaultCfg	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.4.1.15004.4.2.4.2 **Description:** Setting the value of this object to 'true(1)' will force device to load default configuration to all tables. As a result of Read request the agent will return value 'false(2)'.
rcDeviceCommClearAlarms	**Syntax:** Integer **Access:** Read-Write **OID:** 1.3.6.1.4.1.15004.4.2.4.3 **Description:** Setting the value of this object to 'true(1)' will cause device to clear all alarms. As a result of Read request the agent will return value 'false(2)'.
rcDeviceCommClearSyslog	**Syntax:** Integer **Access:** Read-Write **OID:** 1.3.6.1.4.1.15004.4.2.4.4 **Description:** Setting the value of this object to 'true(1)' will cause device to clear syslog.txt file. As a result of Read request the agent will return value 'false(2)'.
rcDeviceCommClearLogs	**Syntax:** Integer **Access:** Read-Write **OID:** 1.3.6.1.4.1.15004.4.2.4.5

Object	Description
	Description: Setting the value of this object to 'true(1)' will cause device to clear syslog.txt and crashlog.txt files. As a result of Read request the agent will return value 'false(2)'.

SNMP-FRAMEWORK-MIB

Object	Description
snmpEngineID	**Syntax:** Hex-String **Access:** Read-Only **OID:** 1.3.6.1.6.3.10.2.1.1 **Description:** An SNMP engine's administratively-unique identifier. This information SHOULD be stored in non-volatile storage so that it remains constant across re-initializations of the SNMP engine.
snmpEngineBoots	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.6.3.10.2.1.2 **Description:** The number of times that the SNMP engine has (re-)initialized itself since snmpEngineID was last configured.
snmpEngineTime	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.6.3.10.2.1.3 **Description:** The number of seconds since the value of the snmpEngineBoots object last changed. When incrementing this object's value would cause it to exceed its maximum, snmpEngineBoots is incremented as if a re-initialization had occurred, and this object's value consequently reverts to zero.
snmpEngineMaxMessageSize	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.6.3.10.2.1.4 **Description:** The maximum length in octets of an SNMP message which this SNMP engine can send or receive and process, determined as the minimum of the maximum message size values supported among all of the transports available to and supported by the engine.

SNMP-USER-BASED-SM-MIB

Object	Description
usmStatsUnsupportedSecLevels	**Syntax:** Counter32 **Access:** Read-Only **OID:** 1.3.6.1.6.3.15.1.1.1 **Description:** The total number of packets received by the SNMP engine which were dropped because they requested a securityLevel that was unknown to the SNMP engine or otherwise unavailable.
usmStatsNotInTimeWindows	**Syntax:** Counter32 **Access:** Read-Only **OID:** 1.3.6.1.6.3.15.1.1.2

Object	Description
	Description: The total number of packets received by the SNMP engine which were dropped because they appeared outside of the authoritative SNMP engine's window.
usmStatsUnknownUserNames	**Syntax:** Counter32 **Access:** Read-Only **OID:** 1.3.6.1.6.3.15.1.1.3 **Description:** The total number of packets received by the SNMP engine which were dropped because they referenced a user that was not known to the SNMP engine.
usmStatsUnknownEngineIDs	**Syntax:** Counter32 **Access:** Read-Only **OID:** 1.3.6.1.6.3.15.1.1.4 **Description:** The total number of packets received by the SNMP engine which were dropped because they referenced an snmpEngineID that was not known to the SNMP engine.
usmStatsWrongDigests	**Syntax:** Counter32 **Access:** Read-Only **OID:** 1.3.6.1.6.3.15.1.1.5 **Description:** The total number of packets received by the SNMP engine which were dropped because they didn't contain the expected digest value.
usmStatsDecryptionErrors	**Syntax:** Counter32 **Access:** Read-Only **OID:** 1.3.6.1.6.3.15.1.1.6 **Description:** The total number of packets received by the SNMP engine which were dropped because they could not be decrypted.
usmUserSpinLock	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.6.3.15.1.2.1 **Description:** An advisory lock used to allow several cooperating Command Generator Applications to coordinate their use of facilities to alter secrets in the usmUserTable.
usmUserSecurityName	**Syntax:** String **Access:** Read-Only **OID:** 1.3.6.1.6.3.15.1.2.2.1.3 **Description:** A human readable string representing the user in Security Model independent format. The default transformation of the User-based Security Model dependent security ID to the securityName and vice versa is the identity function so that the securityName is the same as the userName.
usmUserCloneFrom	**Syntax:** OID **Access:** Read-Only **OID:** 1.3.6.1.6.3.15.1.2.2.1.4 **Description:** A pointer to another conceptual row in this usmUserTable. The user in this other conceptual row is called the clone-from user. When a new user is created (i.e., a new conceptual row is instantiated in this table), the privacy and authentication parameters of the new user must be cloned from its clone-from user. These parameters are: - authentication protocol (usmUserAuthProtocol) - privacy protocol (usmUserPrivProtocol)

Object	Description
	They will be copied regardless of what the current value is. Cloning also causes the initial values of the secret authentication key (authKey) and the secret encryption key (privKey) of the new user to be set to the same values as the corresponding secrets of the clone-from user to allow the KeyChange process to occur as required during user creation. The first time an instance of this object is set by a management operation (either at or after its instantiation), the cloning process is invoked. Subsequent writes are successful but invoke no action to be taken by the receiver. The cloning process fails with an 'inconsistentName' error if the conceptual row representing the clone-from user does not exist or is not in an active state when the cloning process is invoked. When this object is read, the ZeroDotZero OID is returned.
usmUserAuthProtocol	**Syntax:** OID **Access:** Read-Only **OID:** 1.3.6.1.6.3.15.1.2.2.1.5 **Description:** An indication of whether messages sent on behalf of this user to/from the SNMP engine identified by usmUserEngineID, can be authenticated, and if so, the type of authentication protocol which is used. An instance of this object is created concurrently with the creation of any other object instance for the same user (i.e., as part of the processing of the set operation which creates the first object instance in the same conceptual row). If an initial set operation (i.e. at row creation time) tries to set a value for an unknown or unsupported protocol, then a 'wrongValue' error must be returned. The value will be overwritten/set when a set operation is performed on the corresponding instance of usmUserCloneFrom. Once instantiated, the value of such an instance of this object can only be changed via a set operation to the value of the usmNoAuthProtocol. If a set operation tries to change the value of an existing instance of this object to any value other than usmNoAuthProtocol, then an 'inconsistentValue' error must be returned. If a set operation tries to set the value to the usmNoAuthProtocol while the usmUserPrivProtocol value in the same row is not equal to usmNoPrivProtocol, then an 'inconsistentValue' error must be returned. That means that an SNMP command generator application must first ensure that the usmUserPrivProtocol is set to the usmNoPrivProtocol value before it can set the usmUserAuthProtocol value to usmNoAuthProtocol.
usmUserAuthKeyChange	**Syntax:** String **Access:** Read-Only **OID:** 1.3.6.1.6.3.15.1.2.2.1.6 **Description:** An object, which when modified, causes the secret authentication key used for messages sent on behalf of this user to/from the SNMP engine identified by usmUserEngineID, to be modified via a one-way function. The associated protocol is the usmUserAuthProtocol. The associated secret key is the user's secret authentication key (authKey). The associated hash algorithm is the algorithm used by the user's usmUserAuthProtocol. When creating a new user, it is an 'inconsistentName' error for a set operation to refer to this object unless it is previously or concurrently initialized through a set operation on the corresponding instance of usmUserCloneFrom. When the value of the corresponding usmUserAuthProtocol is usmNoAuthProtocol, then a set is successful, but effectively is a no-op. When this object is read, the zero-length (empty) string is returned. The recommended way to do a key change is as follows: 1) GET(usmUserSpinLock.0) and save in sValue. 2) generate the keyChange value based on the old (existing) secret key and the new secret key, let us call this kcValue. If you do the key change on behalf of another user:

Object	Description
	3) SET(usmUserSpinLock.0=sValue, usmUserAuthKeyChange=kcValue usmUserPublic=randomValue) If you do the key change for yourself: 4) SET(usmUserSpinLock.0=sValue, usmUserOwnAuthKeyChange=kcValue usmUserPublic=randomValue) If you get a response with error-status of noError, then the SET succeeded and the new key is active. If you do not get a response, then you can issue a GET(usmUserPublic) and check if the value is equal to the randomValue you did send in the SET. If so, then the key change succeeded and the new key is active (probably the response got lost). If not, then the SET request probably never reached the target and so you can start over with the procedure above.
usmUserOwnAuthKeyChange	**Syntax:** String **Access:** Read-Only **OID:** 1.3.6.1.6.3.15.1.2.2.1.7 **Description:** Behaves exactly as usmUserAuthKeyChange, with one notable difference: in order for the set operation to succeed, the usmUserName of the operation requester must match the usmUserName that indexes the row which is targeted by this operation. In addition, the USM security model must be used for this operation. The idea here is that access to this column can be public, since it will only allow a user to change his own secret authentication key (authKey). Note that this can only be done once the row is active. When a set is received and the usmUserName of the requester is not the same as the umsUserName that indexes the row which is targeted by this operation, then a 'noAccess' error must be returned. When a set is received and the security model in use is not USM, then a 'noAccess' error must be returned.
usmUserPrivProtocol	**Syntax:** OID **Access:** Read-Only **OID:** 1.3.6.1.6.3.15.1.2.2.1.8 **Description:** An indication of whether messages sent on behalf of this user to/from the SNMP engine identified by usmUserEngineID, can be protected from disclosure, and if so, the type of privacy protocol which is used. An instance of this object is created concurrently with the creation of any other object instance for the same user (i.e., as part of the processing of the set operation which creates the first object instance in the same conceptual row). If an initial set operation (i.e. at row creation time) tries to set a value for an unknown or unsupported protocol, then a 'wrongValue' error must be returned. The value will be overwritten/set when a set operation is performed on the corresponding instance of usmUserCloneFrom. Once instantiated, the value of such an instance of this object can only be changed via a set operation to the value of the usmNoPrivProtocol. If a set operation tries to change the value of an existing instance of this object to any value other than usmNoPrivProtocol, then an 'inconsistentValue' error must be returned. Note that if any privacy protocol is used, then you must also use an authentication protocol. In other words, if usmUserPrivProtocol is set to anything else than usmNoPrivProtocol, then the corresponding instance of usmUserAuthProtocol cannot have a value of usmNoAuthProtocol. If it does, then an 'inconsistentValue' error must be returned.
usmUserPrivKeyChange	**Syntax:** String **Access:** Read-Only **OID:** 1.3.6.1.6.3.15.1.2.2.1.9 **Description:** An object, which when modified, causes the secret encryption key used for messages sent on behalf of this user to/from the SNMP engine identified by usmUserEngineID, to be modified via a one-way function. The

Object	Description
	associated protocol is the usmUserPrivProtocol. The associated secret key is the user's secret privacy key (privKey). The associated hash algorithm is the algorithm used by the user's usmUserAuthProtocol. When creating a new user, it is an 'inconsistentName' error for a set operation to refer to this object unless it is previously or concurrently initialized through a set operation on the corresponding instance of usmUserCloneFrom. When the value of the corresponding usmUserPrivProtocol is usmNoPrivProtocol, then a set is successful, but effectively is a no-op. When this object is read, the zero-length (empty) string is returned. See the description clause of usmUserAuthKeyChange for a recommended procedure to do a key change.
usmUserOwnPrivKeyChange	**Syntax:** String **Access:** Read-Only **OID:** 1.3.6.1.6.3.15.1.2.2.1.10 **Description:** Behaves exactly as usmUserPrivKeyChange, with one notable difference: in order for the Set operation to succeed, the usmUserName of the operation requester must match the usmUserName that indexes the row which is targeted by this operation. In addition, the USM security model must be used for this operation. The idea here is that access to this column can be public, since it will only allow a user to change his own secret privacy key (privKey). Note that this can only be done once the row is active. When a set is received and the usmUserName of the requester is not the same as the umsUserName that indexes the row which is targeted by this operation, then a 'noAccess' error must be returned. When a set is received and the security model in use is not USM, then a 'noAccess' error must be returned.
usmUserPublic	**Syntax:** String **Access:** Read-Only **OID:** 1.3.6.1.6.3.15.1.2.2.1.11 **Description:** A publicly-readable value which can be written as part of the procedure for changing a user's secret authentication and/or privacy key, and later read to determine whether the change of the secret was effected.
usmUserStorageType	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.6.3.15.1.2.2.1.12 **Description:** The storage type for this conceptual row. Conceptual rows having the value 'permanent' must allow write-access at a minimum to: - usmUserAuthKeyChange, usmUserOwnAuthKeyChange and usmUserPublic for a user who employs authentication, and - usmUserPrivKeyChange, usmUserOwnPrivKeyChange and usmUserPublic for a user who employs privacy. Note that any user who employs authentication or privacy must allow its secret(s) to be updated and thus cannot be 'readOnly'. If an initial set operation tries to set the value to 'readOnly' for a user who employs authentication or privacy, then an 'inconsistentValue' error must be returned. Note that if the value has been previously set (implicit or explicit) to any value, then the rules as defined in the StorageType Textual Convention apply. It is an implementation issue to decide if a SET for a readOnly or permanent row is accepted at all. In some contexts this may make sense, in others it may not. If a SET for a readOnly or permanent row is not accepted at all, then a 'wrongValue' error must be returned.
usmUserStatus	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.6.3.15.1.2.2.1.13

Object	Description
	Description: The status of this conceptual row. Until instances of all corresponding columns are appropriately configured, the value of the corresponding instance of the usmUserStatus column is 'notReady'. In particular, a newly created row for a user who employs authentication, cannot be made active until the corresponding usmUserCloneFrom and usmUserAuthKeyChange have been set. Further, a newly created row for a user who also employs privacy, cannot be made active until the usmUserPrivKeyChange has been set. The RowStatus TC [RFC2579] requires that this DESCRIPTION clause states under which circumstances other objects in this row can be modified: The value of this object has no effect on whether other objects in this conceptual row can be modified, except for usmUserOwnAuthKeyChange and usmUserOwnPrivKeyChange. For these 2 objects, the value of usmUserStatus MUST be active.

SNMPv2-MIB

Object	Description
snmpInPkts	**Syntax:** Counter32 **Access:** Read-Only **OID:** 1.3.6.1.2.1.11.1 **Description:** The total number of messages delivered to the SNMP entity from the transport service.
snmpInBadVersions	**Syntax:** Counter32 **Access:** Read-Only **OID:** 1.3.6.1.2.1.11.3 **Description:** The total number of SNMP messages which were delivered to the SNMP entity and were for an unsupported SNMP version.
snmpInASNParseErrs	**Syntax:** Counter32 **Access:** Read-Only **OID:** 1.3.6.1.2.1.11.6 **Description:** The total number of ASN.1 or BER errors encountered by the SNMP entity when decoding received SNMP messages.
snmpSilentDrops	**Syntax:** Counter32 **Access:** Read-Only **OID:** 1.3.6.1.2.1.11.31 **Description:** The total number of Confirmed Class PDUs (such as GetRequest-PDUs, GetNextRequest-PDUs, GetBulkRequest-PDUs, SetRequest-PDUs, and InformRequest-PDUs) delivered to the SNMP entity which were silently dropped because the size of a reply containing an alternate Response Class PDU (such as a Response-PDU) with an empty variable-bindings field was greater than either a local constraint or the maximum message size associated with the originator of the request.
snmpProxyDrops	**Syntax:** Counter32 **Access:** Read-Only **OID:** 1.3.6.1.2.1.11.32 **Description:** The total number of Confirmed Class PDUs (such as GetRequest-PDUs, GetNextRequest-PDUs, GetBulkRequest-PDUs, SetRequest-PDUs, and InformRequest-PDUs) delivered to the SNMP entity which were silently dropped because the transmission of the (possibly translated)

Object	Description
	message to a proxy target failed in a manner (other than a time-out) such that no Response Class PDU (such as a Response-PDU) could be returned.
snmpEnableAuthenTraps	**Syntax:** Integer **Access:** Read-Write **OID:** 1.3.6.1.2.1.11.30 **Description:** Indicates whether the SNMP entity is permitted to generate authenticationFailure traps. The value of this object overrides any configuration information; as such, it provides a means whereby all authenticationFailure traps may be disabled. Note that it is strongly recommended that this object be stored in non-volatile memory so that it remains constant across re-initializations of the network management system.
snmpInBadCommunityNames	**Syntax:** Counter32 **Access:** Read-Only **OID:** 1.3.6.1.2.1.11.4 **Description:** The total number of community-based SNMP messages (for example, SNMPv1) delivered to the SNMP entity which used an SNMP community name not known to said entity. Also, implementations which authenticate community-based SNMP messages using check(s) in addition to matching the community name (for example, by also checking whether the message originated from a transport address allowed to use a specified community name) MAY include in this value the number of messages which failed the additional check(s). It is strongly recommended that the documentation for any security model which is used to authenticate community-based SNMP messages specify the precise conditions that contribute to this value.
snmpInBadCommunityUses	**Syntax:** Counter32 **Access:** Read-Only **OID:** 1.3.6.1.2.1.11.5 **Description:** A collection of objects providing basic instrumentation of a SNMP entity which supports community-based authentication.
snmpSetSerialNo	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.6.3.1.1.6.1 **Description:** An advisory lock used to allow several cooperating command generator applications to coordinate their use of the SNMP set operation. This object is used for coarse-grain coordination. To achieve fine-grain coordination, one or more similar objects might be defined within each MIB group, as appropriate.

SNMP-VIEW-BASED-ACM-MIB

Object	Description
vacmContextName	**Syntax:** String **Access:** Read-Only **OID:** 1.3.6.1.6.3.16.1.1.1.1 **Description:** A human readable name identifying a particular context at a particular SNMP entity. The empty contextName (zero length) represents the default context.

Object	Description
vacmGroupName	**Syntax:** String **Access:** Read-Only **OID:** 1.3.6.1.6.3.16.1.2.1.3 **Description:** The name of the group to which this entry (e.g., the combination of securityModel and securityName) belongs. This groupName is used as index into the vacmAccessTable to select an access control policy. However, a value in this table does not imply that an instance with the value exists in table vacmAccesTable.
vacmSecurityToGroupStorageType	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.6.3.16.1.2.1.4 **Description:** The storage type for this conceptual row. Conceptual rows having the value 'permanent' need not allow write-access to any columnar objects in the row.
vacmSecurityToGroupStatus	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.6.3.16.1.2.1.5 **Description:** The status of this conceptual row. Until instances of all corresponding columns are appropriately configured, the value of the corresponding instance of the vacmSecurityToGroupStatus column is 'notReady'. In particular, a newly created row cannot be made active until a value has been set for vacmGroupName. The RowStatus TC [RFC2579] requires that this DESCRIPTION clause states under which circumstances other objects in this row can be modified: The value of this object has no effect on whether other objects in this conceptual row can be modified.
vacmAccessContextMatch	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.6.3.16.1.4.1.4 **Description:** If the value of this object is exact(1), then all rows where the contextName exactly matches vacmAccessContextPrefix are selected. If the value of this object is prefix(2), then all rows where the contextName whose starting octets exactly match vacmAccessContextPrefix are selected. This allows for a simple form of wildcarding.
vacmAccessReadViewName	**Syntax:** String **Access:** Read-Only **OID:** 1.3.6.1.6.3.16.1.4.1.5 **Description:** The value of an instance of this object identifies the MIB view of the SNMP context to which this conceptual row authorizes read access. The identified MIB view is that one for which the vacmViewTreeFamilyViewName has the same value as the instance of this object; if the value is the empty string or if there is no active MIB view having this value of vacmViewTreeFamilyViewName, then no access is granted.
vacmAccessWriteViewName	**Syntax:** String **Access:** Read-Only **OID:** 1.3.6.1.6.3.16.1.4.1.6 **Description:** The value of an instance of this object identifies the MIB view of the SNMP context to which this conceptual row authorizes write access. The identified MIB view is that one for which the vacmViewTreeFamilyViewName has the same value as the instance of this

Object	Description
	object; if the value is the empty string or if there is no active MIB view having this value of vacmViewTreeFamilyViewName, then no access is granted.
vacmAccessNotifyViewName	**Syntax:** String **Access:** Read-Only **OID:** 1.3.6.1.6.3.16.1.4.1.7 **Description:** The value of an instance of this object identifies the MIB view of the SNMP context to which this conceptual row authorizes access for notifications. The identified MIB view is that one for which the vacmViewTreeFamilyViewName has the same value as the instance of this object; if the value is the empty string or if there is no active MIB view having this value of vacmViewTreeFamilyViewName, then no access is granted.
vacmAccessStorageType	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.6.3.16.1.4.1.8 **Description:** The storage type for this conceptual row. Conceptual rows having the value 'permanent' need not allow write-access to any columnar objects in the row.
vacmAccessStatus	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.6.3.16.1.4.1.9 **Description:** The status of this conceptual row. The RowStatus TC [RFC2579] requires that this DESCRIPTION clause states under which circumstances other objects in this row can be modified: The value of this object has no effect on whether other objects in this conceptual row can be modified.
vacmViewSpinLock	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.6.3.16.1.5.1 **Description:** An advisory lock used to allow cooperating SNMP Command Generator applications to coordinate their use of the Set operation in creating or modifying views. When creating a new view or altering an existing view, it is important to understand the potential interactions with other uses of the view. The vacmViewSpinLock should be retrieved. The name of the view to be created should be determined to be unique by the SNMP Command Generator application by consulting the vacmViewTreeFamilyTable. Finally, the named view may be created (Set), including the advisory lock. If another SNMP Command Generator application has altered the views in the meantime, then the spin lock's value will have changed, and so this creation will fail because it will specify the wrong value for the spin lock. Since this is an advisory lock, the use of this lock is not enforced.
vacmViewTreeFamilyMask	**Syntax:** String **Access:** Read-Only **OID:** 1.3.6.1.6.3.16.1.5.2.1.3 **Description:** Locally held information about families of subtrees within MIB views. Each MIB view is defined by two sets of view subtrees: - the included view subtrees, and - the excluded view subtrees. Every such view subtree, both the included and the excluded ones, is defined in this table. To determine if a particular object instance is in a particular MIB view, compare the object instance's OBJECT IDENTIFIER with each of the MIB view's active entries in this table. If none match, then the

Object	Description
	object instance is not in the MIB view. If one or more match, then the object instance is included in, or excluded from, the MIB view according to the value of vacmViewTreeFamilyType in the entry whose value of vacmViewTreeFamilySubtree has the most sub-identifiers. If multiple entries match and have the same number of sub-identifiers (when wildcarding is specified with the value of vacmViewTreeFamilyMask), then the lexicographically greatest instance of vacmViewTreeFamilyType determines the inclusion or exclusion. An object instance's OBJECT IDENTIFIER X matches an active entry in this table when the number of sub-identifiers in X is at least as many as in the value of vacmViewTreeFamilySubtree for the entry, and each sub-identifier in the value of vacmViewTreeFamilySubtree matches its corresponding sub-identifier in X. Two sub-identifiers match either if the corresponding bit of the value of vacmViewTreeFamilyMask for the entry is zero (the 'wild card' value), or if they are equal. A 'family' of subtrees is the set of subtrees defined by a particular combination of values of vacmViewTreeFamilySubtree and vacmViewTreeFamilyMask. In the case where no 'wild card' is defined in the vacmViewTreeFamilyMask, the family of subtrees reduces to a single subtree. When creating or changing MIB views, an SNMP Command Generator application should utilize the vacmViewSpinLock to try to avoid collisions. See DESCRIPTION clause of vacmViewSpinLock. When creating MIB views, it is strongly advised that first the 'excluded' vacmViewTreeFamilyEntries are created and then the 'included' entries. When deleting MIB views, it is strongly advised that first the 'included' vacmViewTreeFamilyEntries are deleted and then the 'excluded' entries. If a create for an entry for instance-level access control is received and the implementation does not support instance-level granularity, then an inconsistentName error must be returned.
vacmViewTreeFamilyType	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.6.3.16.1.5.2.1.4 **Description:** Indicates whether the corresponding instances of vacmViewTreeFamilySubtree and vacmViewTreeFamilyMask define a family of view subtrees which is included in or excluded from the MIB view.
vacmViewTreeFamilyStorageType	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.6.3.16.1.5.2.1.5 **Description:** The storage type for this conceptual row. Conceptual rows having the value 'permanent' need not allow write-access to any columnar objects in the row.
vacmViewTreeFamilyStatus	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.6.3.16.1.5.2.1.6 **Description:** The status of this conceptual row. The RowStatus TC [RFC2579] requires that this DESCRIPTION clause states under which circumstances other objects in this row can be modified: The value of this object has no effect on whether other objects in this conceptual row can be modified.

BGP4-MIB

Object	Description
bgpVersion	**Syntax:** Hex-String

Object	Description
	Access: Read-Only **OID:** 1.3.6.1.2.1.15.1 **Description:** Vector of supported BGP protocol version numbers. Each peer negotiates the version from this vector. Versions are identified via the string of bits contained within this object. The first octet contains bits 0 to 7, the second octet contains bits 8 to 15, and so on, with the most significant bit referring to the lowest bit number in the octet (e.g., the MSB of the first octet refers to bit 0). If a bit, i, is present and set, then the version (i+1) of the BGP is supported.
bgpLocalAs	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.2.1.15.2 **Description:** The local autonomous system number.
bgpIdentifier	**Syntax:** IpAddress **Access:** Read-Only **OID:** 1.3.6.1.2.1.15.4 **Description:** The BGP Identifier of the local system.

IP-FORWARD-MIB

Object	Description
ipCidrRouteNumber	**Syntax:** Gauge32 **Access:** Read-Only **OID:** 1.3.6.1.2.1.4.24.3 **Description:** The number of current ipCidrRouteTable entries that are not invalid. This object is deprecated in favor of inetCidrRouteNumber and the inetCidrRouteTable.
ipCidrRouteDest	**Syntax:** IpAddress **Access:** Read-Only **OID:** 1.3.6.1.2.1.4.24.4.1.1 **Description:** The destination IP address of this route. This object may not take a Multicast (Class D) address value. Any assignment (implicit or otherwise) of an instance of this object to a value x must be rejected if the bitwise logical-AND of x with the value of the corresponding instance of the ipCidrRouteMask object is not equal to x.
ipCidrRouteNextHop	**Syntax:** IpAddress **Access:** Read-Only **OID:** 1.3.6.1.2.1.4.24.4.1.4 **Description:** On remote routes, the address of the next system en route; Otherwise, 0.0.0.0.
ipCidrRouteType	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.2.1.4.24.4.1.6 **Description:** The type of route. Note that local(3) refers to a route for which the next hop is the final destination; remote(4) refers to a route for which the next hop is not the final destination. Routes that do not result in traffic

Object	Description
	forwarding or rejection should not be displayed, even if the implementation keeps them stored internally. reject (2) refers to a route that, if matched, discards the message as unreachable. This is used in some protocols as a means of correctly aggregating routes.
ipCidrRouteInfo	**Syntax:** OID **Access:** Read-Only **OID:** 1.3.6.1.2.1.4.24.4.1.9 **Description:** A reference to MIB definitions specific to the particular routing protocol that is responsible for this route, as determined by the value specified in the route's ipCidrRouteProto value. If this information is not present, its value should be set to the OBJECT IDENTIFIER { 0 0 }, which is a syntactically valid object identifier, and any implementation conforming to ASN.1 and the Basic Encoding Rules must be able to generate and recognize this value.
ipCidrRouteMetric1	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.2.1.4.24.4.1.11 **Description:** The primary routing metric for this route. The semantics of this metric are determined by the routing- protocol specified in the route's ipCidrRouteProto value. If this metric is not used, its value should be set to -1.
ipCidrRouteMetric3	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.2.1.4.24.4.1.13 **Description:** An alternate routing metric for this route. The semantics of this metric are determined by the routing- protocol specified in the route's ipCidrRouteProto value. If this metric is not used, its value should be set to -1.
ipCidrRouteMetric5	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.2.1.4.24.4.1.15 **Description:** An alternate routing metric for this route. The semantics of this metric are determined by the routing- protocol specified in the route's ipCidrRouteProto value. If this metric is not used, its value should be set to -1.
ipCidrRouteMask	**Syntax:** IpAddress **Access:** Read-Only **OID:** 1.3.6.1.2.1.4.24.4.1.2 **Description:** Indicate the mask to be logical-ANDed with the destination address before being compared to the value in the ipCidrRouteDest field. For those systems that do not support arbitrary subnet masks, an agent constructs the value of the ipCidrRouteMask by reference to the IP Address Class. Any assignment (implicit or otherwise) of an instance of this object to a value x must be rejected if the bitwise logical-AND of x with the value of the corresponding instance of the ipCidrRouteDest object is not equal to ipCidrRouteDest.
ipCidrRouteTos	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.2.1.4.24.4.1.3

Object	Description
	Description: The policy specifier is the IP TOS Field. The encoding of IP TOS is as specified by the following convention. Zero indicates the default path if no more specific policy applies.
ipCidrRouteIfIndex	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.2.1.4.24.4.1.5 **Description:** The ifIndex value that identifies the local interface through which the next hop of this route should be reached.
ipCidrRouteProto	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.2.1.4.24.4.1.7 **Description:** The routing mechanism via which this route was learned. Inclusion of values for gateway routing protocols is not intended to imply that hosts should support those protocols.
ipCidrRouteAge	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.2.1.4.24.4.1.8 **Description:** The number of seconds since this route was last updated or otherwise determined to be correct. Note that no semantics of `too old' can be implied, except through knowledge of the routing protocol by which the route was learned.
ipCidrRouteNextHopAS	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.2.1.4.24.4.1.10 **Description:** The Autonomous System Number of the Next Hop. The semantics of this object are determined by the routing- protocol specified in the route's ipCidrRouteProto value. When this object is unknown or not relevant, its value should be set to zero.
ipCidrRouteMetric2	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.2.1.4.24.4.1.12 **Description:** An alternate routing metric for this route. The semantics of this metric are determined by the routing- protocol specified in the route's ipCidrRouteProto value. If this metric is not used, its value should be set to -1.
ipCidrRouteMetric4	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.2.1.4.24.4.1.14 **Description:** An alternate routing metric for this route. The semantics of this metric are determined by the routing- protocol specified in the route's ipCidrRouteProto value. If this metric is not used, its value should be set to -1.
ipCidrRouteStatus	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.2.1.4.24.4.1.16 **Description:** The row status variable, used according to row installation and removal conventions.

RFC1213-MIB

Object	Description
icmpInMsgs	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.5.1 **Description:** The total number of ICMP messages which the entity received. Note that this counter includes all those counted by icmpInErrors.
icmpInDestUnreachs	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.5.3 **Description:** The number of ICMP Destination Unreachable messages received.
icmpInParmProbs	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.5.5 **Description:** The number of ICMP Parameter Problem messages received.
icmpInRedirects	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.5.7 **Description:** The number of ICMP Redirect messages received.
icmpInEchoReps	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.5.9 **Description:** The number of ICMP Echo Reply messages received.
icmpInTimestampReps	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.5.11 **Description:** The number of ICMP Timestamp Reply messages received.
icmpInAddrMaskReps	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.5.13 **Description:** The number of ICMP Address Mask Reply messages received.
icmpOutErrors	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.5.15 **Description:** The number of ICMP messages which this entity did not send due to problems discovered within ICMP such as a lack of buffers. This value should not include errors discovered outside the ICMP layer such as the inability of IP to route the resultant datagram. In some implementations there may be no types of error which contribute to this counter's value.
icmpOutTimeExcds	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.5.17 **Description:** The number of ICMP Time Exceeded messages sent.

Object	Description
icmpOutSrcQuenchs	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.5.19 **Description:** The number of ICMP Source Quench messages sent.
icmpOutEchos	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.5.21 **Description:** The number of ICMP Echo (request) messages sent.
icmpOutTimestamps	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.5.23 **Description:** The number of ICMP Timestamp (request) messages sent.
icmpOutAddrMaskReps	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.5.26 **Description:** The number of ICMP Address Mask Reply messages sent.
icmpInErrors	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.5.2 **Description:** The number of ICMP messages which the entity received but determined as having ICMP-specific errors (bad ICMP checksums, bad length, etc.).
icmpInTimeExcds	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.5.4 **Description:** The number of ICMP Time Exceeded messages received.
icmpInSrcQuenchs	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.5.6 **Description:** The number of ICMP Source Quench messages received.
icmpInEchos	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.5.8 **Description:** The number of ICMP Echo (request) messages received.
icmpInTimestamps	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.5.10 **Description:** The number of ICMP Timestamp (request) messages received.
icmpInAddrMasks	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.5.12 **Description:** The number of ICMP Address Mask Request messages received.

Object	Description
icmpOutMsgs	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.5.14 **Description:** The total number of ICMP messages which this entity attempted to send. Note that this counter includes all those counted by icmpOutErrors.
icmpOutDestUnreachs	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.5.16 **Description:** The number of ICMP Destination Unreachable messages sent.
icmpOutParmProbs	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.5.18 **Description:** The number of ICMP Parameter Problem messages sent.
icmpOutRedirects	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.5.20 **Description:** The number of ICMP Redirect messages sent. For a host, this object will always be zero, since hosts do not send redirects.
icmpOutEchoReps	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.5 **Description:** The number of ICMP Echo Reply messages sent.
icmpOutTimestampReps	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.5.24 **Description:** The number of ICMP Timestamp Reply messages sent.
icmpOutAddrMaskReps	**Syntax:** Counter32 **Access:** Read-Only **OID:** .1.3.6.1.2.1.5.26 **Description:** The number of ICMP Address Mask Reply messages sent.

PIM-STD-MIB

Object	Description
pimInterfaceAddressType	**Syntax:** IpAddress **Access:** Read-Only **OID:** 1.3.6.1.2.1.157.1.1.1.3 **Description:** The address type of this PIM interface.
pimInterfaceAddress	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.2.1.157.1.1.1.4

Object	Description
	Description: The primary IP address of this router on this PIM interface. The InetAddressType is given by the pimInterfaceAddressType object.
pimInterfaceStorageType	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.2.1.157.1.1.1.28 **Description:** The storage type for this row. Rows having the value 'permanent' need not allow write-access to any columnar objects in the row.

MPLS-LDP-STD-MIB

Object	Description
mplsLdpLsrId	**Syntax:** IpAddress **Access:** Read-Only **OID:** 1.3.6.1.2.1.10.166.4.1.1.1 **Description:** A indication of whether this Label Switching Router supports loop detection. • none(1) -- Loop Detection is not supported on this LSR. • other(2) -- Loop Detection is supported but by a method other than those listed below. • hopCount(3) -- Loop Detection is supported by Hop Count only. • pathVector(4) -- Loop Detection is supported by Path Vector only. • hopCountAndPathVector(5) -- Loop Detection is supported by both Hop Count And Path Vector. Since Loop Detection is determined during Session Initialization, an individual session may not be running with loop detection. This object simply gives an indication of whether or not the LSR has the ability to support Loop Detection and which types.

MPLS-LDP-GENERIC-STD-MIB

Object	Description
mplsLdpEntityGenericLabelSpace	**Syntax:** Integer **Access:** Read-Only **OID:** 1.3.6.1.2.1.10.166.7.1.1.1.1.3 **Description:** This value of this object is perPlatform(1), then this means that the label space type is per platform. If this object is perInterface(2), then this means that the label space type is per Interface.

IEC-62439-2-MIB

Object	Description
mrpDomainIndex	**Syntax:** Unsigned32 **Access:** not-accessible **OID:** 1.0.62439.1.1.1.1.1 **Description:** The index of the entry.
mrpDomainID	**Syntax:** IEC62439UuidType

Object	Description
	Access: read-only **OID:** 1.0.62439.1.1.1.1.2 **Description:** Universally unique identifier belongs to the MRP domain, which represents a ring.
mrpDomainName	**Syntax:** DisplayString **Access:** read-only **OID:** 1.0.62439.1.1.1.1.3 **Description:** A logical name for the MRP domain to ease the management of MRP domains.
mrpDomainAdminRole	**Syntax:** INTEGER **Access:** read-only **OID:** 1.0.62439.1.1.1.1.4 **Description:** Control the MRP behavior of the system per domain. If the value is set to disable(0) the MRP entity of this domain shall be disabled. If the value is set to client(1) the entity shall be set to the role of a Media Redundancy Client (MRC). If the value is set to manager(2) the entity shall be set to the role of a Media Redundancy Manager (MRM). If the value is set to managerAutoComp(3) the entity shall be set to the role of a Media Redundancy Manager Auto (MRA) complying to Annex A. If the value is set to managerAuto(4) the entity shall be set to the role of a Media Redundancy Manager Auto (MRA) not supporting Annex A. The factory settings are recommended to adjust the value of this object to the client(1) capability of the component, or, if supported, to the managerAutoComp(3) or managerAuto(4) capability, in order to prevent multiple managers are in ring (the order of the capabilities are not necessarily conform to the order of the object values here). If the agent restricts the write access, no matter what reason, it shall reject write requests by responding with 'badValue'.
mrpDomainOperRole	**Syntax:** INTEGER **Access:** read-only **OID:** 1.0.62439.1.1.1.1.5 **Description:** The operational role of an MRP entity per domain. A value of disabled(0) signals that the entity doesn't work (whatever reason). A value of client(1) signals that the entity is in a client role. A value of manager(2) signals that the entity is the manager of this MRP domain. A value of managerAutoComp(3) signals that the entity is in automanager role complying to Annex A. A value of managerAuto(4) signals that the entity is in automanager role not supporting Annex A.
mrpDomainRingPort1	**Syntax:** Integer32 **Access:** read-only **OID:** 1.0.62439.1.1.1.1.6 **Description:** The ifIndex of the layer 2 interface which is used as ring port 1.
mrpDomainRingPort1State	**Syntax:** INTEGER

Object	Description
	Access: read-only **OID:** 1.0.62439.1.1.1.1.7 **Description:** Operational state of the first Ring-Port. • disabled(1) indicates that all frames are dropped • blocked(2) indicates that all frames are dropped except • MRP topology change frames and MRP test frames from a MRM, • MRP link change frames from an MRC, • MRP interconnection topology change from a MIM, • MRP interconnection link change from a MIC, • frames from other protocols that also define to pass blocked(2) ports. • forwarding(3) indicates that all frames are passed through according to the forwarding behavior of IEEE 802.1D • not-connected(4) indicates that the port has no link
mrpDomainRingPort2	**Syntax:** Integer32 **Access:** read-only **OID:** 1.0.62439.1.1.1.1.8 **Description:** The ifIndex of the layer 2 interface, which is used as ring port 2.
mrpDomainRingPort2State	**Syntax:** INTEGER **Access:** read-only **OID:** 1.0.62439.1.1.1.1.9 **Description:** Operational state of the second Ring-Port. • disabled(1) indicates that all frames are dropped • blocked(2) indicates that all frames are dropped except • MRP topology change frames and MRP test frames from a MRM, • MRP link change frames from an MRC, • MRP interconnection topology change from a MIM, • MRP interconnection link change from a MIC, • frames from other protocols that also define to pass blocked(2) ports. • forwarding(3) indicates that all frames are passed through according to the forwarding behavior of IEEE 802.1D • not-connected(4) indicates that the port has no link
mrpDomainState	**Syntax:** BITS **Access:** read-only **OID:** 1.0.62439.1.1.1.1.10 **Description:** Operational status of the MRP entity. • disabled(0) – MRP switched off. All higher bits are invalid and shall be reset. • undefined(1) – Value is not valid. All higher bits are invalid and shall be reset. • ringOpen(2) – MRP ring redundancy lost. All higher bits are invalid and shall be reset. • reserved(3) – reserved for further extensions.
mrpDomainError	**Syntax:** BITS **Access:** read-only

Object	Description
	OID: 1.0.62439.1.1.1.1.11 **Description:** If the device couldn't switch to the desired administrative state (thus the value of 'mrpDomainState' is not the expected one), this value provides the reason. Otherwise the bit noError(0) is set. • noError(0) – the operational state of the device is confom to administrative state. All higher bits are invalid and shall be reset. • invalidVlanId(1) – the assigned VLAN ID is not permitted. • invalid (2) – Value is not valid. All higher bits are invalid and shall be reset. • multipleMRM(3) – multiple active managers in ring domain. • singleSideReceive(4) – the test frames of an MRM have been seen, but only on one port.
mrpDomainBlocked	**Syntax:** INTEGER **Access:** read-only **OID:** 1.0.62439.1.1.1.1.12 **Description:** The entity supports blocked ring ports. Shows whether a mrp domain requires the support of the BLOCKED port state at ring ports. The manager of a mrp domain decides whether this support is required. Set to enabled the manager demands that all clients shall support the blocked attribute also set to enabled. If mrpDomainBlocked is set disabled at the manager, then the value of mrpDomainBlocked can be arbitrary at the clients. • enabled(1) client: supports ring ports whose port state can be blocked. • manager: works only with clients supporting blocked ring ports. • disabled(2) client: no support of blocked ring ports. • manager: Work with clients supporting blocked ring ports and with clients not supporting blocked ring ports.
mrpDomainVlanId	**Syntax:** Unsigned32 **Access:** read-only **OID:** 1.0.62439.1.1.1.1.13 **Description:** The VLAN ID assigned to the MRP protocol. The VLAN ID only is in use when the bit invalidVlanId is not set in mrpDomainError. If value is set to 0 no VLAN is assigned. The invalidVlanId shall be set to 0 (no Error).
mrpDomainManagerPriority	**Syntax:** INTEGER **Access:** read-only **OID:** 1.0.62439.1.1.1.1.14 **Description:** The priority of this MRP entity. If the device is client only, the value of this object shall be ignored by the MRP entity. Only the four most significant bits shall be used, the bits 0 to 11 are reserved. The smaller value has the higher priority.
mrpDomainRingOpenCount	**Syntax:** Counter32 **Access:** read-only **OID:** 1.0.62439.1.1.1.1.15

Object	Description
	Description: Counter for ring-state changes to open.
mrpDomainLastRingOpenChange	**Syntax:** TimeTicks **Access:** read-only **OID:** 1.0.62439.1.1.1.1.16 **Description:** Timeticks since last change of ring-state to ring open.
mrpDomainRoundTripDelayMax	**Syntax:** Unsigned32 **Access:** read-only **OID:** 1.0.62439.1.1.1.1.17 **Description:** The max. Round-Trip-Delay (in milliseconds), which was measured since startup.
mrpDomainRoundTripDelayMin	**Syntax:** Unsigned32 **Access:** read-only **OID:** 1.0.62439.1.1.1.1.18 **Description:** The min. Round-Trip-Delay (in milliseconds), which was measured since startup.
mrpDomainResetRoundTripDelays	**Syntax:** INTEGER **Access:** not-accessible **OID:** 1.0.62439.1.1.1.1.19 **Description:** A write request with resetDelays(1) shall reset the values of mrpDomainRoundTripDelayMax and mrpDomainRoundTripDelayMin to zero at the same time.
mrpDomainMRMReactOnLinkChange	**Syntax:** INTEGER **Access:** read-only **OID:** 1.0.62439.1.1.1.1.20 **Description:** Tells whether the MRM reacts on link down MRP link change frames. • enabled(1) indicates that the MRM reacts immediately on link down MRP link change frames • disabled(2) indicates that the MRM does not react on link down MRP link change frames

20.2 Standard SNMP Traps

The current MIB files supported by RUGGEDCOM ROX II can be downloaded from the https://www.siemens.com.

Note
SNMP traps are not configurable in RUGGEDCOM ROX II.

The following table lists all standard traps in RUGGEDCOM ROX II:

Variable	Description
authenticationFailure	**MIB:** SNMPv2-MIB **Standard:** RFC 3418 **OID:** 1.3.6.1.6.3.1.1.5.5

Variable	Description
	Definition: An authenticationFailure trap signifies that the SNMP entity has received a protocol message that is not properly authenticated. While all implementations of SNMP entities MAY be capable of generating this trap, the snmpEnableAuthenTraps object indicates whether this trap will be generated.
coldStart	**MIB:** SNMPv2-MIB **Standard:** RFC 3418 **OID:** 1.3.6.1.6.3.1.1.5.1 **Definition:** A coldStart trap signifies that the SNMP entity, supporting a notification originator application, is reinitializing itself and that its configuration may have been altered.
warmStart	**MIB:** SNMPv2-MIB **Standard:** RFC 3418 **OID:** 1.3.6.1.6.3.1.1.5.2 **Definition:** A warmStart trap signifies that the SNMP entity, supporting a notification originator application, is reinitializing itself such that its configuration is unaltered.
newRoot	**MIB:** BRIDGE-MIB **Standard:** RFC 4188 **OID:** 1.3.6.1.2.1.17.0.1 **Definition:** The newRoot trap indicates that the sending agent has become the new root of the Spanning Tree. The trap is sent by a bridge soon after its election as the new root (e.g. upon expiration of the Topology Change Timer) immediately subsequent to its election. Implementation of this trap is optional.
topologyChange	**MIB:** BRIDGE-MIB **Standard:** RFC 4188 **OID:** 1.3.6.1.2.1.17.0.2 **Definition:** A topologyChange trap is sent by a bridge when any of its configured ports transitions from the Learning state to the Forwarding state, or from the Forwarding state to the Blocking state. The trap is not sent if a newRoot trap is sent for the same transition. Implementation of this trap is optional.
lldpRemTablesChange	**MIB:** LLDP-MIB **Standard:** IEEE Std 802.1AB-2005 **OID:** 1.0.8802.1.1.2.0.0.1 **Definition:** An lldpRemTablesChange notification is sent when the value of lldpStatsRemTableLastChangeTime changes. It can be utilized by a Network Management System (NMS) to trigger LLDP remote systems table maintenance polls. Note that transmission

Variable	Description
	of lldpRemTablesChange notifications are throttled by the agent, as specified by the lldpNotificationInterval object.
linkUp	**MIB:** IF-MIB **Standard:** RFC 1229, 2863, 2233, 1573 **OID:** 1.3.6.1.6.3.1.1.5.4 **Definition:** A linkUp trap signifies that the SNMP entity, acting in an agent role, has detected that the ifOperStatus object for one of its communication links left the down state and transitioned into some other state (but not into the notPresent state). This other state is indicated by the included value of ifOperStatus.
linkDown	**MIB:** IF-MIB **Standard:** RFC 1229, 2863, 2233, 1573 **OID:** 1.3.6.1.6.3.1.1.5.3 **Definition:** A linkDown trap signifies that the SNMP entity, acting in an agent role, has detected that the ifOperStatus object for one of its communication links is about to enter the down state from some other state (but not from the notPresent state). This other state is indicated by the included value of ifOperStatus.
dsx1LineStatusChange	**MIB:** DS1-MIB **Standard:** RFC 3895 **OID:** 1.3.6.1.2.1.10.18.15.0.1 **Definition:** A dsx1LineStatusChange trap is sent when the value of an instance dsx1LineStatus changes. It can be utilized by an Network Management Station (NMS) to trigger polls. When the line status change results from a higher-level line status change (i.e. DS3), then no traps for the DS1 are sent.

20.3 Proprietary SNMP Traps

The current MIB files supported by RUGGEDCOM ROX II can be downloaded from the https://www.siemens.com.

Note
SNMP traps are not configurable in RUGGEDCOM ROX II.

The following table lists all proprietary traps in RUGGEDCOM ROX II:

Variable	Description
ruggedcomMgmt	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.4

Variable	Description
	Definition: The main subtree for new MIB development where specific RUGGEDCOM proprietary MIBs can be placed.
ruggedcomTrapsModule	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.4.1 **Definition:** The RUGGEDCOM MIB providing traps information.
ruggedcomTrapsModuleObjects	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.4.1.1 **Definition:** A group of objects that define the RUGGEDCOM traps module.
trapGenericTrap	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.4.1.1.1 **Definition:** The main subtree for the RUGGEDCOM generic traps.
genericTrapSeverity	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.4.1.1.1.1 **Syntax:** Integer **Definition:** The severity level of the generic trap.
genericTrapDescription	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.4.1.1.1.2 **Syntax:** String **Definition:** A description of a generic trap.
trapSwUpgradeTrap	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.4.1.1.3 **Definition:** The main subtree for the RUGGEDCOM software upgrade trap.
trapRTCBatteryLowTrap	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.4.1.1.11 **Definition:** The main subtree for the RUGGEDCOM RTC battery low trap.
trapSecurityCertificateExpiryTrap	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.4.1.1.12 **Definition:** The main subtree for the RUGGEDCOM security certificate expiration trap.
trapUserAuthFailure	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.4.1.1.14 **Syntax:** String **Definition:** The main subtree for the RUGGEDCOM login failure trap.
userAuthFailureMessage	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.4.1.1.14.1 **Syntax:** String

Variable	Description
	Definition: The login failure message. The message contains the name, reason, IP address, context, and protocol.
trapSuccessUsrChgPwd	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.4.1.1.15 **Syntax:** String **Definition:** The main subtree for the RUGGEDCOM successful user changed password trap.
successUsrChgPwd	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.4.1.1.15.1 **Syntax:** String **Definition:** The username of the user whose password was successfully changed.
trapRmonThresholdRise	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.4.1.1.16 **Definition:** The main subtree for the RUGGEDCOM RMON threshold rising alarm trap.
rmonThresholdRiseInterface	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.4.1.1.16.1 **Syntax:** String **Definition:** The name of the interface that crossed an RMON threshold value.
rmonThresholdRiseStatistic	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.4.1.1.16.2 **Syntax:** String **Definition:** The specific statistic for which an RMON threshold was crossed.
rmonThresholdRiseThroughput	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.4.1.1.16.3 **Syntax:** String **Definition:** The current throughput value when this trap is sent.
ruggedcomTrapsModuleConformance	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.4.1.5 **Definition:** A group of objects that define the RUGGEDCOM module conformance trap.
ruggedcomTrapsModuleGroups	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.4.1.5.2 **Definition:** A group of objects that define the RUGGEDCOM traps module.
ruggedcomGenericTrapGroup	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.4.1.5.2.1 **Definition:** A group of objects that define the generic trap.

Variable	Description
ruggedcomPowerSupplyGroup	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.4.1.5.2.2 **Definition:** A group of objects that define the RUGGEDCOM power supply failure trap.
ruggedcomNotificationsGroup	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.4.1.5.2.3 **Definition:** The RUGGEDCOM notifications group.
ruggedcomRTCBatteryLowGroup	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.4.1.5.2.13 **Definition:** A group of objects for RTC battery low indication.
ruggedcomSecurityGroup02	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.4.1.5.2.14 **Definition:** A group of objects to indicate security certificate expiry.
rcPswdChgTrapNotifyGroup	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.4.1.5.2.25 **Definition:** A group of trap objects to notify the password was successfully changed.
rcSysInfo	**MIB:** RUGGEDCOM-SYS-INFO-MIB **OID:** 1.3.6.1.4.1.15004.4.2 **Definition:** RUGGEDCOM system information MIB.
rcDeviceInfo	**MIB:** RUGGEDCOM-SYS-INFO-MIB **OID:** 1.3.6.1.4.1.15004.4.2.3 **Definition:** The main subtree for the RUGGEDCOM device info trap.
rcDeviceInfoBootSwVersion	**MIB:** RUGGEDCOM-SYS-INFO-MIB **OID:** 1.3.6.1.4.1.15004.4.2.3.2 **Definition:** The version and the build date of the boot loader software
rcDeviceInfoMainSwVersion	**MIB:** RUGGEDCOM-SYS-INFO-MIB **OID:** 1.3.6.1.4.1.15004.4.2.3.3 **Definition:** The version and the build date of the main operating system software.
rcDeviceInfoPendingBootSwVersion	**MIB:** RUGGEDCOM-SYS-INFO-MIB **OID:** 1.3.6.1.4.1.15004.4.2.3.6 **Definition:** The version and the build date of the boot loader software that has been loaded to the device and is pending reboot. Whenever the value of this object changes from zero-length string to any string of non-zero length, the device will generate a swUpgradeTrap notification.
rcDeviceInfoPendingMainSwVersion	**MIB:** RUGGEDCOM-SYS-INFO-MIB **OID:** 1.3.6.1.4.1.15004.4.2.3.7

Variable	Description
	Definition: The version and the build date of the main operating system software that has been loaded to the device and is pending reboot. Whenever the value of this object changes from zero-length string to any string of non-zero length, the device will generate a swUpgradeTrap notification.
rcDeviceInfoCfgRevision	**MIB:** RUGGEDCOM-SYS-INFO-MIB **OID:** 1.3.6.1.4.1.15004.4.2.3.8 **Syntax:** Integer **Definition:** The configuration file revision. The revision number will be updated whenever file is saved to the flash memory. This number is recorded in config.csv at the time file is uploaded from the device. Whenever the value of this object changes the device will generate a cfgChangeTrap notification.
rcCellularModem	**MIB:** RUGGEDCOM-SYS-INFO-MIB **OID:** 1.3.6.1.4.1.15004.4.15 **Definition:** The main subtree for the cellular modem.
rcCellularModemStats	**MIB:** RUGGEDCOM-SYS-INFO-MIB **OID:** 1.3.6.1.4.1.15004.4.15.1
rcCellularModemStatsTable	**MIB:** RUGGEDCOM-SYS-INFO-MIB **OID:** 1.3.6.1.4.1.15004.4.15.1.1 **Syntax:** SEQUENCE OF RcCellularModemStatsEntry **Definition:** The Table of Currently Active Sim Cards.
rcCellularModemStatsEntry	**MIB:** RUGGEDCOM-SYS-INFO-MIB **OID:** 1.3.6.1.4.1.15004.4.15.1.1.1 **Syntax:** RcCellularModemStatsEntry **Definition:** The Current Sim Card information.
rcCellularModemStatsCurrentSlot	**MIB:** RUGGEDCOM-SYS-INFO-MIB **OID:** 1.3.6.1.4.1.15004.4.15.1.1.1.1 **Definition:** The name of the SIM card which is currently being used.
rcCellularModemStatsCurrentPort	**MIB:** RUGGEDCOM-SYS-INFO-MIB **OID:** 1.3.6.1.4.1.15004.4.15.1.1.1.2 **Syntax:** String
rcCellularModemStatsActiveSimName	**MIB:** RUGGEDCOM-SYS-INFO-MIB **OID:** 1.3.6.1.4.1.15004.4.15.1.1.1.3 **Syntax:** String **Definition:** The name of the SIM card which is currently being used.
rcCellularModemStatsActiveSimIccid	**MIB:** RUGGEDCOM-SYS-INFO-MIB **OID:** 1.3.6.1.4.1.15004.4.15.1.1.1.4

Variable	Description
	Syntax: String **Definition:** The ICCID of the SIM card which is currently being used.
ruggedcomTraps	**MIB:** RUGGEDCOM-MIB.mib **OID:** 1.3.6.1.4.1.15004.5 **Definition:** The root of the subtree where RUGGEDCOM traps can be placed.
genericTrap	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.5.1 **Definition:** A generic trap generated by RUGGEDCOM devices.
swUpgradeTrap	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.5.3 **Definition:** A generic trap generated upon software upgrade. The rate at which this notification is provided is 60 seconds.
cfgChangeTrap	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.5.4 **Definition:** A generic trap generated upon configuration change. The rate at which this notification is provided is 60 seconds.
securityCertificateExpiryTrap	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.5.16 **Definition:** A trap indicating that at least one security certificate on the device is within 30 days of expiration. It is generated by RUGGEDCOM devices.
rcSuccessUsrChgPwdTrap	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.5.20 **Definition:** A trap generated when a user's password is successfully changed.
rcCellularModemStatsTrap	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.5.45 **Definition:** A trap generated when a failover event occurs.
rcUserLoginFailureTrap	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.5.46 **Definition:** A trap generated when a user login failure occurs.
rcRmonThresholdRiseTrap	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.5.48 **Definition:** A trap generated when a threshold value has been crossed for an interface.
rcMrpManagerRingClosed	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.5.50

Variable	Description
	Definition: A trap indicating the closed state of the MRP Manager ring. The Manager is identified by its MRP instance ID.
rcMrpManagerRingOpen	**MIB:** RUGGEDCOM-TRAPS-MIB **OID:** 1.3.6.1.4.1.15004.5.51 **Definition:** A trap indicating the open state of the MRP Manager ring. The Manager is identified by its MRP instance ID.
rcTunnels	**MIB:** RUGGEDCOM-TUNNELS-MIB **OID:** 1.3.6.1.4.1.15004.4.16 **Definition:** The RUGGEDCOM MIB providing tunnel status and traps.
rcIpsecTunnelObjects	**MIB:** RUGGEDCOM-TUNNELS-MIB **OID:** 1.3.6.1.4.1.15004.4.16.1 **Definition:** The main subtree for all IPsec tunnel objects.
rcIpsecTunnelTable	**MIB:** RUGGEDCOM-TUNNELS-MIB **OID:** 1.3.6.1.4.1.15004.4.16.1.1 **Syntax:** SEQUENCE OF RcIpsecTunnelEntry **Definition:** The IPsec Connections Tunnel Table. There is one entry in this table for each IPsec Tunnel.
rcIpsecTunnelEntry	**MIB:** RUGGEDCOM-TUNNELS-MIB **OID:** 1.3.6.1.4.1.15004.4.16.1.1.1 **Syntax:** RcIpsecTunnelEntry **Definition:** Each entry contains the attributes associated with an IPsec Tunnel.
rcIpsecConnIndex	**MIB:** RUGGEDCOM-TUNNELS-MIB **OID:** 1.3.6.1.4.1.15004.4.16.1.1.1.1 **Syntax:** Integer **Definition:** The table index number of the IPsec connection.
rcIpsecConnName	**MIB:** RUGGEDCOM-TUNNELS-MIB **OID:** 1.3.6.1.4.1.15004.4.16.1.1.1.2 **Syntax:** String **Definition:** The name of the IPsec connection. The name is unique so it can be used as an index into the connection table.
rcIpsecConnStatus	**MIB:** RUGGEDCOM-TUNNELS-MIB **OID:** 1.3.6.1.4.1.15004.4.16.1.1.1.3 **Syntax:** RcTunnelStatus **Definition:** The status of the IPsec connection. Refer to the TunnelStatus object for definitions of states.
rcIpsecConnNumPeers	**MIB:** RUGGEDCOM-TUNNELS-MIB **OID:** 1.3.6.1.4.1.15004.4.16.1.1.1.4

Variable	Description
	Syntax: Integer **Definition:** The number of active peers on the IPsec connection.
rcGreTunnelObjects	**MIB:** RUGGEDCOM-TUNNELS-MIB **OID:** 1.3.6.1.4.1.15004.4.16.2 **Definition:** The main subtree for all the various GRE tunnel objects.
rcGreTunnelTable	**MIB:** RUGGEDCOM-TUNNELS-MIB **OID:** 1.3.6.1.4.1.15004.4.16.2.1 **Syntax:** SEQUENCE OF RcGreTunnelEntry **Definition:** The GRE Tunnels Table. There is one entry in this table for each GRE Tunnel.
rcGreTunnelEntry	**MIB:** RUGGEDCOM-TUNNELS-MIB **OID:** 1.3.6.1.4.1.15004.4.16.2.1.1 **Syntax:** RcGreTunnelEntry **Definition:** Each entry contains the attributes associated with a GRE Tunnel.
rcGreTunnelIndex	**MIB:** RUGGEDCOM-TUNNELS-MIB **OID:** 1.3.6.1.4.1.15004.4.16.2.1.1.1 **Syntax:** Integer **Definition:** The table index number of the GRE tunnel.
rcGreTunnelName	**MIB:** RUGGEDCOM-TUNNELS-MIB **OID:** 1.3.6.1.4.1.15004.4.16.2.1.1.2 **Syntax:** String **Definition:** The name of the GRE tunnel.
rcGreTunnelStatus	**MIB:** RUGGEDCOM-TUNNELS-MIB **OID:** 1.3.6.1.4.1.15004.4.16.2.1.1.3 **Syntax:** RcTunnelStatus **Definition:** The status of the GRE tunnel. Refer to the *TunnelStatus* object for definitions of states.
rcTunnelTraps	**MIB:** RUGGEDCOM-TUNNELS-MIB **OID:** 1.3.6.1.4.1.15004.4.16.5 **Definition:** The main subtree for the RUGGEDCOM tunnel traps.
rcTunnelIpsecTraps	**MIB:** RUGGEDCOM-TUNNELS-MIB **OID:** 1.3.6.1.4.1.15004.4.16.5.1 **Definition:** The main subtree for the RUGGEDCOM IPsec tunnel traps.
rcIpsecTunnelUpTrap (Notifications)	**MIB:** RUGGEDCOM-TUNNELS-MIB **OID:** 1.3.6.1.4.1.15004.4.16.5.1.1 **Definition:** A trap generated when IPsec tunnel connections are established (come up).
rcIpsecTunnelDownTrap (Notifications)	**MIB:** RUGGEDCOM-TUNNELS-MIB

Variable	Description
	OID: 1.3.6.1.4.1.15004.4.16.5.1.2 **Definition:** A trap generated when IPsec tunnel connections are disconnected (go down).
rcTunnelGreTraps	**MIB:** RUGGEDCOM-TUNNELS-MIB **OID:** 1.3.6.1.4.1.15004.4.16.5.2 **Definition:** The main subtree for the RUGGEDCOM GRE tunnel traps.
rcGreTunnelDownTrap (Notifications)	**MIB:** RUGGEDCOM-TUNNELS-MIB **OID:** 1.3.6.1.4.1.15004.4.16.5.2.2 **Definition:** A trap generated when GRE tunnels are disconnected (go down).
rcGreTunnelUpTrap (Notifications)	**MIB:** RUGGEDCOM-TUNNELS-MIB **OID:** 1.3.6.1.4.1.15004.4.16.5.2.1 **Definition:** A trap generated when GRE tunnels are established (come up).
rcTunnelsConformance	**MIB:** RUGGEDCOM-TUNNELS-MIB **OID:** 1.3.6.1.4.1.15004.4.16.6 **Definition:** The main subtree for the RUGGEDCOM tunnels conformance traps.
rcTunnelsIpsecGroups	**MIB:** RUGGEDCOM-TUNNELS-MIB **OID:** 1.3.6.1.4.1.15004.4.16.6.1 **Definition:** A group of objects that define RUGGEDCOM IPsec tunnels.
rcTunIpsecObjectsGroup	**MIB:** RUGGEDCOM-TUNNELS-MIB **OID:** 1.3.6.1.4.1.15004.4.16.6.1.1 **Definition:** A group of objects providing information for IPsec tunnels.
rcTunIpsecTrapsGroup	**MIB:** RUGGEDCOM-TUNNELS-MIB **OID:** 1.3.6.1.4.1.15004.4.16.6.1.2 **Definition:** A group of objects that define RUGGEDCOM Ipsec tunnel traps.
rcTunIpsecNotificationsGroup	**MIB:** RUGGEDCOM-TUNNELS-MIB **OID:** 1.3.6.1.4.1.15004.4.16.6.1.3 **Definition:** The RUGGEDCOM notifications group for IPsec tunnel traps.
rcTunnelsGreGroups	**MIB:** RUGGEDCOM-TUNNELS-MIB **OID:** 1.3.6.1.4.1.15004.4.16.6.2 **Definition:** A group of objects that define RUGGEDCOM GRE tunnels.
rcTunGreObjectsGroup	**MIB:** RUGGEDCOM-TUNNELS-MIB **OID:** 1.3.6.1.4.1.15004.4.16.6.2.1 **Definition:** A group of objects providing information for GRE tunnels.
rcTunGreTrapsGroup	**MIB:** RUGGEDCOM-TUNNELS-MIB **OID:** 1.3.6.1.4.1.15004.4.16.6.2.2

Variable	Description
	Definition: A group of objects that define RUGGEDCOM GRE tunnel traps.
rcTunGreNotificationsGroup	**MIB:** RUGGEDCOM-TUNNELS-MIB **OID:** 1.3.6.1.4.1.15004.4.16.6.2.3 **Definition:** The RUGGEDCOM notifications group for GRE tunnel traps.

For more information

Siemens RUGGEDCOM
https://www.siemens.com/ruggedcom

Industry Online Support (service and support)
https://support.industry.siemens.com

Industry Mall
https://mall.industry.siemens.com

Siemens Canada Ltd.
Digital Industries
Process Automation
300 Applewood Crescent
Concord, Ontario, L4K 4E5
Canada

© 2022 Siemens Canada Ltd.
Subject to change