



# Cumulus Linux 3.7

## User Guide

---



# Table of Contents

<b>What is Cumulus Linux? .....</b>	<b>17</b>
What's New in this Release? .....	18
Open Source Contributions .....	18
Hardware Compatibility List .....	18
<b>Quick Start Guide .....</b>	<b>18</b>
Contents .....	19
Install Cumulus Linux .....	20
Getting Started .....	21
Login Credentials .....	21
Serial Console Management .....	21
Wired Ethernet Management .....	21
Configure the Hostname and Timezone .....	22
Verify the System Time .....	23
Install the License .....	23
Configure Breakout Ports with Splitter Cables .....	24
Test Cable Connectivity .....	24
Configure Switch Ports .....	26
Layer 2 Port Configuration .....	26
Layer 3 Port Configuration .....	27
Configure a Loopback Interface .....	29
<b>Installation Management .....</b>	<b>30</b>
Managing Cumulus Linux Disk Images .....	31
Contents .....	31
Determine the Switch Platform .....	31
Reprovision the System (Restart the Installer) .....	31
Uninstall All Images and Remove the Configuration .....	32
Boot into Rescue Mode .....	33
Inspect the Image File .....	33
Related Information .....	34
Installing a New Cumulus Linux Image .....	35
Contents .....	35
Install Using a DHCP/Web Server with DHCP Options .....	35
Install Using a DHCP/Web Server without DHCP Options .....	36
Install Using a Web Server with no DHCP .....	37
Install Using FTP Without a Web Server .....	38
Install Using a Local File .....	38
Install Using a USB Drive .....	39
Related Information .....	45
Upgrading Cumulus Linux .....	45



Contents .....	45
Before You Upgrade Cumulus Linux .....	45
Upgrade Cumulus Linux .....	49
Upgrade Switches in an MLAG Pair .....	53
Roll Back a Cumulus Linux Installation .....	56
Third Party Packages .....	56
Related Information .....	56
Using Snapshots .....	56
Contents .....	57
Install the Snapshot Package .....	57
Take and Manage Snapshots .....	57
Roll Back to Earlier Snapshots .....	61
Configure Automatic Time-based Snapshots .....	62
Caveats and Errata .....	63
Adding and Updating Packages .....	63
Contents .....	64
Update the Package Cache .....	64
List Available Packages .....	66
List Installed Packages .....	67
Display the Version of a Package .....	67
Upgrade Packages .....	68
Add New Packages .....	68
Add Packages from Another Repository .....	69
Cumulus Supplemental Repository .....	71
Related Information .....	72
Zero Touch Provisioning - ZTP .....	72
Contents .....	72
Zero Touch Provisioning Using a Local File .....	73
Zero Touch Provisioning Using a USB Drive (ZTP-USB) .....	73
Zero Touch Provisioning over DHCP .....	74
Write ZTP Scripts .....	76
Best Practices for ZTP Scripts .....	77
Test ZTP Scripts .....	80
Common ZTP Script Errors .....	84
Manually Use the ztp Command .....	86
Notes .....	87
<b>System Configuration .....</b>	<b>87</b>
Network Command Line Utility - NCLU .....	88
Contents .....	88
Install NCLU .....	89
NCLU Basics .....	89
Configure User Accounts .....	94
Edit the netd.conf File .....	96
Restart the netd Service .....	96



Back Up the Configuration to a Single File .....	97
Advanced Configuration .....	97
Setting Date and Time .....	99
Contents .....	99
Set the Time Zone .....	99
Set the Date and Time .....	101
Set the Time Using NTP and NCLU .....	101
Specify the NTP Source Interface .....	103
NTP Default Configuration .....	103
Precision Time Protocol (PTP) Boundary Clock .....	105
Use NTP in a DHCP Environment .....	111
System Clock and NCLU Commands .....	112
Related Information .....	112
Authentication, Authorization and Accounting .....	112
SSH for Remote Access .....	112
User Accounts .....	114
Using sudo to Delegate Privileges .....	116
TACACS Plus .....	122
RADIUS AAA .....	136
Netfilter - ACLs .....	142
Contents .....	144
Traffic Rules In Cumulus Linux .....	145
Install and Manage ACL Rules with NCLU .....	156
Install and Manage ACL Rules with cl-acltool .....	157
Install Packet Filtering (ACL) Rules .....	158
Specify the Policy Files to Install .....	160
Hardware Limitations on Number of Rules .....	161
Supported Rule Types .....	163
Common Examples .....	167
Example Scenario .....	173
Useful Links .....	176
Caveats and Errata .....	176
Default Cumulus Linux ACL Configuration .....	180
Filtering Learned MAC Addresses .....	190
Services and Daemons in Cumulus Linux .....	192
Contents .....	193
systemd and the systemctl Command .....	193
Identify Active Listener Ports for IPv4 and IPv6 .....	196
Identify Services Currently Active or Stopped .....	197
Identify Essential Services .....	202
Configuring switchd .....	204
Contents .....	204
The switchd File System .....	205
Configure switchd Parameters .....	206
Restart switchd .....	207



Power over Ethernet - PoE .....	207
Contents .....	207
PoE Basics .....	208
Configure PoE .....	208
Troubleshooting .....	213
Configuring a Global Proxy .....	216
Related Information .....	217
HTTP API .....	217
Contents .....	217
<b>Layer1 and Switch Ports .....</b>	<b>220</b>
Interface Configuration and Management .....	221
Contents .....	221
Basic Commands .....	221
ifupdown2 Interface Classes .....	222
Configure a Loopback Interface .....	224
ifupdown Behavior with Child Interfaces .....	224
ifupdown2 Interface Dependencies .....	225
Subinterfaces .....	228
ifup and Upper (Parent) Interfaces .....	228
Configure IP Addresses .....	229
Specify User Commands .....	232
Source Interface File Snippets .....	233
Use Globs for Port Lists .....	234
Use Templates .....	235
Run ifupdown Scripts under /etc/network/ with ifupdown2 .....	236
Add Descriptions to Interfaces .....	236
Caveats and Errata .....	237
Related Information .....	238
Switch Port Attributes .....	239
ifplugd .....	273
Buffer and Queue Management .....	275
Contents .....	275
Commands .....	276
Example Configuration File .....	276
Configure Traffic Marking through ACL Rules .....	280
Configure Priority Flow Control .....	281
Port Groups .....	283
Configure Link Pause .....	284
Configure Cut-through Mode and Store and Forward Switching .....	285
Configure Explicit Congestion Notification .....	286
Check Interface Buffer Status .....	288
Related Information .....	288
Hardware-enabled DDOS Protection .....	288
DHCP Relays .....	290



Contents .....	290
Configure IPv4 DHCP Relays .....	291
Configure IPv6 DHCP Relays .....	294
Configure Multiple DHCP Relays .....	295
Configure a DHCP Relay with VRR .....	296
Configure the DHCP Relay Service Manually (Advanced) .....	296
Use the Gateway IP Address as the Source IP for Relayed DHCP Packets (Advanced) .....	297
Troubleshooting .....	297
DHCP Servers .....	299
Contents .....	299
Configure the DHCP Server on Cumulus Linux Switches .....	300
Assign Port-Based IP Addresses .....	301
Troubleshooting .....	301
Facebook Voyager Optical Interfaces .....	302
Contents .....	302
The Voyager Platform .....	302
Configure the Voyager Ports .....	305
Configure the Transponder Modules .....	306
802.1X Interfaces .....	338
Contents .....	338
Supported Features and Limitations .....	339
Install the 802.1X Package .....	340
Configure the RADIUS Server .....	340
Configure 802.1X Interfaces .....	340
Configure the Linux Supplicants .....	344
Configure Accounting and Authentication Ports .....	345
Configure MAC Authentication Bypass .....	346
Configure a Parking VLAN .....	347
Configure Dynamic VLAN Assignments .....	349
Configure MAC Addresses per Port .....	351
Configure EAP Requests from the Switch .....	352
RADIUS Change of Authorization and Disconnect Requests .....	352
Troubleshooting .....	357
Related Information .....	359
Prescriptive Topology Manager - PTM .....	360
Contents .....	360
Supported Features .....	361
Configure PTM .....	361
Basic Topology Example .....	361
ptmd Scripts .....	362
Configuration Parameters .....	362
Bidirectional Forwarding Detection (BFD) .....	365
Check Link State with FRRouting .....	366
ptmd Service Commands .....	367
ptmctl Commands .....	367



Caveats and Errata .....	370
Related Information .....	371
<b>Layer 2 .....</b>	<b>371</b>
Spanning Tree and Rapid Spanning Tree .....	372
Contents .....	372
Supported Modes .....	372
View Bridge and STP Status and Logs .....	373
Customize Spanning Tree Protocol .....	377
Related Information .....	390
Link Layer Discovery Protocol .....	390
Contents .....	390
Configure LLDP .....	390
Example lldpccli Commands .....	391
Enable the SNMP Subagent in LLDP .....	396
Caveats and Errata .....	396
Related Information .....	396
Voice VLAN .....	396
Bonding - Link Aggregation .....	399
Contents .....	400
Hash Distribution .....	400
Create a Bond .....	400
Example Configuration: Bonding 4 Slaves .....	404
Caveats and Errata .....	406
Related Information .....	407
Ethernet Bridging - VLANs .....	407
Contents .....	408
Create a VLAN-aware Bridge .....	408
Create a Traditional Mode Bridge .....	408
Configure Bridge MAC Addresses .....	408
MAC Address Ageing .....	409
Configure an SVI (Switch VLAN Interface) .....	409
IPv6 Link-local Address Generation .....	412
Understanding `bridge fdb` Output .....	413
Caveats and Errata .....	414
Related Information .....	414
VLAN-aware Bridge Mode .....	415
Traditional Bridge Mode .....	427
VLAN Tagging .....	433
Multi-Chassis Link Aggregation - MLAG .....	440
Contents .....	441
MLAG Requirements .....	442
LACP and Dual-Connectedness .....	444
Configure MLAG .....	444
Example MLAG Configuration .....	448



Disable clagd on an Interface .....	456
Check the MLAG Configuration Status .....	456
Configure MLAG with a Traditional Mode Bridge .....	457
Peer Link Interfaces and the protodown State .....	458
Monitor Dual-Connected Peers .....	462
Configure Layer 3 Routed Uplinks .....	462
IGMP Snooping with MLAG .....	464
Monitor the Status of the clagd Service .....	464
MLAG Best Practices .....	465
STP Interoperability with MLAG .....	468
Troubleshooting .....	469
Caveats and Errata .....	471
LACP Bypass .....	471
Contents .....	471
LACP Bypass All-active Mode .....	471
Configure LACP Bypass .....	472
Virtual Router Redundancy - VRR and VRRP .....	474
Contents .....	474
VRR .....	475
VRRP .....	481
IGMP and MLD Snooping .....	485
Contents .....	485
Configure IGMP/MLD Snooping over VXLAN .....	486
Configure IGMP/MLD Querier .....	486
Disable IGMP and MLD Snooping .....	487
Troubleshooting .....	488
Related Information .....	489
<b>Network Virtualization .....</b>	<b>490</b>
Caveats and Errata .....	491
Cut-through Mode and Store and Forward Switching .....	491
MTU Size for Virtual Network Interfaces .....	491
VLANs and VXLANs Cannot Share the Same ID .....	492
Useful Links .....	492
Static VXLAN Tunnels .....	492
Contents .....	492
Requirements .....	492
Example Configuration .....	493
Configure Static VXLAN Tunnels .....	493
Verify the Configuration .....	497
Caveats and Errata .....	498
Static MAC Bindings with VXLAN .....	498
Contents .....	498
Requirements .....	498
Example VXLAN Configuration .....	499



Configure the Static MAC Bindings VXLAN .....	499
Troubleshooting .....	500
Ethernet Virtual Private Network - EVPN .....	501
Contents .....	503
Basic EVPN Configuration .....	504
ARP and ND Suppression .....	510
EVPN and VXLAN Active-active Mode .....	513
Inter-subnet Routing .....	514
Prefix-based Routing – EVPN Type-5 Routes .....	519
EVPN Enhancements .....	521
EVPN Operational Commands .....	530
Troubleshooting .....	544
Caveats .....	545
Example Configurations .....	547
Lightweight Network Virtualization Overview .....	602
Contents .....	603
LNV Concepts .....	604
Requirements .....	606
Sample LNV Configuration .....	606
Configure the VLAN to VXLAN Mapping .....	613
Verify the VLAN to VXLAN Mapping .....	615
Enable and Manage Service Node and Registration Daemons .....	615
Configure the Registration Node .....	617
Configure the Service Node .....	619
Advanced LNV Usage .....	620
Related Information .....	626
LNV Full Example .....	626
VXLAN Active-Active Mode .....	633
Contents .....	634
Terminology .....	634
Configure VXLAN Active-active Mode .....	635
Example VXLAN Active-Active Configuration .....	638
Using Active-active Mode with LNV .....	643
Troubleshooting .....	648
Caveats and Errata .....	649
Related Information .....	651
VXLAN Routing .....	651
Contents .....	651
Supported Platforms .....	651
VXLAN Routing Data Plane and the Broadcom Trident II+, Trident3, Maverick, Tomahawk, and Tomahawk+ Platforms .....	652
VXLAN Routing Data Plane and Broadcom Trident II Platforms .....	653
VXLAN Routing Data Plane and the Mellanox Spectrum Platform .....	655
VXLAN Scale .....	655
Hybrid Cloud Connectivity with QinQ and VXLANS .....	657



Contents .....	657
Remove the Early Access QinQ Metapackage .....	657
Configure Single Tag Translation .....	658
Configure Double Tag Translation .....	661
Caveats and Errata .....	664
Troubleshooting VXLANS .....	665
Contents .....	665
Verify the Registration Node Daemon .....	665
Verify the Service Node Daemon .....	666
Verify Traffic Flow and Check Counters .....	666
Ping to Test Connectivity .....	667
Troubleshoot with MAC Addresses .....	669
Check the Service Node Configuration .....	669
Integrating Hardware VTEPs with Midokura MidoNet and OpenStack .....	670
Contents .....	670
Getting Started .....	671
Configure the MidoNet Integration on the Switch .....	671
Configure MidoNet VTEP and Port Bindings .....	673
Troubleshooting .....	679
Integrating Hardware VTEPs with VMware NSX-V .....	687
Contents .....	687
Getting Started .....	688
Configure the Switch for NSX-V Integration .....	688
Provision VMware NSX-V .....	692
Configure the Transport and Logical Layers .....	693
Verify the VXLAN Configuration .....	698
Integrating Hardware VTEPs with VMware NSX-MH .....	699
Contents .....	700
Getting Started .....	700
Configure the Switch for NSX-MH Integration .....	700
Provision VMware NSX-V .....	704
Configure the Transport and Logical Layers .....	706
Verify the VXLAN Configuration .....	711
OVSDB Server High Availability .....	712
Contents .....	713
Getting Started .....	713
Configure the NSX Integration on the Switch .....	715
Configure the Transport and Logical Layers .....	717
Troubleshooting .....	717
<b>Layer 3 .....</b>	<b>719</b>
Routing .....	720
Contents .....	720
Manage Static Routes .....	720
Configure a Gateway or Default Route .....	723



Supported Route Table Entries .....	723
Caveats and Errata .....	726
Related Information .....	728
Introduction to Routing Protocols .....	728
Contents .....	728
Routing Protocols .....	728
Configure Routing Protocols .....	728
Protocol Tuning .....	729
Network Topology .....	729
Contents .....	729
Clos Topologies .....	730
Over-Subscribed and Non-Blocking Configurations .....	730
Containing the Failure Domain .....	731
Load Balancing .....	731
FRRouting Overview .....	731
Contents .....	731
Architecture .....	732
About zebra .....	732
Related Information .....	732
Upgrading from Quagga to FRRouting .....	732
Configuring FRRouting .....	737
Contents .....	737
Configure FRRouting .....	737
Interface IP Addresses and VRFs .....	740
FRRouting vtysh Modal CLI .....	740
Reload the FRRouting Configuration .....	745
FRR Logging .....	745
Caveats .....	746
Related Information .....	746
Comparing NCLU and vtysh Commands .....	747
Address Resolution Protocol - ARP .....	749
Contents .....	749
Standard Debian ARP Behavior and the Tunable ARP Parameters .....	749
ARP Tunable Parameter Settings in Cumulus Linux .....	750
Change Tunable ARP Parameters .....	752
Change Port-specific ARP Parameters .....	754
Configure Proxy ARP .....	755
Open Shortest Path First - OSPF .....	756
Contents .....	756
Scalability and Areas .....	757
Configure OSPFv2 .....	757
Scaling Tips .....	760
Unnumbered Interfaces .....	767
Apply a Route Map for Route Updates .....	768
ECMP .....	768



Topology Changes and OSPF Reconvergence .....	768
Troubleshooting .....	769
Related Information .....	769
<b>Open Shortest Path First v3 - OSPFv3 .....</b>	<b>770</b>
Contents .....	770
Configure OSPFv3 .....	770
Configure the OSPFv3 Area .....	771
Configure the OSPFv3 Distance .....	771
Configure OSPFv3 Interfaces .....	772
Troubleshooting .....	773
Related Information .....	773
<b>Border Gateway Protocol - BGP .....</b>	<b>773</b>
Contents .....	774
Autonomous System Number (ASN) .....	775
eBGP and iBGP .....	775
Route Reflectors .....	775
ECMP with BGP .....	777
Configure BGP .....	777
BGP Unnumbered Interfaces .....	779
RFC 5549 Support with Global IPv6 Peers (Cumulus Linux 3.7.2 and later) .....	784
BGP add-path .....	789
Fast Convergence Design Considerations .....	793
Peer Groups to Simplify Configuration .....	794
Configure BGP Dynamic Neighbors .....	794
Configure BGP Peering Relationships across Switches .....	795
Configure MD5-enabled BGP Neighbors .....	797
Configure eBGP Multihop .....	800
Configure BGP TTL Security .....	801
Configure Graceful BGP Shutdown .....	803
Configuration Tips .....	804
Troubleshooting .....	806
Enable Read-only Mode .....	811
Apply a Route Map for Route Updates .....	812
Protocol Tuning .....	812
Caveats and Errata .....	815
<b>Policy-based Routing .....</b>	<b>816</b>
Contents .....	816
Configure PBR .....	817
Configuration Example .....	818
Review Your Configuration .....	819
Delete PBR Rules and Policies .....	820
<b>Bidirectional Forwarding Detection - BFD .....</b>	<b>821</b>
Contents .....	822
BFD Multihop Routed Paths .....	822
BFD Parameters .....	822



Configure BFD .....	822
BFD in BGP .....	823
BFD in OSPF .....	824
OSPF Show Commands .....	825
Scripts .....	826
Echo Function .....	827
Troubleshooting .....	828
Related Information .....	829
Equal Cost Multipath Load Sharing - Hardware ECMP .....	829
Contents .....	829
Equal Cost Routing .....	829
ECMP Hashing .....	830
Resilient Hashing .....	834
Redistribute Neighbor .....	838
Contents .....	838
Availability .....	839
Target Use Cases and Best Practices .....	839
How It Works .....	839
Example Configuration .....	839
Known Limitations .....	844
Troubleshooting .....	844
Virtual Routing and Forwarding - VRF .....	847
Contents .....	848
Configure VRF .....	849
VRF Route Leaking .....	852
FRRouting Operation in a VRF .....	858
Example Commands to Show VRF Data .....	860
BGP Unnumbered Interfaces with VRF .....	870
DHCP with VRF .....	872
ping or traceroute on a VRF .....	876
Caveats and Errata .....	877
Management VRF .....	877
Contents .....	877
Enable Management VRF .....	878
Run Services within the Management VRF .....	879
OSPF and BGP .....	883
SSH within a Management VRF Context .....	883
View the Routing Tables .....	884
mgmt Interface Class .....	884
Management VRF and DNS .....	885
Incompatibility with cl-ns-mgmt .....	886
GRE Tunneling .....	886
Contents .....	887
Configure GRE Tunneling .....	887
Verify GRE Tunnel Settings .....	889



Delete a GRE Tunnel Interface .....	889
Change GRE Tunnel Settings .....	890
Protocol Independent Multicast - PIM .....	890
Contents .....	890
PIM Overview .....	891
PIM Sparse Mode (PIM-SM) .....	895
Configure PIM .....	900
Source Specific Multicast Mode (SSM) .....	905
IP Multicast Boundaries .....	906
Multicast Source Discovery Protocol (MSDP) .....	907
Verify PIM .....	908
PIM in a VRF .....	912
BFD for PIM Neighbors .....	915
Troubleshooting .....	915
Caveats and Errata .....	919
Segment Routing .....	919
Contents .....	920
Features .....	920
Example Configuration .....	920
Configure Segment Routing .....	927
View the Configuration .....	927
<b>Monitoring and Troubleshooting .....</b>	<b>929</b>
Contents .....	930
Serial Console .....	930
Configure the Serial Console on ARM Switches .....	930
Configure the Serial Console on x86 Switches .....	931
Show General System Information .....	932
Diagnostics Using cl-support .....	932
Send Log Files to a syslog Server .....	933
NCLU .....	933
Log Technical Details .....	933
Local Logging .....	934
Enable Remote syslog .....	935
Write to syslog with Management VRF Enabled .....	936
Rate-limit syslog Messages .....	936
Harmless syslog Error: Failed to reset devices.list .....	937
Syslog Troubleshooting Tips .....	937
Next Steps .....	940
Single User Mode - Boot Recovery .....	940
Resource Diagnostics Using cl-resource-query .....	941
Monitoring System Hardware .....	944
Contents .....	945
Retrieve Hardware Information Using decode-syseeprom .....	945
Monitor System Units Using smond .....	946



Monitor Hardware Health Using sensors .....	948
Monitor Switch Hardware Using SNMP .....	949
Keep the Switch Alive Using the Hardware Watchdog .....	949
Related Information .....	950
Network Switch Port LED and Status LED Guidelines .....	950
Monitoring Virtual Device Counters .....	953
Contents .....	953
Sample VXLAN Statistics .....	953
Sample VLAN Statistics .....	955
Configure the Counters in switchd .....	956
Caveats and Errata .....	957
ASIC Monitoring .....	957
What Type of Statistics Can You Collect? .....	957
Collecting Queue Lengths in Histograms .....	958
Configure ASIC Monitoring .....	959
Configuration Examples .....	962
Example Snapshot File .....	964
Example Log Message .....	964
ASIC Monitoring Settings .....	964
Understanding the cl-support Output File .....	968
Troubleshooting Log Files .....	969
Troubleshooting the etc Directory .....	971
Troubleshooting Network Interfaces .....	985
Contents .....	985
Enable Logging for Networking .....	985
Use ifquery to Validate and Debug Interface Configurations .....	986
Mako Template Errors .....	987
ifdown Cannot Find an Interface that Exists .....	988
Remove All References to a Child Interface .....	988
MTU Set on a Logical Interface Fails with Error: "Numerical result out of range" .....	989
iproute2 batch Command Failures .....	989
"RTNETLINK answers: Invalid argument" Error when Adding a Port to a Bridge .....	990
MLAG Peerlink Interface Drops Many Packets .....	990
Monitoring Interfaces and Transceivers Using ethtool .....	990
Monitoring Interfaces and Transceivers Using ethtool — ethtool Counter Definitions .....	995
Network Troubleshooting .....	1003
Contents .....	1004
Check Reachability Using ping .....	1004
Print Route Trace Using traceroute .....	1005
Run Commands in a Non-default VRF .....	1005
Manipulate the System ARP Cache .....	1006
Generate Traffic Using mz .....	1007
Create Counter ACL Rules .....	1008
Configure SPAN and ERSPAN .....	1009
Related Information .....	1018



Using NCLU to Troubleshoot Your Network Configuration .....	1018
Monitoring System Statistics and Network Traffic with sFlow .....	1021
Simple Network Management Protocol (SNMP) Monitoring .....	1024
Contents .....	1024
History .....	1024
Introduction to Simple Network Management Protocol .....	1025
Getting Started .....	1027
Configure SNMP .....	1027
Configure SNMP Manually .....	1034
Enable SNMP Support for FRRouting .....	1041
Manually Configure SNMP Traps (Non-NCLU) .....	1046
Supported MIBs .....	1056
Pass Persist Scripts .....	1059
Troubleshooting .....	1059
Using Nutanix Prism as a Monitoring Tool .....	1060
Monitoring Best Practices .....	1070
Contents .....	1070
Overview .....	1070
Hardware .....	1071
System Data .....	1073
Process Restart .....	1075
Layer 1 Protocols and Interfaces .....	1076
Layer 2 Protocols .....	1083
Layer 3 Protocols .....	1085
Logging .....	1087
Protocols and Services .....	1089
Device Management .....	1090
FRRouting Log Message Reference .....	1090
<b>Network Solutions .....</b>	<b>1106</b>
Data Center Host to ToR Architecture .....	1107
Contents .....	1107
Layer 2 - Architecture .....	1107
Layer 3 Architecture .....	1111
Network Virtualization .....	1118
Cumulus Networks Services Demos .....	1120
Contents .....	1120
Reference Topology .....	1120
Docker on Cumulus Linux .....	1123
Set up Docker on Cumulus Linux .....	1123
Performance Notes .....	1125
OpenStack Neutron ML2 and Cumulus Linux .....	1125
Contents .....	1126
Configure the REST API .....	1126
Install and Configure the Cumulus Networks Modular Layer 2 Mechanism Driver .....	1127



Try OpenStack with Cumulus in the Cloud .....	1127
Anycast Design Guide .....	1128
Anycast Architecture .....	1128
Anycast with TCP and UDP .....	1129
Resilient Hashing .....	1130
Applications for Anycast .....	1132
Conclusion .....	1133
RDMA over Converged Ethernet - RoCE .....	1134
Contents .....	1134
Enable RDMA over Converged Ethernet with PFC .....	1134
Enable RDMA over Converged Ethernet with ECN .....	1135
Related Information .....	1136
Cumulus Hyperconverged Solution with Nutanix .....	1136
Contents .....	1137
Prerequisites .....	1137
Configure Cumulus HCS and Nutanix .....	1138
Configure Uplinks .....	1142
Add Local Default Gateways .....	1143
Out-of-band Solutions .....	1144
Troubleshoot Cumulus HCS .....	1145
Caveats .....	1146
More Information .....	1147
<b>Index .....</b>	<b>1148</b>

©2019 Cumulus Networks. All rights reserved

CUMULUS, the Cumulus Logo, CUMULUS NETWORKS, and the Rocket Turtle Logo (the “Marks”) are trademarks and service marks of Cumulus Networks, Inc. in the U.S. and other countries. You are not permitted to use the Marks without the prior written consent of Cumulus Networks. The registered trademark Linux® is used pursuant to a sublicense from LMI, the exclusive licensee of Linus Torvalds, owner of the mark on a worldwide basis. All other marks are used under fair use or license from their respective owners.



# What is Cumulus Linux?

Cumulus Linux is the first full-featured Linux operating system for the networking industry. The [Debian Jessie](#)-based, networking-focused distribution runs on hardware produced by a [broad partner ecosystem](#), ensuring unmatched customer choice regarding silicon, optics, cables, and systems.

This user guide provides in-depth documentation on the Cumulus Linux installation process, system configuration and management, network solutions, and monitoring and troubleshooting recommendations. In addition, the quick start guide provides an end-to-end setup process to get you started.

This documentation is current as of May 7, 2019 for version 3.7.6. Visit the [Cumulus Networks Web site](#) for the most up to date documentation.

Read the [release notes](#) for new features and known issues in this release.

## What's New in this Release?

For information on new features, bug fixes, and known issues present in this release, refer to the [product release notes](#).

## Open Source Contributions

To implement various Cumulus Linux features, Cumulus Networks has forked various software projects, like CFEngine, Netdev and some Puppet Labs packages. The forked code resides in the Cumulus Networks [GitHub repository](#).

Cumulus Networks has also developed and released new applications as open source. The list of open source projects is on the [open source software](#) page.

## Hardware Compatibility List

You can find the most up-to-date hardware compatibility list (HCL) [here](#). Use the HCL to confirm that your switch model is supported by Cumulus Networks. The HCL is updated regularly, listing products by port configuration, manufacturer, and SKU part number.

# Quick Start Guide

This quick start guide provides an end-to-end setup process for installing and running Cumulus Linux, as well as a collection of example commands for getting started after installation is complete.

## Prerequisites

Intermediate-level Linux knowledge is assumed for this guide. You should be familiar with basic text editing, Unix file permissions, and process monitoring. A variety of text editors are pre-installed, including `vi` and `nano`.

You must have access to a Linux or UNIX shell. If you are running Windows, use a Linux environment like [Cygwin](#) as your command line tool for interacting with Cumulus Linux.

 If you are a networking engineer but are unfamiliar with Linux concepts, refer to [this reference guide](#) to compare the Cumulus Linux CLI and configuration options, and their equivalent Cisco Nexus 3000 NX-OS commands and settings. You can also [watch a series of short videos](#) introducing you to Linux and Cumulus Linux-specific concepts.

## Contents

This topic describes ...

- Install Cumulus Linux (see page 20)
- Getting Started (see page 21)
  - Login Credentials (see page 21)
  - Serial Console Management (see page 21)
  - Wired Ethernet Management (see page 21)
  - Configure the Hostname and Timezone (see page 22)
  - Verify the System Time (see page 23)
  - Install the License (see page 23)
- Configure Breakout Ports with Splitter Cables (see page 24)
- Test Cable Connectivity (see page 24)
- Configure Switch Ports (see page 26)
  - Layer 2 Port Configuration (see page 26)
  - Layer 3 Port Configuration (see page 27)
- Configure a Loopback Interface (see page 29)



## Install Cumulus Linux

To install Cumulus Linux, you use [ONIE](#) (Open Network Install Environment), an extension to the traditional U-Boot software that allows for automatic discovery of a network installer image. This facilitates the ecosystem model of procuring switches with an operating system choice, such as Cumulus Linux.



If Cumulus Linux is already installed on your switch and you need to upgrade the software only, skip to [Upgrading Cumulus Linux \(see page 45\)](#).

The easiest way to install Cumulus Linux with ONIE is with local HTTP discovery:

1. If your host (laptop or server) is IPv6-enabled, make sure it is running a web server. If the host is IPv4-enabled, make sure it is running DHCP in addition to a web server.
2. [Download](#) the Cumulus Linux installation file to the root directory of the web server. Rename this file `onie-installer`.
3. Connect your host using an Ethernet cable to the management Ethernet port of the switch.
4. Power on the switch. The switch downloads the ONIE image installer and boots. You can watch the progress of the install in your terminal. After the installation completes, the Cumulus Linux login prompt appears in the terminal window.



These steps describe a flexible unattended installation method. You do not need a console cable. A fresh install with ONIE using a local web server typically completes in less than ten minutes.

You have more options for installing Cumulus Linux with ONIE. Read [Installing a New Cumulus Linux Image \(see page 35\)](#) to install Cumulus Linux using ONIE in the following ways:

- DHCP/web server with and without DHCP options
- Web server without DHCP
- FTP or TFTP without a web server
- Local file
- USB

ONIE supports many other discovery mechanisms using USB (copy the installer to the root of the drive), DHCPv6 and DHCPv4, and image copy methods including HTTP, FTP, and TFTP. For more information on these discovery methods, refer to the [ONIE documentation](#).

After installing Cumulus Linux, you are ready to:

- Log in to Cumulus Linux on the switch.
- Install the Cumulus Linux license.
- Configure Cumulus Linux. This quick start guide provides instructions on configuring switch ports and a loopback interface.



## Getting Started

When starting Cumulus Linux for the first time, the management port makes a DHCPv4 request. To determine the IP address of the switch, you can cross reference the MAC address of the switch with your DHCP server. The MAC address is typically located on the side of the switch or on the box in which the unit ships.

### Login Credentials

The default installation includes one system account, `root`, with full system privileges, and one user account, `cumulus`, with `sudo` privileges. The `root` account password is set to null by default (which prohibits login), while the `cumulus` account is configured with this default password:

```
CumulusLinux!
```

In this quick start guide, you use the `cumulus` account to configure Cumulus Linux.



For optimum security, change the default password (using the `passwd` command) before you configure Cumulus Linux on the switch.

All accounts except `root` are permitted remote SSH login; you can use `sudo` to grant a non-root account root-level access. Commands that change the system configuration require this elevated level of access.

For more information about `sudo`, read [Using sudo to Delegate Privileges \(see page 116\)](#).

### Serial Console Management

You are encouraged to perform management and configuration over the network, [either in band or out of band \(see page 116\)](#). Using a serial console is fully supported; however, many customers prefer the convenience of network-based management.

Typically, switches ship from the manufacturer with a mating DB9 serial cable. Switches with ONIE are always set to a 115200 baud rate.

### Wired Ethernet Management

Switches supported in Cumulus Linux always contain at least one dedicated Ethernet management port, which is named `eth0`. This interface is geared specifically for out-of-band management use. The management interface uses DHCPv4 for addressing by default. You can set a static IP address with the Network Command Line Utility (NCLU).



#### Example IP Configuration

Set the static IP address with the `interface address` and `interface gateway` NCLU commands:



```
cumulus@switch:~$ net add interface eth0 ip address 192.0.2.42  
/24  
cumulus@switch:~$ net add interface eth0 ip gateway 192.0.2.1  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

These commands produce the following snippet in the `/etc/network/interfaces` file:

```
auto eth0  
iface eth0  
    address 192.0.2.42/24  
    gateway 192.0.2.1
```

## Configure the Hostname and Timezone

To change the hostname, run `net add hostname`, which modifies both the `/etc/hostname` and `/etc/hosts` files with the desired hostname.

```
cumulus@switch:~$ net add hostname <hostname>  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```



The command prompt in the terminal does not reflect the new hostname until you either log out of the switch or start a new shell.



When you use this NCLU command to set the hostname, DHCP **does not** override the hostname when you reboot the switch. However, if you disable the hostname setting with NCLU, DHCP **does** override the hostname the next time you reboot the switch.

To update the timezone, use NTP interactive mode:

1. Run the following command in a terminal:

```
sudo dpkg-reconfigure tzdata
```

2. Follow the on screen menu options to select the geographic area and region.



Programs that are already running (including log files) and users currently logged in, do not see timezone changes made with interactive mode. To have the timezone set for all services and daemons, a reboot is required.



## Verify the System Time

Before you install the license, verify that the date and time on the switch are correct. You must [correct the date and time \(see page 99\)](#) if they are incorrect. The wrong date and time can have impacts on the switch, such as the inability to synchronize with Puppet or return errors like this one after you restart `switchd`:

*Warning: Unit file of `switchd.service` changed on disk, 'systemctl daemon-reload' recommended.*

## Install the License

Cumulus Linux is licensed on a per-instance basis. Each network system is fully operational, enabling any capability to be utilized on the switch with the exception of forwarding on switch panel ports. Only `eth0` and console ports are activated on an unlicensed instance of Cumulus Linux. Enabling front panel ports requires a license.

You receive a license key from Cumulus Networks or an authorized reseller. Here is a sample license key:

```
user@company.com|thequickbrownfoxjumpsoverthelazydog312
```

There are three ways to install the license onto the switch:

- Copy the license from a local server. Create a text file with the license and copy it to a server accessible from the switch. On the switch, use the following command to transfer the file directly on the switch, then install the license file:

```
cumulus@switch:~$ scp user@my_server:/home/user/my_license_file.txt .
cumulus@switch:~$ sudo cl-license -i my_license_file.txt
```

- Copy the file to an HTTP server (not HTTPS), then reference the URL when you run `cl-license`:

```
cumulus@switch:~$ sudo cl-license -i <URL>
```

- Copy and paste the license key into the `cl-license` command:

```
cumulus@switch:~$ sudo cl-license -i
<paste license key>
^+d
```



It is not necessary to reboot the switch to activate the switch ports. After you install the license, restart the `switchd` service. All front panel ports become active and show up as `swp1`, `swp2`, and so on.



```
cumulus@switch:~$ sudo systemctl restart switchd.service
```



If a license is not installed on a Cumulus Linux switch, the `switchd` service does not start. After you install the license, start `switchd` as described above.

## Configure Breakout Ports with Splitter Cables

If you are using 4x10G DAC or AOC cables, or want to break out 100G or 40G switch ports, configure the breakout ports. For more details, see [Layer 1 and Switch Port Attributes \(see page 261\)](#).

## Test Cable Connectivity

By default, all data plane ports (every Ethernet port except the management interface, `eth0`) are disabled. To test cable connectivity, administratively enable a port:

```
cumulus@switch:~$ net add interface swp1
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

To administratively enable all physical ports, run the following command, where `swp1-52` represents a switch with switch ports numbered from `swp1` to `swp52`:

```
cumulus@switch:~$ net add interface swp1-52
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

To view link status, use the `net show interface all` command. The following examples show the output of ports in `admin down`, `down`, and `up` modes:

```
cumulus@switch:~$ net show interface all
State  Name          Spd   MTU    Mode
LLDP           Summary
-----  -----
UP      lo          N/A   65536
Loopback                                IP: 127.0.0.1/8
                                         IP:
lo
10.0.0.11/32
```



```
lo IP:  
10.0.0.112/32  
  
lo IP:  
::1/128  
UP eth0 1G 1500 Mgmt oob-mgmt-switch  
(swp6) Master: mgmt(UP)  
  
eth0 IP:  
192.168.0.11/24(DHCP)  
UP swp1 1G 9000 BondMember server01  
(eth1) Master: bond01(UP)  
UP swp2 1G 9000 BondMember server02  
(eth1) Master: bond02(UP)  
ADMDN swp45 N/A 1500 NotConfigured  
ADMDN swp46 N/A 1500 NotConfigured  
ADMDN swp47 N/A 1500 NotConfigured  
ADMDN swp48 N/A 1500 NotConfigured  
UP swp49 1G 9000 BondMember leaf02  
(swp49) Master: peerlink(UP)  
UP swp50 1G 9000 BondMember leaf02  
(swp50) Master: peerlink(UP)  
UP swp51 1G 9216 NotConfigured spine01 (swp1)  
UP swp52 1G 9216 NotConfigured spine02 (swp1)  
UP bond01 1G 9000 802.3  
ad Master: bridge(UP)  
  
bond01  
Bond Members: swp1(UP)  
UP bond02 1G 9000 802.3  
ad Master: bridge(UP)  
  
bond02  
Bond Members: swp2(UP)  
UP bridge N/A 1500 Bridge/L2  
UP mgmt N/A 65536 Interface  
/L3 IP: 127.0.0.1/8  
UP peerlink 2G 9000 802.3  
ad Master: bridge(UP)  
  
peerlink  
Bond Members: swp49(UP)  
  
peerlink  
Bond Members: swp50(UP)  
DN peerlink.4094 2G 9000 SubInt  
/L3 IP: 169.254.1.1/30  
ADMDN vagrant N/A 1500 NotConfigured  
UP vlan13 N/A 1500 Interface  
/L3 Master: vrf1(UP)
```



```
vlan13 IP:  
10.1.3.11/24  
UP     vlan13-v0      N/A  1500  Interface  
/L3          Master: vrf1(UP)  
    vlan13-  
  
v0 IP:  
10.1.3.1/24  
UP     vlan24      N/A  1500  Interface  
/L3          Master: vrf1(UP)  
  
vlan24 IP:  
10.2.4.11/24  
UP     vlan24-v0      N/A  1500  Interface  
/L3          Master: vrf1(UP)  
    vlan24-  
  
v0 IP:  
10.2.4.1/24  
UP     vlan4001      N/A  1500  
NotConfigured          Master: vrf1(UP)  
UP     vni13       N/A  9000  Access  
/L2          Master: bridge(UP)  
UP     vni24       N/A  9000  Access  
/L2          Master: bridge(UP)  
UP     vrf1        N/A  65536 NotConfigured  
UP     vxlan4001     N/A  1500  Access  
/L2          Master: bridge(UP)
```

## Configure Switch Ports

### Layer 2 Port Configuration

Cumulus Linux does not put all ports into a bridge by default. To create a bridge and configure one or more front panel ports as members of the bridge, use the following examples as a guide.

#### Examples

##### ① Example One

In the following configuration example, the front panel port `swp1` is placed into a bridge called `bridge`. The NCLU commands are:

```
cumulus@switch:~$ net add bridge bridge ports swp1  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

The commands above produce the following `/etc/network/interfaces` snippet:



```
auto bridge
iface bridge
    bridge-ports swp1
    bridge-vlan-aware yes
```

## Example Two

You can add a range of ports in one command. For example, add swp1 through swp10, swp12, and swp14 through swp20 to bridge:

```
cumulus@switch:~$ net add bridge bridge ports swp1-10,12,14-20
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

The commands above produce the following snippet in the `/etc/network/interfaces` file:

```
auto bridge
iface bridge
    bridge-ports swp1 swp2 swp3 swp4 swp5 swp6 swp7 swp8
    swp9 swp10 swp12 swp14 swp15 swp16 swp17 swp18 swp19 swp20
    bridge-vlan-aware yes
```

To view the changes in the kernel, use the `brctl` command:

```
cumulus@switch:~$ brctl show
bridge name      bridge id          STP enabled      interfaces
bridge           8000.443839000004    yes              swp1
                                         swp2
```

## Layer 3 Port Configuration

You can also use NCLU to configure a front panel port or bridge interface as a layer 3 port.

In the following configuration example, the front panel port swp1 is configured as a layer 3 access port:

```
cumulus@switch:~$ net add interface swp1 ip address 10.1.1.1/30
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

The commands above produce the following snippet in the `/etc/network/interfaces` file:



```
auto swp1
iface swp1
    address 10.1.1.1/30
```

To add an IP address to a bridge interface, you must put it into a VLAN interface:

```
cumulus@switch:~$ net add vlan 100 ip address 10.2.2.1/24
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

The commands above produce the following snippet in the /etc/network/interfaces file:

```
auto bridge
iface bridge
    bridge-vids 100
    bridge-vlan-aware yes

auto vlan100
iface vlan100
    address 192.168.10.1/24
    vlan-id 100
    vlan-raw-device bridge
```

To view the changes in the kernel, use the `ip addr show` command:

```
cumulus@switch:~$ ip addr show
...
4: swp1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast
    master bridge state UP group default qlen 1000
        link/ether 44:38:39:00:6e:fe brd ff:ff:ff:ff:ff:ff
...
14: bridge: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue
    state UP group default
        link/ether 44:38:39:00:00:04 brd ff:ff:ff:ff:ff:ff
        inet6 fe80::4638:39ff:fe00:4/64 scope link
            valid_lft forever preferred_lft forever
...
```



## Configure a Loopback Interface

Cumulus Linux has a loopback preconfigured in the `/etc/network/interfaces` file. When the switch boots up, it has a loopback interface, called `lo`, which is up and assigned an IP address of 127.0.0.1.

- ✔ The loopback interface `lo` must always be specified in the `/etc/network/interfaces` file and must always be up.

To see the status of the loopback interface (`lo`), use the `net show interface lo` command:

```
cumulus@switch:~$ net show interface lo
  Name      MAC              Speed      MTU      Mode
  --  -----  -----  -----  -----
UP   lo      00:00:00:00:00:00  N/A       65536    Loopback

  Alias
  -----
  loopback interface
  IP Details
  -----
  IP:                  127.0.0.1/8, ::1/128
  IP Neighbor(ARP) Entries: 0
```

Note that the loopback is up and is assigned an IP address of 127.0.0.1.

To add an IP address to a loopback interface, configure the `lo` interface with NCLU:

```
cumulus@switch:~$ net add loopback lo ip address 10.1.1.1/32
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

You can configure multiple loopback addresses by adding additional address lines:

```
cumulus@switch:~$ net add loopback lo ip address 172.16.2.1/24
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

The commands above produce the following snippet in the `/etc/network/interfaces` file:

```
auto lo
iface lo inet loopback
  address 10.1.1.1/32
  address 172.16.2.1/24
```





# Installation Management

You can only install one image of the operating system on a Cumulus Linux switch. This section discusses how to install new and update existing Cumulus Linux disk images, and configure those images with additional applications (using packages) if desired.

Zero touch provisioning provides a way to quickly deploy and configure new switches in a large-scale environment.

## Managing Cumulus Linux Disk Images

The Cumulus Linux operating system resides on a switch as a *disk image*. This section discusses how to manage the disk image.

For information on installing a new Cumulus Linux disk image, refer to [Installing a New Cumulus Linux Image \(see page 35\)](#). For information on upgrading Cumulus Linux, refer to [Upgrading Cumulus Linux \(see page 45\)](#).

## Contents

This topic describes ...

- Determine the Switch Platform (see page 31)
- Reprovision the System (Restart the Installer) (see page 31)
- Uninstall All Images and Remove the Configuration (see page 32)
- Boot into Rescue Mode (see page 33)
- Inspect the Image File (see page 33)
- Related Information (see page 34)

## Determine the Switch Platform

To determine if your switch is on an x86 or ARM platform, run the `uname -m` command.

For example, on an x86 platform, `uname -m` outputs `x86_64`:

```
cumulus@x86switch$ uname -m
x86_64
```

On an ARM platform, `uname -m` outputs `armv7l`:

```
cumulus@ARMswitch$ uname -m
armv7l
```

You can also visit the HCL ([hardware compatibility list](#)) to look at your hardware and determine the processor type.



## Revision the System (Restart the Installer)

Revisioning the system deletes all system data from the switch.

To initiate the provisioning and installation process, run the `onie-select -i` command:

```
cumulus@switch:~$ sudo onie-select -i
WARNING:
WARNING: Operating System install requested.
WARNING: This will wipe out all system data.
WARNING:
Are you sure (y/N)? y
Enabling install at next reboot...done.
Reboot required to take effect.
```



A reboot is required for the reinstall to begin.



To cancel a pending reinstall operation, run the `onie-select -c` command:

```
cumulus@switch:~$ sudo onie-select -c
 Cancelling pending install at next reboot...done.
```

## Uninstall All Images and Remove the Configuration

To remove all installed images and configurations and return the switch to its factory defaults, run the `onie-select -k` command:

```
cumulus@switch:~$ sudo onie-select -k
WARNING:
WARNING: Operating System uninstall requested.
WARNING: This will wipe out all system data.
WARNING:
Are you sure (y/N)? y
Enabling uninstall at next reboot...done.
Reboot required to take effect.
```



A reboot is required for the uninstall to begin.





- To cancel a pending uninstall operation, run the `onie-select -c` command:

```
cumulus@switch:~$ sudo onie-select -c  
Cancelling pending uninstall at next reboot...done.
```

## Boot into Rescue Mode

If your system becomes broken in some way, you can correct certain issues by booting into ONIE rescue mode. In rescue mode, the file systems are unmounted and you can use various Cumulus Linux utilities to try and resolve a problem.

To reboot the system into ONIE rescue mode, run the `onie-select -r` command:

```
cumulus@switch:~$ sudo onie-select -r  
WARNING:  
WARNING: Rescue boot requested.  
WARNING:  
Are you sure (y/N)? y  
Enabling rescue at next reboot...done.  
Reboot required to take effect.
```



A reboot is required to boot into rescue mode.



- To cancel a pending rescue boot operation, run the `onie-select -c` command:

```
cumulus@switch:~$ sudo onie-select -c  
Cancelling pending rescue at next reboot...done.
```

## Inspect the Image File

The Cumulus Linux installation disk image file is executable. From a running switch, you can display, extract, and verify the contents of the image file.

To display the contents of the Cumulus Linux image file, pass the `info` option to the image file. For example, to display the contents of an image file called `onie-installer` located in the `/var/lib/cumulus/installer` directory:

```
cumulus@switch:~$ sudo /var/lib/cumulus/installer/onie-installer info  
Verifying image checksum ...OK.  
Preparing image archive ... OK.
```



```
Control File Contents
=====
Description: Cumulus Linux 3.7.6
Release: 3.7.6
Architecture: amd64
Switch-Architecture: bcm-amd64
Build-Id: 03bbebdzc4d0ff5
Build-Date: 2019-05-01T19:04:25+0000
Build-User: clbuilder
Homepage: http://www.cumulusnetworks.com/
Min-Disk-Size: 1073741824
Min-Ram-Size: 536870912
mkimage-version: 0.11.118_gf541
```

To extract the contents of the image file, use with the `extract <path>` option. For example, to extract an image file called `onie-installer` located in the `/var/lib/cumulus/installer` directory to the `mypath` directory:

```
cumulus@switch:~$ sudo /var/lib/cumulus/installer/onie-installer
extract mypath
total 181860
-rw-r--r-- 1 4000 4000 308 May 16 19:04 control
drwxr-xr-x 5 4000 4000 4096 Apr 26 21:28 embedded-installer
-rw-r--r-- 1 4000 4000 13273936 May 16 19:04 initrd
-rw-r--r-- 1 4000 4000 4239088 May 16 19:04 kernel
-rw-r--r-- 1 4000 4000 168701528 May 16 19:04 sysroot.tar
```

To verify the contents of the image file, use with the `verify` option. For example, to verify the contents of an image file called `onie-installer` located in the `/var/lib/cumulus/installer` directory:

```
cumulus@switch:~$ sudo /var/lib/cumulus/installer/onie-installer
verify
Verifying image checksum ...OK.
Preparing image archive ... OK.
./cumulus-linux-bcm-amd64.bin.1: 161: ./cumulus-linux-bcm-amd64.bin.
1: onie-sysinfo: not found
Verifying image compatibility ...OK.
Verifying system ram ...OK.
```

## Related Information

[Open Network Install Environment \(ONIE\) Home Page](#)



## Installing a New Cumulus Linux Image

This topic discusses how to install a new Cumulus Linux disk image using [ONIE](#), an open source project (equivalent to PXE on servers) that enables the installation of network operating systems (NOS) on bare metal switches.

Before you install Cumulus Linux, the switch can be in two different states:

- No image is installed on the switch (the switch is only running ONIE).
- Cumulus Linux is already installed on the switch but you want to use ONIE to reinstall Cumulus Linux or upgrade to a newer version.

The sections below describe some of the different ways you can install the Cumulus Linux disk image, such as using a DHCP/web server, FTP, a local file, or a USB drive. Steps are provided for both installing directly from ONIE (if no image is installed on the switch) and from Cumulus Linux (if the image is already installed on the switch), where applicable. For additional methods to find and install the Cumulus Linux image, see the [ONIE Design Specification](#).

You can download a Cumulus Linux image from the [Cumulus Networks Downloads](#) page.



Installing the Cumulus Linux disk image is destructive; configuration files on the switch are not saved; copy them to a different server before installing.

## Contents

### This topic describes ...

- [Install Using a DHCP/Web Server with DHCP Options \(see page 35\)](#)
- [Install Using a DHCP/Web Server without DHCP Options \(see page 36\)](#)
- [Install Using a Web Server with no DHCP \(see page 37\)](#)
- [Install Using FTP Without a Web Server \(see page 38\)](#)
- [Install Using a Local File \(see page 38\)](#)
- [Install Using a USB Drive \(see page 39\)](#)
  - [Prepare for USB Installation \(see page 40\)](#)
  - [Instructions for x86 Platforms \(see page 41\)](#)
  - [Instructions for ARM Platforms \(see page 43\)](#)
- [Related Information \(see page 45\)](#)

In the following procedures:

- You can name your Cumulus Linux installer disk image using any of the [ONIE naming schemes mentioned here](#).
- In the example commands, `[PLATFORM]` can be any supported Cumulus Linux platform, such as `x86_64`, or `arm`.
- Run the `sudo onie-install -h` command to show the ONIE installer options.
- After you install the Cumulus Linux disk image, you need to install the license file. Refer to [Install the License \(see page 23\)](#).

## Install Using a DHCP/Web Server with DHCP Options

To install Cumulus Linux using a DHCP/web server *with* DHCP options, set up a DHCP/web server on your laptop and connect the eth0 management port of the switch to your laptop. After you connect the cable, the installation proceeds as follows:

1. The bare metal switch boots up and requests an IP address (DHCP request).
2. The DHCP server acknowledges and responds with DHCP option 114 and the location of the installation image.
3. ONIE downloads the Cumulus Linux disk image, installs, and reboots.
4. Success! You are now running Cumulus Linux.



The most common method is to send DHCP option 114 with the entire URL to the web server (this can be the same system). However, there are many other ways to use DHCP even if you do not have full control over DHCP. See the ONIE user guide for help with [partial installer URLs](#) and [advanced DHCP options](#); both articles list more supported DHCP options.

Here is an example DHCP configuration with an [ISC DHCP server](#):

```
subnet 172.0.24.0 netmask 255.255.255.0 {
    range 172.0.24.20 172.0.24.200;
    option default-url = "http://172.0.24.14/onie-installer-[PLATFORM]" ;
}
```

Here is an example DHCP configuration with [dnsmasq](#) (static address assignment):

```
dhcp-host=sw4,192.168.100.14,6c:64:1a:00:03:ba,set:sw4
dhcp-option>tag:sw4,114,"http://roz.rtplab.test/onie-installer-
[PLATFORM]"
```

If you do not have a web server, you can use [this free Apache example](#).

## Install Using a DHCP/Web Server without DHCP Options

Follow the steps below if you have a laptop on the same network and the switch can pull DHCP from the corporate network, but you *cannot* modify DHCP options (maybe it is controlled by another team).

### Install from ONIE

1. Place the Cumulus Linux disk image in a directory on the web server.
2. Run the `onie-nos-install` command:



```
ONIE:/ #onie-nos-install http://10.0.1.251/path/to/cumulus-
install-[PLATFORM].bin
```

## Install from Cumulus Linux

1. Place the Cumulus Linux disk image in a directory on the web server.
2. From the Cumulus Linux command prompt, run the `onie-install` command:

```
cumulus@switch:~$ sudo onie-install -a -i http://10.0.1.251/path
/to/cumulus-install-[PLATFORM].bin && sudo reboot
```

## Install Using a Web Server with no DHCP

Follow the steps below if your laptop is on the same network as the switch eth0 interface but *no* DHCP server is available.

### Install from ONIE

1. ONIE is in *discovery mode*. You must disable discovery mode with the following command:

```
onie# onie-discovery-stop
```

On older ONIE versions, if the `onie-discovery-stop` command is not supported, run:

```
onie# /etc/init.d/discover.sh stop
```

2. Assign a static address to eth0 with the `ip addr add` command:

```
ONIE:/ #ip addr add 10.0.1.252/24 dev eth0
```

3. Place the Cumulus Linux disk image in a directory on your web server.
4. Run the installer manually (because there are no DHCP options):

```
ONIE:/ #onie-nos-install http://10.0.1.251/path/to/cumulus-
install-[PLATFORM].bin
```

### Install from Cumulus Linux

1. Place the Cumulus Linux disk image in a directory on your web server.
2. From the Cumulus Linux command prompt, run the `onie-install` command:



```
cumulus@switch:~$ sudo onie-install -a -i http://10.0.1.251/path  
/to/cumulus-install-[PLATFORM].bin && sudo reboot
```

## Install Using FTP Without a Web Server

Follow the steps below if your laptop is on the same network as the switch eth0 interface but *no* DHCP server is available.

### Install from ONIE

1. Set up DHCP or static addressing for eth0. The following example assigns a static address to eth0:

```
ONIE:/ #ip addr add 10.0.1.252/24 dev eth0
```

2. If you are using static addressing, disable ONIE discovery mode:

```
onie# onie-discovery-stop
```

On older ONIE versions, if the `onie-discovery-stop` command is not supported, run:

```
onie# /etc/init.d/discover.sh stop
```

3. Place the Cumulus Linux disk image into a TFTP or FTP directory.
4. If you are not using DHCP options, run one of the following commands (`tftp` for TFTP or `ftp` for FTP):

```
ONIE# onie-nos-install ftp://local-ftp-server/cumulus-install-  
[PLATFORM].bin  
ONIE# onie-nos-install tftp://local-tftp-server/cumulus-install-  
[PLATFORM].bin
```

### Install from Cumulus Linux

1. Place the Cumulus Linux disk image into a TFTP or FTP directory.
2. From the Cumulus Linux command prompt, run one of the following commands (`tftp` for TFTP or `ftp` for FTP):

```
cumulus@switch:~$ sudo onie-install -a -i ftp://local-ftp-server  
/cumulus-install-[PLATFORM].bin && sudo reboot  
cumulus@switch:~$ sudo onie-install -a -i tftp://local-tftp-server  
/cumulus-install-[PLATFORM].bin && sudo reboot
```



## Install Using a Local File

Follow the steps below to install the disk image referencing a local file.

### Install from ONIE

1. Set up DHCP or static addressing for eth0. The following example assigns a static address to eth0:

```
ONIE:/ #ip addr add 10.0.1.252/24 dev eth0
```

2. If you are using static addressing, disable ONIE discovery mode.

```
onie# onie-discovery-stop
```

On older ONIE versions, if the `onie-discovery-stop` command is not supported, run:

```
onie# /etc/init.d/discover.sh stop
```

3. Use `scp` to copy the Cumulus Linux disk image to the switch. (Windows users can use [WinScp](#).)
4. Run the installer manually from ONIE:

```
ONIE:/ #onie-nos-install /path/to/local/file/cumulus-install-[PLATFORM].bin
```

### Install from Cumulus Linux

1. Copy the Cumulus Linux disk image to the switch.
2. From the Cumulus Linux command prompt, run the `onie-install` command:

```
cumulus@switch:~$ sudo onie-install -a -i /path/to/local/file/cumulus-install-[PLATFORM].bin && sudo reboot
```

## Install Using a USB Drive

Follow the steps below to install the Cumulus Linux disk image using a USB drive. Instructions are provided for x86 and ARM platforms.

### ⓘ Tips

- Installing Cumulus Linux using a USB drive is fine for a single switch here and there but is not scalable. DHCP can scale to hundreds of switch installs with zero manual input unlike USB installs.



- Cumulus Networks also provides *Cumulus on a Stick*, which packages Cumulus Linux images with your license. You can download your personalized ZIP file, transfer it to a USB drive, insert the drive into your switch, apply power, and you are ready to go. See [Cumulus on a Stick](#) for information.

## Prepare for USB Installation

1. From the [Cumulus Networks Downloads page](#), download the appropriate Cumulus Linux image for your x86 or ARM platform.
2. From a computer, prepare your USB drive by formatting it using one of the supported formats: FAT32, vFAT or EXT2.

### Optional: Prepare a USB Drive inside Cumulus Linux

**!** Use caution when performing the actions below; it is possible to severely damage your system with the following utilities.

- a. Insert your USB drive into the USB port on the switch running Cumulus Linux and log in to the switch.
- b. Examine output from `cat /proc/partitions` and `sudo fdisk -l [device]` to determine on which device your USB drive can be found. For example, `sudo fdisk -l /dev/sdb`.

**!** These instructions assume your USB drive is the `/dev/sdb` device, which is typical if you insert the USB drive after the machine is already booted. However, if you insert the USB drive during the boot process, it is possible that your USB drive is the `/dev/sda` device. Make sure to modify the commands below to use the proper device for your USB drive.

- c. Create a new partition table on the USB drive:

```
sudo parted /dev/sdb mklabel msdos
```

**!** The `parted` utility should already be installed. However, if it is not, install it with:  
`sudo -E apt-get install parted`

- d. Create a new partition on the USB drive:

```
sudo parted /dev/sdb -a optimal mkpart primary 0% 100%
```

- e. Format the partition to your filesystem of choice using one of the examples below:



```
sudo mkfs.ext2 /dev/sdb1
sudo mkfs.msdos -F 32 /dev/sdb1
sudo mkfs.vfat /dev/sdb1
```



To use `mkfs.msdos` or `mkfs.vfat`, you need to install the `dosfstools` package from the [Debian software repositories](#), as they are not included by default.

- f. To continue installing Cumulus Linux, mount the USB drive to move files.

```
sudo mkdir /mnt/usb
sudo mount /dev/sdb1 /mnt/usb
```

3. Copy the Cumulus Linux disk image to the USB drive, then rename the image file to:

- `onie-installer-x86_64`, if installing on an x86 platform
- `onie-installer-arm`, if installing on an ARM platform



You can also use any of the [ONIE naming schemes mentioned here](#).



When using a Mac or Windows computer to rename the installation file, the file extension might still be present. Make sure to remove the file extension otherwise ONIE is not able to detect the file.

4. Insert the USB drive into the switch, then continue with the appropriate instructions below for your x86 or ARM platform.

### *Instructions for x86 Platforms*

[Click to expand x86 instructions...](#)

1. Prepare the switch for installation:

- If the switch is offline, connect to the console and power on the switch.
- If the switch is already online in ONIE, use the `reboot` command.



SSH sessions to the switch get dropped after this step. To complete the remaining instructions, connect to the console of the switch. Cumulus Linux switches display their boot process to the console; you need to monitor the console specifically to complete the next step.

2. Monitor the console and select the ONIE option from the first GRUB screen shown below.

3. Cumulus Linux on x86 uses GRUB chainloading to present a second GRUB menu specific to the ONIE partition. No action is necessary in this menu to select the default option *ONIE: Install OS*.

```
+-----+  
| *ONIE: Install OS  
| ONIE: Rescue  
| ONIE: Uninstall OS  
| ONIE: Update ONIE  
| ONIE: Embed ONIE  
|  
|  
|  
|  
|  
|  
+-----+
```

- The USB drive is recognized and mounted automatically. The image file is located and automatic installation of Cumulus Linux begins. Here is some sample output:

```
ONIE: OS Install Mode ...
Version : quanta_common_rangeley-2014.05.05-6919d98-201410171013
Build Date: 2014-10-17T10:13+0800
Info: Mounting kernel filesystems... done.
Info: Mounting LABEL=ONIE-BOOT on /mnt/onie-boot ...
initializing eth0...
scsi 6:0:0:0: Direct-Access SanDisk Cruzer Facet 1.26 PQ: 0
ANSI: 6
sd 6:0:0:0: [sdb] 31266816 512-byte logical blocks: (16.0 GB/14.
9 GiB)
sd 6:0:0:0: [sdb] Write Protect is off
sd 6:0:0:0: [sdb] Write cache: disabled, read cache: enabled,
doesn't support DPO or FUA
sd 6:0:0:0: [sdb] Attached SCSI disk
```



```
<...snip...>
ONIE: Executing installer: file://dev/sdb1/onie-installer-x86_64
Verifying image checksum ... OK.
Preparing image archive ... OK.
Dumping image info...
Control File Contents
=====
Description: Cumulus Linux
OS-Release: 3.0.0-3b46bef-201509041633-build
Architecture: amd64
Date: Fri, 27 May 2016 17:10:30 -0700
Installer-Version: 1.2
Platforms: accton_as5712_54x accton_as6712_32x
mlx_sx1400_i73612 dell_s6000_s1220 dell_s4000_c2338
dell_s3000_c2338 cel_redstone_xp cel_smallstone_xp cel_pebble
quanta_panther quanta_ly8_rangeley quanta_ly6_rangeley
quanta_ly9_rangeley
Homepage: http://www.cumulusnetworks.com/
```

5. After installation completes, the switch automatically reboots into the newly installed instance of Cumulus Linux.

### *Instructions for ARM Platforms*

#### **Click to expand ARM instructions...**

1. Prepare the switch for installation:

- If the switch is offline, connect to the console and power on the switch.
- If the switch is already online in ONIE, use the `reboot` command.



SSH sessions to the switch get dropped after this step. To complete the remaining instructions, connect to the console of the switch. Cumulus Linux switches display their boot process to the console; you need to monitor the console specifically to complete the next step.

2. Interrupt the normal boot process before the countdown (shown below) completes. Press any key to stop the autoboot.

```
U-Boot 2013.01-00016-gddbf4a9-dirty (Feb 14 2014 - 16:30:46)
Accton: 1.4.0.5
CPU0: P2020, Version: 2.1, (0x80e20021)
Core: E500, Version: 5.1, (0x80211051)
Clock Configuration:
    CPU0:1200 MHz, CPU1:1200 MHz,
    CCB:600 MHz,
    DDR:400 MHz (800 MT/s data rate) (Asynchronous), LBC:37.500 MHz
L1: D-cache 32 kB enabled
    I-cache 32 kB enabled
<...snip...>
```



```
USB: USB2513 hub OK
Hit any key to stop autoboot: 0
```

3. A command prompt appears so that you can run commands. Execute the following command:

```
run onie_bootcmd
```

4. The USB drive is recognized and mounted automatically. The image file is located and automatic installation of Cumulus Linux begins. Here is some sample output:

```
Loading Open Network Install Environment ...
Platform: arm-as4610_54p-r0
Version : 1.6.1.3
WARNING: adjusting available memory to 30000000
## Booting kernel from Legacy Image at ec040000 ...
    Image Name:    as6701_32x.1.6.1.3
    Image Type:    ARM Linux Multi-File Image (gzip compressed)
    Data Size:    4456555 Bytes = 4.3 MiB
    Load Address: 00000000
    Entry Point:  00000000
    Contents:
        Image 0: 3738543 Bytes = 3.6 MiB
        Image 1: 706440 Bytes = 689.9 KiB
        Image 2: 11555 Bytes = 11.3 KiB
    Verifying Checksum ... OK
## Loading init Ramdisk from multi component Legacy Image at
ec040000 ...
## Flattened Device Tree from multi component Image at EC040000
    Booting using the fdt at 0xec47d388
    Uncompressing Multi-File Image ... OK
    Loading Ramdisk to 2ff53000, end 2fffff788 ... OK
    Loading Device Tree to 03ffa000, end 03ffffd22 ... OK
<...snip...
ONIE: Starting ONIE Service Discovery
ONIE: Executing installer: file://dev/sdb1/onie-installer-arm
Verifying image checksum ... OK.
Preparing image archive ... OK.
Dumping image info...
Control File Contents
=====
Description: Cumulus Linux
OS-Release: 3.0.0-3b46bef-201509041633-build
Architecture: arm
Date: Fri, 27 May 2016 17:08:35 -0700
Installer-Version: 1.2
Platforms: accton_as4600_54t, accton_as6701_32x, accton_5652,
accton_as5610_52x, dni_6448, dni_7448, dni_c7448n, cel_kennisis,
cel_redstone, cel_smallstone, cumulus_p2020, quanta_lb9,
quanta_ly2, quanta_ly2r, quanta_ly6_p2020
```



Homepage: <http://www.cumulusnetworks.com/>

5. After installation completes, the switch automatically reboots into the newly installed instance of Cumulus Linux.

## Related Information

- ONIE Design Specification
- Cumulus Networks Downloads page
- Cumulus on a Stick
- Managing Cumulus Linux Disk Images (see page 31)

## Upgrading Cumulus Linux

This topic describes how to upgrade Cumulus Linux on your switches to a more recent release.

Cumulus Networks recommends that you deploy, provision, configure, and upgrade switches using automation, even with small networks or test labs. During the upgrade process, you can quickly upgrade dozens of devices in a repeatable manner. Using tools like Ansible, Chef, or Puppet for configuration management greatly increases the speed and accuracy of the next major upgrade; these tools also enable the quick swap of failed switch hardware.

## Contents

### This topic describes ...

- Before You Upgrade Cumulus Linux (see page 45)
- Upgrade Cumulus Linux (see page 49)
  - Should I Install a Disk Image or Upgrade Packages? (see page 49)
  - Disk Image Install (ONIE) (see page 50)
  - Package Upgrade (see page 51)
  - Upgrade Notes (see page 52)
- Upgrade Switches in an MLAG Pair (see page 53)
  - Upgrade from Cumulus Linux 3.y.z to a Later 3.y.z Release (see page 53)
  - Upgrade from Cumulus Linux 2.y.z to 3.y.z (see page 54)
- Roll Back a Cumulus Linux Installation (see page 56)
- Third Party Packages (see page 56)
- Related Information (see page 56)

## Before You Upgrade Cumulus Linux



Be sure to read the knowledge base article [Upgrades: Network Device and Linux Host Worldview Comparison](#), which provides a detailed comparison between the network device and Linux host worldview of upgrade and installation.

Understanding the location of configuration data is required for successful upgrades, migrations, and backup. As with other Linux distributions, the `/etc` directory is the primary location for all configuration data in Cumulus Linux. The following list is a likely set of files that you need to back up and migrate to a new release. Make sure you examine any file that has been changed. Cumulus Networks recommends you consider making the following files and directories part of a backup strategy.

### Network Configuration Files

File Name and Location	Explanation	Cumulus Linux Documentation	Debian Documentation
<code>/etc/network/</code>	Network configuration files, most notably <code>/etc/network/interfaces</code> and <code>/etc/network/interfaces.d/</code>	<a href="#">Switch Port Attributes (see page 239)</a>	N/A
<code>/etc/resolv.conf</code>	DNS resolution	Not unique to Cumulus Linux: <a href="http://wiki.debian.org/NetworkConfiguration">wiki.debian.org/NetworkConfiguration</a>	<a href="http://www.debian.org/doc/manuals/debian-reference/ch05.en.html">www.debian.org/doc/manuals/debian-reference/ch05.en.html</a>
<code>/etc/frr/</code>	Routing application (responsible for BGP and OSPF)	<a href="#">FRRouting Overview (see page 731)</a>	N/A
<code>/etc/hostname</code>	Configuration file for the hostname of the switch	<a href="#">Quick Start Guide (see page )</a>	<a href="http://wiki.debian.org/HowTo/ChangeHostname">wiki.debian.org/HowTo/ChangeHostname</a>
<code>/etc/cumulus/acl/*</code>	Netfilter configuration	<a href="#">Netfilter - ACLs (see page 142)</a>	N/A
<code>/etc/cumulus/ports.conf</code>	Breakout cable configuration file	<a href="#">Switch Port Attributes (see page )</a>	N/A; please read the guide on breakout cables
<code>/etc/cumulus/switchd.conf</code>	Switchd configuration	<a href="#">Configuring switchd (see page 204)</a>	N/A; please read the guide on switchd configuration



If you are using the root user account, consider including `/root/`.

If you have custom user accounts, consider including `/home/<username>/`.

### Additional Commonly Used Files



File Name and Location	Explanation	Cumulus Linux Documentation	Debian Documentation
/etc/motd	Message of the day	Not unique to Cumulus Linux	<a href="http://wiki.debian.org/motd">wiki.debian.org/motd</a>
/etc/passwd	User account information	Not unique to Cumulus Linux	<a href="http://www.debian.org/doc/manuals/debian-reference/ch04.en.html">www.debian.org/doc/manuals/debian-reference/ch04.en.html</a>
/etc/shadow	Secure user account information	Not unique to Cumulus Linux	<a href="http://www.debian.org/doc/manuals/debian-reference/ch04.en.html">www.debian.org/doc/manuals/debian-reference/ch04.en.html</a>
/etc/group	Defines user groups on the switch	Not unique to Cumulus Linux	<a href="http://www.debian.org/doc/manuals/debian-reference/ch04.en.html">www.debian.org/doc/manuals/debian-reference/ch04.en.html</a>
/etc/lldpd.conf	Link Layer Discover Protocol (LLDP) daemon configuration	<a href="#">Link Layer Discovery Protocol (see page 390)</a>	<a href="http://packages.debian.org/wheezy/llpd">packages.debian.org/wheezy/llpd</a>
/etc/lldpd.d/	Configuration directory for llpd	<a href="#">Link Layer Discovery Protocol (see page 390)</a>	<a href="http://packages.debian.org/wheezy/llpd">packages.debian.org/wheezy/llpd</a>
/etc/nsswitch.conf	Name Service Switch (NSS) configuration file	<a href="#">TACACS Plus (see page 122)</a>	N/A
/etc/ssh/	SSH configuration files	<a href="#">SSH for Remote Access (see page 112)</a>	<a href="http://wiki.debian.org/SSH">wiki.debian.org/SSH</a>
/etc/sudoers /etc/sudoers.d	Best practice is to place changes in /etc/sudoers.d/ instead of /etc/sudoers; changes in the /etc/sudoers.d/ directory are not lost during upgrade. If you are upgrading from a release prior to 3.2 (such as 3.1.2) to a 3.2 or later release, be aware that the sudoers file changed in Cumulus Linux 3.2.	<a href="#">Using sudo to Delegate Privileges (see page 116)</a>	



If you are using the root user account, consider including `/root/`.

If you have custom user accounts, consider including `/home/<username>/`.

### Files to Never Migrate between Versions or Switches

File Name and Location	Explanation
<code>/etc/bcm.d/</code>	Per-platform hardware configuration directory, created on first boot. Do not copy.
<code>/etc/mlx/</code>	Per-platform hardware configuration directory, created on first boot. Do not copy.
<code>/etc/default/clagd</code>	Created and managed by <code>ifupdown2</code> . Do not copy.
<code>/etc/default/grub</code>	Grub init table. Do not modify manually.
<code>/etc/default/hwclock</code>	Platform hardware-specific file. Created during first boot. Do not copy.
<code>/etc/init</code>	Platform initialization files. Do not copy.
<code>/etc/init.d/</code>	Platform initialization files. Do not copy.
<code>/etc/fstab</code>	Static info on filesystem. Do not copy.
<code>/etc/image-release</code>	System version data. Do not copy.
<code>/etc/os-release</code>	System version data. Do not copy.
<code>/etc/lsb-release</code>	System version data. Do not copy.
<code>/etc/lvm/archive</code>	Filesystem files. Do not copy.
<code>/etc/lvm/backup</code>	Filesystem files. Do not copy.
<code>/etc/modules</code>	Created during first boot. Do not copy.
<code>/etc/modules-load.d/</code>	Created during first boot. Do not copy.
<code>/etc/sensors.d</code>	Platform-specific sensor data. Created during first boot. Do not copy.
<code>/root/.ansible</code>	Ansible tmp files. Do not copy.



File Name and Location	Explanation
/home/cumulus/.ansible	Ansible tmp files. Do not copy.

If you are using certain forms of [network virtualization](#) (see page 490), including [VMware NSX-V](#) (see page 687) or [Midokura MidoNet](#) (see page 670), you might have updated the `/usr/share/openvswitch/scripts/ovs-ctl-vtep` file. This file is not marked as a configuration file; therefore, if the file contents change in a newer release of Cumulus Linux, they overwrite any changes you made to the file. Be sure to back up this file and the database file `conf.db` before upgrading.

## Upgrade Cumulus Linux

You can upgrade Cumulus Linux in one of two ways:

- Install a disk image of the new release, using ONIE.
- Upgrade only the changed packages using the `sudo -E apt-get update` and `sudo -E apt-get upgrade` command.



Upgrading an MLAG pair requires additional steps. If you are using MLAG to dual connect two Cumulus Linux switches in your environment, follow the steps in [Upgrade Switches in an MLAG Pair](#) (see page 53) below to ensure a smooth upgrade.

### Should I Install a Disk Image or Upgrade Packages?

The decision to upgrade Cumulus Linux by either installing a disk image or upgrading packages depends on your environment and your preferences. Here are some recommendations for each upgrade method.

**Installing a disk image** is recommended if you are performing a rolling upgrade in a production environment and if are using up-to-date and comprehensive automation scripts. This upgrade method enables you to choose the exact release to which you want to upgrade and is the *only* method available to upgrade your switch to a new release train (for example, from 2.5.6 to 3.7.0) or from a release earlier than 3.6.2.

Be aware of the following when installing the disk image:

- Installing a disk image is destructive; any configuration files on the switch are not saved; copy them to a different server before you start the disk image install.
- You must move configuration data to the new OS using ZTP or automation while the OS is first booted, or soon afterwards using out-of-band management.
- Moving a configuration file might cause issues;
  - Identifying all the locations of configuration data is not always an easy task. See [Before You Upgrade Cumulus Linux](#) (see page 45) above.
  - Merge conflicts with configuration file changes in the new release might go undetected.
- If configuration files are not restored correctly, you might be unable to ssh to the switch from in-band management. Out-of-band connectivity (eth0 or console) is recommended.
- You *must* reinstall and reconfigure third-party applications after upgrade.



**Package upgrade** is recommended if you are upgrading from Cumulus Linux 3.6.2 or later, or if you use third-party applications (package upgrade does not replace or remove third-party applications, unlike disk image install).

Be aware of the following when upgrading packages:

- You cannot upgrade the switch to a new release train. For example, you **cannot** upgrade the switch from **2.5.6** to **3.y.z**.
- If you are upgrading Cumulus Linux from a release earlier than 3.6.2, you might encounter certain issues due to package changes and service restarts.
- You cannot choose the exact release that you want to run. When you upgrade, you upgrade all packages to the latest available release in the Cumulus Networks repository.
- If you are upgrading from a release earlier than 3.6.2, certain upgrade operations terminate SSH sessions and/or routing on the in-band (front panel) ports, leaving you unable to monitor the upgrade process. (As a workaround, you can use the `dtach` tool.)
  - The `sudo -E apt-get upgrade` command might result in services being restarted or stopped as part of the upgrade process.
  - The `sudo -E apt-get install` command might disrupt core services by changing core service dependency packages.
- After you upgrade, account UIDs and GIDs created by packages might be different on different switches, depending on the configuration and package installation history.

## Disk Image Install (ONIE)

ONIE is an open source project (equivalent to PXE on servers) that enables the installation of network operating systems (NOS) on a bare metal switch.

To upgrade the switch with a new disk image using ONIE:

1. Back up the configurations off the switch.
2. Download the Cumulus Linux image you want to install.
3. Install the disk image with the `onie-install -a -i <image-location>` command, which boots the switch into ONIE.

The following example command installs the image from a web server, then reboots the switch. There are additional ways to install the disk image, such as using FTP, a local file, or a USB drive. For more information, see [Installing a New Cumulus Linux Image \(see page 35\)](#).

```
cumulus@switch:~$ sudo onie-install -a -i http://10.0.1.251
/cumulus-linux-3.7.1-mlx-amd64.bin && sudo reboot
```

4. Restore the configuration files to the new release — ideally with automation.
5. Verify correct operation with the old configurations on the new release.
6. Reinstall third party applications and associated configurations.



## Package Upgrade

Cumulus Linux completely embraces the Linux and Debian upgrade workflow, where you use an installer to install a base image, then perform any upgrades within that release train with `-E apt-get update` and `-E apt-get upgrade` commands. Any packages that have been changed since the base install get upgraded in place from the repository. All switch configuration files remain untouched, or in rare cases merged (using the Debian merge function) during the package upgrade.

When you use package upgrade to upgrade your switch, configuration data stays in place while the packages are upgraded. If the new release updates a configuration file that you changed previously, you are prompted for the version you want to use or if you want to evaluate the differences.

To upgrade the switch using package upgrade:

1. Back up the configurations from the switch.
2. Fetch the latest update metadata from the repository.

```
cumulus@switch:~$ sudo -E apt-get update
```

3. Review potential upgrade issues (in some cases, upgrading new packages might also upgrade additional existing packages due to dependencies). Run the following command to see the additional packages that will be installed or upgraded.

```
cumulus@switch:~$ sudo -E apt-get install --dry-run
```

4. Upgrade all the packages to the latest distribution.

```
cumulus@switch:~$ sudo -E apt-get upgrade
```

If no reboot is required after the upgrade completes, the upgrade ends, restarts all upgraded services, and logs messages in the `/var/log/syslog` file similar to the ones shown below. In the examples below, only the `frr` package was upgraded.

```
Policy: Service frr.service action stop postponed
Policy: Service frr.service action start postponed
Policy: Restarting services: frr.service
Policy: Finished restarting services
Policy: Removed /usr/sbin/policy-rc.d
Policy: Upgrade is finished
```

If the upgrade process encounters changed configuration files that have new versions in the release to which you are upgrading, you see a message similar to this:

```
Configuration file '/etc/frr/daemons'
==> Modified (by you or by a script) since installation.
==> Package distributor has shipped an updated version.
```



```
What would you like to do about it ? Your options are:  
Y or I : install the package maintainer's version  
N or O : keep your currently-installed version  
D : show the differences between the versions  
Z : start a shell to examine the situation  
The default action is to keep your current version.  
*** daemons (Y/I/N/O/D/Z) [default=N] ?
```

- To see the differences between the currently installed version and the new version, type **D**. To keep the currently installed version, type **N**. The new package version is installed with the suffix **\_dpkg-dist** (for example, **/etc/frr/daemons.dpkg-dist**). When upgrade is complete and **before** you reboot, merge your changes with the changes from the newly installed file.
- To install the new version, type **I**. Your currently installed version is saved with the suffix **.dpkg-old**.

When the upgrade is complete, you can search for the files with the **sudo find / -mount -type f -name '\*.\*dpkg-\*'** command.



If you see errors for expired GPG keys that prevent you from upgrading packages, follow the steps in [Upgrading Expired GPG Keys](#).

5. Reboot the switch if the upgrade messages indicate that a system restart is required.

```
cumulus@switch:~$ sudo -E apt-get upgrade  
... upgrade messages here ...  
  
*** Caution: Service restart prior to reboot could cause  
unpredictable behavior  
*** System reboot required ***  
cumulus@switch:~$ sudo reboot
```

6. Verify correct operation with the old configurations on the new version.

## Upgrade Notes

*Package upgrade* always updates to the latest available release in the Cumulus Linux repository. For example, if you are currently running Cumulus Linux 3.0.1 and run the **sudo -E apt-get upgrade** command on that switch, the packages are upgraded to the latest releases contained in the latest 3.y.z release.

Because Cumulus Linux is a collection of different Debian Linux packages, be aware of the following:

- The **/etc/os-release** and **/etc/lsb-release** files are updated to the currently installed Cumulus Linux release when you upgrade the switch using either *package upgrade* or *disk image install*. For example, if you run **sudo -E apt-get upgrade** and the latest Cumulus Linux release on the repository is 3.7.1, these two files display the release as 3.7.1 after the upgrade.
- The **/etc/image-release** file is updated **only** when you run a disk image install. Therefore, if you run a disk image install of Cumulus Linux 3.5.0, followed by a package upgrade to 3.7.1 using **sudo -E apt-get upgrade**, the **/etc/image-release** file continues to display Cumulus Linux 3.5.0, which is the originally installed base image.



## Upgrade Switches in an MLAG Pair

If you are using [MLAG \(see page 440\)](#) to dual connect two switches in your environment, follow the steps below according to the version of Cumulus Linux from which you are upgrading.

### *Upgrade from Cumulus Linux 3.y.z to a Later 3.y.z Release*

When you upgrade Cumulus Linux from 3.y.z to a later 3.y.z release, you can either install a disk image using ONIE or use package upgrade. Both methods are included below.

To upgrade the switches:

1. Verify the switch is in the secondary role:

```
cumulus@switch:~$ clagctl status
```

2. If you want to install a disk image, go to the next step. If you want to use package upgrade, update the Cumulus Linux repositories:

```
cumulus@switch:~$ sudo -E apt-get update
```

3. Shut down the core uplink layer 3 interfaces:

```
cumulus@switch:~$ sudo ip link set swpX down
```

4. Shut down the peerlink:

```
cumulus@switch:~$ sudo ip link set peerlink down
```

5. Perform the upgrade either by installing a disk image or upgrading packages.

To *install a disk image*, run the `onie-install -a -i <image-location>` command to boot the switch into ONIE. The following example command installs the image from a web server. There are additional ways to install the disk image, such as using FTP, a local file, or a USB drive. For more information, see [Installing a New Cumulus Linux Image \(see page 35\)](#).

```
cumulus@switch:~$ sudo onie-install -a -i http://10.0.1.251  
/downloads/cumulus-linux-3.7.1-mlx-amd64.bin
```

To use *package upgrade*, run the `-E apt-get upgrade` command:

```
cumulus@switch:~$ sudo -E apt-get upgrade
```

6. Reboot the switch:



```
cumulus@switch:~$ sudo reboot
```

7. If you were originally running Cumulus Linux 3.0.0 through 3.3.2, follow the steps for [upgrading from Quagga to FRRouting \(see page 732\)](#).
8. Verify STP convergence across both switches:

```
cumulus@switch:~$ mstpcctl showall
```

9. Verify core uplinks and peerlinks are UP:

```
cumulus@switch:~$ net show interface
```

10. Verify MLAG convergence:

```
cumulus@switch:~$ clagctl status
```

11. Make this secondary switch the primary:

```
cumulus@switch:~$ clagctl priority 2048
```

12. Verify the other switch is now in the secondary role.
13. Repeat steps 2-10 on the new secondary switch.
14. Remove the priority 2048 and restore the priority back to 32768 on the current primary switch:

```
cumulus@switch:~$ clagctl priority 32768
```

### *Upgrade from Cumulus Linux 2.y.z to 3.y.z*

If you are using [MLAG \(see page 440\)](#) to dual connect two switches in your environment and those switches are still running Cumulus Linux 2.5 ESR or any other release earlier than 3.0.0, the switches are not dual-connected after you upgrade the first switch.

To upgrade the switches, you **must** install a new disk image using ONIE; you cannot use package upgrade:

1. Disable `clagd` in the `/etc/network/interfaces` file (set `clagd-enable` to `no`), then restart `switchd`, networking, and FRR services.

```
cumulus@switch:~$ sudo systemctl restart switchd.service
cumulus@switch:~$ sudo systemctl restart networking.service
cumulus@switch:~$ sudo systemctl restart frr.service
```

2. If you are using BGP, notify the BGP neighbors that the switch is going down:



```
cumulus@switch:~$ sudo vtysh -c "config t" -c "router bgp" -c  
"neighbor X.X.X.X shutdown"
```

3. Stop the Quagga service:

```
cumulus@switch:~$ sudo systemctl stop [quagga|frr].service
```

4. Bring down all the front panel ports:

```
cumulus@switch:~$ sudo ip link set swp<#> down
```

5. Run `cl-img-select -fr` to boot the switch in the secondary role into ONIE, then reboot the switch.
6. Install Cumulus Linux onto the secondary switch using ONIE. At this time, all traffic goes to the switch in the primary role.
7. After the install, copy the license file and all the configuration files you backed up, then restart the `switchd`, networking, and Quagga services. All traffic is still going to the primary switch.

```
cumulus@switch:~$ sudo systemctl restart switchd.service  
cumulus@switch:~$ sudo systemctl restart networking.service  
cumulus@switch:~$ sudo systemctl restart quagga.service
```

8. Run `cl-img-select -fr` to boot the switch in the primary role into ONIE, then reboot the switch. Now, all traffic is going to the switch in the *secondary role* that you just upgraded.
9. Install Cumulus Linux onto the *primary switch* using ONIE.
10. After the install, copy the license file and all the configuration files you backed up.
11. Follow the steps for [upgrading from Quagga to FRRouting \(see page 732\)](#).
12. Enable `clagd` again in the `/etc/network/interfaces` file (set `clagd-enable` to yes), then run `ifreload -a`.

```
cumulus@switch:~$ sudo ifreload -a
```

13. Bring up all the front panel ports:

```
cumulus@switch:~$ sudo ip link set swp<#> up
```

The two switches are dual-connected again and traffic flows to both switches.



## Roll Back a Cumulus Linux Installation

Even the most well planned and tested upgrades can result in unforeseen problems; sometimes the best solution is to roll back to the previous state. There are three main strategies; all require detailed planning and execution:

- Back out individual packages: If you identify the problematic package, you can downgrade the affected package directly. In rare cases, you might need to restore the configuration files from backup or edit to back out any changes made automatically by the upgrade package.
- Flatten and rebuild: If the OS becomes unusable, you can use orchestration tools to reinstall the previous OS release from scratch and then rebuild the configuration automatically.
- Backup and restore: Another common strategy is to restore to a previous state using a backup captured before the upgrade.

The method you employ is specific to your deployment strategy, so providing detailed steps for each scenario is outside the scope of this document.

## Third Party Packages

Third party packages in the *Linux host* world often use the same package system as the distribution into which it is to be installed (for example, Debian uses `apt-get`). Or, the package might be compiled and installed by the system administrator. Configuration and executable files generally follow the same filesystem hierarchy standards as other applications.

If you install any third party applications on a Cumulus Linux switch, configuration data is typically installed into the `/etc` directory, but it is not guaranteed. It is your responsibility to understand the behavior and configuration file information of any third party packages installed on the switch.

After you upgrade using a full disk image install, you need to reinstall any third party packages or any Cumulus Linux add-on packages, such as `vxsnd` or `vxrd`.

## Related Information

- Upgrades: Network Device Worldview and Linux Host Worldview Comparison
- Automation Solutions
- ONIE Design Specification
- Multi-Chassis Link Aggregation - MLAG (see page 440)
- Configuration File Migration Script
- Zero Touch Provisioning - ZTP (see page 72)

## Using Snapshots

Cumulus Linux supports the ability to take snapshots of the complete file system as well as the ability to roll back to a previous snapshot. Snapshots are performed automatically right before and after you upgrade Cumulus Linux using [package install \(see page 51\)](#), and right before and after you commit a switch configuration using [NCLU \(see page 88\)](#). In addition, you can take a snapshot at any time. You can roll back the entire file system to a specific snapshot or just retrieve specific files.

The primary snapshot components include:

- `btrfs` — an underlying file system in Cumulus Linux, which supports snapshots.



- [snapper](#) — a userspace utility to create and manage snapshots on demand as well as taking snapshots automatically before and after running `apt-get upgrade|install|remove|dist-upgrade`. You can use `snapper` to roll back to earlier snapshots, view existing snapshots, or delete one or more snapshots.
- [NCLU \(see page 88\)](#) — takes snapshots automatically before and after committing network configurations. You can use NCLU to roll back to earlier snapshots, view existing snapshots, or delete one or more snapshots.

## Contents

This topic describes ...

- [Install the Snapshot Package \(see page 57\)](#)
- [Take and Manage Snapshots \(see page 57\)](#)
  - [View Available Snapshots \(see page 57\)](#)
  - [View Differences between Snapshots \(see page 59\)](#)
  - [Delete Snapshots \(see page 60\)](#)
- [Roll Back to Earlier Snapshots \(see page 61\)](#)
  - [Roll Back with snapper \(see page 61\)](#)
- [Configure Automatic Time-based Snapshots \(see page 62\)](#)
- [Caveats and Errata \(see page 63\)](#)

## Install the Snapshot Package

If you are upgrading from a version of Cumulus Linux earlier than version 3.2, you need to install the `cumulus-snapshot` package before you can use snapshots.

```
cumulus@switch:~$ sudo -E apt-get update
cumulus@switch:~$ sudo -E apt-get install cumulus-snapshot
cumulus@switch:~$ sudo -E apt-get upgrade
```

## Take and Manage Snapshots

Snapshots are taken automatically:

- Before and after you update your switch configuration by running the NCLU `net commit` command.
- Before and after you update Cumulus Linux by running `apt-get upgrade|install|remove|dist-upgrade`, via `snapper`.

You can also take snapshots as needed using the `snapper` utility. Run:

```
cumulus@switch:~$ sudo snapper create -d SNAPSHOT_NAME
```

For more information about using `snapper`, run `snapper --help` or `man snapper(8)`.

## *View Available Snapshots*

You can use both NCLU and `snapper` to view available snapshots on the switch.

```
cumulus@switch:~$ net show commit history
# Date Description
--- -----
20 Thu 01 Dec 2016 01:43:29 AM UTC nclu pre 'net commit' (user
cumulus)
21 Thu 01 Dec 2016 01:43:31 AM UTC nclu post 'net commit' (user
cumulus)
22 Thu 01 Dec 2016 01:44:18 AM UTC nclu pre '20 rollback' (user
cumulus)
23 Thu 01 Dec 2016 01:44:18 AM UTC nclu post '20 rollback' (user
cumulus)
24 Thu 01 Dec 2016 01:44:22 AM UTC nclu pre '22 rollback' (user
cumulus)
31 Fri 02 Dec 2016 12:18:08 AM UTC nclu pre 'ACL' (user cumulus)
32 Fri 02 Dec 2016 12:18:10 AM UTC nclu post 'ACL' (user cumulus)
```

However, `net show commit history` only displays snapshots taken when you update your switch configuration. It does not list any snapshots taken directly with `snapper`. To see all the snapshots on the switch, run the `sudo snapper list` command:

```
cumulus@switch:~$ sudo snapper list
Type | # | Pre # | Date | User |
Cleanup | Description | Userdata |
-----+-----+-----+-----+
single | 0 | | | root |
| current | |
single | 1 | | Sat 24 Sep 2016 01:45:36 AM UTC | root |
| first root filesystem | |
pre | 20 | | Thu 01 Dec 2016 01:43:29 AM UTC | root |
number | nclu pre 'net commit' (user cumulus) | |
post | 21 | 20 | Thu 01 Dec 2016 01:43:31 AM UTC | root |
number | nclu post 'net commit' (user cumulus) | |
pre | 22 | | Thu 01 Dec 2016 01:44:18 AM UTC | root |
number | nclu pre '20 rollback' (user cumulus) | |
post | 23 | 22 | Thu 01 Dec 2016 01:44:18 AM UTC | root |
number | nclu post '20 rollback' (user cumulus) | |
single | 26 | | Thu 01 Dec 2016 11:23:06 PM UTC | root |
| test_snapshot | |
pre | 29 | | Thu 01 Dec 2016 11:55:16 PM UTC | root |
number | pre-apt | important=yes |
post | 30 | 29 | Thu 01 Dec 2016 11:55:21 PM UTC | root |
number | post-apt | important=yes |
```

```

pre    | 31 |           | Fri 02 Dec 2016 12:18:08 AM UTC | root |
number | nclu pre 'ACL' (user cumulus)          |
post   | 32 | 31       | Fri 02 Dec 2016 12:18:10 AM UTC | root |
number | nclu post 'ACL' (user cumulus)          |

```

### *View Differences between Snapshots*

To see a line by line comparison of changes between two snapshots, run the `sudo snapper diff` command:

```

cumulus@switch:~$ sudo snapper diff 20..21
--- /.snapshots/20/snapshot/etc/cumulus/acl/policy.d/50_nclu_acl.
rules      2016-11-30 23:00:42.675092103 +0000
+++ /.snapshots/21/snapshot/etc/cumulus/acl/policy.d/50_nclu_acl.
rules      2016-12-01 01:43:30.029171289 +0000
@@ -1,7 +0,0 @@
-[iptables]
-# control-plane: acl ipv4 EXAMPLE1 inbound
--A INPUT --in-interface swp+ -j ACCEPT -p tcp -s 10.0.0.11/32 -d
10.0.0.12/32 --dport 110
-
-# swp1: acl ipv4 EXAMPLE1 inbound
--A FORWARD --in-interface swp1 --out-interface swp2 -j ACCEPT -p tcp
-s 10.0.0.11/32 -d 10.0.0.12/32 --dport 110
-
--- /.snapshots/20/snapshot/var/lib/cumulus/nclu/nclu_acl.conf
2016-11-30 23:00:18.030079000 +0000
+++ /.snapshots/21/snapshot/var/lib/cumulus/nclu/nclu_acl.conf
2016-12-01 00:23:10.096136000 +0000
@@ -1,8 +1,3 @@
-acl ipv4 EXAMPLE1 priority 10 accept tcp 10.0.0.11/32 10.0.0.12/32
pop3 outbound-interface swp2

-control-plane
-acl ipv4 EXAMPLE1 inbound

-iface swp1
-acl ipv4 EXAMPLE1 inbound

```

You can view the diff for a single file by specifying the name in the command:

```

cumulus@switch:~$ sudo snapper diff 20..21 /var/lib/cumulus/nclu
/nclu_acl.conf
--- /.snapshots/20/snapshot/var/lib/cumulus/nclu/nclu_acl.conf
2016-11-30 23:00:18.030079000 +0000
+++ /.snapshots/21/snapshot/var/lib/cumulus/nclu/nclu_acl.conf
2016-12-01 00:23:10.096136000 +0000
@@ -1,8 +1,3 @@

```



```
-acl ipv4 EXAMPLE1 priority 10 accept tcp 10.0.0.11/32 10.0.0.12/32  
pop3 outbound-interface swp2  
  
-control-plane  
-    acl ipv4 EXAMPLE1 inbound  
  
-iface swp1  
-    acl ipv4 EXAMPLE1 inbound
```

For a higher level view; for example, to display the names of changed, added, or deleted files only, run the `sudo snapper status` command:

```
cumulus@switch:~$ sudo snapper status 20..21  
c..... /etc/cumulus/acl/policy.d/50_nclu_acl.rules  
c..... /var/lib/cumulus/nclu/nclu_acl.conf
```

### Delete Snapshots

You can remove one or more snapshots using NCLU or `snapper`.



Take care when deleting a snapshot. You cannot restore a snapshot after you delete it.

To remove a single snapshot or a range of snapshots created with NCLU, run:

```
cumulus@switch:~$ net commit delete SNAPSHOT|SNAPSHOT1-SNAPSHOT2
```

To remove a single snapshot or a range of snapshots using `snapper`, run:

```
cumulus@switch:~$ sudo snapper delete SNAPSHOT|SNAPSHOT1-SNAPSHOT2
```



Snapshot 0 is the running configuration. You cannot roll back to it or delete it. However, you can take a snapshot of it.

Snapshot 1 is the root file system.

The `snapper` utility preserves a number of snapshots and automatically deletes older snapshots after the limit is reached. It does this in two ways.

By default, `snapper` preserves 10 snapshots that are labeled *important*. A snapshot is labeled important if it is created when you run `apt-get`. To change this number, run:

```
cumulus@switch:~$ sudo snapper set-config NUMBER_LIMIT_IMPORTANT=<NUM>
```



Always make `NUMBER_LIMIT_IMPORTANT` an even number as two snapshots are always taken before and after an upgrade. This does not apply to `NUMBER_LIMIT`, described next.

`snapper` also deletes unlabeled snapshots. By default, `snapper` preserves five snapshots. To change this number, run:

```
cumulus@switch:~$ sudo snapper set-config NUMBER_LIMIT=<NUM>
```

You can prevent snapshots from being taken automatically before and after running `apt-get upgrade|install|remove|dist-upgrade`. Edit `/etc/cumulus/apt-snapshot.conf` and set:

```
APT_SNAPSHOT_ENABLE=no
```

## Roll Back to Earlier Snapshots

If you need to restore Cumulus Linux to an earlier state, you can roll back to an older snapshot.

For a snapshot created with NCLU, you can revert to the configuration prior to a specific snapshot listed in the output from `net show commit history` by running `net rollback SNAPSHOT_NUMBER`. For example, if you have snapshots 10, 11 and 12 in your commit history and you run `net rollback 11`, the switch configuration reverts to the configuration captured by snapshot 10.

You can also revert to the previous snapshot by specifying `last` by running `net rollback last`.

```
cumulus@switch:~$ net rollback SNAPSHOT_NUMBER|last
```

If you provided a description when you committed changes, mentioning a description rolls the configuration back to the commit prior to the specified description. For example, consider the following commit history:

```
cumulus@switch:~$ net show commit history
#  Date                                Description
--  -----
10  Tue 06 Nov 2018 12:07:14 AM UTC    nclu "net commit" (user cumulus)
12  Tue 06 Nov 2018 10:19:50 PM UTC    nclu rocket
14  Tue 06 Nov 2018 10:20:22 PM UTC    nclu turtle
```

Running `net rollback description turtle` rolls the configuration back to the state it was in when you ran `net commit description rocket`.

### Roll Back with snapper

For any snapshot on the switch, you can use `snapper` to roll back to a specific snapshot. When running `snapper rollback`, you must reboot the switch for the rollback to complete:



```
cumulus@switch:~$ sudo snapper rollback SNAPSHOT_NUMBER  
cumulus@switch:~$ sudo reboot
```

You can revert to an earlier version of a specific file instead of rolling back the whole file system:

```
cumulus@switch:~$ sudo snapper undochange 31..32 /etc/cumulus/acl  
/policy.d/50_nclu_acl.rules
```



You can also copy the file directly from the snapshot directory:

```
cumulus@switch:~$ cp /.snapshots/32/snapshot/etc/cumulus/acl  
/policy.d/50_nclu_acl.rules /etc/cumulus/acl/policy.d/
```

## Configure Automatic Time-based Snapshots

You can configure Cumulus Linux to take hourly snapshots. Enable `TIMELINE_CREATE` in the snapper configuration:

```
cumulus@switch:~$ sudo snapper set-config TIMELINE_CREATE=yes  
cumulus@switch:~$ sudo snapper get-  
config  
Key | Value  
----+----  
ALLOW_GROUPS  
ALLOW_USERS  
BACKGROUND_COMPARISON | yes  
EMPTY_PRE_POST_CLEANUP | yes  
EMPTY_PRE_POST_MIN_AGE | 1800  
FSTYPE | btrfs  
NUMBER_CLEANUP | yes  
NUMBER_LIMIT | 5  
NUMBER_LIMIT_IMPORTANT | 10  
NUMBER_MIN_AGE | 1800  
QGROUP  
SPACE_LIMIT | 0.5  
SUBVOLUME | /  
SYNC_ACL | no  
TIMELINE_CLEANUP | yes  
TIMELINE_CREATE | yes  
TIMELINE_LIMIT_DAILY | 5  
TIMELINE_LIMIT_HOURLY | 5  
TIMELINE_LIMIT_MONTHLY | 5  
TIMELINE_LIMIT_YEARLY | 5
```



TIMELINE\_MIN\_AGE | 1800

## Caveats and Errata

You might notice that the root partition is mounted multiple times. This is due to the way the `btrfs` file system handles subvolumes, mounting the root partition once for each subvolume. `btrfs` keeps one subvolume for each snapshot taken, which stores the snapshot data. While all snapshots are subvolumes, not all subvolumes are snapshots.

Cumulus Linux excludes a number of directories when taking a snapshot of the root file system (and from any rollbacks):

Directory	Reason
<code>/home</code>	This directory is excluded to avoid user data loss on rollbacks.
<code>/var/log</code> , <code>/var/support</code>	The log file and Cumulus support location. These directories are excluded from snapshots to allow post-rollback analysis.
<code>/tmp</code> , <code>/var/tmp</code>	There is no need to rollback temporary files.
<code>/opt</code> , <code>/var/opt</code>	Third-party software is installed typically in <code>/opt</code> . Exclude <code>/opt</code> to avoid re-installing these applications after rollbacks.
<code>/srv</code>	This directory contains data for HTTP and FTP servers. Exclude this directory to avoid server data loss on rollbacks.
<code>/usr/local</code>	This directory is used when installing locally built software. Exclude this directory to avoid re-installing this software after rollbacks.
<code>/var/spool</code>	Exclude this directory to avoid loss of mail after a rollback.
<code>/var/lib/libvirt/images</code>	This is the default directory for libvirt VM images. Exclude this directory from the snapshot. Additionally, disable Copy-On-Write (COW) for this subvolume as COW and VM image I/O access patterns are not compatible.
<code>/boot/grub/i386-pc</code> , <code>/boot/grub/x86_64-efi</code> , <code>/boot/grub/arm-uboot</code>	The GRUB kernel modules must stay in sync with the GRUB kernel installed in the master boot record or UEFI system partition.

## Adding and Updating Packages

You use the Advanced Packaging Tool (`apt`) to manage additional applications (in the form of packages) and to install the latest updates.





## ⚠️ Network Disruptions

Updating, upgrading, and installing packages with `apt` causes disruptions to network services:

- Upgrading a package might result in services being restarted or stopped as part of the upgrade process.
- Installing a package might disrupt core services by changing core service dependency packages. In some cases, installing new packages might also upgrade additional existing packages due to dependencies.

If services are stopped, you might need to reboot the switch for those services to restart.

## Contents

### This topic describes ...

- Update the Package Cache (see page 64)
- List Available Packages (see page 66)
- List Installed Packages (see page 67)
- Display the Version of a Package (see page 67)
- Upgrade Packages (see page 68)
- Add New Packages (see page 68)
- Add Packages from Another Repository (see page 69)
- Cumulus Supplemental Repository (see page 71)
- Related Information (see page 72)

## Update the Package Cache

To work properly, `apt` relies on a local cache of the available packages. You must populate the cache initially, and then periodically update it with `-E apt-get update`:

```
cumulus@switch:~$ sudo -E apt-get update
Get:1 http://repo3.cumulusnetworks.com CumulusLinux-3 InRelease
[7,624 B]
Get:2 http://repo3.cumulusnetworks.com CumulusLinux-3-security-
updates InRelease [7,555 B]
Get:3 http://repo3.cumulusnetworks.com CumulusLinux-3-updates
InRelease [7,660 B]
Get:4 http://repo3.cumulusnetworks.com CumulusLinux-3/cumulus Sources
[20 B]
Get:5 http://repo3.cumulusnetworks.com CumulusLinux-3/upstream
Sources [20 B]
Get:6 http://repo3.cumulusnetworks.com CumulusLinux-3/cumulus amd64
Packages [38.4 kB]
Get:7 http://repo3.cumulusnetworks.com CumulusLinux-3/upstream amd64
Packages [445 kB]
Get:8 http://repo3.cumulusnetworks.com CumulusLinux-3-security-updates
/cumulus Sources [20 B]
```



```
Get:9 http://repo3.cumulusnetworks.com CumulusLinux-3-security-updates  
/upstream Sources [11.8 kB]  
Get:10 http://repo3.cumulusnetworks.com CumulusLinux-3-security-  
updates/cumulus amd64 Packages [20 B]  
Get:11 http://repo3.cumulusnetworks.com CumulusLinux-3-security-  
updates/upstream amd64 Packages [8,941 B]  
Get:12 http://repo3.cumulusnetworks.com CumulusLinux-3-updates  
/cumulus Sources [20 B]  
Get:13 http://repo3.cumulusnetworks.com CumulusLinux-3-updates  
/upstream Sources [776 B]  
Get:14 http://repo3.cumulusnetworks.com CumulusLinux-3-updates  
/cumulus amd64 Packages [38.4 kB]  
Get:15 http://repo3.cumulusnetworks.com CumulusLinux-3-updates  
/upstream amd64 Packages [444 kB]  
Ign http://repo3.cumulusnetworks.com CumulusLinux-3/cumulus  
Translation-en_US  
Ign http://repo3.cumulusnetworks.com CumulusLinux-3/cumulus  
Translation-en  
Ign http://repo3.cumulusnetworks.com CumulusLinux-3/upstream  
Translation-en_US  
Ign http://repo3.cumulusnetworks.com CumulusLinux-3/upstream  
Translation-en  
Ign http://repo3.cumulusnetworks.com CumulusLinux-3-security-updates  
/cumulus Translation-en_US  
Ign http://repo3.cumulusnetworks.com CumulusLinux-3-security-updates  
/cumulus Translation-en  
Ign http://repo3.cumulusnetworks.com CumulusLinux-3-security-updates  
/upstream Translation-en_US  
Ign http://repo3.cumulusnetworks.com CumulusLinux-3-updates/cumulus  
Translation-en_US  
Ign http://repo3.cumulusnetworks.com CumulusLinux-3-updates/cumulus  
Translation-en  
Ign http://repo3.cumulusnetworks.com CumulusLinux-3-updates/upstream  
Translation-en_US  
Ign http://repo3.cumulusnetworks.com CumulusLinux-3-updates/upstream  
Translation-en  
Fetched 1,011 kB in 1s (797 kB/s)  
Reading package lists... Done
```



Cumulus Networks recommends you use the `-E` option with `sudo` whenever you run any `apt-get` command. This option preserves your environment variables (such as HTTP proxies) before you install new packages or upgrade your distribution.



## List Available Packages

After the cache is populated, use the `apt-cache` command to search the cache and find the packages in which you are interested or to get information about an available package. Here are examples of the `search` and `show` sub-commands:

```
cumulus@switch:~$ apt-cache search tcp
socat - multipurpose relay for bidirectional data transfer
fakeroot - tool for simulating superuser privileges
tcpdump - command-line network traffic analyzer
openssh-server - secure shell (SSH) server, for secure access from
remote machines
openssh-sftp-server - secure shell (SSH) sftp server module, for SFTP
access from remote machines
python-dpkt - Python packet creation / parsing module
libfakeroot - tool for simulating superuser privileges - shared
libraries
openssh-client - secure shell (SSH) client, for secure access to
remote machines
rsyslog - reliable system and kernel logging daemon
libwrap0 - Wietse Venema's TCP wrappers library
netbase - Basic TCP/IP networking system
```

```
cumulus@switch:~$ apt-cache show tcpdump
Package: tcpdump
Status: install ok installed
Priority: optional
Section: net
Installed-Size: 1092
Maintainer: Romain Francoise <rfrancoise@debian.org>
Architecture: amd64
Multi-Arch: foreign
Version: 4.6.2-5+deb8u1
Depends: libc6 (>= 2.14), libpcap0.8 (>= 1.5.1), libssl1.0.0 (>=
1.0.0)
Description: command-line network traffic analyzer
This program allows you to dump the traffic on a network. tcpdump
is able to examine IPv4, ICMPv4, IPv6, ICMPv6, UDP, TCP, SNMP, AFS
BGP, RIP, PIM, DVMRP, IGMP, SMB, OSPF, NFS and many other packet
types.
.
It can be used to print out the headers of packets on a network
interface, filter packets that match a certain expression. You can
use this tool to track down network problems, to detect attacks
or to monitor network activities.
Description-md5: f01841bfda357d116d7ff7b7a47e8782
Homepage: http://www.tcpdump.org/
```



```
cumulus@switch:~$
```



The search commands look for the search terms not only in the package name but in other parts of the package information; the search matches on more packages than you might expect.

## List Installed Packages

The APT cache contains information about all the packages available in the repository. To see which packages are actually installed on your system, use `dpkg`. The following example lists all the package names on the system that contain `tcp`:

```
cumulus@switch:~$ dpkg -l \*tcp\*
Desired=Unknown/Install/Remove/Purge/Hold
| Status=Not/Inst/Conf-files/Unpacked/half-conf/Half-inst/trig-aWait
/Trig-pend
| / Err?=(none)/Reinst-required (Status,Err: uppercase=bad)
|| / Name                           Version
Architecture      Description
=====
un  tcpd              <none>
<none>          (no description available)
ii   tcpdump           4.6.2-5+deb8u1
amd64            command-line network traffic analyzer
cumulus@switch:~$
```

## Display the Version of a Package

To show the version of a specific package installed on the system, run the `net show package version <package>` command. For example, the following command shows which version of the `vrf` package is installed on the system:

```
cumulus@switch:~$ net show package version vrf
1.0-cl3ull
```

As an alternative to the NCLU command described above, you can run the Linux `dpkg -l <package_name>` command.

To see a list of all packages installed on the system with their versions, run the `net show package version` command. For example:

```
cumulus@switch:~$ net show package version
Package           Installed Version(s)
```



```
-----  
-  
acl 2.2.52-2  
acpi 1.7-1  
acpi-support-base 0.142-6  
acpid 1:2.0.23-2  
adduser 3.113+nmu3  
apt 1.0.9.8.2-cl3u3~1532198712.6d9298c  
apt-doc 1.0.9.8.2-cl3u3~1532198712.6d9298c  
apt-transport-https 1.0.9.8.2-cl3u3~1532198712.6d9298c  
apt-utils 1.0.9.8.2-cl3u3~1532198712.6d9298c  
arping 2.14-1  
arptables 0.0.3.4-1  
...
```

## Upgrade Packages

To upgrade all the packages installed on the system to their latest versions, run the following commands:

```
cumulus@switch:~$ sudo -E apt-get update  
cumulus@switch:~$ sudo -E apt-get upgrade
```

A list of packages that will be upgraded is displayed and you are prompted to continue.

The above commands upgrade all installed versions with their latest versions but do not install any new packages.

Refer to [Upgrading Cumulus Linux \(see page 45\)](#) for additional information.

## Add New Packages

To add a new package:

1. First ensure the package is not already installed on the system:

```
cumulus@switch:~$ dpkg -l | grep <name of package>
```

If the package is installed already, you can update the package from the Cumulus Linux repository as part of the package upgrade process, which upgrades all packages on the system. See [Upgrade Packages \(see page 68\)](#) above.

2. If the package is *not* already installed, add it by running `-E apt-get install <name of package>`. This retrieves the package from the Cumulus Linux repository and installs it on your system together with any other packages on which this package might depend. The following example adds the `tcpreplay` package to the system:

```
cumulus@switch:~$ sudo -E apt-get install tcpreplay  
Reading package lists... Done
```



```
Building dependency tree
Reading state information... Done
The following NEW packages will be installed:
tcpreplay
0 upgraded, 1 newly installed, 0 to remove and 1 not upgraded.
Need to get 436 kB of archives.
After this operation, 1008 kB of additional disk space will be
used.
Get:1 https://repo.cumulusnetworks.com/ CumulusLinux-1.5/main
tcpreplay amd64 4.6.2-5+deb8u1 [436 kB]
Fetched 436 kB in 0s (1501 kB/s)
Selecting previously unselected package tcpreplay.
(Reading database ... 15930 files and directories currently
installed.)
Unpacking tcpreplay (from .../tcpreplay_4.6.2-5+deb8u1_amd64.
deb) ...
Processing triggers for man-db ...
Setting up tcpreplay (4.6.2-5+deb8u1) ...
cumulus@switch:~$
```

You can install several packages at the same time:

```
cumulus@switch:~$ sudo -E apt-get install <package 1> <package
2> <package 3>
```

- ✔ In some cases, installing a new package might also upgrade additional existing packages due to dependencies. To view these additional packages before you install, run the `apt-get install --dry-run` command.

## Add Packages from Another Repository

As shipped, Cumulus Linux searches the Cumulus Linux repository for available packages. You can add additional repositories to search by adding them to the list of sources that `apt-get` consults. See `man sources.list` for more information.

- ✔ Cumulus Networks has added features or made bug fixes to certain packages; you must not replace these packages with versions from other repositories. Cumulus Linux is configured to ensure that the packages from the Cumulus Linux repository are always preferred over packages from other repositories.

If you want to install packages that are not in the Cumulus Linux repository, the procedure is the same as above, but with one additional step.

- ⚠ Packages that are not part of the Cumulus Linux Repository are not typically tested and might not be supported by Cumulus Linux Technical Support.



Installing packages outside of the Cumulus Linux repository requires the use of `-E apt-get`; however, depending on the package, you can use `easy-install` and other commands.

To install a new package, complete the following steps:

1. Run the `dpkg` command to ensure that the package is not already installed on the system:

```
cumulus@switch:~$ dpkg -l | grep {name of package}
```

2. If the package is installed already, ensure it is the version you need. If it is an older version, update the package from the Cumulus Linux repository:

```
cumulus@switch:~$ sudo -E apt-get update
cumulus@switch:~$ sudo -E apt-get install {name of package}
cumulus@switch:~$ sudo -E apt-get upgrade
```

3. If the package is not on the system, the package source location is most likely **not** in the `/etc/apt/sources.list` file. If the source for the new package is **not** in `sources.list`, edit and add the appropriate source to the file. For example, add the following if you want a package from the Debian repository that is **not** in the Cumulus Linux repository:

```
deb http://http.us.debian.org/debian jessie main
deb http://security.debian.org/ jessie/updates main
```

Otherwise, the repository might be listed in `/etc/apt/sources.list` but is commented out, as can be the case with the early-access repository:

```
#deb http://repo3.cumulusnetworks.com/repo CumulusLinux-3-early-
access cumulus
```

To uncomment the repository, remove the `#` at the start of the line, then save the file:

```
deb http://repo3.cumulusnetworks.com/repo CumulusLinux-3-early-
access cumulus
```

4. Run `-E apt-get update`, then install the package and upgrade:

```
cumulus@switch:~$ sudo -E apt-get update
cumulus@switch:~$ sudo -E apt-get install {name of package}
cumulus@switch:~$ sudo -E apt-get upgrade
```



## Cumulus Supplemental Repository

Cumulus Networks provides a *Supplemental Repository* that contains third party applications commonly installed on switches.

The repository is provided for convenience only. You can download and use these applications; however, the applications in this repository are not tested, developed, certified, or supported by Cumulus Networks.

Below is a non-exhaustive list of some of the packages present in the repository:

- `htop` lets you view CPU, memory, and process information.
- `scamper` is an ECMP traceroute utility.
- `mtr` is an ECMP traceroute utility.
- `dhcpdump` is similar to TCPdump but focused only on DHCP traffic.
- `vim` is a text editor.
- `fping` provides a list of targets through textfile to check reachability.
- `scapy` is a custom packet generator for testing.
- `bwm-ng` is a real-time bandwidth monitor.
- `iftop` is a real-time traffic monitor.
- `tshark` is a CLI version of wireshark.
- `nmap` is a network scanning utility.
- `minicom` is a USB/Serial console utility that turns your switch into a terminal server (useful for out of band management switches to provide a console on the dataplane switches in the rack).
- `apt-cacher-ng` caches packages for mirroring purposes.
- `iptraf` is a ncurses-based traffic visualization utility.
- `swatch` monitors system activity. It reads a configuration file that contains patterns for which to search and actions to perform when each pattern is found.
- `dos2unix` converts line endings from Windows to Unix.
- `fail2ban` monitors log files (such as `/var/log/auth.log` and `/var/log/apache/access.log`) and temporarily or persistently bans the login of failure-prone IP addresses by updating existing firewall rules. This utility is not hardware accelerated on a Cumulus Linux switch, so only affects the control plane.

To enable the Supplemental Repository:

1. In a file editor, open the `/etc/apt/sources.list` file.

```
cumulus@leaf01:~$ sudo nano /etc/apt/sources.list
```

2. Uncomment the following lines:

```
#deb http://repo3.cumulusnetworks.com/repo Jessie-supplemental
upstream
```



```
#deb-src http://repo3.cumulusnetworks.com/repo Jessie-  
supplemental upstream
```

3. Update the list of software packages:

```
cumulus@leaf01:~$ sudo -E apt-get update -y
```

4. Install the software in which you are interested:

```
cumulus@leaf01:~$ sudo -E apt-get install htop
```

## Related Information

- [Debian GNU/Linux FAQ, Ch 8 Package management tools](#)
- [man pages for apt-get, dpkg, sources.list, apt\\_preferences](#)

## Zero Touch Provisioning - ZTP

*Zero touch provisioning* (ZTP) enables you to deploy network devices quickly in large-scale environments. On first boot, Cumulus Linux invokes ZTP, which executes the provisioning automation used to deploy the device for its intended role in the network.

The provisioning framework allows for a one-time, user-provided script to be executed. You can develop this script using a variety of automation tools and scripting languages, providing ample flexibility for you to design the provisioning scheme to meet your needs. You can also use it to add the switch to a configuration management (CM) platform such as [Puppet](#), [Chef](#), [CFEngine](#) or possibly a custom, proprietary tool.

While developing and testing the provisioning logic, you can use the `ztp` command in Cumulus Linux to manually invoke your provisioning script on a device.

ZTP in Cumulus Linux can occur automatically in one of the following ways, in this order:

- Through a local file
- Using a USB drive inserted into the switch (ZTP-USB)
- Through DHCP

Each method is discussed in greater detail below.

## Contents

### This topic describes...

- Zero Touch Provisioning Using a Local File (see page 73)
- Zero Touch Provisioning Using a USB Drive (ZTP-USB) (see page 73)
- Zero Touch Provisioning over DHCP (see page 74)
  - Trigger ZTP over DHCP (see page 75)
  - Configure the DHCP Server (see page 75)



- [Inspect HTTP Headers \(see page 75\)](#)
- [Write ZTP Scripts \(see page 76\)](#)
- [Best Practices for ZTP Scripts \(see page 77\)](#)
  - [Install a License \(see page 77\)](#)
  - [Test DNS Name Resolution \(see page 78\)](#)
  - [Check the Cumulus Linux Release \(see page 78\)](#)
  - [Apply Management VRF Configuration \(see page 79\)](#)
  - [Perform Ansible Provisioning Callbacks \(see page 79\)](#)
  - [Disable the DHCP Hostname Override Setting \(see page 79\)](#)
  - [NCLU in ZTP Scripts \(see page 80\)](#)
- [Test ZTP Scripts \(see page 80\)](#)
- [Common ZTP Script Errors \(see page 84\)](#)
- [Manually Use the ztp Command \(see page 86\)](#)
- [Notes \(see page 87\)](#)

## Zero Touch Provisioning Using a Local File

ZTP only looks once for a ZTP script on the local file system when the switch boots. ZTP searches for an install script that matches an ONIE-style waterfall in `/var/lib/cumulus/ztp`, looking for the most specific name first, and ending at the most generic:

- `'cumulus-ztp-' + architecture + '-' + vendor + '_' + model + '-r' + revision`
- `'cumulus-ztp-' + architecture + '-' + vendor + '_' + model`
- `'cumulus-ztp-' + vendor + '_' + model`
- `'cumulus-ztp-' + architecture`
- `'cumulus-ztp'`

For example:

```
cumulus-ztp-amd64-cel_pebble-rUNKNOWN
cumulus-ztp-amd64-cel_pebble
cumulus-ztp-cel_pebble
cumulus-ztp-amd64
cumulus-ztp
```

You can also trigger the ZTP process manually by running the `ztp --run <URL>` command, where the URL is the path to the ZTP script.

## Zero Touch Provisioning Using a USB Drive (ZTP-USB)



This feature has been tested only with *thumb* drives, not an actual external large USB hard drive.



If the `ztp` process does not discover a local script, it tries once to locate an inserted but unmounted USB drive. If it discovers one, it begins the ZTP process.

Cumulus Linux supports the use of a FAT32, FAT16, or VFAT-formatted USB drive as an installation source for ZTP scripts. You must plug in the USB drive **before** you power up the switch.

At minimum, the script must:

- Install the Cumulus Linux operating system and license.
- Copy over a basic configuration to the switch.
- Restart the switch or the relevant servers to get `switchd` up and running with that configuration.

Follow these steps to perform zero touch provisioning using a USB drive:

1. Copy the Cumulus Linux license and installation image to the USB drive.
2. The `ztp` process searches the root filesystem of the newly mounted drive for filenames matching an [ONIE-style waterfall](#) (see the patterns and examples above), looking for the most specific name first, and ending at the most generic.
3. The contents of the script are parsed to ensure it contains the `CUMULUS-AUTOPROVISIONING` flag (see [example scripts \(see page 76\)](#)).



The USB drive is mounted to a temporary directory under `/tmp` (for example, `/tmp/tmpigGgjf/`). To reference files on the USB drive, use the environment variable `ZTP_USB_MOUNTPOINT` to refer to the USB root partition.

## Zero Touch Provisioning over DHCP

If the `ztp` process does not discover a local/ONIE script or applicable USB drive, it checks DHCP every ten seconds for up to five minutes for the presence of a ZTP URL specified in `/var/run/ztp.dhcp`. The URL can be any of HTTP, HTTPS, FTP or TFTP.

For ZTP using DHCP, provisioning initially takes place over the management network and is initiated through a DHCP hook. A DHCP option is used to specify a configuration script. This script is then requested from the Web server and executed locally on the switch.

The zero touch provisioning process over DHCP follows these steps:

1. The first time you boot Cumulus Linux, `eth0` is configured for DHCP and makes a DHCP request.
2. The DHCP server offers a lease to the switch.
3. If option 239 is present in the response, the zero touch provisioning process starts.
4. The zero touch provisioning process requests the contents of the script from the URL, sending additional [HTTP headers \(see page 75\)](#) containing details about the switch.
5. The contents of the script are parsed to ensure it contains the `CUMULUS-AUTOPROVISIONING` flag (see [example scripts \(see page 76\)](#)).
6. If provisioning is necessary, the script executes locally on the switch with root privileges.
7. The return code of the script is examined. If it is 0, the provisioning state is marked as complete in the autoprovioning configuration file.



## Trigger ZTP over DHCP

If provisioning has not already occurred, it is possible to trigger the zero touch provisioning process over DHCP when eth0 is set to use DHCP and one of the following events occur:

- The switch boots.
- You plug a cable into or unplug a cable from the eth0 port.
- You disconnect, then reconnect the switch power cord.

You can also run the `ztp --run <URL>` command, where the URL is the path to the ZTP script.

## Configure the DHCP Server

During the DHCP process over eth0, Cumulus Linux requests DHCP option 239. This option is used to specify the custom provisioning script.

For example, the `/etc/dhcp/dhcpd.conf` file for an ISC DHCP server looks like:

```
option cumulus-provision-url code 239 = text;

subnet 192.0.2.0 netmask 255.255.255.0 {
    range 192.0.2.100 192.168.0.200;
    option cumulus-provision-url "http://192.0.2.1/demo.sh";
}
```

Additionally, you can specify the hostname of the switch with the `host-name` option:

```
subnet 192.168.0.0 netmask 255.255.255.0 {
    range 192.168.0.100 192.168.0.200;
    option cumulus-provision-url "http://192.0.2.1/demo.sh";
    host dcl-tor-swl { hardware ethernet 44:38:39:00:1a:6b; fixed-
        address 192.168.0.101; option host-name "dcl-tor-swl"; }
}
```

## Inspect HTTP Headers

The following HTTP headers are sent in the request to the webserver to retrieve the provisioning script:

Header	Value	Example
-----	-----	-----
User-Agent		CumulusLinux-
AutoProvision/0.4		
CUMULUS-ARCH	CPU architecture	x86_64
CUMULUS-BUILD		3.7.3-5c6829a-
201309251712-final		
CUMULUS-LICENSE-INSTALLED	Either 0 or 1	1
CUMULUS-MANUFACTURER		odm



CUMULUS-PRODUCTNAME	switch_model
CUMULUS-SERIAL	XYZ123004
CUMULUS-BASE-MAC	44:38:39:FF:40:94
CUMULUS-MGMT-MAC	44:38:39:FF:00:00
CUMULUS-VERSION	3.7.3
CUMULUS-PROV-COUNT	0
CUMULUS-PROV-MAX	32

## Write ZTP Scripts



Remember to include the following line in any of the supported scripts that you expect to run using the autoprovisioning framework.

```
# CUMULUS-AUTOPROVISIONING
```

This line is required somewhere in the script file for execution to occur.

The script must contain the `CUMULUS-AUTOPROVISIONING` flag. You can include this flag in a comment or remark; the flag does not need to be echoed or written to `stdout`.

You can write the script in any language currently supported by Cumulus Linux, such as:

- Perl
- Python
- Ruby
- Shell

The script must return an exit code of 0 upon success, as this triggers the autoprovisioning process to be marked as complete in the autoprovisioning configuration file.

The following script installs Cumulus Linux and its license from a USB drive and applies a configuration:

```
#!/bin/bash
function error() {
    echo -e "\e[0;33mERROR: The Zero Touch Provisioning script failed
while running the command $BASH_COMMAND at line $BASH_LINENO.\e[0m"
>&2
    exit 1
}

# Log all output from this script
exec >> /var/log/autoprovision 2>&1
date "+%FT%T ztp starting script $0"

trap error ERR

#Add Debian Repositories
```



```
echo "deb http://http.us.debian.org/debian jessie main" >> /etc/apt
/sources.list
echo "deb http://security.debian.org/ jessie/updates main" >> /etc/apt
/sources.list

#Update Package Cache
apt-get update -y

#Load interface config from usb
cp ${ZTP_USB_MOUNTPOINT}/interfaces /etc/network/interfaces

#Load port config from usb
#   (if breakout cables are used for certain interfaces)
cp ${ZTP_USB_MOUNTPOINT}/ports.conf /etc/cumulus/ports.conf

#Install a License from usb and restart switchd
/usr/cumulus/bin/cl-license -i ${ZTP_USB_MOUNTPOINT}/license.txt &&
systemctl restart switchd.service

#Reload interfaces to apply loaded config
ifreload -a

#Output state of interfaces
net show interface

# CUMULUS-AUTOPROVISIONING
exit 0
```

Several ZTP example scripts are available in the [Cumulus GitHub repository](#).

## Best Practices for ZTP Scripts

ZTP scripts come in different forms and frequently perform many of the same tasks. As BASH is the most common language used for ZTP scripts, the following BASH snippets are provided to accelerate your ability to perform common tasks with robust error checking.

### *Install a License*

Use the following function to include error checking for license file installation.

```
function install_license(){
    # Install license
    echo "$(date) INFO: Installing License..."
    echo $1 | /usr/cumulus/bin/cl-license -i
    return_code=$?
    if [ "$return_code" == "0" ]; then
        echo "$(date) INFO: License Installed."
    else
        echo "$(date) ERROR: License not installed. Return code was:
$return_code"
```



```
    /usr/cumulus/bin/cl-license
    exit 1
}
}
```

### Test DNS Name Resolution

DNS names are frequently used in ZTP scripts. The `ping_until_reachable` function tests that each DNS name resolves into a reachable IP address. Call this function with each DNS target used in your script before you use the DNS name elsewhere in your script.

The following example shows how to call the `ping_until_reachable` function in the context of a larger task.

```
function ping_until_reachable(){
    last_code=1
    max_tries=30
    tries=0
    while [ "0" != "$last_code" ] && [ "$tries" -lt "$max_tries" ]; do
        tries=$((tries+1))
        echo "$(date) INFO: ( Attempt $tries of $max_tries ) Pinging
\$1 Target Until Reachable."
        ping \$1 -c2 &> /dev/null
        last_code=$?
        sleep 1
    done
    if [ "$tries" -eq "$max_tries" ] && [ "$last_code" -ne "0" ]; then
        echo "$(date) ERROR: Reached maximum number of attempts to
ping the target \$1 ."
        exit 1
    fi
}
```

### Check the Cumulus Linux Release

The following script segment demonstrates how to check which Cumulus Linux release is running currently and upgrades the node if the release is not the *target release*. If the release is the target release, normal ZTP tasks execute. This script calls the `ping_until_reachable` script (described above) to make sure the server holding the image server and the ZTP script is reachable.

```
function init_ztp(){
    #do normal ZTP tasks
}

CUMULUS_TARGET_RELEASE=3.5.3
CUMULUS_CURRENT_RELEASE=$(cat /etc/lsb-release | grep RELEASE | cut -
d "=" -f2)
IMAGE_SERVER_HOSTNAME=webserver.example.com
```



```
IMAGE_SERVER="http://$IMAGE_SERVER_HOSTNAME"
/"$CUMULUS_TARGET_RELEASE".bin"
ZTP_URL="http://$IMAGE_SERVER_HOSTNAME/ztp.sh"

if [ "$CUMULUS_TARGET_RELEASE" != "$CUMULUS_CURRENT_RELEASE" ]; then
    ping_until_reachable $IMAGE_SERVER_HOSTNAME
    /usr/cumulus/bin/onie-install -fa -i $IMAGE_SERVER -z $ZTP_URL &&
reboot
else
    init_ztp && reboot
fi
exit 0
```

## Apply Management VRF Configuration

If you apply a management VRF in your script, either apply it last or reboot instead. If you do *not* apply a management VRF last, you need to prepend any commands that require eth0 to communicate out with `/usr/bin/vrf task exec mgmt`; for example, `/usr/bin/vrf task exec mgmt apt-get update -Y`.

## Perform Ansible Provisioning Callbacks

After initially configuring a node with ZTP, use [Provisioning Callbacks](#) to inform Ansible Tower or AWX that the node is ready for more detailed provisioning. The following example demonstrates how to use a provisioning callback:

```
/usr/bin/curl -H "Content-Type:application/json" -k -X POST --data
'{"host_config_key": "'somekey'" }' -u username:password http://ansible.
example.com/api/v2/job_templates/1111/callback/
```

## Disable the DHCP Hostname Override Setting

Make sure to disable the DHCP hostname override setting in your script (NCLU does this for in Cumulus Linux 3.5 and above).

```
function set_hostname(){
    # Remove DHCP Setting of Hostname
    sed s/'SETHOSTNAME="yes"'/'SETHOSTNAME="no"'/g -i /etc/dhcp
/dhclient-exit-hooks.d/dhcp-sethostname
    hostnamectl set-hostname $1
}
```



## NCLU in ZTP Scripts



Not all aspects of NCLU are supported when running during ZTP. Use traditional Linux methods of providing configuration to the switch during ZTP.

When you use NCLU in ZTP scripts, add the following loop to make sure NCLU has time to start up before being called.

```
# Waiting for NCLU to finish starting up
last_code=1
while [ "1" == "$last_code" ]; do
    net show interface &> /dev/null
    last_code=$?
done

net add vrf mgmt
net add time zone Etc/UTC
net add time ntp server 192.168.0.254 iburst
net commit
```

## Test ZTP Scripts

There are a few commands you can use to test and debug your ZTP scripts.

You can use verbose mode to debug your script and see where your script failed. Include the `-v` option when you run `ztp`:

```
cumulus@switch:~$ sudo ztp -v -r http://192.0.2.1/demo.sh
Attempting to provision via ZTP Manual from http://192.0.2.1/demo.sh

Broadcast message from root@dell-s6000-01 (ttyS0) (Tue May 10 22:44:
17 2016):

ZTP: Attempting to provision via ZTP Manual from http://192.0.2.1
/demo.sh
ZTP Manual: URL response code 200
ZTP Manual: Found Marker CUMULUS-AUTOPROVISIONING
ZTP Manual: Executing http://192.0.2.1/demo.sh
error: ZTP Manual: Payload returned code 1
error: Script returned failure
```

To see if ZTP is enabled and to see results of the most recent execution, you can run the `ztp -s` command.

```
cumulus@switch:~$ ztp -s
```



## ZTP INFO:

State	enabled
Version	1.0
Result	Script Failure
Date	Tue May 10 22:42:09 2016 UTC
Method	ZTP DHCP
URL	<a href="http://192.0.2.1/demo.sh">http://192.0.2.1/demo.sh</a>

If ZTP runs when the switch boots and not manually, you can run the `sudo systemctl -l status ztp.service` then `sudo journalctl -l -u ztp.service` to see if any failures occur:

```
cumulus@switch:~$ sudo systemctl -l status ztp.service
ztp.service - Cumulus Linux ZTP
   Loaded: loaded (/lib/systemd/system/ztp.service; enabled)
   Active: failed (Result: exit-code) since Wed 2016-05-11 16:38:45
             UTC; 1min 47s ago
     Docs: man:ztp(8)
   Process: 400 ExecStart=/usr/sbin/ztp -b (code=exited, status=1
/Failure)
   Main PID: 400 (code=exited, status=1/Failure)

May 11 16:37:45 cumulus ztp[400]: ztp [400]: ZTP USB: Device not found
May 11 16:38:45 dell-s6000-01 ztp[400]: ztp [400]: ZTP DHCP: Looking
for ZTP Script provided by DHCP
May 11 16:38:45 dell-s6000-01 ztp[400]: ztp [400]: Attempting to
provision via ZTP DHCP from http://192.0.2.1/demo.sh
May 11 16:38:45 dell-s6000-01 ztp[400]: ztp [400]: ZTP DHCP: URL
response code 200
May 11 16:38:45 dell-s6000-01 ztp[400]: ztp [400]: ZTP DHCP: Found
Marker CUMULUS-AUTOPROVISIONING
May 11 16:38:45 dell-s6000-01 ztp[400]: ztp [400]: ZTP DHCP:
Executing http://192.0.2.1/demo.sh
May 11 16:38:45 dell-s6000-01 ztp[400]: ztp [400]: ZTP DHCP: Payload
returned code 1
May 11 16:38:45 dell-s6000-01 ztp[400]: ztp [400]: Script returned
failure
May 11 16:38:45 dell-s6000-01 systemd[1]: ztp.service: main process
exited, code=exited, status=1/Failure
May 11 16:38:45 dell-s6000-01 systemd[1]: Unit ztp.service entered
failed state.
cumulus@switch:~$
```

```
cumulus@switch:~$ sudo journalctl -l -u ztp.service --no-pager
-- Logs begin at Wed 2016-05-11 16:37:42 UTC, end at Wed 2016-05-11
16:40:39 UTC. --
May 11 16:37:45 cumulus ztp[400]: ztp [400]: /var/lib/cumulus/ztp:
Sate Directory does not exist. Creating it...
May 11 16:37:45 cumulus ztp[400]: ztp [400]: /var/run/ztp.lock: Lock
File does not exist. Creating it...
```



```
May 11 16:37:45 cumulus ztp[400]: ztp [400]: /var/lib/cumulus/ztp  
/ztp_state.log: State File does not exist. Creating it...  
May 11 16:37:45 cumulus ztp[400]: ztp [400]: ZTP LOCAL: Looking for  
ZTP local Script  
May 11 16:37:45 cumulus ztp[400]: ztp [400]: ZTP LOCAL: Waterfall  
search for /var/lib/cumulus/ztp/cumulus-ztp-x86_64-dell_s6000_s1220-  
rUNKNOWN  
May 11 16:37:45 cumulus ztp[400]: ztp [400]: ZTP LOCAL: Waterfall  
search for /var/lib/cumulus/ztp/cumulus-ztp-x86_64-dell_s6000_s1220  
May 11 16:37:45 cumulus ztp[400]: ztp [400]: ZTP LOCAL: Waterfall  
search for /var/lib/cumulus/ztp/cumulus-ztp-x86_64-dell  
May 11 16:37:45 cumulus ztp[400]: ztp [400]: ZTP LOCAL: Waterfall  
search for /var/lib/cumulus/ztp/cumulus-ztp-x86_64  
May 11 16:37:45 cumulus ztp[400]: ztp [400]: ZTP LOCAL: Waterfall  
search for /var/lib/cumulus/ztp/cumulus-ztp  
May 11 16:37:45 cumulus ztp[400]: ztp [400]: ZTP USB: Looking for  
unmounted USB devices  
May 11 16:37:45 cumulus ztp[400]: ztp [400]: ZTP USB: Parsing  
partitions  
May 11 16:37:45 cumulus ztp[400]: ztp [400]: ZTP USB: Device not found  
May 11 16:38:45 dell-s6000-01 ztp[400]: ztp [400]: ZTP DHCP: Looking  
for ZTP Script provided by DHCP  
May 11 16:38:45 dell-s6000-01 ztp[400]: ztp [400]: Attempting to  
provision via ZTP DHCP from http://192.0.2.1/demo.sh  
May 11 16:38:45 dell-s6000-01 ztp[400]: ztp [400]: ZTP DHCP: URL  
response code 200  
May 11 16:38:45 dell-s6000-01 ztp[400]: ztp [400]: ZTP DHCP: Found  
Marker CUMULUS-AUTOPROVISIONING  
May 11 16:38:45 dell-s6000-01 ztp[400]: ztp [400]: ZTP DHCP:  
Executing http://192.0.2.1/demo.sh  
May 11 16:38:45 dell-s6000-01 ztp[400]: ztp [400]: ZTP DHCP: Payload  
returned code 1  
May 11 16:38:45 dell-s6000-01 ztp[400]: ztp [400]: Script returned  
failure  
May 11 16:38:45 dell-s6000-01 systemd[1]: ztp.service: main process  
exited, code=exited, status=1/FAILURE  
May 11 16:38:45 dell-s6000-01 systemd[1]: Unit ztp.service entered  
failed state.
```

Instead of running `journalctl`, you can see the log history by running:

```
cumulus@switch:~$ cat /var/log/syslog | grep ztp  
2016-05-11T16:37:45.132583+00:00 cumulus ztp [400]: /var/lib/cumulus  
/ztp: State Directory does not exist. Creating it...  
2016-05-11T16:37:45.134081+00:00 cumulus ztp [400]: /var/run/ztp.  
lock: Lock File does not exist. Creating it...  
2016-05-11T16:37:45.135360+00:00 cumulus ztp [400]: /var/lib/cumulus  
/ztp/ztp_state.log: State File does not exist. Creating it...  
2016-05-11T16:37:45.185598+00:00 cumulus ztp [400]: ZTP LOCAL:  
Looking for ZTP local Script
```



```
2016-05-11T16:37:45.485084+00:00 cumulus ztp [400]: ZTP LOCAL:  
Waterfall search for /var/lib/cumulus/ztp/cumulus-ztp-x86_64-  
dell_s6000_s1220-rUNKNOWN  
2016-05-11T16:37:45.486394+00:00 cumulus ztp [400]: ZTP LOCAL:  
Waterfall search for /var/lib/cumulus/ztp/cumulus-ztp-x86_64-  
dell_s6000_s1220  
2016-05-11T16:37:45.488385+00:00 cumulus ztp [400]: ZTP LOCAL:  
Waterfall search for /var/lib/cumulus/ztp/cumulus-ztp-x86_64-dell  
2016-05-11T16:37:45.489665+00:00 cumulus ztp [400]: ZTP LOCAL:  
Waterfall search for /var/lib/cumulus/ztp/cumulus-ztp-x86_64  
2016-05-11T16:37:45.490854+00:00 cumulus ztp [400]: ZTP LOCAL:  
Waterfall search for /var/lib/cumulus/ztp/cumulus-ztp  
2016-05-11T16:37:45.492296+00:00 cumulus ztp [400]: ZTP USB: Looking  
for unmounted USB devices  
2016-05-11T16:37:45.493525+00:00 cumulus ztp [400]: ZTP USB: Parsing  
partitions  
2016-05-11T16:37:45.636422+00:00 cumulus ztp [400]: ZTP USB: Device  
not found  
2016-05-11T16:38:43.372857+00:00 cumulus ztp [1805]: Found ZTP DHCP  
Request  
2016-05-11T16:38:45.696562+00:00 cumulus ztp [400]: ZTP DHCP: Looking  
for ZTP Script provided by DHCP  
2016-05-11T16:38:45.698598+00:00 cumulus ztp [400]: Attempting to  
provision via ZTP DHCP from http://192.0.2.1/demo.sh  
2016-05-11T16:38:45.816275+00:00 cumulus ztp [400]: ZTP DHCP: URL  
response code 200  
2016-05-11T16:38:45.817446+00:00 cumulus ztp [400]: ZTP DHCP: Found  
Marker CUMULUS-AUTOPROVISIONING  
2016-05-11T16:38:45.818402+00:00 cumulus ztp [400]: ZTP DHCP:  
Executing http://192.0.2.1/demo.sh  
2016-05-11T16:38:45.834240+00:00 cumulus ztp [400]: ZTP DHCP: Payload  
returned code 1  
2016-05-11T16:38:45.835488+00:00 cumulus ztp [400]: Script returned  
failure  
2016-05-11T16:38:45.876334+00:00 cumulus systemd[1]: ztp.service:  
main process exited, code=exited, status=1/FAILURE  
2016-05-11T16:38:45.879410+00:00 cumulus systemd[1]: Unit ztp.service  
entered failed state.
```

If you see that the issue is a script failure, you can modify the script and then run `ztp` manually using `ztp -v -r <URL/path to that script>`, as above.

```
cumulus@switch:~$ sudo ztp -v -r http://192.0.2.1/demo.sh  
Attempting to provision via ZTP Manual from http://192.0.2.1/demo.sh  
  
Broadcast message from root@dell-s6000-01 (ttyS0) (Tue May 10 22:44:  
17 2016):  
  
ZTP: Attempting to provision via ZTP Manual from http://192.0.2.1  
/demo.sh
```



```
ZTP Manual: URL response code 200
ZTP Manual: Found Marker CUMULUS-AUTOPROVISIONING
ZTP Manual: Executing http://192.0.2.1/demo.sh
error: ZTP Manual: Payload returned code 1
error: Script returned failure
cumulus@switch:~$ sudo ztp -s
State      enabled
Version    1.0
Result     Script Failure
Date       Tue May 10 22:44:17 2016 UTC
Method     ZTP Manual
URL        http://192.0.2.1/demo.sh
```

Use the following command to check `syslog` for information about ZTP:

```
cumulus@switch:~$ sudo grep -i ztp /var/log/syslog
```

## Common ZTP Script Errors

*Could not find referenced script/interpreter in downloaded payload.*

```
cumulus@leaf01:~$ sudo cat /var/log/syslog | grep ztp
2018-04-24T15:06:08.887041+00:00 leaf01 ztp [13404]: Attempting to
provision via ZTP Manual from http://192.168.0.254/ztp_oob_windows.sh
2018-04-24T15:06:09.106633+00:00 leaf01 ztp [13404]: ZTP Manual: URL
response code 200
2018-04-24T15:06:09.107327+00:00 leaf01 ztp [13404]: ZTP Manual:
Found Marker CUMULUS-AUTOPROVISIONING
2018-04-24T15:06:09.107635+00:00 leaf01 ztp [13404]: ZTP Manual:
Executing http://192.168.0.254/ztp_oob_windows.sh
2018-04-24T15:06:09.132651+00:00 leaf01 ztp [13404]: ZTP Manual:
Could not find referenced script/interpreter in downloaded payload.
2018-04-24T15:06:14.135521+00:00 leaf01 ztp [13404]: ZTP Manual:
Retrying
2018-04-24T15:06:14.138915+00:00 leaf01 ztp [13404]: ZTP Manual: URL
response code 200
2018-04-24T15:06:14.139162+00:00 leaf01 ztp [13404]: ZTP Manual:
Found Marker CUMULUS-AUTOPROVISIONING
2018-04-24T15:06:14.139448+00:00 leaf01 ztp [13404]: ZTP Manual:
Executing http://192.168.0.254/ztp_oob_windows.sh
2018-04-24T15:06:14.143261+00:00 leaf01 ztp [13404]: ZTP Manual:
Could not find referenced script/interpreter in downloaded payload.
2018-04-24T15:06:24.147580+00:00 leaf01 ztp [13404]: ZTP Manual:
Retrying
2018-04-24T15:06:24.150945+00:00 leaf01 ztp [13404]: ZTP Manual: URL
response code 200
2018-04-24T15:06:24.151177+00:00 leaf01 ztp [13404]: ZTP Manual:
Found Marker CUMULUS-AUTOPROVISIONING
```



```
2018-04-24T15:06:24.151374+00:00 leaf01 ztp [13404]: ZTP Manual:  
Executing http://192.168.0.254/ztp_oob_windows.sh  
2018-04-24T15:06:24.155026+00:00 leaf01 ztp [13404]: ZTP Manual:  
Could not find referenced script/interpreter in downloaded payload.  
2018-04-24T15:06:39.164957+00:00 leaf01 ztp [13404]: ZTP Manual:  
Retrying  
2018-04-24T15:06:39.165425+00:00 leaf01 ztp [13404]: Script returned  
failure  
2018-04-24T15:06:39.175959+00:00 leaf01 ztp [13404]: ZTP script  
failed. Exiting...
```

Errors in syslog for ZTP like those shown above often occur if the script is created (or edited as some point) on a Windows machine. Check to make sure that the \r\n characters are *not* present in the end-of-line encodings.

Use the `cat -v ztp.sh` command to view the contents of the script and search for any hidden characters.

```
root@oob-mgmt-server:/var/www/html# cat -v ./ztp_oob_windows.sh  
#!/bin/bash^M  
^M  
#####^M  
# ZTP Script^M  
#####^M  
^M  
/usr/cumulus/bin/cl-license -i http://192.168.0.254/license.txt^M  
^M  
# Clean method of performing a Reboot^M  
nohup bash -c 'sleep 2; shutdown now -r "Rebooting to Complete ZTP"'  
&^M  
^M  
exit 0^M  
^M  
# The line below is required to be a valid ZTP script^M  
#CUMULUS-AUTOPROVISIONING^M  
root@oob-mgmt-server:/var/www/html#
```

The ^M characters in the output of your ZTP script, as shown above, indicate the presence of Windows end-of-line encodings that you need to remove.

Use the translate (`tr`) command on any Linux system to remove the '\r' characters from the file.

```
root@oob-mgmt-server:/var/www/html# tr -d '\r' < ztp_oob_windows.sh >  
ztp_oob_unix.sh  
root@oob-mgmt-server:/var/www/html# cat -v ./ztp_oob_unix.sh  
#!/bin/bash  
#####  
# ZTP Script  
#####  
/usr/cumulus/bin/cl-license -i http://192.168.0.254/license.txt
```

```
# Clean method of performing a Reboot
nohup bash -c 'sleep 2; shutdown now -r "Rebooting to Complete ZTP"' &
exit 0
# The line below is required to be a valid ZTP script
#CUMULUS-AUTOPROVISIONING
root@oob-mgmt-server:/var/www/html#
```

## Manually Use the ztp Command

To enable zero touch provisioning, use the `-e` option:

```
cumulus@switch:~$ sudo ztp -e
```



Enabling `ztp` means that `ztp` tries to run the next time the switch boots. However, if ZTP already ran on a previous boot up or if a manual configuration has been found, ZTP will just exit without trying to look for any script.

ZTP checks for these manual configurations during bootup:

- Password changes
- Users and groups changes
- Packages changes
- Interfaces changes
- The presence of an installed license

When the switch is booted for the very first time, ZTP records the state of important files that are most likely going to be modified after that the switch is configured. If ZTP is still enabled after a reboot, ZTP compares the recorded state to the current state of these files. If they do not match, ZTP considers that the switch has already been provisioned and exits. These files are only erased after a reset.

To reset `ztp` to its original state, use the `-R` option and the `-i` option. This removes the `ztp` directory and `ztp` runs the next time the switch reboots.

```
cumulus@switch:~$ sudo ztp -R
cumulus@switch:~$ sudo ztp -i
```

To disable zero touch provisioning, use the `-d` option:

```
cumulus@switch:~$ sudo ztp -d
```

To force provisioning to occur and ignore the status listed in the configuration file, use the `-r` option:

```
cumulus@switch:~$ sudo ztp -r cumulus-ztp.sh
```



To see the current `ztp` state, use the `-s` option:

```
cumulus@switch:~$ sudo ztp -s
ZTP INFO:
State disabled
Version 1.0
Result success
Date Thu May 5 16:49:33 2016 UTC
Method Switch manually configured
URL None
```

## Notes

- During the development of a provisioning script, the switch might need to be rebooted.
- You can use the Cumulus Linux `onie-select -i` command to cause the switch to reprovision itself and install a network operating system again using ONIE.

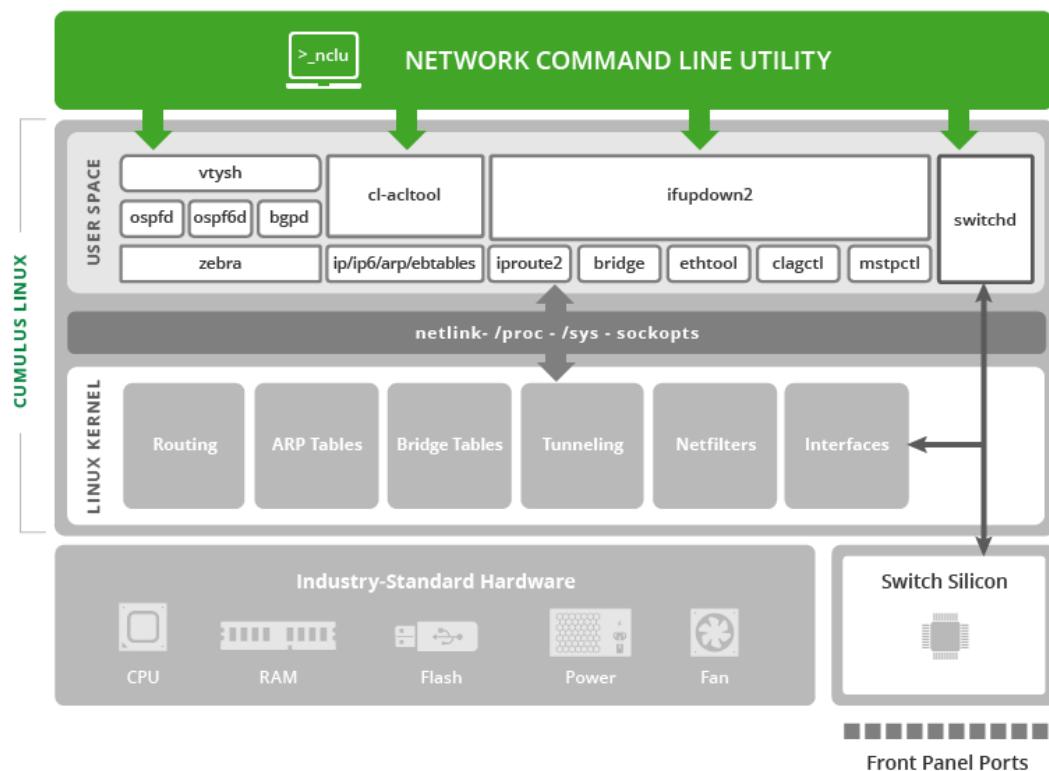
# System Configuration

## Network Command Line Utility - NCLU

The Network Command Line Utility (NCLU) is a command line interface for Cumulus Networks products that simplifies the networking configuration process for all users.

NCLU resides in the Linux user space and provides consistent access to networking commands directly through bash, making configuration and troubleshooting simple and easy; no need to edit files or enter modes and sub-modes. NCLU provides these benefits:

- Embeds help, examples, and automatic command checking with suggestions in case you enter a typo.
- Runs directly from and integrates with bash, while being interoperable with the regular way of accessing underlying configuration files and automation.
- Configures dependent features automatically so that you don't have to.



The NCLU wrapper utility called `net` is capable of configuring layer 2 and layer 3 features of the networking stack, installing ACLs and VXLANs, rolling back and deleting snapshots, as well as providing monitoring and troubleshooting functionality for these features. You can configure both the `/etc/network/interfaces` and `/etc/frr/frr.conf` files with `net`, in addition to running `show` and `clear` commands related to `ifupdown2` and FRRouting.

## Contents

This topic describes ...



- [Install NCLU \(see page 89\)](#)
- [NCLU Basics \(see page 89\)](#)
  - [Tab Completion, Verification, and Inline Help \(see page 90\)](#)
  - [Add ? \(Question Mark\) Ability to NCLU \(see page 92\)](#)
  - [Built-In Examples \(see page 93\)](#)
- [Configure User Accounts \(see page 94\)](#)
- [Edit the netd.conf File \(see page 96\)](#)
- [Restart the netd Service \(see page 96\)](#)
- [Back Up the Configuration to a Single File \(see page 97\)](#)
- [Advanced Configuration \(see page 97\)](#)

## Install NCLU

If you upgraded Cumulus Linux from a version earlier than 3.2 instead of performing a full disk image install, you need to install the `nclu` package on your switch:

```
cumulus@switch:~$ sudo -E apt-get update
cumulus@switch:~$ sudo -E apt-get install nclu
cumulus@switch:~$ sudo -E apt-get upgrade
```



The `nclu` package installs a new bash completion script and displays the following message:

```
Setting up nclu (1.0-cl3u3) ...
To enable the newly installed bash completion for nclu in this
shell, execute...
  source /etc/bash_completion
```

## NCLU Basics

Use the following workflow to stage and commit changes to Cumulus Linux with NCLU:

1. Use the `net add` and `net del` commands to stage and remove configuration changes.
2. Use the `net pending` command to review staged changes.
3. Use `net commit` and `net abort` to commit and delete staged changes.



`net commit` applies the changes to the relevant configuration files, such as `/etc/network/interfaces`, then runs necessary follow on commands to enable the configuration, such as `ifreload -a`.

If two different users try to commit a change at the same time, NCLU displays a warning but implements the change according to the first commit received. The second user will need to abort the commit.

If you provision a new switch without setting the system clock (manually or with NTP or PTP), the NCLU `net commit` command fails when the system clock is earlier than the modification date of configuration files. Make sure to set the system clock on the switch.

When you have a running configuration, you can review and update the configuration with the following commands:

- `net show` is a series of commands for viewing various parts of the network configuration. For example, use `net show configuration` to view the complete network configuration, `net show commit history` to view a history of commits using NCLU, and `net show bgp` to view BGP status.
- `net clear` provides a way to clear `net show` counters, BGP and OSPF neighbor content, and more.
- `net rollback` provides a mechanism to [revert back \(see page 61\)](#) to an earlier configuration.
- `net commit confirm` requires you to press *Enter* to commit changes using NCLU. If you run `net commit confirm` but do not press *Enter* within 10 seconds, the commit automatically reverts and no changes are made.
- `net commit description <description>` enables you to provide a descriptive summary of the changes you are about to commit.
- `net commit permanent` retains the [snapshot \(see page 56\)](#) taken when committing the change. Otherwise, the snapshots created from NCLU commands are cleaned up periodically with a snapper cron job.
- `net commit delete` deletes one or more snapshots created when committing changes with NCLU.
- `net del all` deletes all configurations and stops the IEEE 802.1X service.



The `net del all` command does not remove [management VRF \(see page 877\)](#) configurations; NCLU does not interact with eth0 interfaces and management VRF.

### Tab Completion, Verification, and Inline Help

In addition to tab completion and partial keyword command identification, NCLU includes verification checks to ensure correct syntax is used. The examples below show the output for incorrect commands:

```
cumulus@switch:~$ net add bgp router-id 1.1.1.1/32
ERROR: Command not found

Did you mean one of the following?

    net add bgp router-id <ipv4>
        This command is looking for an IP address, not an IP/prefixlen
```



```
cumulus@switch:~$ net add bgp router-id 1.1.1.1
cumulus@switch:~$ net add int swp10 mtu <TAB>
<552-9216> :
cumulus@switch:~$ net add int swp10 mtu 9300
ERROR: Command not found

Did you mean one of the following?
    net add interface <interface> mtu <552-9216>
```

NCLU has a comprehensive built in help system. In addition to the net man page, you can use `?` and `help` to display available commands:

```
cumulus@switch:~$ net help

Usage:
# net <COMMAND> [<ARGS>] [help]
#
# net is a command line utility for networking on Cumulus Linux
switches.
#
# COMMANDS are listed below and have context specific arguments
which can
# be explored by typing "<TAB>" or "help" anytime while using net.
#
# Use 'man net' for a more comprehensive overview.
```

```
net abort
net commit [verbose] [confirm] [description <wildcard>]
net commit delete (<number>|<number-range>)
net help [verbose]
net pending
net rollback (<number>|last)
net show commit (history|<number>|<number-range>|last)
net show rollback (<number>|last)
net show configuration
[commands|files|acl|bgp|ospf|ospf6|interface <interface>]
```

Options:

```
# Help commands
help      : context sensitive information; see section below
example   : detailed examples of common workflows
```

```
# Configuration commands
add       : add/modify configuration
del       : remove configuration
```

```

# Commit buffer commands
abort      : abandon changes in the commit buffer
commit     : apply the commit buffer to the system
pending    : show changes staged in the commit buffer
rollback   : revert to a previous configuration state

# Status commands
show       : show command output
clear      : clear counters, BGP neighbors, etc

cumulus@switch:~$ net help bestpath
The following commands contain keyword(s) 'bestpath'

  net (add|del) bgp bestpath as-path multipath-relax [as-set|no-as-
  set]
  net (add|del) bgp bestpath compare-routerid
  net (add|del) bgp bestpath med missing-as-worst
  net (add|del) bgp vrf <text> bestpath as-path multipath-relax [as-
  set|no-as-set]
  net (add|del) bgp vrf <text> bestpath compare-routerid
  net (add|del) bgp vrf <text> bestpath med missing-as-worst
  net add bgp debug bestpath <ip/prefixlen>
  net del bgp debug bestpath [<ip/prefixlen>]
  net show bgp (<ipv4>|<ipv4/prefixlen>) [bestpath|multipath] [json]
  net show bgp (<ipv6>|<ipv6/prefixlen>) [bestpath|multipath] [json]
  net show bgp vrf <text> (<ipv4>|<ipv4/prefixlen>)
  [bestpath|multipath] [json]

```



You can configure multiple interfaces at once:

```
cumulus@switch:~$ net add int swp7-9,12,15-17,22 mtu 9216
```

## Add ? (Question Mark) Ability to NCLU

While tab completion is enabled by default, you can also configure NCLU to use the **?** (question mark character) to look at available commands. To enable this feature for the *cumulus* user, open the following file:

```
cumulus@leaf01:~$ sudo nano ~/.inputrc
```

Uncomment the very last line in the *.inputrc* file so that the file changes from this:



```
# Uncomment to use ? as an alternative to
# ?: complete
```

to this:

```
# Uncomment to use ? as an alternative to
?: complete
```

Save the file and reconnect to the switch. The ? (question mark) ability will work on all subsequent sessions on the switch.

```
cumulus@leaf01:~$ net
  abort      : abandon changes in the commit buffer
  add        : add/modify configuration
  clear      : clear counters, BGP neighbors, etc
  commit     : apply the commit buffer to the system
  del        : remove configuration
  example    : detailed examples of common workflows
  help       : Show this screen and exit
  pending    : show changes staged in the commit buffer
  rollback   : revert to a previous configuration state
  show       : show command output
```



When the question mark is typed, NCLU autocompletes and shows all available options, but the question mark does not actually appear on the terminal. This is normal, expected behavior.

## Built-In Examples

NCLU has a number of built in examples to guide users through basic configuration setup:

```
cumulus@switch:~$ net example
  acl          : access-list
  bgp         : Border Gateway Protocol
  bond        : Bond, port-channel, etc
  bridge      : A layer2 bridge
  clag        : Multi-Chassis Link Aggregation
  dot1x      : Configure, Enable, Delete or Show IEEE 802.1X
EAPOL
  link-settings : Physical link parameters
  lnv         : Lightweight Network Virtualization
  management-vrf : Management VRF
  mlag        : Multi-Chassis Link Aggregation
  ospf        : Open Shortest Path First (OSPFv2)
  vlan-interfaces : IP interfaces for VLANs
```

```
cumulus@switch:~$ net example bridge

Scenario
=====
We are configuring switch1 and would like to configure the following
- configure switch1 as an L2 switch for host-11 and host-12
- enable vlans 10-20
- place host-11 in vlan 10
- place host-12 in vlan 20
- create an SVI interface for vlan 10
- create an SVI interface for vlan 20
- assign IP 10.0.0.1/24 to the SVI for vlan 10
- assign IP 20.0.0.1/24 to the SVI for vlan 20
- configure swp3 as a trunk for vlans 10, 11, 12 and 20
    swp3
        *switch1 ----- switch2
            / \
        swp1 /   \ swp2
            /     \
            /       \
        host-11   host-12

switch1 net commands
=====
- enable vlans 10-20
switch1# net add vlan 10-20
- place host-11 in vlan 10
- place host-12 in vlan 20
switch1# net add int swp1 bridge access 10
switch1# net add int swp2 bridge access 20
- create an SVI interface for vlan 10
- create an SVI interface for vlan 20
- assign IP 10.0.0.1/24 to the SVI for vlan 10
- assign IP 20.0.0.1/24 to the SVI for vlan 20
switch1# net add vlan 10 ip address 10.0.0.1/24
switch1# net add vlan 20 ip address 20.0.0.1/24
- configure swp3 as a trunk for vlans 10, 11, 12 and 20
switch1# net add int swp3 bridge trunk vlans 10-12,20
# Review and commit changes
switch1# net pending
switch1# net commit

Verification
=====
switch1# net show interface
switch1# net show bridge macs
```

## Configure User Accounts

You can configure user accounts in Cumulus Linux with read-only or edit permissions for NCLU:



- You create user accounts with **read-only** permissions for NCLU by adding them to the `netshow` group. A user in the `netshow` group can run NCLU `net show` commands, such as `net show interface` or `net show config`, and certain general Linux commands, such as `ls`, `cd` or `man`, but cannot run `net add`, `net del` or `net commit` commands.
- You create user accounts with **edit** permissions for NCLU by adding them to the `netedit` group. A user in the `netedit` group can run NCLU configuration commands, such `net add`, `net del` or `net commit` in addition to NCLU `net show` commands.

The examples below demonstrate how to add a new user account or modify an existing user account called `myuser`.

To add a new user account with NCLU show permissions:

```
cumulus@switch:~$ sudo adduser --ingroup netshow myuser
Adding user `myuser' ...
Adding new user `myuser' (1001) with group `netshow' ...
```

To add NCLU show permissions to a user account that already exists:

```
cumulus@switch:~$ sudo addgroup myuser netshow
Adding user `myuser' to group `netshow' ...
Adding user myuser to group netshow
Done
```

To add a new user account with NCLU edit permissions:

```
cumulus@switch:~$ sudo adduser --ingroup netedit myuser
Adding user `myuser' ...
Adding new user `myuser' (1001) with group `netedit' ...
```

To add NCLU edit permissions to a user account that already exists:

```
cumulus@switch:~$ sudo addgroup myuser netedit
Adding user `myuser' to group `netedit' ...
Adding user myuser to group netedit
Done
```



You can use the `adduser` command for local user accounts only. You can use the `addgroup` command for both local and remote user accounts. For a remote user account, you must use the mapping username, such as `tacacs3` or `radius_user`, not the [TACACS \(see page 122\)](#) or [RADIUS \(see page 136\)](#) account name.

If the user tries to run commands that are not allowed, the following error displays:



```
myuser@switch:~$ net add hostname host01
ERROR: User username does not have permission to make networking
changes.
```

## Edit the netd.conf File

Instead of using the NCLU commands described above, you can manually configure users and groups to be able to run NCLU commands.

Edit the `/etc/netd.conf` file to add users to the `users_with_edit` and `users_with_show` lines in the file, then save the file.

For example, if you want the user `netoperator` to be able to run both edit and show commands, add the user to the `users_with_edit` and `users_with_show` lines in the `/etc/netd.conf` file:

```
cumulus@switch:~$ sudo nano /etc/netd.conf

# Control which users/groups are allowed to run 'add', 'del',
# 'clear', 'net abort', 'net commit' and restart services
# to apply those changes
users_with_edit = root, cumulus, netoperator
groups_with_edit = root, cumulus

# Control which users/groups are allowed to run 'show' commands
users_with_show = root, cumulus, netoperator
groups_with_show = root, cumulus
```

To configure a new user group to use NCLU, add that group to the `groups_with_edit` and `groups_with_show` lines in the file.



Use caution giving edit permissions to groups. For example, don't give edit permissions to the `tacacs` group (see page 127).

## Restart the netd Service

Whenever you modify `netd.conf` or NSS services change, you must restart the `netd` service for the changes to take effect:

```
cumulus@switch:~$ sudo systemctl restart netd.service
```



## Back Up the Configuration to a Single File

You can easily back up your NCLU configuration to a file by outputting the results of `net show configuration commands` to a file, then retrieving the contents of the file using the `source` command. You can then view the configuration at any time or copy it to other switches and use the `source` command to apply that configuration to those switches.

For example, to copy the configuration of a leaf switch called `leaf01`, run the following command:

```
cumulus@leaf01:~$ net show configuration commands >> leaf01.txt
```

With the commands all stored in a single file, you can now copy this file to another ToR switch in your network called `leaf01` and apply the configuration by running:

```
cumulus@leaf01:~$ source leaf01.txt
```

## Advanced Configuration

NCLU needs no initial configuration; however, if you need to modify its configuration, you must manually update the `/etc/netd.conf` file. You can configure this file to allow different permission levels for users to edit configurations and run `show` commands. The file also contains a blacklist that hides less frequently used terms from the tabbed autocomplete.

After you edit the `netd.conf` file, restart the `netd` service for the changes to take effect.

```
cumulus@switch:~$ sudo nano /etc/netd.conf
cumulus@switch:~$ sudo systemctl restart netd.service
```

Configuration Variable	Default Setting	Description
<code>show_linux_command</code>	False	When true, displays the Linux command running in the background.
<code>enable_ifupdown2</code>	True	Enables <code>net</code> wrapping of <code>ifupdown2</code> commands.
<code>enable_frr</code>	True	

Configuration Variable	Default Setting	Description
		Enables net wrapping of FRRouting commands.
users_with_edit	root, cumulus	Sets the Linux users with root edit privileges.
groups_with_edit	root, cumulus	Sets the Linux groups with root edit privileges.
users_with_show	root, cumulus	Controls which users are allowed to run show commands.
groups_with_show	root, cumulus	Controls which groups are allowed to run show commands.
ifupdown_blacklist	address-purge, bond-ad-actor-sys-prio, bond-ad-actor-system, bond-mode, bond-num-grat-arp, bond-num-unsol-na, bond-use-carrier, bond-xmit-hash-policy, bridge-bridgeprio, bridge-fd, bridge-hashed, bridge-hashmax, bridge-hello, bridge-maxage, bridge-maxwait, bridge-mclmc, bridge-mclmi, bridge-mcmi, bridge-mcqj, bridge-mcqpi, bridge-mcqri, bridge-mcrouter, bridge-mcsqc, bridge-mcsqi, bridge-pathcosts, bridge-port-pvids, bridge-port-vids, bridge-portprios, bridge-stp, bridge-waitport, broadcast, hwaddress, link-type, mstpcctl-ageing, mstpcctl-fdelay, mstpcctl-forcevers, mstpcctl-hello, mstpcctl-maxage, mstpcctl-maxhops, mstpcctl-portp2p, mstpcctl-portpathcost, mstpcctl-portrestrrole, mstpcctl-portrestrtcn, mstpcctl-treeportcost, mstpcctl-treeportprio, mstpcctl-txholdcount, netmask, preferred-lifetime, scope, vxlan-ageing, vxlan-learning, up, down, bridge-ageing, bridge-gcint, bridge-mcqifaddr, bridge-mcqv4src	Hides corner case command options from tab complete, to simplify and streamline output.

## ⓘ Net Tab Complete Output

`net` provides an environment variable to set where the `net` output is directed. To only use `stdout`, set the `NCLU_TAB_STDOUT` environment variable to `true`. The value is not case sensitive.

## Setting Date and Time

Setting the time zone, date and time requires root privileges; use `sudo`.

### Contents

This topic describes ...

- Set the Time Zone (see page 99)
  - Edit the `/etc/timezone` File (see page 99)
  - Use the Guided Wizard (see page 100)
- Set the Date and Time (see page 101)
- Set the Time Using NTP and NCLU (see page 101)
- Specify the NTP Source Interface (see page 103)
- NTP Default Configuration (see page 103)
- Precision Time Protocol (PTP) Boundary Clock (see page 105)
  - Enable the PTP Boundary Clock on the Switch (see page 106)
  - Configure the PTP Boundary Clock (see page 106)
  - Example Configuration (see page 108)
  - Verify PTP Boundary Clock Configuration (see page 108)
  - View PTP Status Information (see page 109)
  - Delete PTP Boundary Clock Configuration (see page 110)
- Use NTP in a DHCP Environment (see page 111)
- System Clock and NCLU Commands (see page 112)
- Related Information (see page 112)

### Set the Time Zone

You can use one of two methods to set the time zone on the switch:

- Edit the `/etc/timezone` file.
- Use the guided wizard.

#### *Edit the `/etc/timezone` File*

To see the current time zone, list the contents of `/etc/timezone`:

```
cumulus@switch:~$ cat /etc/timezone
US/Eastern
```



Edit the file to add your desired time zone. A list of valid time zones can be found at the following [link](#). Use the following command to apply the new time zone immediately.

```
cumulus@switch:~$ sudo dpkg-reconfigure --frontend noninteractive tzdata
```

### *Use the Guided Wizard*

To set the time zone using the guided wizard, run `dpkg-reconfigure tzdata` as root:

```
cumulus@switch:~$ sudo dpkg-reconfigure tzdata
```

Then navigate the menus to enable the time zone you want. The following example selects the US/Pacific time zone:

```
cumulus@switch:~$ sudo dpkg-reconfigure tzdata

Configuring tzdata
-----

Please select the geographic area in which you live. Subsequent
configuration
questions will narrow this down by presenting a list of cities,
representing
the time zones in which they are located.

 1. Africa      4. Australia   7. Atlantic   10. Pacific   13. Etc
 2. America     5. Arctic       8. Europe     11. SystemV
 3. Antarctica  6. Asia        9. Indian     12. US
Geographic area: 12

Please select the city or region corresponding to your time zone.

 1. Alaska      4. Central     7. Indiana-Starke 10. Pacific
 2. Aleutian    5. Eastern     8. Michigan      11. Pacific-New
 3. Arizona     6. Hawaii      9. Mountain     12. Samoa
Time zone: 10

Current default time zone: 'US/Pacific'
Local time is now:      Mon Jun 17 09:27:45 PDT 2013.
Universal Time is now:  Mon Jun 17 16:27:45 UTC 2013.
```

For more info see the Debian [System Administrator's Manual – Time](#).



## Set the Date and Time

The switch contains a battery backed hardware clock that maintains the time while the switch is powered off and in between reboots. When the switch is running, the Cumulus Linux operating system maintains its own software clock.

During boot up, the time from the hardware clock is copied into the operating system's software clock. The software clock is then used for all timekeeping responsibilities. During system shutdown, the software clock is copied back to the battery backed hardware clock.

You can set the date and time on the software clock using the `date` command. First, determine your current time zone:

```
cumulus@switch$ date +%Z
```



If you need to reconfigure the current time zone, refer to the instructions above.

Then, to set the system clock according to the time zone configured:

```
cumulus@switch$ sudo date -s "Tue Jan 12 00:37:13 2016"
```

See `man date(1)` for more information.

You can write the current value of the system (software) clock to the hardware clock using the `hwclock` command:

```
cumulus@switch$ sudo hwclock -w
```

See `man hwclock(8)` for more information.

You can find a good overview of the software and hardware clocks in the Debian [System Administrator's Manual – Time](#), specifically the section [Setting and showing hardware clock](#).

## Set the Time Using NTP and NCLU

The `ntpd` daemon running on the switch implements the NTP protocol. It synchronizes the system time with time servers listed in `/etc/ntp.conf`. The `ntpd` daemon is started at boot by default. See `man ntpd(8)` for `ntpd` details. You can check [this site](#) for an explanation of the output.



If you intend to run this service within a [VRF \(see page 847\)](#), including the [management VRF \(see page 877\)](#), follow [these steps \(see page 879\)](#) for configuring the service.

By default, `/etc/ntp.conf` contains some default time servers. You can specify the NTP server or servers you want to use with [NCLU \(see page 88\)](#); include the `iburst` option to increase the sync speed.



```
cumulus@switch:~$ net add time ntp server 4.cumulusnetworks.pool.ntp.org iburst
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands add the NTP server to the list of servers in `/etc/ntp.conf`:

```
# pool.ntp.org maps to about 1000 low-stratum NTP servers. Your
server will
# pick a different set every time it starts up. Please consider
joining the
# pool: <http://www.pool.ntp.org/join.html>
server 0.cumulusnetworks.pool.ntp.org iburst
server 1.cumulusnetworks.pool.ntp.org iburst
server 2.cumulusnetworks.pool.ntp.org iburst
server 3.cumulusnetworks.pool.ntp.org iburst
server 4.cumulusnetworks.pool.ntp.org iburst
```

To set the initial date and time via NTP before starting the `ntpd` daemon, use `ntpd -q`. This is the same as `ntpdate`, which is to be retired and no longer available. See `man ntp.conf(5)` for details on configuring `ntpd` using `ntp.conf`.



`ntpd -q` can hang if the time servers are not reachable.

To verify that `ntpd` is running on the system:

```
cumulus@switch:~$ ps -ef | grep ntp
ntp        4074      1  0 Jun20 ?          00:00:33 /usr/sbin/ntpd -p /var
/run/ntpd.pid -g -u 101:102
```

To check the NTP peer status:

```
cumulus@switch:~$ net show time ntp servers
      remote           refid      st t when poll reach   delay
offset  jitter
=====
=====
+minime.fdf.net  58.180.158.150    3 u    140 1024   377   55.659
0.339  1.464
+69.195.159.158 128.138.140.44    2 u    259 1024   377   41.587
1.011  1.677
*chl.la         216.218.192.202    2 u    210 1024   377    4.008
1.277  1.628
+vps3.drown.org 17.253.2.125      2 u    743 1024   377   39.319
-0.316  1.384
```



To remove one or more NTP servers:

```
cumulus@switch:~$ net del time ntp server 0.cumulusnetworks.pool.ntp.org iburst
cumulus@switch:~$ net del time ntp server 1.cumulusnetworks.pool.ntp.org iburst
cumulus@switch:~$ net del time ntp server 2.cumulusnetworks.pool.ntp.org iburst
cumulus@switch:~$ net del time ntp server 3.cumulusnetworks.pool.ntp.org iburst
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

## Specify the NTP Source Interface

You can change the source interface that NTP uses if you want to use an interface other than eth0, which is the default.

```
cumulus@switch:~$ net add time ntp source swp10
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands create the following configuration snippet in the `ntp.conf` file:

```
...
# Specify interfaces
interface listen swp10
...
```

## NTP Default Configuration

The default NTP configuration comprises the following servers, which are listed in the `/etc/ntp.conf` file:

- server `0.cumulusnetworks.pool.ntp.org` iburst
- server `1.cumulusnetworks.pool.ntp.org` iburst
- server `2.cumulusnetworks.pool.ntp.org` iburst
- server `3.cumulusnetworks.pool.ntp.org` iburst

The contents of the `/etc/ntp.conf` file are listed below.

### Default `ntp.conf` file ...

```
# /etc/ntp.conf, configuration for ntpd; see ntp.conf(5) for help
```



```
driftfile /var/lib/ntp/ntp.drift
# Enable this if you want statistics to be logged.
#statsdir /var/log/ntpstats/
statistics loopstats peerstats clockstats
filegen loopstats file loopstats type day enable
filegen peerstats file peerstats type day enable
filegen clockstats file clockstats type day enable
# You do need to talk to an NTP server or two (or three).
#server ntp.your-provider.example
# pool.ntp.org maps to about 1000 low-stratum NTP servers. Your
server will
# pick a different set every time it starts up. Please consider
joining the
# pool: <http://www.pool.ntp.org/join.html>
server 0.cumulusnetworks.pool.ntp.org iburst
server 1.cumulusnetworks.pool.ntp.org iburst
server 2.cumulusnetworks.pool.ntp.org iburst
server 3.cumulusnetworks.pool.ntp.org iburst
# Access control configuration; see /usr/share/doc/ntp-doc/html
/acctopt.html for
# details. The web page <http://support.ntp.org/bin/view/Support
/AccessRestrictions>
# might also be helpful.
#
# Note that "restrict" applies to both servers and clients, so a
configuration
# that might be intended to block requests from certain clients could
also end
# up blocking replies from your own upstream servers.
# By default, exchange time with everybody, but don't allow
configuration.
restrict -4 default kod notrap nomodify nopeer noquery
restrict -6 default kod notrap nomodify nopeer noquery
# Local users may interrogate the ntp server more closely.
restrict 127.0.0.1
restrict ::1
# Clients from this (example!) subnet have unlimited access, but only
if
# cryptographically authenticated.
#restrict 192.168.123.0 mask 255.255.255.0 notrust
# If you want to provide time to your local subnet, change the next
line.
# (Again, the address is an example only.)
#broadcast 192.168.123.255
# If you want to listen to time broadcasts on your local subnet, de-
comment the
# next lines. Please do this only if you trust everybody on the
network!
#disable auth
#broadcastclient
# Specify interfaces, don't listen on switch ports
interface listen eth0
```



## Precision Time Protocol (PTP) Boundary Clock

With the growth of low latency and high performance applications, precision timing has become increasingly important. Precision Time Protocol (PTP) is used to synchronize clocks in a network and is capable of sub-microsecond accuracy. The clocks are organized in a master-slave hierarchy. The slaves are synchronized to their masters, which can be slaves to their own masters. The hierarchy is created and updated automatically by the best master clock (BMC) algorithm, which runs on every clock. The grandmaster clock is the top-level master and is typically synchronized by using a Global Positioning System (GPS) time source to provide a high-degree of accuracy.

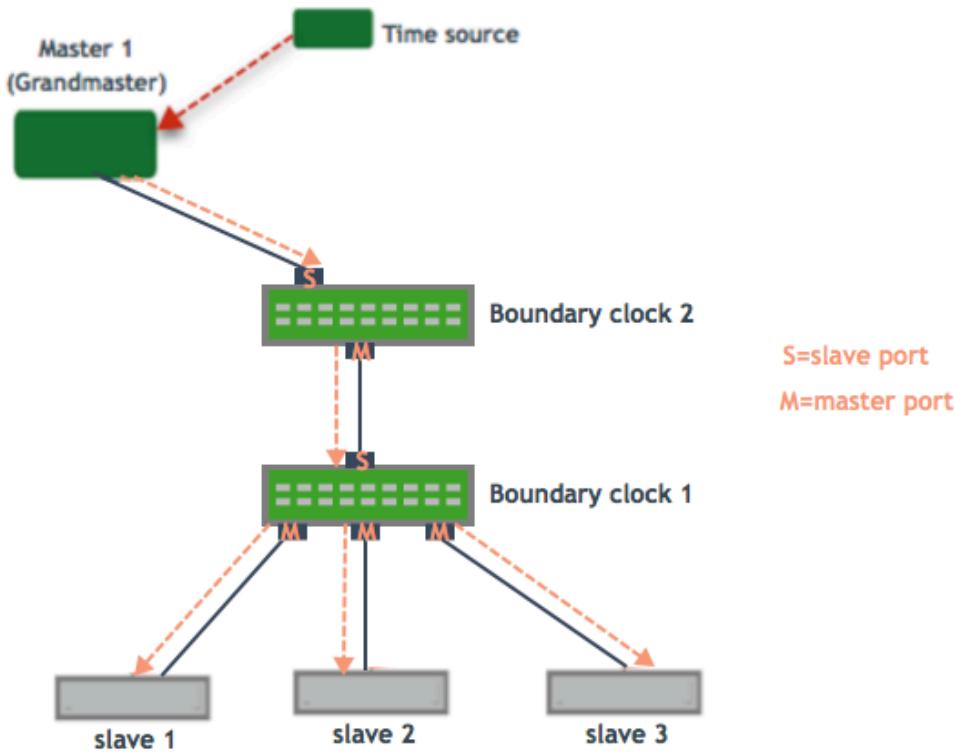
A boundary clock has multiple ports; one or more master ports and one or more slave ports. The master ports provide time (the time can originate from other masters further up the hierarchy) and the slave ports receive time. The boundary clock absorbs sync messages in the slave port, uses that port to set its clock, then generates new sync messages from this clock out of all of its master ports.

Cumulus Linux includes the `linuxptp` package for PTP, which uses the `phc2sys` daemon to synchronize the PTP clock with the system clock.



- Cumulus Linux currently supports PTP on the Mellanox Spectrum ASIC only.
- If you do not perform a full disk image install of Cumulus Linux 3.6 or later, you need to install the `linuxptp` package with the `sudo -E apt-get install linuxptp` command.
- PTP is supported in boundary clock mode only (the switch provides timing to downstream servers; it is a slave to a higher-level clock and a master to downstream clocks).
- The switch uses hardware time stamping to capture timestamps from an Ethernet frame at the physical layer. This allows PTP to account for delays in message transfer and greatly improves the accuracy of time synchronization.
- Only IPv4/UDP PTP packets are supported.
- Only a single PTP domain per network is supported. A PTP domain is a network or a portion of a network within which all the clocks are synchronized.

In the following example, boundary clock 2 receives time from Master 1 (the grandmaster) on a PTP slave port, sets its clock and passes the time down from the PTP master port to boundary clock 1. Boundary clock 1 receives the time on a PTP slave port, sets its clock and passes the time down the hierarchy through the PTP master ports to the hosts that receive the time.



### *Enable the PTP Boundary Clock on the Switch*

To enable the PTP boundary clock on the switch:

1. Open the `/etc/cumulus/switchd.conf` file in a text editor and add the following line:

```
ptp.timestamping = TRUE
```

2. Restart `switchd`:

```
cumulus@switch:~$ sudo systemctl restart switchd.service
```

### *Configure the PTP Boundary Clock*

To configure a boundary clock:

1. Configure the interfaces on the switch that you want to use for PTP. Each interface must be configured as a layer 3 routed interface with an IP address.





PTP is supported on BGP unnumbered interfaces.

PTP is *not* supported on switched virtual interfaces (SVIs).

```
cumulus@switch:~$ net add interface swp13s0 ip address 10.0.0.9  
/32  
cumulus@switch:~$ net add interface swp13s1 ip address 10.0.0.10  
/32
```

## 2. Configure PTP options on the switch:

- Set the `gm-capable` option to `no` to configure the switch to be a boundary clock.
- Set the priority, which selects the best master clock. You can set priority 1 or 2. For each priority, you can use a number between 0 and 255. The default priority is 255. For the boundary clock, use a number above 128. The lower priority is applied first.
- Add the `time-stamping` parameter. The switch automatically enables hardware time-stamping to capture timestamps from an Ethernet frame at the physical layer. If you are testing PTP in a virtual environment, hardware time-stamping is not available; however the `time-stamping` parameter is still required.
- Add the PTP master and slave interfaces. You do not specify which is a master interface and which is a slave interface; this is determined by the PTP packet received.

The following commands provide an example configuration:

```
cumulus@switch:~$ net add ptp global gm-capable no  
cumulus@switch:~$ net add ptp global priority2 254  
cumulus@switch:~$ net add ptp global priority1 254  
cumulus@switch:~$ net add ptp global time-stamping  
cumulus@switch:~$ net add ptp interface swp13s0  
cumulus@switch:~$ net add ptp interface swp13s1  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

The `ptp4l` man page describes all the configuration parameters.

## 3. Restart the `ptp4l` and `phc2sys` daemons:

```
cumulus@switch:~$ sudo systemctl restart ptp4l.service phc2sys.  
service
```

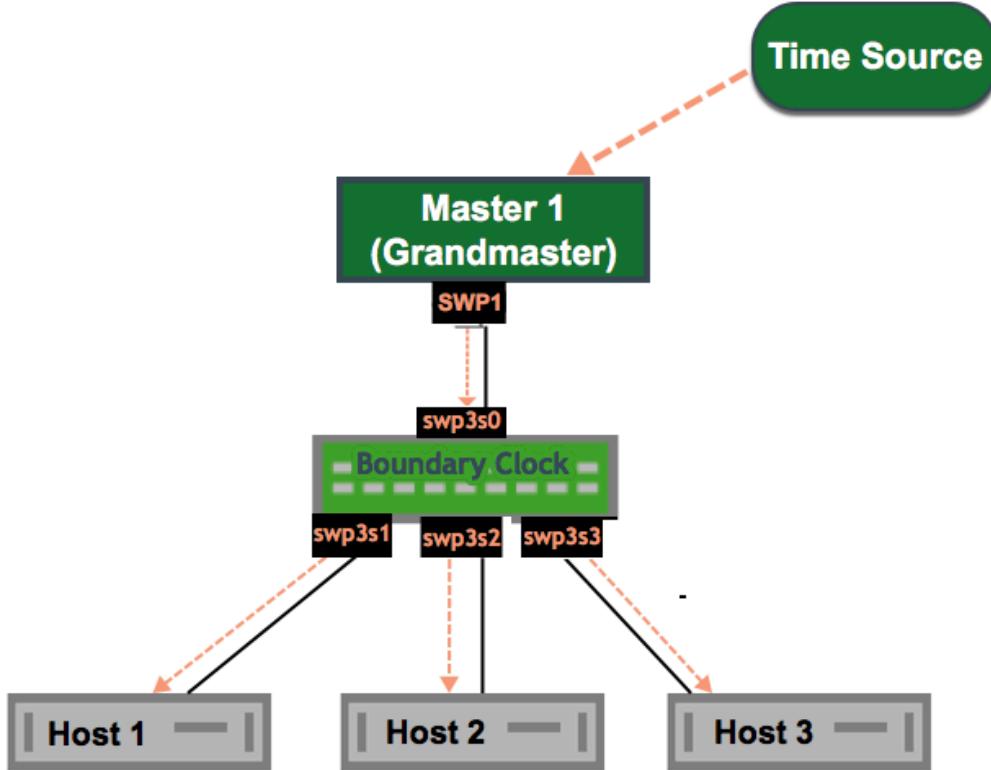
The configuration is saved in the `/etc/ptp4l.conf` file.

## 4. Enable the services to start at boot time:

```
cumulus@switch:~$ sudo systemctl enable ptp4l.service phc2sys.  
service
```

## Example Configuration

In the following example, the boundary clock on the switch receives time from Master 1 (the grandmaster) on PTP slave port `swp3s0`, sets its clock and passes the time down through PTP master ports `swp3s1`, `swp3s2`, and `swp3s3` to the hosts that receive the time.



The configuration for the above example is shown below. The example assumes that you have already configured the layer 3 routed interfaces (`swp3s0`, `swp3s1`, `swp3s2`, and `swp3s3`) you want to use for PTP.

```
cumulus@switch:~$ net add ptp global gm-capable no
cumulus@switch:~$ net add ptp global priority2 254
cumulus@switch:~$ net add ptp global priority1 254
cumulus@switch:~$ net add ptp global time-stamping
cumulus@switch:~$ net add ptp interface swp3s0
cumulus@switch:~$ net add ptp interface swp3s1
cumulus@switch:~$ net add ptp interface swp3s2
cumulus@switch:~$ net add ptp interface swp3s3
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

## Verify PTP Boundary Clock Configuration

To view a summary of the PTP configuration on the switch, run the `net show configuration ptp` command:



```
cumulus@switch:~$ net show configuration ptp

ptp
  global

    slaveOnly
      0

    priority1
      255

    priority2
      255

    domainNumber
      0

    logging_level
      5

    path_trace_enabled
      0

    use_syslog
      1

    verbose
      0

    summary_interval
      0

    time_stamping
      hardware

    gmCapable
      0
  swp15s0
  swp15s1
  ...
  
```

### *View PTP Status Information*

To view PTP status information, run the `net show ptp parent_data_set` command:

```
cumulus@switch:~$ net show ptp parent_data_set
parent_data_set
=====
parentPortIdentity          000200.ffff.000001-1
  
```

```

parentStats          0
observedParentOffsetScaledLogVariance 0xffff
observedParentClockPhaseChangeRate   0xffffffff
grandmasterPriority1      127
gm.ClockClass           248
gm.ClockAccuracy        0xfe
gm.OffsetScaledLogVariance 0xffff
grandmasterPriority2      127
grandmasterIdentity      000200.ffffe.000001

```

To view the additional PTP status information, including the delta in nanoseconds from the master clock, run the `sudo pmc -u -b 0 'GET TIME_STATUS_NP'` command:

```

cumulus@switch:~$ sudo pmc -u -b 0 'GET TIME_STATUS_NP'
sending: GET TIME_STATUS_NP
    7cfe90.ffffe.f56dfc-0 seq 0 RESPONSE MANAGEMENT TIME_STATUS_NP
        master_offset          12610
        ingress_time           1525717806521177336
        cumulativeScaledRateOffset +0.000000000
        scaledLastGmPhaseChange 0
        gmTimeBaseIndicator     0
        lastGmPhaseChange       0x0000'0000000000000000.0000
        gmPresent                true
        gmIdentity               000200.ffffe.000005
    000200.ffffe.000005-1 seq 0 RESPONSE MANAGEMENT TIME_STATUS_NP
        master_offset          0
        ingress_time           0
        cumulativeScaledRateOffset +0.000000000
        scaledLastGmPhaseChange 0
        gmTimeBaseIndicator     0
        lastGmPhaseChange       0x0000'0000000000000000.0000
        gmPresent                false
        gmIdentity               000200.ffffe.000005
    000200.ffffe.000006-1 seq 0 RESPONSE MANAGEMENT TIME_STATUS_NP
        master_offset          5544033534
        ingress_time           1525717812106811842
        cumulativeScaledRateOffset +0.000000000
        scaledLastGmPhaseChange 0
        gmTimeBaseIndicator     0
        lastGmPhaseChange       0x0000'0000000000000000.0000
        gmPresent                true
        gmIdentity               000200.ffffe.000005

```

### *Delete PTP Boundary Clock Configuration*

To delete PTP configuration, delete the PTP master and slave interfaces. The following example commands delete the PTP interfaces `swp3s0`, `swp3s1`, and `swp3s2`.



```
cumulus@switch:~$ net del ptp interface swp3s0
cumulus@switch:~$ net del ptp interface swp3s1
cumulus@switch:~$ net del ptp interface swp3s2
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

## Use NTP in a DHCP Environment

If you use DHCP and want to specify your NTP servers, you must specify an alternate configuration file for NTP.

Before you create the file, ensure that the DHCP-generated configuration file exists. In Cumulus Linux 3.6.1 and later (which uses NTP 1:4.2.8), the DHCP-generated file is named `/run/ntp.conf.dhcp` while in Cumulus Linux 3.6.0 and earlier (which uses NTP 1:4.2.6) the file is named `/var/lib/ntp/ntp.conf.dhcp`. This file is generated by the `/etc/dhcp/dhclient-exit-hooks.d/ntp` script and is a copy of the default `/etc/ntp.conf` with a modified server list from the DHCP server. If this file does not exist and you plan on using DHCP in the future, you can copy your current `/etc/ntp.conf` file to the location of the DHCP file.

To use an alternate configuration file that persists across upgrades of Cumulus Linux, create a `systemd` unit override file called `/etc/systemd/system/ntp.service.d/config.conf` and add the following content:

```
cumulus@switch:~$ sudo echo '
[Service]
ExecStart=
ExecStart=/usr/sbin/ntpd -n -u ntp:ntp -g -c /run/ntp.conf.dhcp
' > ~/over
sudo mkdir -p /etc/systemd/system/ntp.service.d
sudo mv ~/over /etc/systemd/system/ntp.service.d/ntp.conf.dhcp
sudo chown root:root /etc/systemd/system/ntp.service.d/ntp.conf.dhcp
```

To validate that your configuration, run these commands:

```
cumulus@switch:~$ sudo systemctl daemon-reload
cumulus@switch:~$ sudo systemctl restart ntp
cumulus@switch:~$ sudo systemctl status -n0 ntp.service
```

If the state is not *Active*, or the alternate configuration file does not appear in the `ntp` command line — for example:

```
cumulus@switch:~$ /usr/sbin/ntpd -n -u ntp:ntp -g -c /run/ntp.conf.dhcp
```

— then it is likely that a mistake was made. In this case, correct the mistake and rerun the three commands above to verify.





With this unit file override present, changing NTP settings using NCLU do not take effect until the DHCP script regenerates the alternate NTP configuration file.

## System Clock and NCLU Commands

If you provision a new switch without setting the system clock (manually or with NTP or PTP), the NCLU `net commit` command fails when the system clock is earlier than the modification date of configuration files. Make sure to set the system clock on the switch.

## Related Information

- [Debian System Administrator's Manual – Time](#)
- [www.ntp.org](#)
- [en.wikipedia.org/wiki/Network\\_Time\\_Protocol](#)
- [wiki.debian.org/NTP](#)

## Authentication, Authorization and Accounting

### SSH for Remote Access

You can generate authentication keys to access a Cumulus Linux switch securely with the `ssh-keygen` component of the Secure Shell (SSH) protocol. Cumulus Linux uses the OpenSSH package to provide this functionality. This section describes how to generate an SSH key pair.

#### Contents

##### This topic describes ...

- Generate an SSH Key Pair (see page 112)
- Related Information (see page 114)

#### Generate an SSH Key Pair

1. To generate the SSH key pair, run the `ssh-keygen` command and follow the prompts:

### Configure a Passwordless System

To configure a completely passwordless system, do not enter a passphrase when prompted in the following step.

```
cumulus@leaf01:~$ ssh-keygen
Generating public/private rsa key pair.
Enter file in which to save the key (/home/cumulus/.ssh/id_rsa):
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
```



```
Your identification has been saved in /home/cumulus/.ssh/id_rsa.  
Your public key has been saved in /home/cumulus/.ssh/id_rsa.pub.  
The key fingerprint is:  
5a:b4:16:a0:f9:14:6b:51:f6:f6:c0:76:1a:35:2b:bb cumulus@leaf04  
The key's randomart image is:  
+---[RSA 2048]---+  
| +.o o |  
| o * o . o |  
| o + o O o |  
| + . = O |  
| . S o . |  
| + . |  
| . E |  
+-----+
```

2. To copy the generated public key to the desired location, run the `ssh-copy-id` command and follow the prompts:

```
cumulus@leaf01:~$ ssh-copy-id -i /home/cumulus/.ssh/id_rsa.pub  
cumulus@leaf02  
The authenticity of host 'leaf02 (192.168.0.11)' can't be  
established.  
ECDSA key fingerprint is b1:ce:b7:6a:20:f4:06:3a:09:3c:d9:42:de:  
99:66:6e.  
Are you sure you want to continue connecting (yes/no)? yes  
/usr/bin/ssh-copy-id: INFO: attempting to log in with the new key  
(s), to filter out any that are already installed  
/usr/bin/ssh-copy-id: INFO: 1 key(s) remain to be installed --  
if you are prompted now it is to install the new keys  
cumulus@leaf01's password:  
  
Number of key(s) added: 1
```

! `ssh-copy-id` does not work if the username on the remote switch is different from the username on the local switch. To work around this issue, use the `scp` command instead:

```
cumulus@leaf01:~$ scp .ssh/id_rsa.pub cumulus@leaf02:.ssh  
/authorized_keys  
Enter passphrase for key '/home/cumulus/.ssh/id_rsa':  
id_rsa.pub
```

3. Connect to the remote switch to confirm that the authentication keys are in place:



```
cumulus@leaf01:~$ ssh cumulus@leaf02
Welcome to Cumulus VX (TM)

Cumulus VX (TM) is a community supported virtual appliance
designed for
experiencing, testing and prototyping Cumulus Networks' latest
technology.
For any questions or technical support, visit our community site
at:
http://community.cumulusnetworks.com

The registered trademark Linux (R) is used pursuant to a
sublicense from LMI,
the exclusive licensee of Linus Torvalds, owner of the mark on a
world-wide
basis.
Last login: Thu Sep 29 16:56:54 2016
```

## Related Information

- [Debian Documentation - Password-less logins with OpenSSH](#)
- [Wikipedia - Secure Shell \(SSH\)](#)

## User Accounts

By default, Cumulus Linux has two user accounts: *cumulus* and *root*.

The *cumulus* account:

- Uses the default password *CumulusLinux!*
- Is a user account in the *sudo* group with *sudo* privileges.
- Can log in to the system through all the usual channels, such as console and [SSH \(see page 112\)](#).
- Along with the *cumulus* group, has both show and edit rights for [NCLU \(see page 88\)](#).

The *root* account:

- Has the default password disabled by default.
- Has the standard Linux root user access to everything on the switch.
- Disabled password prohibits login to the switch by SSH, telnet, FTP, and so on.

For optimal security, change the default password with the `passwd` command before you configure Cumulus Linux on the switch.

You can add additional user accounts as needed. Like the *cumulus* account, these accounts must use *sudo* to [execute privileged commands \(see page 116\)](#); be sure to include them in the *sudo* group.

To access the switch without a password, you need to [boot into a single shell/user mode \(see page 940\)](#).

You can add and configure user accounts in Cumulus Linux with read-only or edit permissions for NCLU. For more information, see [Configure User Accounts \(see page 94\)](#).



## Enable Remote Access for the root User

The root user does not have a password and cannot log into a switch using SSH. This default account behavior is consistent with Debian. To connect to a switch using the root account, you can do one of the following:

- Generate an SSH key
- Set a password

### Generate an SSH Key for the root Account

1. In a terminal on your host system (not the switch), check to see if a key already exists:

```
root@host:~# ls -al ~/.ssh/
```

The key is named something like `id_dsa.pub`, `id_rsa.pub` or `id_ecdsa.pub`.

2. If a key does not exist, generate a new one by first creating the RSA key pair:

```
root@host:~# ssh-keygen -t rsa
```

3. You are prompted to enter a file in which to save the key (`/root/.ssh/id_rsa`). Press Enter to use the home directory of the root user or provide a different destination.
4. You are prompted to enter a passphrase (empty for no passphrase). This is optional but it does provide an extra layer of security.
5. The public key is now located in `/root/.ssh/id_rsa.pub`. The private key (identification) is now located in `/root/.ssh/id_rsa`.
6. Copy the public key to the switch. SSH to the switch as the cumulus user, then run:

```
cumulus@switch:~$ sudo mkdir -p /root/.ssh
cumulus@switch:~$ echo <SSH public key string> | sudo tee -a
/root/.ssh/authorized_keys
```

### Set the root User Password

1. Run the following command:

```
cumulus@switch:~$ sudo passwd root
```

2. Change the `PermitRootLogin` setting in the `/etc/ssh/sshd_config` file from `without-password` to `yes`.



```
cumulus@switch:~$ sudo nano /etc/ssh/sshd_config  
...  
# Authentication:  
LoginGraceTime 120  
PermitRootLogin yes  
StrictModes yes  
...
```

3. Restart the `ssh` service:

```
cumulus@switch:~$ sudo systemctl reload ssh.service
```

## Using sudo to Delegate Privileges

By default, Cumulus Linux has two user accounts: `root` and `cumulus`. The `cumulus` account is a normal user and is in the group `sudo`.

You can add more user accounts as needed. Like the `cumulus` account, these accounts must use `sudo` to execute privileged commands.

### Contents

#### This topic describes ...

- [sudo Basics \(see page 116\)](#)
- [sudoers Examples \(see page 117\)](#)
- [Related Information \(see page 122\)](#)

### *sudo Basics*

`sudo` allows you to execute a command as superuser or another user as specified by the security policy. See `man sudo(8)` for details.

The default security policy is `sudoers`, which is configured using `/etc/sudoers`. Use `/etc/sudoers.d/` to add to the default `sudoers` policy. See `man sudoers(5)` for details.



Use `visudo` only to edit the `sudoers` file; do not use another editor like `vi` or `emacs`. See `man visudo(8)` for details.

When creating a new file in `/etc/sudoers.d/`, use `visudo -f`. This option performs sanity checks before writing the file to avoid errors that prevent sudo from working.

Errors in the `sudoers` file can result in losing the ability to elevate privileges to root. You can fix this issue only by power cycling the switch and booting into single user mode. Before modifying `sudoers`, enable the root user by setting a password for the root user.



By default, users in the `sudo` group can use `sudo` to execute privileged commands. To add users to the `sudo` group, use the `useradd(8)` or `usermod(8)` command. To see which users belong to the `sudo` group, see `/etc/group` (`man group(5)`).

Any command can be run as `sudo`, including `su`. A password is required.

The example below shows how to use `sudo` as a non-privileged user *cumulus* to bring up an interface:

```
cumulus@switch:~$ ip link show dev swp1
3: swp1: <BROADCAST,MULTICAST> mtu 1500 qdisc pfifo_fast master br0
state DOWN mode DEFAULT qlen 500
link/ether 44:38:39:00:27:9f brd ff:ff:ff:ff:ff:ff

cumulus@switch:~$ ip link set dev swp1 up
RTNETLINK answers: Operation not permitted

cumulus@switch:~$ sudo ip link set dev swp1 up
Password:

cumulus@switch:~$ ip link show dev swp1
3: swp1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast
master br0 state UP mode DEFAULT qlen 500
link/ether 44:38:39:00:27:9f brd ff:ff:ff:ff:ff:ff
```

## *sudoers* Examples

The following examples show how you grant as few privileges as necessary to a user or group of users to allow them to perform the required task. For each example, the system group *noc* is used; groups are prefixed with an %.

When executed by an unprivileged user, the example commands below must be prefixed with `sudo`.

Category	Privilege	Example Command	<code>sudoers</code> Entry
Monitoring	Switch port info	<code>ethtool -m swp1</code>	<code>%noc ALL=(ALL) NOPASSWD: /sbin/ethtool</code>
Monitoring	System diagnostics	<code>cl-support</code>	<code>%noc ALL=(ALL) NOPASSWD:/usr/cumulus/bin/cl-support</code>
Monitoring	Routing diagnostics		



Category	Privilege	Example Command	sudoers Entry
		cl-resource-query	%noc ALL=(ALL) NOPASSWD:/usr/cumulus/bin/cl-resource-query
Image management	Install images	onie-select http://lab/install.bin	%noc ALL=(ALL) NOPASSWD:/usr/cumulus/bin/onie-select
Package management	Any apt-get command	apt-get update or apt-get install	%noc ALL=(ALL) NOPASSWD:/usr/bin/apt-get
Package management	Just apt-get update	apt-get update	%noc ALL=(ALL) NOPASSWD:/usr/bin/apt-get update
Package management	Install packages	apt-get install vim	%noc ALL=(ALL) NOPASSWD:/usr/bin/apt-get install *
Package management	Upgrading	apt-get upgrade	%noc ALL=(ALL) NOPASSWD:/usr/bin/apt-get upgrade
Netfilter	Install ACL policies	cl-acltool -i	%noc ALL=(ALL) NOPASSWD:/usr/cumulus/bin/cl-acltool



Category	Action	Example Command	Success Entry
Netfilter	List iptables rules	<code>iptables -L</code>	<code>%noc ALL=(ALL) NOPASSWD:/sbin/iptables</code>
L1 + 2 features	Any LLDP command	<code>lldpcli show neighbors / configure</code>	<code>%noc ALL=(ALL) NOPASSWD:/usr/sbin/lldpcli</code>
L1 + 2 features	Just show neighbors	<code>lldpcli show neighbors</code>	<code>%noc ALL=(ALL) NOPASSWD:/usr/sbin/lldpcli show neighbors*</code>
Interfaces	Modify any interface	<code>ip link set dev swp1 {up down}</code>	<code>%noc ALL=(ALL) NOPASSWD:/sbin/ip link set *</code>
Interfaces	Up any interface	<code>ifup swp1</code>	<code>%noc ALL=(ALL) NOPASSWD:/sbin/ifup</code>
Interfaces	Down any interface	<code>ifdown swp1</code>	<code>%noc ALL=(ALL) NOPASSWD:/sbin/ifdown</code>
Interfaces	Up/down only swp2	<code>ifup swp2 / ifdown swp2</code>	



Category	Privilege	Example Command	sudoers Entry
			%noc ALL=(ALL) NOPASSWD: /sbin/ifup swp2,/sbin /ifdown swp2
Interfaces	Any IP address chg	ip addr {add del} 192.0.2.1/30 dev swp1	%noc ALL=(ALL) NOPASSWD: /sbin/ip addr *
Interfaces	Only set IP address	ip addr add 192.0.2.1/30 dev swp1	%noc ALL=(ALL) NOPASSWD: /sbin/ip addr add *
Ethernet bridging	Any bridge command	brctl addbr br0 / brctl delif br0 swp1	%noc ALL=(ALL) NOPASSWD: /sbin/brctl
Ethernet bridging	Add bridges and ints	brctl addbr br0 / brctl addif br0 swp1	%noc ALL=(ALL) NOPASSWD: /sbin/brctl addbr *,/sbin /brctl addif *
Spanning tree	Set STP properties	mstptctl setmaxage br2 20	%noc ALL=(ALL) NOPASSWD: /sbin/mstptctl



Category	Privilege	Example Command	sudoers Entry
Troubleshooting	Restart switchd	<pre>systemctl restart switchd. service</pre>	<pre>%noc ALL=(ALL) NOPASSWD:/usr /sbin/service switchd *</pre>
Troubleshooting	Restart any service	<pre>systemctl cron switchd.service</pre>	<pre>%noc ALL=(ALL) NOPASSWD:/usr /sbin/service</pre>
Troubleshooting	Packet capture	<pre>tcpdump</pre>	<pre>%noc ALL=(ALL) NOPASSWD:/usr /sbin/tcpdump</pre>
L3	Add static routes	<pre>ip route add 10.2.0.0/16 via 10.0.0.1</pre>	<pre>%noc ALL=(ALL) NOPASSWD:/bin /ip route add *</pre>
L3	Delete static routes	<pre>ip route del 10.2.0.0/16 via 10.0.0.1</pre>	<pre>%noc ALL=(ALL) NOPASSWD:/bin /ip route del *</pre>
L3	Any static route chg	<pre>ip route *</pre>	<pre>%noc ALL=(ALL) NOPASSWD:/bin /ip route *</pre>
L3	Any iproute command	<pre>ip *</pre>	



Category	Privilege	Example Command	sudoers Entry
			%noc ALL=(ALL) NOPASSWD:/bin /ip
L3	Non-modal OSPF	cl-ospf area 0.0.0.1 range 10.0.0.0/24	%noc ALL=(ALL) NOPASSWD:/usr /bin/cl-ospf

### Related Information

- [sudo](#)
- [Adding Yourself to sudoers](#)

## TACACS Plus

Cumulus Linux implements TACACS+ client AAA (Accounting, Authentication, and Authorization) in a transparent way with minimal configuration. The client implements the TACACS+ protocol as described in [this IETF document](#). There is no need to create accounts or directories on the switch. Accounting records are sent to all configured TACACS+ servers by default. Use of per-command authorization requires additional setup on the switch.

### Contents

#### This topic describes ...

- [Supported Features \(see page 123\)](#)
- [Install the TACACS+ Client Packages \(see page \)](#)
- [Configure the TACACS+ Client \(see page \)](#)
- [TACACS+ Authentication \(login\) \(see page \)](#)
- [Local Fallback Authentication \(see page 125\)](#)
- [TACACS+ Accounting \(see page \)](#)
- [Configure NCLU for TACACS+ Users \(see page \)](#)
- [TACACS+ Per-command Authorization \(see page \)](#)
- [NSS Plugin \(see page 129\)](#)
- [TACACS Configuration Parameters \(see page 130\)](#)
- [Remove the TACACS+ Client Packages \(see page \)](#)
- [Troubleshooting \(see page 132\)](#)



- Basic Server Connectivity or NSS Issues (see page 132)
- Issues with Per-command Authorization (see page 133)
- Debug Issues with Accounting Records (see page 134)
- TACACS Component Software Descriptions (see page 134)
- Limitations (see page 135)
  - TACACS+ Client Is only Supported through the Management Interface (see page )
  - Multiple TACACS+ Users (see page )
  - Issues with deluser Command (see page 136)

### *Supported Features*

- Authentication using PAM; includes `login`, `ssh`, `sudo` and `su`
- Runs over the `eth0` management interface
- Ability to run in the [management VRF \(see page 877\)](#)
- TACACS+ privilege 15 users can run any command with `sudo` using the `/etc/sudoers.d/tacplus` file that is installed by the `libtacplus-map1` package
- Up to seven TACACS+ servers

### *Install the TACACS+ Client Packages*

TACACS+ requires the following packages to be installed on Cumulus Linux. These packages are not part of the base Cumulus Linux image installation.

To install all required packages, run these commands:

```
cumulus@switch:~$ sudo -E apt-get update
cumulus@switch:~$ sudo -E apt-get install tacplus-client
```

### *Configure the TACACS+ Client*

After installing TACACS+, edit the `/etc/tacplus_servers` file to add at least one server and one shared secret (key). You can specify the `server` and secret parameters in any order anywhere in the file. Whitespace (spaces or tabs) are not allowed. For example, if your TACACS+ server IP address is `192.168.0.30` and your shared secret is `tacacskey`, add these parameters to the `/etc/tacplus_servers` file:

```
secret=tacacskey
server=192.168.0.30
```

Cumulus Linux supports a maximum of seven TACACS+ servers.



To specify multiple servers, they can be added, one per line, to the `/etc/tacplus_servers` file.

Connections are made in the order in which they are listed in this file. In most cases, you do not need to change any other parameters. You can add parameters used by any of the packages to this file, which affects all the TACACS+ client software. For example, the timeout value for NSS lookups (see description below) is set to 5 seconds by default in the `/etc/tacplus_nss.conf` file, whereas the timeout value for other packages is 10 seconds and is set in the `/etc/tacplus_servers` file. The timeout value is per connection to the TACACS+ servers. (If authorization is configured per command, the timeout occurs for each command.) There are several (typically four) connections to the server per login attempt from PAM, as well as two or more through NSS. Therefore, with the default timeout values, a TACACS+ server that is not reachable can delay logins by a minute or more per unreachable server. If you must list unreachable TACACS+ servers, place them at the end of the server list and consider reducing the timeout values.

When you add or remove TACACS+ servers, you must restart `auditd` (with the `systemctl restart auditd` command) or you must send a signal (with `killall -HUP audisp-tacplus`) before `audisp-tacplus` rereads the configuration to see the changed server list.

You can also configure the IP address used as the source IP address when communicating with the TACACS+ server. See [TACACS Configuration Parameters \(see page 130\)](#) below for the full list of TACACS+ parameters.

Following is the complete list of the TACACS+ client configuration files, and their use.

<b>Filename</b>	<b>Description</b>
<code>/etc/tacplus_servers</code>	This is the primary file that requires configuration after installation. The file is used by all packages with <code>include=/etc/tacplus_servers</code> parameters in the other configuration files that are installed. Typically, this file contains the shared secrets; make sure that the Linux file mode is 600.
<code>/etc/nsswitch.conf</code>	When the <code>libnss_tacplus</code> package is installed, this file is configured to enable tacplus lookups via <code>libnss_tacplus</code> . If you replace this file by automation or other means, you need to add tacplus as the first lookup method for the <code>passwd</code> database line.
<code>/etc/tacplus_nss.conf</code>	This file sets the basic parameters for <code>libnss_tacplus</code> . It includes a debug variable for debugging NSS lookups separately from other client packages.
<code>/usr/share/pam-configs/tacplus</code>	This is the configuration file for <code>pam-auth-update</code> to generate the files in the next row. These configurations are used at <code>login</code> , by <code>su</code> , and by <code>ssh</code> .
<code>/etc/pam.d/common-*</code>	The <code>/etc/pam.d/common-*</code> files are updated for <code>tacplus</code> authentication. The files are updated with <code>pam-auth-update</code> , when <code>libpam-tacplus</code> is installed or removed.
<code>/etc/sudoers.d/tacplus</code>	This file allows TACACS+ privilege level 15 users to run commands with <code>sudo</code> . The file includes an example (commented out) of how to enable privilege level 15 TACACS users to use <code>sudo</code> without having to enter a password and provides an example of how to enable all TACACS users to run specific commands with <code>sudo</code> . Only edit this file with the command <code>visudo -f /etc/sudoers.d/tacplus</code> .
<code>audisp-tacplus.conf</code>	This is the <code>audisp</code> plugin configuration file. Typically, no modifications are required.



Filename	Description
/etc/audisp/audisp-tac_plus.conf	This is the TACACS+ server configuration file for accounting. Typically, no modifications are required. You can use this configuration file when you only want to debug TACACS+ accounting issues, not all TACACS+ users.
/etc/audit/rules.d/audisp-tacplus.rules	The <code>auditd</code> rules for TACACS+ accounting. The <code>augenrules</code> command uses all rule files to generate the rules file (described below).
/etc/audit/audit.rules	This is the audit rules file generated when <code>auditd</code> is installed.



You can edit the `/etc/pam.d/common-*` files manually. However, if you run `pam-auth-update` again after making the changes, the update fails. Only perform configuration in `/usr/share/pam-configs/tacplus`, then run `pam-auth-update`.

### TACACS+ Authentication (login)

The initial authentication configuration is done through the PAM modules and an updated version of the `libpam-tacplus` package. When the package is installed, the PAM configuration is updated in `/etc/pam.d` with the `pam-auth-update` command. If you have made changes to your PAM configuration, you need to integrate these changes yourself. If you are also using LDAP with the `libpam-ldap` package, you might need to edit the PAM configuration to ensure the LDAP and TACACS ordering that you prefer. The `libpam-tacplus` are configured to skip over rules and the values in the `success=2` might require adjustments to skip over LDAP rules.

A user privilege level is determined by the TACACS+ privilege attribute `priv_lvl` for the user that is returned by the TACACS+ server during the user authorization exchange. The client accepts the attribute in either the mandatory or optional forms and also accepts `priv-lvl` as the attribute name. The attribute value must be a numeric string in the range 0 to 15, with 15 the most privileged level.



By default, TACACS+ users at privilege levels other than 15 are not allowed to run `sudo` commands and are limited to commands that can be run with standard Linux user permissions.

### Local Fallback Authentication

If a site wants to allow local fallback authentication for a user when none of the TACACS servers can be reached, you can add a privileged user account as a local account on the switch.

To configure local fallback authentication:

1. Edit the `/etc/nsswitch.conf` file to remove the keyword `tacplus` from the line starting with `passwd`. (You need to add the keyword back in step 3.)

An example of the `/etc/nsswitch.conf` file with the keyword `tacplus` removed from the line starting with `passwd` is shown below.

```
cumulus@switch:~$ sudo vi /etc/nsswitch.conf
#
# Example configuration of GNU Name Service Switch functionality.
# If you have the `glibc-doc-reference` and `info` packages
installed, try:
# `info libc "Name Service Switch"` for information about this
file.
passwd:      compat
group:       compat
shadow:      compat
gshadow:     files
...
...
```

2. To enable the local privileged user to run `sudo` and NCLU commands, run the `adduser` commands shown below. In the example commands, the TACACS account name is `tacadmin`.



The first `adduser` command prompts for information and a password. You can skip most of the requested information by pressing ENTER.

```
cumulus@switch:~$ sudo adduser --ingroup tacacs tacadmin
cumulus@switch:~$ sudo adduser tacadmin netedit
cumulus@switch:~$ sudo adduser tacadmin sudo
```

3. Edit the `/etc/nsswitch.conf` file to add the keyword `tacplus` back to the line starting with `passwd` (the keyword you removed in the first step).
4. Restart the `netd` service with the following command:

```
cumulus@switch:~$ sudo systemctl restart netd
```

## TACACS+ Accounting

TACACS+ accounting is implemented with the `audisp` module, with an additional plugin for `auditd/audisp`. The plugin maps the `uid` in the accounting record to a TACACS login, based on the `uid` and `sessionid`. The `audisp` module requires `libnss_tacplus` and uses the `libtacplus_map.so` library interfaces as part of the modified `lipam_tacplus` package.

Communication with the TACACS+ servers is done with the `libsimple-tacact1` library, through `dlopen()`. A maximum of 240 bytes of command name and arguments are sent in the accounting record, due to the TACACS+ field length limitation of 255 bytes.



All Linux commands result in an accounting record, including commands run as part of the login process or as sub-processes of other commands. This can sometimes generate a large number of accounting records.



Configure the IP address and encryption key of the server in the `/etc/tacplus_servers` file. Minimal configuration to `auditd` and `audisp` is necessary to enable the audit records necessary for accounting. These records are installed as part of the package.

`audisp-tacplus` installs the audit rules for command accounting. Modifying the configuration files is not usually necessary. However, when a [management VRF \(see page 877\)](#) is configured, the accounting configuration does need special modification because the `auditd` service starts prior to networking. It is necessary to add the `vrf` parameter and to signal the `audisp-tacplus` process to reread the configuration. The example below shows that the management VRF is named `mgmt`. You can place the `vrf` parameter in either the `/etc/tacplus_servers` file or in the `/etc/audisp/audisp-tac_plus.conf` file.

```
vrf=mgmt
```

After editing the configuration file, send the **HUP** signal `killall -HUP audisp-tacplus` to notify the accounting process to reread the file.



All `sudo` commands run by TACACS+ users generate accounting records against the original TACACS+ login name.

For more information, refer to the `audisp.8` and `auditd.8` man pages.

### Configure NCLU for TACACS+ Users

When you install or upgrade TACACS+ packages, mapped user accounts are created automatically. All `tacacs0` through `tacacs15` users are added to the `netshow` group.

In order for any TACACS+ users to execute `net add`, `net del`, and `net commit` commands and to restart services with NCLU, you need to add those users to the `users_with_edit` variable in the `/etc/netd.conf` file. Cumulus Networks recommends you add the `tacacs15` user and, depending upon your policies, other users (`tacacs1` through `tacacs14`) to this variable.

To give a TACACS+ user access to the show commands, add the `tacacs` group to the `groups_with_show` variable.



Do not add the `tacacs` group to the `groups_with_edit` variable; this is dangerous and can potentially enable any user to log into the switch as the root user.

To add the users, edit the `/etc/netd.conf` file:

```
cumulus@switch:~$ sudo nano /etc/netd.conf
...
# Control which users/groups are allowed to run "add", "del",
# "clear", "abort", and "commit" commands.
users_with_edit = root, cumulus, tacacs15
groups_with_edit = netedit
```



```
# Control which users/groups are allowed to run "show" commands
users_with_show = root, cumulus
groups_with_show = netshow, netedit, tacacs

...
```

After you save and exit the `netd.conf` file, restart the `netd` service. Run:

```
cumulus@switch:~$ sudo systemctl restart netd
```

### TACACS+ Per-command Authorization

The `tacplus-auth` command handles the per-command authorization. To make this an enforced authorization, you must change the TACACS+ login to use a restricted shell, with a very limited executable search path. Otherwise, the user can bypass the authorization. The `tacplus-restrict` utility simplifies the setup of the restricted environment. The example below initializes the environment for the `tacacs0` user account. This is the account used for TACACS+ users at privilege level 0.

```
tacuser0@switch:~$ sudo tacplus-restrict -i -u tacacs0 -a command1
command2 ... commandN
```

If the user/command combination is not authorized by the TACACS+ server, a message similar to the following displays:

```
tacuser0@switch:~$ net show version
net not authorized by TACACS+ with given arguments, not executing
```

The following table provides the command options:

Option	Description
-i	Initializes the environment. You only need to issue this option once per username.
-a	You can invoke the utility with the <code>-a</code> option as many times as desired. For each command in the <code>-a</code> list, a symbolic link is created from <code>tacplus-auth</code> to the relative portion of the command name in the local <code>bin</code> subdirectory. You also need to enable these commands on the TACACS+ server (refer to the TACACS+ server documentation). It is common to have the server allow some options to a command, but not others.
-f	Re-initializes the environment. If you need to restart, issue the <code>-f</code> option with <code>-i</code> to force the re-initialization; otherwise, repeated use of <code>-i</code> is ignored. As part of the initialization: <ul style="list-style-type: none"><li>The user's shell is changed to <code>/bin/rbash</code>.</li></ul>



Option	Description
	<ul style="list-style-type: none"><li>Any existing dot files are saved.</li><li>A limited environment is set up that does not allow general command execution, but instead allows only commands from the user's local <code>bin</code> subdirectory.</li></ul>

For example, if you want to allow the user to be able to run the `net` and `ip` commands (if authorized by the TACACS+ server), use the command:

```
cumulus@switch:~$ sudo tacplus-restrict -i -u tacacs0 -a ip net
```

After running this command, examine the `tacacs0` directory::

```
cumulus@switch:~$ sudo ls -lR ~tacacs0
total 12
lrwxrwxrwx 1 root root 22 Nov 21 22:07 ip -> /usr/sbin/tacplus-auth
lrwxrwxrwx 1 root root 22 Nov 21 22:07 net -> /usr/sbin/tacplus-auth
```

Other than shell built-ins, the only two commands the privilege level 0 TACACS users can run are the `ip` and `net` commands.

If you mistakenly add potential commands with the `-a` option, you can remove them. The example below shows how to remove the `net` command:

```
cumulus@switch:~$ sudo rm ~tacacs0/bin/net
```

You can remove all commands as follows:

```
cumulus@switch:~$ sudo rm ~tacacs0/bin/*
```

Use the `man` command on the switch for more information on `tacplus-auth` and `tacplus-restrict`.

```
cumulus@switch:~$ man tacplus-auth tacplus-restrict
```

## NSS Plugin

When used with `pam_tacplus`, TACACS+ authenticated users can log in without a local account on the system using the NSS plugin that comes with the `tacplus_nss` package. The plugin uses the mapped `tacplus` information if the user is not found in the local password file, provides the `getpwnam()` and `getpwuid()` entry points and uses the TACACS+ authentication functions.

The plugin asks the TACACS+ server if the user is known, and then for relevant attributes to determine the privilege level of the user. When the `libnss_tacplus` package is installed, `nsswitch.conf` is modified to set `tacplus` as the first lookup method for `passwd`. If the order is changed, lookups return the local accounts, such as `tacacs0`

If the user is not found, a mapped lookup is performed using the `libtacplus.so` exported functions. The privilege level is appended to `tacacs` and the lookup searches for the name in the local password file. For example, privilege level 15 searches for the `tacacs15` user. If the user is found, the password structure is filled in with information for the user.

If the user is not found, the privilege level is decremented and checked again until privilege level 0 (user `tacacs0`) is reached. This allows use of only the two local users `tacacs0` and `tacacs15`, if minimal configuration is desired.

### *TACACS Configuration Parameters*

The recognized configuration options are the same as the `libpam_tacplus` command line arguments; however, not all `pam_tacplus` options are supported. These configuration parameters are documented in the `tacplus_servers.5` man page, which is part of the `libpam-tacplus` package.

The table below describes the configuration options available:

Configuration Option	Description
debug	<p>The output debugging information through <code>syslog(3)</code>.</p> <div style="border: 2px solid #f0a; padding: 10px; margin-top: 10px;">  Debugging is heavy, including passwords. Do not leave debugging enabled on a production switch after you have completed troubleshooting.         </div>
secret=STRING	<p>The secret key used to encrypt and decrypt packets sent to and received from the server. You can specify the secret key more than once in any order with respect to the <code>server=</code> parameter. When fewer <code>secret=</code> parameters are specified, the last secret given is used for the remaining servers. Only use this parameter in files such as <code>/etc/tacplus_servers</code> that are not world readable.</p>
server=HOSTNAME server=IP_ADDR	<p>Adds a TACACS+ server to the servers list. Servers are queried in turn until a match is found, or no servers remain in the list. Can be specified up to 7 times. An IP address can be optionally followed by a port number, preceded by a ":". The default port is 49.</p> <div style="border: 2px solid #f0a; padding: 10px; margin-top: 10px;">  When sending accounting records, the record is sent to all servers in the list if <code>acct_all=1</code>, which is the default.         </div>
source_ip=IPv4_ADDRESS	



Configuration Option	Description
	Sets the IP address used as the source IP address when communicating with the TACACS+ server. You must specify an IPv4 address. IPv6 addresses and hostnames are not supported. The address must be valid for the interface being used.
timeout=SECONDS	TACACS+ server(s) communication timeout. This parameter defaults to 10 seconds in the <code>/etc/tacplus_servers</code> file, but defaults to 5 seconds in the <code>/etc/tacplus_nss.conf</code> file.
include=/file/name	A supplemental configuration file to avoid duplicating configuration information. You can include up to 8 more configuration files.
min_uid=value	The minimum user ID that the NSS plugin looks up. Setting it to 0 means uid 0 (root) is never looked up, which is desirable for performance reasons. The value should not be greater than the local TACACS+ user IDs (0 through 15), to ensure they can be looked up.
exclude_users=user1, user2,...	A comma-separated list of usernames that are never looked up by the NSS plugin, set in the <code>tacplus_nss.conf</code> file. You cannot use * (asterisk) as a wild card in the list. While it's not a legal username, bash may lookup this as a user name during pathname completion, so it is included in this list as a username string. <div style="border: 2px solid red; padding: 10px; margin-top: 10px;"><p><span style="color: red;">!</span> Cumulus Networks strongly recommends that you do <b>not</b> remove the <code>cumulus</code> user from the <code>exclude_users</code> list, because doing so can make it impossible to log in as the <code>cumulus</code> user, which is the primary administrative account in Cumulus Linux. If you do remove the <code>cumulus</code> user, Cumulus Networks recommends you add some other local fallback user that does not rely on TACACS but is a member of <code>sudo</code> and <code>netedit</code> groups, so that these accounts can run <code>sudo</code> and NCLU commands.</p></div>
login=STRING	TACACS+ authentication service (pap, chap, or login). The default value is <code>pap</code> .
user_homedir=1	This is not enabled by default. When enabled, a separate home directory for each TACACS+ user is created when the TACACS+ user first logs in. By default, the home directory in the mapping accounts in <code>/etc/passwd</code> ( <code>/home/tacacs0 ... /home/tacacs15</code> ) is used. If the home directory does not exist, it is created with the <code>mkhomedir_helper</code> program, in the same manner as <code>pam_mkhomedir</code> . This option is not honored for accounts with restricted shells when per-command authorization is enabled.
acct_all=1	



Configuration Option	Description
	Configuration option for <code>audisp_tacplus</code> and <code>pam_tacplus</code> sending accounting records to all supplied servers (1), or the first server to respond (0). The default value is 1.
<code>timeout=SECS</code>	Sets the timeout in seconds for connections to each TACACS+ server. The default is 10 seconds for all lookups except that NSS lookups use a 5 second timeout.
<code>vrf=VRFNAME</code>	If the management network is in a VRF, set this variable to the VRF name. This would usually be "mgmt". When this variable is set, the connection to the TACACS+ accounting servers is made through the named VRF.
<code>service</code>	TACACS+ accounting and authorization service. Examples include shell, pap, raccess, ppp, and slip. The default value is <code>shell</code> .
<code>protocol</code>	TACACS+ protocol field. This option is use dependent. PAM uses the SSH protocol.

## Remove the TACACS+ Client Packages

To remove all of the TACACS+ client packages, use the following commands:

```
cumulus@switch:~$ sudo -E apt-get remove tacplus-client
cumulus@switch:~$ sudo -E apt-get autoremove
```

To remove the TACACS+ client configuration files as well as the packages (recommended), use this command:

```
cumulus@switch:~$ sudo -E apt-get autoremove --purge
```

## Troubleshooting

### Basic Server Connectivity or NSS Issues

You can use the `getent` command to determine if TACACS+ is configured correctly and if the local password is stored in the configuration files. In the example commands below, the `cumulus` user represents the local user, while `cumulusTAC` represents the TACACS user.

To look up the username within all NSS methods:

```
cumulus@switch:~$ sudo getent passwd cumulusTAC
```



```
cumulusTAC:x:1016:1001:TACACS+ mapped user at privilege level 15,,,:  
/home/tacacs15:/bin/bash
```

To look up the user within the local database only:

```
cumulus@switch:~$ sudo getent -s compat passwd cumulus  
cumulus:x:1000:1000:cumulus,,,:/home/cumulus:/bin/bash
```

To look up the user within the TACACS+ database only:

```
cumulus@switch:~$ sudo getent -s tacplus passwd cumulusTAC  
cumulusTAC:x:1016:1001:TACACS+ mapped user at privilege level 15,,,:  
/home/tacacs15:/bin/bash
```

If TACACS does not appear to be working correctly, debug the following configuration files by adding the `debug=1` parameter to one or more of these files:

- `/etc/tacplus_servers`
- `/etc/tacplus_nss.conf`



*You can also add `debug=1` to individual `pam_tacplus` lines in `/etc/pam.d/common*`.*

All log messages are stored in `/var/log/syslog`.

### *Incorrect Shared Key*

The TACACS client on the switch and the TACACS server should have the same shared secret key. If this key is incorrect, the following message is printed to `syslog`:

```
2017-09-05T19:57:00.356520+00:00 leaf01 sshd[3176]: nss_tacplus:  
TACACS+ server 192.168.0.254:49 read failed with protocol error  
(incorrect shared secret?) user cumulus
```

### *Issues with Per-command Authorization*

To debug TACACS user command authorization, have the TACACS+ user enter the following command at a shell prompt, then try the command again:

```
tacuser0@switch:~$ export TACACSAUTHDEBUG=1
```

When this debugging is enabled, additional information is shown for the command authorization conversation with the TACACS+ server:



```
tacuser0@switch:~$ net pending
tacplus-auth: found matching command (/usr/bin/net) request
authorization
tacplus-auth: error connecting to 10.0.3.195:49 to request
authorization for net: Transport endpoint is not connected
tacplus-auth: cmd not authorized (16)
tacplus-auth: net not authorized from 192.168.3.189:49
net not authorized by TACACS+ with given arguments, not executing

tacuser0@switch:~$ net show version
tacplus-auth: found matching command (/usr/bin/net) request
authorization
tacplus-auth: error connecting to 10.0.3.195:49 to request
authorization for net: Transport endpoint is not connected
tacplus-auth: 192.168.3.189:49 authorized command net
tacplus-auth: net authorized, executing
DISTRIB_ID="Cumulus Linux"
DISTRIB_RELEASE=3.4.0
DISTRIB_DESCRIPTION="Cumulus Linux 3.4.0"
```

To disable debugging:

```
tacuser0@switch:~$ export -n TACACSAUTHDEBUG
```

### Debug Issues with Accounting Records

If you have added or deleted TACACS+ servers from the configuration files, make sure you notify the `audisp` plugin with this command:

```
cumulus@switch:~$ sudo killall -HUP audisp-tacplus
```

If accounting records are still not being sent, add `debug=1` to the `/etc/audisp/audisp-tac_plus.conf` file, then issue the command above to notify the plugin. Ask the TACACS+ user to run a command and examine the end of `/var/log/syslog` for messages from the plugin. You can also check the auditing log file `/var/log/audit/audit.log` to be sure the auditing records are being written. If they are not, restart the audit daemon with:

```
cumulus@switch:~$ sudo systemctl restart auditd.service
```

### TACACS Component Software Descriptions

The following table describes the different pieces of software involved with delivering TACACS.



Package Name	Description
audisp-tacplus_1.0.0-1-cl3u3	This package uses auditing data from <code>auditd</code> to send accounting records to the TACACS+ server and is started as part of <code>auditd</code> .
libtac2_1.4.0-cl3u2	Basic TACACS+ server utility and communications routines.
libnss-tacplus_1.0.1-cl3u3	Provides an interface between <code>libc</code> username lookups, the mapping functions, and the TACACS+ server.
tacplus-auth-1.0.0-cl3u1	This package includes the <code>tacplus-restrict</code> setup utility, which enables you to perform per-command TACACS+ authorization. Per-command authorization is not done by default.
libpam-tacplus_1.4.0-1-cl3u2	A modified version of the standard Debian package.
libtacplus-map1_1.0.0-cl3u2	The mapping functionality between local and TACACS+ users on the server. Sets the immutable <code>sessionid</code> and auditing UID to ensure the original user can be tracked through multiple processes and privilege changes. Sets the auditing <code>loginuid</code> as immutable if supported. Creates and maintains a status database in <code>/run/tacacs_client_map</code> to manage and lookup mappings.
libsimple-tacacct1_1.0.0-cl3u2	Provides an interface for programs to send accounting records to the TACACS+ server. Used by <code>audisp-tacplus</code> .
libtac2-bin_1.4.0-cl3u2	Provides the <code>tacc</code> testing program and TACACS+ man page.

## Limitations

### *TACACS+ Client Is only Supported through the Management Interface*

The TACACS+ client is only supported through the management interface on the switch: eth0, eth1, or the VRF management interface. The TACACS+ client is not supported through bonds, switch virtual interfaces (SVIs), or switch port interfaces (swp).



## Multiple TACACS+ Users

If two or more TACACS+ users are logged in simultaneously with the same privilege level, while the accounting records are maintained correctly, a lookup on either name will match both users, while a UID lookup will only return the user that logged in first.

This means that any processes run by either user will be attributed to both, and all files created by either user will be attributed to the first name matched. This is similar to adding two local users to the password file with the same UID and GID, and is an inherent limitation of using the UID for the base user from the password file.



The current algorithm returns the first name matching the UID from the mapping file; this can be the first or the second user that logged in.

To work around this issue, you can use the switch audit log or the TACACS server accounting logs to determine which processes and files are created by each user.

- For commands that do not execute other commands (for example, changes to configurations in an editor, or actions with tools like `c1agctl` and `vtysh`), no additional accounting is done.
- Per-command authorization is implemented at the most basic level (commands are permitted or denied based on the standard Linux user permissions for the local TACACS users and only privilege level 15 users can run `sudo` commands by default).

The Linux `auditd` system does not always generate audit events for processes when terminated with a signal (with the `kill` system call or internal errors such as `SIGSEGV`). As a result, processes that exit on a signal that is not caught and handled, might not generate a STOP accounting record.

## Issues with `deluser` Command

TACACS+ and other non-local users that run the `deluser` command with the `--remove-home` option will see an error about not finding the user in `/etc/passwd`:

```
tacuser0@switch: deluser --remove-home USERNAME
userdel: cannot remove entry 'USERNAME' from /etc/passwd
/usr/sbin/deluser: `/usr/sbin/userdel USERNAME' returned error code
1. Exiting
```

However, the command does remove the home directory. The user can still log in on that account, but will not have a valid home directory. This is a known upstream issue with the `deluser` command for all non-local users.

Only use the `--remove-home` option when the `user_homedir=1` configuration command is in use.

## RADIUS AAA

Cumulus Networks offers add-on packages that enable [RADIUS](#) users to log in to Cumulus Linux switches in a transparent way with minimal configuration. There is no need to create accounts or directories on the switch. Authentication is handled with PAM and includes `login`, `ssh`, `sudo` and `su`.



## Contents

### This topic describes ...

- Install the RADIUS Packages (see page 137)
- Configure the RADIUS Client (see page 138)
- Enable Login without Local Accounts (see page 139)
- Local Fallback Authentication (see page 139)
- Verify RADIUS Client Configuration (see page 140)
- Remove RADIUS Client Packages (see page 141)
- Limitations (see page 142)
- Related Information (see page 142)

### *Install the RADIUS Packages*

The RADIUS packages are not included in the base Cumulus Linux image; there is no RADIUS metapackage.

To install the RADIUS packages:

```
cumulus@switch:~$ sudo apt-get update
cumulus@switch:~$ sudo apt-get install libnss-mapuser libpam-radius-
auth
```

After installation is complete, either reboot the switch or run the `sudo systemctl restart netd` command.

The `libpam-radius-auth` package supplied with the Cumulus Linux RADIUS client is a newer version than the one in [Debian Jessie](#). This package has added support for IPv6, the `src_ip` option described below, as well as a number of bug fixes and minor features. The package also includes VRF support, provides man pages describing the PAM and RADIUS configuration, and sets the `SUDO_PROMPT` environment variable to the login name for RADIUS mapping support.

The `libnss_mapuser` package is specific to Cumulus Linux and supports the `getgrent`, `getgrnam` and `getrgid` library interfaces. These interfaces add logged in RADIUS users to the group member list for groups that contain the `mapped_user` (`radius_user`) if the RADIUS account is unprivileged, and add privileged RADIUS users to the group member list for groups that contain the `mapped_priv_user` (`radius_priv_user`) during the group lookups.

During package installation:

- The PAM configuration is modified automatically using `pam-auth-update` (8), and the NSS configuration file `/etc/nsswitch.conf` is modified to add the `mapuser` and `mapuid` plugins. If you remove or purge the packages, these files are modified to remove the configuration for these plugins.
- The `radius_shell` package is added, which installs the `/sbin/radius_shell` and `setcap cap_setuid` program used as the login shell for RADIUS accounts. The package adjusts the `UID` when needed, then runs the bash shell with the same arguments. When installed, the package changes the shell of the RADIUS accounts to `/sbin//radius_shell`, and to `/bin/shell` if the package is removed. This package is required for privileged RADIUS users to be enabled. It is not required for regular RADIUS client use.



- The `radius_user` account is added to the `netshow` group and the `radius_priv_user` account to the `netedit` and `sudo` groups. This change enables all RADUS logins to run NCLU `net show` commands and all privileged RADIUS users to also run `net add`, `net del`, and `net commit` commands, and to use `sudo`.

## Configure the RADIUS Client

To configure the RADIUS client, edit the `/etc/pam_radius_auth.conf` file:

1. Add the hostname or IP address of at least one RADIUS server (such as a `freeradius` server on Linux) and the shared secret used to authenticate and encrypt communication with each server. Multiple server configuration lines are verified in the order listed. Other than memory, there is no limit to the number of RADIUS servers you want to use. The server port number or name is optional. The system looks up the port in the `/etc/services` file. However, you can override the ports in the `/etc/pam_radius_auth.conf` file.
2. If the server is slow or latencies are high, change the `timeout` setting. The setting defaults to 3 seconds.
3. If you want to use a specific interface to reach the RADIUS server, specify the `src_ip` option. You can specify the hostname of the interface, an IPv4, or an IPv6 address. If you specify the `src_ip` option, you must also specify the `timeout` option.
4. Set the `vrf-name` field. This is typically set to `mgmt` if you are using a [management VRF \(see page 877\)](#). You cannot specify more than one VRF.

The configuration file includes the `mapped_priv_user` field that sets the account used for privileged RADIUS users and the `priv-lvl` field that sets the minimum value for the privilege level to be considered a privileged login (the default value is 15). If you edit these fields, make sure the values match those set in the `/etc/nss_mapuser.conf` file.

The following example provides a sample `/etc/pam_radius_auth.conf` file configuration:

```
mapped_priv_user    radius_priv_user
# server[:port]      shared_secret  timeout (secs)  src_ip
192.168.0.254      secretkey
other-server        othersecret     3                  192.168.1.10
# when mgmt vrf is in use
vrf-name mgmt
```



If this is the first time you are configuring the RADIUS client, uncomment the `debug` line to help with troubleshooting. The debugging messages are written to `/var/log/syslog`. When the RADIUS client is working correctly, comment out the `debug` line.

As an optional step, you can set PAM configuration keywords by editing the `/usr/share/pam-configs/radius` file. After you edit the file, you must run the `pam-auth-update --package` command. PAM configuration keywords are described in the `pam_radius_auth (8)` man page.



## Enable Login without Local Accounts

Because LDAP is not commonly used with switches and adding accounts locally is cumbersome, Cumulus Linux includes a mapping capability with the `libnss-mapuser` package.

Mapping is done using two NSS (Name Service Switch) plugins, one for account name, and one for UID lookup. These accounts are configured automatically in `/etc/nsswitch.conf` during installation and are removed when the package is removed. See the `nss_mapuser` (8) man page for the full description of this plugin.

A username is mapped at login to a fixed account specified in the configuration file, with the fields of the fixed account used as a template for the user that is logging in.

For example, if the name being looked up is `dave` and the fixed account in the configuration file is `radius_user`, and that entry in `/etc/passwd` is:

```
radius_user:x:1017:1002:radius user:/home/radius_user:/bin/bash
```

then the matching line returned by running `getent passwd dave` is:

```
cumulus@switch:~$ getent passwd dave
dave:x:1017:1002:dave mapped user:/home/dave:/bin/bash
```

The home directory `/home/dave` is created during the login process if it does not already exist and is populated with the standard skeleton files by the `mkhomedir_helper` command.

The configuration file `/etc/nss_mapuser.conf` is used to configure the plugins. The file includes the mapped account name, which is `radius_user` by default. You can change the mapped account name by editing the file. The `nss_mapuser` (5) man page describes the configuration file.

A flat file mapping is done based on the session number assigned during login, which persists across `su` and `sudo`. The mapping is removed at logout.

## Local Fallback Authentication

If a site wants to allow local fallback authentication for a user when none of the RADIUS servers can be reached, you can add a privileged user account as a local account on the switch. The local account must have the same unique identifier as the privileged user and the shell must be the same.

To configure local fallback authentication:

1. Add a local privileged user account. For example, if the `radius_priv_user` account in the `/etc/passwd` file is `radius_priv_user:x:1002:1001::/home/radius_priv_user:/sbin/radius_shell`, run the following command to add a local privileged user account named `johnadmin`:

```
cumulus@switch:~$ sudo useradd -u 1002 -g 1001 -o -s /sbin
/radius_shell johnadmin
```

2. To enable the local privileged user to run `sudo` and NCLU commands, run the following commands:



```
cumulus@switch:~$ sudo adduser johnadmin netedit
cumulus@switch:~$ sudo adduser johnadmin sudo
cumulus@switch:~$ sudo systemctl restart netd
```

3. Edit the /etc/passwd file to move the local user line before to the radius\_priv\_user line:

```
cumulus@switch:~$ sudo vi /etc/passwd
...
johnadmin:x:1002:1001::/home/johnadmin:/sbin/radius_shell
radius_priv_user:x:1002:1001::/home/radius_priv_user:/sbin
/radius_shell
```

4. To set the local password for the local user, run the following command:

```
cumulus@switch:~$ sudo passwd johnadmin
```

### Verify RADIUS Client Configuration

To verify that the RADIUS client is configured correctly, log in as a non-privileged user and run a `net add interface` command.

In this example, the `ops` user is not a privileged RADIUS user so they cannot add an interface.

```
ops@leaf01:~$ net add interface swp1
ERROR: User ops does not have permission to make networking changes.
```

In this example, the `admin` user is a privileged RADIUS user (with privilege level 15) so is able to add interface `swp1`.

```
admin@leaf01:~$ net add interface swp1
admin@leaf01:~$ net pending
--- /etc/network/interfaces      2018-04-06 14:49:33.099331830 +0000
+++ /var/run/nclu iface/interfaces.tmp      2018-04-06 16:01:
16.057639999 +0000
@@ -3,10 +3,13 @@
source /etc/network/interfaces.d/*.intf

# The loopback network interface
auto lo
iface lo inet loopback

# The primary network interface
```



```
auto eth0
iface eth0 inet dhcp
+
+auto swp1
+iface swp1
...
```

## Remove RADIUS Client Packages

Remove the RADIUS packages with the following command:

```
cumulus@switch:~$ sudo apt-get remove libnss-mapuser libpam-radius-
auth
```

When you remove the packages, the plugins are removed from the `/etc/nsswitch.conf` file and from the PAM files.

To remove all configuration files for these packages, run:

```
cumulus@switch:~$ sudo apt-get purge libnss-mapuser libpam-radius-auth
```



The RADIUS fixed account is not removed from the `/etc/passwd` or `/etc/group` file and the home directories are not removed. They remain in case there are modifications to the account or files in the home directories.

To remove the home directories of the RADIUS users, first get the list by running:

```
cumulus@switch:~$ sudo ls -l /home | grep radius
```

For all users listed, except the `radius_user`, run this command to remove the home directories:

```
cumulus@switch:~$ sudo deluser --remove-home USERNAME
```

where `USERNAME` is the account name (the home directory relative portion). This command gives the following warning because the user is not listed in the `/etc/passwd` file.

```
userdel: cannot remove entry 'USERNAME' from /etc/passwd
/usr/sbin/deluser: `/usr/sbin/userdel USERNAME' returned error code
1. Exiting.
```

After removing all the RADIUS users, run the command to remove the fixed account. If the account has been changed in the `/etc/nss_mapuser.conf` file, use that account name instead of `radius_user`.



```
cumulus@switch:~$ sudo deluser --remove-home radius_user
cumulus@switch:~$ sudo deluser --remove-home radius_priv_user
cumulus@switch:~$ sudo delgroup radius_users
```

## Limitations

If two or more RADIUS users are logged in simultaneously, a UID lookup only returns the user that logged in first. Any processes run by either user get attributed to both, and all files created by either user get attributed to the first name matched. This is similar to adding two local users to the password file with the same UID and GID, and is an inherent limitation of using the UID for the fixed user from the password file.

The current algorithm returns the first name matching the UID from the mapping file; this might be the first or second user that logged in.

## Related Information

- TACACS+ client (see page 122)
- Cumulus Networks RADIUS demo on GitHub
- Cumulus Network TACACS demo on GitHub

## Netfilter - ACLs

Netfilter is the packet filtering framework in Cumulus Linux as well as most other Linux distributions. There are a number of tools available for configuring ACLs in Cumulus Linux:

- `iptables`, `ip6tables`, and `ebtables` are Linux userspace tools used to administer filtering rules for IPv4 packets, IPv6 packets, and Ethernet frames (layer 2 using MAC addresses).
- [NCLU \(see page 88\)](#) is a Cumulus Linux-specific userspace tool used to configure custom ACLs.
- `cl-acltool` is a Cumulus Linux-specific userspace tool used to administer filtering rules and configure default ACLs.

NCLU and `cl-acltool` operate on various configuration files and use `iptables`, `ip6tables`, and `ebtables` to install rules into the kernel. In addition, NCLU and `cl-acltool` program rules in hardware for interfaces involving switch port interfaces, which `iptables`, `ip6tables` and `ebtables` cannot do on their own.



In many instances, you can use NCLU to configure ACLs; however, in some cases, you must use `cl-acltool`. The examples below specify when to use which tool.



If you need help to configure ACLs, run `net example acl` to see a basic configuration:

[Click to see the example ...](#)

```
cumulus@leaf01:~$ net example acl
Scenario
=====
```



```
We would like to use access-lists on 'switch' to
- Restrict inbound traffic on swp1 to traffic from 10.1.1.0/24
destined for 10.1.2.0/24
- Restrict outbound traffic on swp2 to http, https, or ssh
  *switch
    \\
  swp1 /   \ swp2
    /     \
    /       \
host-11   host-12
switch net commands
=====
Create an ACL that accepts traffic from 10.1.1.0/24 destined
for 10.1.2.0/24
and drops all other traffic
switch# net add acl ipv4 MYACL accept source-ip 10.1.1.0/24
dest-ip 10.1.2.0/24
switch# net add acl ipv4 MYACL drop source-ip any dest-ip any
Apply MYACL inbound on swp1
switch# net add interface swp1 acl ipv4 MYACL inbound
Create an ACL that accepts http, https, or ssh traffic and
drops all
other traffic.
switch# net add acl ipv4 WEB_OR_SSH accept tcp source-ip any
source-port any dest-ip any dest-port http
switch# net add acl ipv4 WEB_OR_SSH accept tcp source-ip any
source-port http dest-ip any dest-port any
switch# net add acl ipv4 WEB_OR_SSH accept tcp source-ip any
source-port any dest-ip any dest-port https
switch# net add acl ipv4 WEB_OR_SSH accept tcp source-ip any
source-port https dest-ip any dest-port any
switch# net add acl ipv4 WEB_OR_SSH accept tcp source-ip any
source-port any dest-ip any dest-port ssh
switch# net add acl ipv4 WEB_OR_SSH accept tcp source-ip any
source-port ssh dest-ip any dest-port any
switch# net add acl ipv4 WEB_OR_SSH drop source-ip any dest-ip
any
Apply WEB_OR_SSH outbound on swp2
switch# net add interface swp2 acl ipv4 WEB_OR_SSH outbound
commit the staged changes
switch# net commit
Verification
=====
switch# net show configuration acl
```



The interfaces in the sample configuration in `net example acl` are layer 3; they are not layer 2 bridge members.



## Contents

This topic describes ...

- Traffic Rules In Cumulus Linux (see page 145)
  - Chains (see page 145)
  - Tables (see page 146)
  - Rules (see page 147)
  - How Rules Are Parsed and Applied (see page 148)
  - Rule Placement in Memory (see page 150)
  - Nonatomic Update Mode and Update Mode (see page 150)
  - Use iptables, ip6tables, and ebtables Directly (see page 153)
  - Estimate the Number of Rules (see page 154)
  - Match SVI and Bridged Interfaces in Rules (see page 155)
- Install and Manage ACL Rules with NCLU (see page 156)
- Install and Manage ACL Rules with cl-acltool (see page 157)
- Install Packet Filtering (ACL) Rules (see page 158)
- Specify the Policy Files to Install (see page 160)
- Hardware Limitations on Number of Rules (see page 161)
  - Broadcom Tomahawk Limits (see page 161)
  - Broadcom Trident II+ and Trident3 Limits (see page )
  - Broadcom Trident II Limits (see page 162)
  - Broadcom Helix4 Limits (see page 162)
  - Mellanox Spectrum Limits (see page 163)
- Supported Rule Types (see page 163)
  - iptables/ip6tables Rule Support (see page 164)
  - ebtables Rule Support (see page 165)
  - Other Unsupported Rules (see page 166)
  - IPv6 Egress Rules on Broadcom Switches (see page 166)
- Common Examples (see page 167)
  - Control Plane and Data Plane Traffic (see page 167)
  - Set DSCP on Transit Traffic (see page 169)
  - Verify DSCP Values on Transit Traffic (see page 169)
  - Check the Packet and Byte Counters for ACL Rules (see page 170)
  - Filter Specific TCP Flags (see page 172)
- Example Scenario (see page 173)
  - Switch 1 Configuration (see page 173)
  - Switch 2 Configuration (see page 174)
  - Egress Rule (see page 175)
  - Ingress Rule (see page 175)



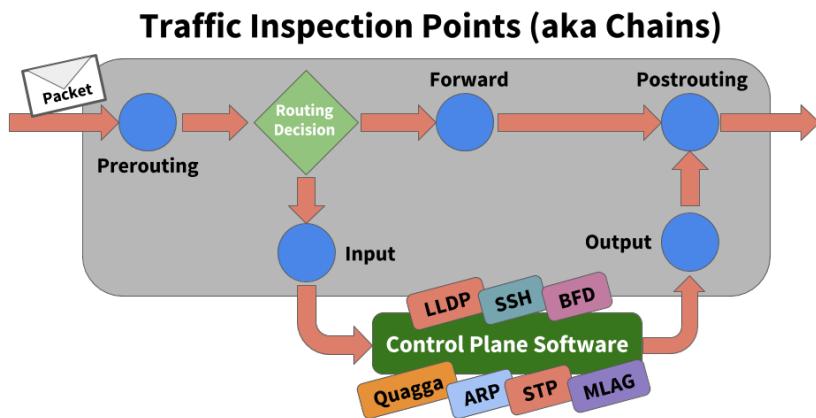
- [Input Rule \(see page 175\)](#)
- [Output Rule \(see page 175\)](#)
- [Combined Rules \(see page 175\)](#)
- [Layer 2-only Rules/ebtables \(see page 176\)](#)
- [Useful Links \(see page 176\)](#)
- [Caveats and Errata \(see page 176\)](#)
  - [Not All Rules Supported \(see page 176\)](#)
  - [ACL Log Policier Limits Traffic \(see page 176\)](#)
  - [Bridge Traffic Limitations \(see page 176\)](#)
  - [Log Actions Cannot Be Forwarded \(see page 176\)](#)
  - [Broadcom Range Checker Limitations \(see page 176\)](#)
  - [Inbound LOG Actions Only for Broadcom Switches \(see page 177\)](#)
  - [SPAN Sessions that Reference an Outgoing Interface \(see page 177\)](#)
  - [Tomahawk Hardware Limitations \(see page 177\)](#)
  - [Trident II+ Hardware Limitations \(see page \)](#)
  - [Trident3 Hardware Limitations \(see page 178\)](#)
  - [iptables Interactions with cl-acltool \(see page 178\)](#)
  - [Mellanox Spectrum Hardware Limitations \(see page 179\)](#)
  - [Where to Assign Rules \(see page 179\)](#)
  - [Generic Error Message Displayed after ACL Rule Installation Failure \(see page 179\)](#)
  - [Dell S3048-ON Supports only 24K MAC Addresses \(see page 180\)](#)
  - [Mellanox Spectrum Switches and INPUT Chain Rules \(see page 180\)](#)
  - [Hardware Policing of Packets in the Input Chain \(see page 180\)](#)

## Traffic Rules In Cumulus Linux

### *Chains*

Netfilter describes the mechanism for which packets are classified and controlled in the Linux kernel. Cumulus Linux uses the Netfilter framework to control the flow of traffic to, from, and across the switch. Netfilter does not require a separate software daemon to run; it is part of the Linux kernel itself. Netfilter asserts policies at layers 2, 3 and 4 of the [OSI model](#) by inspecting packet and frame headers based on a list of rules. Rules are defined using syntax provided by the `iptables`, `ip6tables` and `ebtables` userspace applications.

The rules created by these programs inspect or operate on packets at several points in the life of the packet through the system. These five points are known as *chains* and are shown here:



The chains and their uses are:

- **PREROUTING** touches packets before they are routed
- **INPUT** touches packets after they are determined to be destined for the local system but before they are received by the control plane software
- **FORWARD** touches transit traffic as it moves through the box
- **OUTPUT** touches packets that are sourced by the control plane software before they are put on the wire
- **POSTROUTING** touches packets immediately before they are put on the wire but after the routing decision has been made

## Tables

When building rules to affect the flow of traffic, the individual chains can be accessed by *tables*. Linux provides three tables by default:

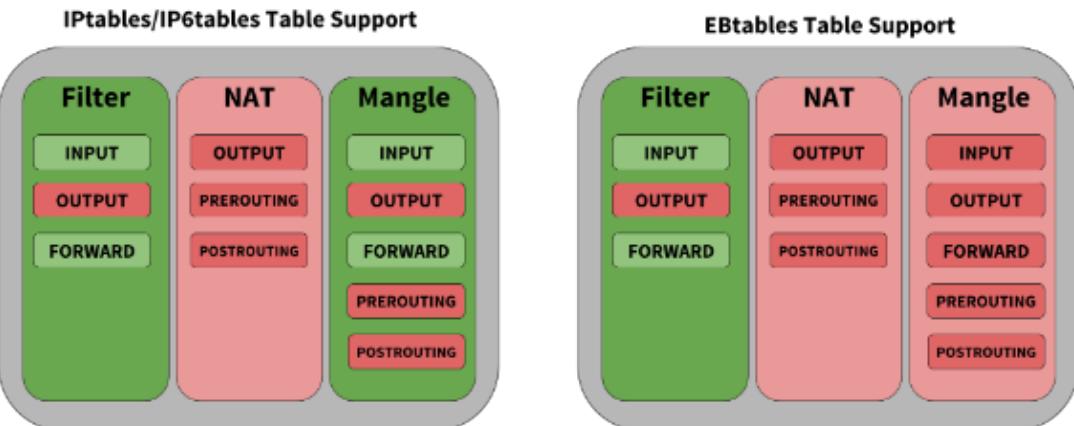
- **Filter** classifies traffic or filters traffic
- **NAT** applies Network Address Translation rules



Cumulus Linux does not support NAT.

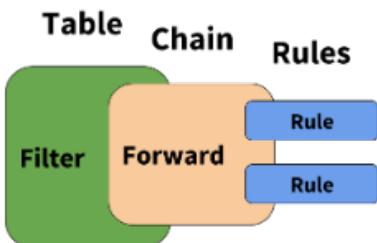
- **Mangle** alters packets as they move through the switch

Each table has a set of default chains that can be used to modify or inspect packets at different points of the path through the switch. Chains contain the individual rules to influence traffic. Each table and the default chains they support are shown below. Tables and chains in green are supported by Cumulus Linux, those in red are not supported (that is, they are not hardware accelerated) at this time.



## Rules

Rules are the items that actually classify traffic to be acted upon. Rules are applied to chains, which are attached to tables, similar to the graphic below.



Rules have several different components; the examples below highlight those different components.

(Sets SSH as high priority traffic)

```
-t mangle -A FORWARD -p tcp --dport 22 -j DSCP --set-dscp 46
```

Table	Chain	Matches	Jump	Targets
	-A INPUT	-i swp1 -p tcp --dport bgp	-j	POLICE --set-mode pkt --set-rate 2000 --set-burst 2000 --set-class 7

(Police and Prioritize BGP Traffic)

- **Table:** The first argument is the *table*. Notice the second example does not specify a table, that is because the filter table is implied if a table is not specified.
- **Chain:** The second argument is the *chain*. Each table supports several different chains. See Understanding Tables above.
- **Matches:** The third argument(s) are called the *matches*. You can specify multiple matches in a single rule. However, the more matches you use in a rule, the more memory that rule consumes.
- **Jump:** The *jump* specifies the target of the rule; that is, what action to take if the packet matches the rule. If this option is omitted in a rule, then matching the rule will have no effect on the packet's fate, but the counters on the rule will be incremented.
- **Target(s):** The *target* can be a user-defined chain (other than the one this rule is in), one of the special built-in targets that decides the fate of the packet immediately (like `DROP`), or an extended target. See the [Supported Rule Types and Common Usages](#) (see page 163) section below for examples of different targets.

### How Rules Are Parsed and Applied

All the rules from each chain are read from `iptables`, `ip6tables`, and `ebtables` and entered in order into either the filter table or the mangle table. The rules are read from the kernel in the following order:

- IPv6 (`ip6tables`)
- IPv4 (`iptables`)
- `ebtables`

When rules are combined and put into one table, the order determines the relative priority of the rules; `iptables` and `ip6tables` have the highest precedence and `ebtables` has the lowest.

The Linux packet forwarding construct is an overlay for how the silicon underneath processes packets. Be aware of the following:

- The order of operations for how rules are processed is not perfectly maintained when you compare how `iptables` and the switch silicon process packets. The switch silicon reorders rules when `switchd` writes to the ASIC, whereas traditional `iptables` execute the list of rules in order.



- All rules are terminating; after a rule matches, the action is carried out and no more rules are processed. The exception to this is when a SETCLASS rule is placed immediately before another rule; this exists multiple times in the default ACL configuration.  
In the example below, the SETCLASS action applied with the `--in-interface` option, creates the internal ASIC classification, and **continues to process** the next rule, which does the rate-limiting for the matched protocol:

```
-A $INGRESS_CHAIN --in-interface $INGRESS_INTF -p udp --dport  
$BFD_ECHO_PORT -j SETCLASS --class 7  
-A $INGRESS_CHAIN -p udp --dport $BFD_ECHO_PORT -j POLICE --set-  
mode pkt --set-rate 2000 --set-burst 2000
```



If multiple contiguous rules with the same match criteria are applied to `--in-interface`, **only** the first rule gets processed and then terminates processing. This is a misconfiguration; there is no reason to have duplicate rules with different actions.

- When processing traffic, rules affecting the FORWARD chain that specify an ingress interface are performed prior to rules that match on an egress interface. As a workaround, rules that only affect the egress interface can have an ingress interface wildcard (currently, only `swp+` and `bond+` are supported as wildcard names; see below) that matches any interface applied so that you can maintain order of operations with other input interface rules. For example, with the following rules:

```
-A FORWARD -i $PORTA -j ACCEPT  
-A FORWARD -o $PORTA -j ACCEPT    <-- This rule is performed LAST  
(because of egress interface matching)  
-A FORWARD -i $PORTB -j DROP
```

If you modify the rules like this, they are performed in order:

```
-A FORWARD -i $PORTA -j ACCEPT  
-A FORWARD -i swp+ -o $PORTA -j ACCEPT    <-- These rules are  
performed in order (because of wildcard match on ingress  
interface)  
-A FORWARD -i $PORTB -j DROP
```

- When using rules that do a mangle and a filter lookup for a packet, Cumulus Linux processes them in parallel and combines the action.
- If a switch port is assigned to a bond, any egress rules must be assigned to the bond.
- When using the OUTPUT chain, rules must be assigned to the source. For example, if a rule is assigned to the switch port in the direction of traffic but the source is a bridge (VLAN), the traffic is not affected by the rule and must be applied to the bridge.
- If all transit traffic needs to have a rule applied, use the FORWARD chain, not the OUTPUT chain.
- `ehtable` rules are put into either the IPv4 or IPv6 memory space depending on whether the rule utilizes IPv4 or IPv6 to make a decision. Layer 2-only rules that match the MAC address are put into the IPv4 memory space.



On Broadcom switches, the ingress INPUT chain rules match layer 2 and layer 3 multicast packets **before** multicast packet replication has occurred; therefore, a DROP rule affects all copies.

### Rule Placement in Memory

INPUT and ingress (`FORWARD -i`) rules occupy the same memory space. A rule counts as ingress if the `-i` option is set. If both input and output options (`-i` and `-o`) are set, the rule is considered as ingress and occupies that memory space. For example:

```
-A FORWARD -i swp1 -o swp2 -s 10.0.14.2 -d 10.0.15.8 -p tcp -j ACCEPT
```



If you set an output flag with the INPUT chain, you see an error. For example, running `cl-acltool -i` on the following rule:

```
-A FORWARD,INPUT -i swp1 -o swp2 -s 10.0.14.2 -d 10.0.15.8 -p  
tcp -j ACCEPT
```

generates the following error:

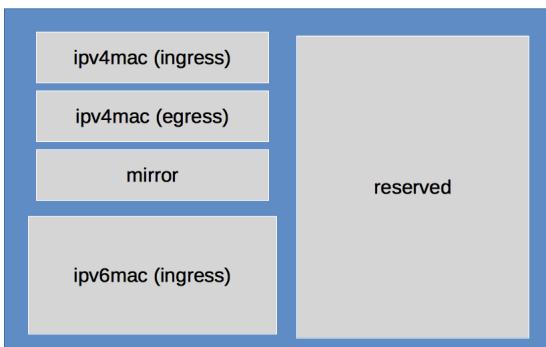
```
error: line 2 : output interface specified with INPUT chain  
error processing rule '-A FORWARD,INPUT -i swp1 -o swp2 -s  
10.0.14.2 -d 10.0.15.8 -p tcp -j ACCEPT'
```

However, removing the `-o` option and interface make it a valid rule.

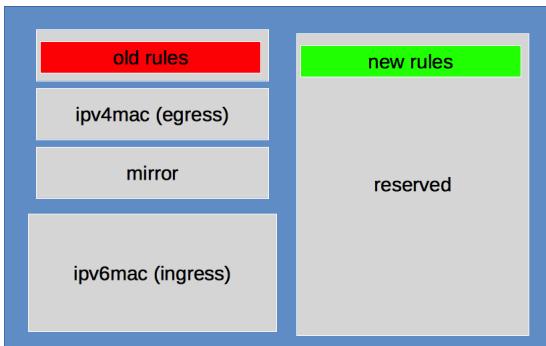
### Nonatomic Update Mode and Update Mode

In Cumulus Linux, *update mode* is enabled by default. However, this mode limits the number of ACL rules that you can configure.

Atomic Mode (default)

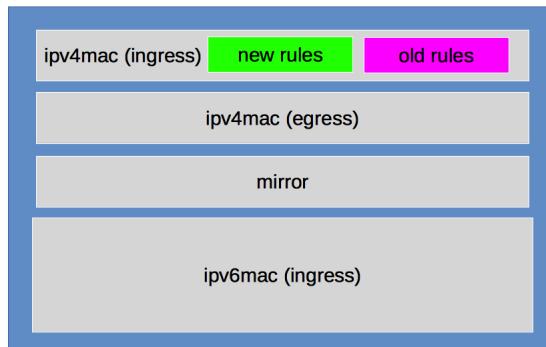


Atomic Mode (default)

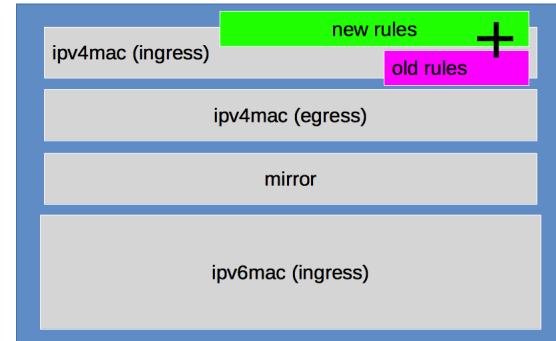


To increase the number of ACL rules that can be configured, configure the switch to operate in *nonatomic mode*.

Nonatomic Mode, Incremental Update



Nonatomic Mode, Regular Update



How the Rules Get Installed

Instead of reserving 50% of your TCAM space for atomic updates, incremental update uses the available free space to write the new TCAM rules and swap over to the new rules after this is complete. Cumulus Linux then deletes the old rules and frees up the original TCAM space. If there is insufficient free space to complete this task, the original nonatomic update is performed, which interrupts traffic.



### *Enable Nonatomic Update Mode*

You can enable nonatomic updates for `switchd`, which offer better scaling because all TCAM resources are used to actively impact traffic. With atomic updates, half of the hardware resources are on standby and do not actively impact traffic.

*Incremental nonatomic updates* are table based, so they do not interrupt network traffic when new rules are installed. The rules are mapped into the following tables and are updated in this order:

- mirror (ingress only)
- ipv4-mac (can be both ingress and egress)
- ipv6 (ingress only)



Only Broadcom-based switches support incremental nonatomic updates. Mellanox-based switches do **not** support incremental updates; therefore traffic **is** affected and gets stopped.



The incremental nonatomic update operation follows this order:

1. Updates are performed incrementally, one table at a time without stopping traffic.
2. Cumulus Linux checks if the rules in a table have changed since the last time they were installed; if a table does not have any changes, it is not reinstalled.
3. If there are changes in a table, the new rules are populated in new groups or slices in hardware, then that table is switched over to the new groups or slices.
4. Finally, old resources for that table are freed. This process is repeated for each of the tables listed above.
5. If sufficient resources do not exist to hold both the new rule set and old rule set, the regular nonatomic mode is attempted. This interrupts network traffic.
6. If the regular nonatomic update fails, Cumulus Linux reverts back to the previous rules.

To always start `switchd` with nonatomic updates:

1. Edit `/etc/cumulus/switchd.conf`.
2. Add the following line to the file:

```
acl.non_atomic_update_mode = TRUE
```

3. Restart `switchd`:

```
cumulus@switch:~$ sudo systemctl restart switchd.service
```



During regular *non-incremental nonatomic updates*, traffic is stopped first, then enabled after the new configuration is written into the hardware completely.

### Use `iptables`, `ip6tables`, and `eptables` Directly

Using `iptables`, `ip6tables`, `eptables` directly is not recommended because any rules installed in these cases only are applied to the Linux kernel and are not hardware accelerated using synchronization to the switch silicon. Running `cl-acltool -i` (the installation command) resets all rules and deletes anything that is not stored in `/etc/cumulus/acl/policy.conf`.

For example, performing:

```
cumulus@switch:~$ sudo iptables -A INPUT -p icmp --icmp-type echo-request -j DROP
```

Appears to work, and the rule appears when you run `cl-acltool -L`:

```
cumulus@switch:~$ sudo cl-acltool -L ip
```



```
Listing rules of type iptables:
```

```
-----  
TABLE filter :  
Chain INPUT (policy ACCEPT 72 packets, 5236 bytes)  
pkts bytes target prot opt in out source destination  
0 0 DROP icmp -- any any anywhere anywhere icmp echo-request
```

However, the rule is not synced to hardware when applied in this way and running `cl-acltool -i` or `reboot` removes the rule without replacing it. To ensure all rules that can be in hardware are hardware accelerated, place them in `/etc/cumulus/acl/policy.conf` and install them by running `cl-acltool -i`.

### *Estimate the Number of Rules*

To estimate the number of rules you can create from an ACL entry, first determine if that entry is an ingress or an egress. Then, determine if it is an IPv4-mac or IPv6 type rule. This determines the slice to which the rule belongs. Use the following to determine how many entries are used up for each type.

By default, each entry occupies one double wide entry, except if the entry is one of the following:

- An entry with multiple comma-separated input interfaces is split into one rule for each input interface (listed after `--in-interface` below). For example, this entry splits into two rules:

```
-A FORWARD --in-interface swp1s0,swp1s1 -p icmp -j ACCEPT
```

- An entry with multiple comma-separated output interfaces is split into one rule for each output interface (listed after `--out-interface` below). This entry splits into two rules:

```
-A FORWARD --in-interface swp+ --out-interface swp1s0,swp1s1 -p  
icmp -j ACCEPT
```

- An entry with both input and output comma-separated interfaces is split into one rule for each combination of input and output interface (listed after `--in-interface` and `--out-interface` below). This entry splits into four rules:

```
-A FORWARD --in-interface swp1s0,swp1s1 --out-interface swp1s2,  
swp1s3 -p icmp -j ACCEPT
```

- An entry with multiple layer 4 port ranges is split into one rule for each range (listed after `--dports` below). For example, this entry splits into two rules:

```
-A FORWARD --in-interface swp+ -p tcp -m multiport --dports 1050:  
1051,1055:1056 -j ACCEPT
```



Port ranges are only allowed for ingress rules.



## Match SVI and Bridged Interfaces in Rules

Cumulus Linux supports matching ACL rules for both ingress and egress interfaces on both [VLAN-aware](#) (see page 415) and [traditional mode](#) (see page 427) bridges, including bridge SVIs ([switch VLAN interfaces](#) (see page 409)) for input and output. However, keep the following in mind:

- If a traditional mode bridge has a mix of different VLANs, or has both access and trunk members, output interface matching is not supported.
- For `iptables` rules, all IP packets in a bridge are matched, not just routed packets.
- You cannot match both input and output interfaces in a rule.
- For routed packets, Cumulus Linux cannot match the output bridge for SPAN/ERSPAN.
- Matching SVI interfaces in `ebtables` rules is supported on switches based on Broadcom ASICs. This feature is not currently supported on switches with Mellanox Spectrum ASICs.

Following are example rules for a VLAN-aware bridge:

```
[ebtables]
-A FORWARD -i br0.100 -p IPv4 --ip-protocol icmp -j DROP
-A FORWARD -o br0.100 -p IPv4 --ip-protocol icmp -j ACCEPT

[iptables]
-A FORWARD -i br0.100 -p icmp -j DROP
-A FORWARD --out-interface br0.100 -p icmp -j ACCEPT
-A FORWARD --in-interface br0.100 -j POLICE --set-mode pkt --set-rate 1 --set-burst 1 --set-class 0
```

And here are example rules for a traditional mode bridge:

```
[ebtables]
-A FORWARD -i br0 -p IPv4 --ip-protocol icmp -j DROP
-A FORWARD -o br0 -p IPv4 --ip-protocol icmp -j ACCEPT

[iptables]
-A FORWARD -i br0 -p icmp -j DROP
-A FORWARD --out-interface br0 -p icmp -j ACCEPT
-A FORWARD --in-interface br0 -j POLICE --set-mode pkt --set-rate 1 --set-burst 1 --set-class 0
```



## Install and Manage ACL Rules with NCLU

NCLU provides an easy way to create custom ACLs in Cumulus Linux. The rules you create live in the `/var/lib/cumulus/nclu/nclu_acl.conf` file, which gets converted to a rules file, `/etc/cumulus/acl/policy.d/50_nclu_acl.rules`. This way, the rules you create with NCLU are independent of the two default files in `/etc/cumulus/acl/policy.d/00control_plane.rules` and `99control_plane_catch_all.rules`, as the content in these files might get updated after you upgrade Cumulus Linux.

Instead of crafting a rule by hand then installing it using `cl-acltool`, NCLU handles many of the options automatically. For example, consider the following `iptables` rule:

```
-A FORWARD -i swp1 -o swp2 -s 10.0.14.2 -d 10.0.15.8 -p tcp -j ACCEPT
```

You create this rule, called `EXAMPLE1`, using NCLU like this:

```
cumulus@switch:~$ net add acl ipv4 EXAMPLE1 accept tcp source-ip  
10.0.14.2/32 source-port any dest-ip 10.0.15.8/32 dest-port any  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

All options, such as the `-j` and `-p`, even `FORWARD` in the above rule, are added automatically when you apply the rule to the control plane; NCLU figures it all out for you.

You can also set a priority value, which specifies the order in which the rules get executed and the order in which they appear in the rules file. Lower numbers are executed first. To add a new rule in the middle, first run `net show config acl`, which displays the priority numbers. Otherwise, new rules get appended to the end of the list of rules in the `nclu_acl.conf` and `50_nclu_acl.rules` files.



If you need to hand edit a rule, do not edit the `50_nclu_acl.rules` file. Instead, edit the `nclu_acl.conf` file.

After you add the rule, you need to apply it to an inbound or outbound interface using `net add int acl`. The inbound interface in our example is `swp1`:

```
cumulus@switch:~$ net add int swp1 acl ipv4 EXAMPLE1 inbound  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

After you commit your changes, you can verify the rule you created with NCLU by running `net show configuration acl`:

```
cumulus@switch:~$ net show configuration acl  
acl ipv4 EXAMPLEv4 priority 10 accept tcp source-ip 10.0.14.2/32  
source-port any dest-ip 10.0.15.8/32 dest-port any
```



```
interface swp1
  acl ipv4 EXAMPLE1 inbound
```

Or you can see all of the rules installed by running `cat` on the `50_nclu_acl.rules` file:

```
cumulus@switch:~$ cat /etc/cumulus/acl/policy.d/50_nclu_acl.rules
[iptables]
# swp1: acl ipv4 EXAMPLE1 inbound
-A FORWARD --in-interface swp1 --out-interface swp2 -j ACCEPT -p tcp -
s 10.0.14.2/32 -d 10.0.15.8/32 --dport 110
```

For INPUT and FORWARD rules, apply the rule to a control plane interface using `net add control-plane`:

```
cumulus@switch:~$ net add control-plane acl ipv4 EXAMPLE1 inbound
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

To remove a rule, use `net del acl ipv4|ipv6|mac RULENAME`:

```
cumulus@switch:~$ net del acl ipv4 EXAMPLE1
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

This deletes all rules from the `50_nclu_acl.rules` file with that name. It also deletes the interfaces referenced in the `nclu_acl.conf` file.

## Install and Manage ACL Rules with cl-acltool

You can manage Cumulus Linux ACLs with `cl-acltool`. Rules are first written to the `iptables` chains, as described above, and then synced to hardware via `switchd`.



Use `iptables/ip6tables/ebtables` and `cl-acltool` to manage rules in the default files, `00control_plane.rules` and `99control_plane_catch_all.rules`; they are not aware of rules created using NCLU.

To examine the current state of chains and list all installed rules, run:

```
cumulus@switch:~$ sudo cl-acltool -L all
-----
Listing rules of type iptables:
-----
```



```
TABLE filter :  
Chain INPUT (policy ACCEPT 90 packets, 14456 bytes)  
pkts bytes target prot opt in out source destination  
0 0 DROP all -- swp+ any 240.0.0.0/5 anywhere  
0 0 DROP all -- swp+ any loopback/8 anywhere  
0 0 DROP all -- swp+ any base-address.mcast.net/8 anywhere  
0 0 DROP all -- swp+ any 255.255.255.255 anywhere ...
```

To list installed rules using native `iptables`, `ip6tables` and `ebtables`, use the `-L` option with the respective commands:

```
cumulus@switch:~$ sudo iptables -L  
cumulus@switch:~$ sudo ip6tables -L  
cumulus@switch:~$ sudo ebtables -L
```

To flush all installed rules, run:

```
cumulus@switch:~$ sudo cl-acltool -F all
```

To flush only the IPv4 `iptables` rules, run:

```
cumulus@switch:~$ sudo cl-acltool -F ip
```

If the install fails, ACL rules in the kernel and hardware are rolled back to the previous state. Errors from programming rules in the kernel or ASIC are reported appropriately.

## Install Packet Filtering (ACL) Rules

`cl-acltool` takes access control list (ACL) rules input in files. Each ACL policy file contains `iptables`, `ip6tables` and `ebtables` categories under the tags `[iptables]`, `[ip6tables]` and `[ebtables]` respectively.

Each rule in an ACL policy must be assigned to one of the rule categories above.

See `man cl-acltool(5)` for ACL rule details. For `iptables` rule syntax, see `man iptables(8)`. For `ip6tables` rule syntax, see `man ip6tables(8)`. For `ebtables` rule syntax, see `man ebtables(8)`.

See `man cl-acltool(5)` and `man cl-acltool(8)` for further details on using `cl-acltool`. Some examples are listed here and more are listed [later in this chapter \(see page \)](#).



By default:

- ACL policy files are located in `/etc/cumulus/acl/policy.d/`.
- All `*.rules` files in this directory are included in `/etc/cumulus/acl/policy.conf`.
- All files included in this `policy.conf` file are installed when the switch boots up.
- The `policy.conf` file expects rules files to have a `.rules` suffix as part of the file name.



Here is an example ACL policy file:

```
[iptables]
-A INPUT --in-interface swp1 -p tcp --dport 80 -j ACCEPT
-A FORWARD --in-interface swp1 -p tcp --dport 80 -j ACCEPT

[ip6tables]
-A INPUT --in-interface swp1 -p tcp --dport 80 -j ACCEPT
-A FORWARD --in-interface swp1 -p tcp --dport 80 -j ACCEPT

[ebtables]
-A INPUT -p IPv4 -j ACCEPT
-A FORWARD -p IPv4 -j ACCEPT
```

You can use wildcards or variables to specify chain and interface lists to ease administration of rules.

## ⚠ Interface Wildcards

Currently only *swp+* and *bond+* are supported as wildcard names. There might be kernel restrictions in supporting more complex wildcards like *swp1+* etc.

```
INGRESS = swp+
INPUT_PORT_CHAIN = INPUT, FORWARD

[iptables]
-A $INPUT_PORT_CHAIN --in-interface $INGRESS -p tcp --dport 80 -j ACCEPT

[ip6tables]
-A $INPUT_PORT_CHAIN --in-interface $INGRESS -p tcp --dport 80 -j ACCEPT

[ebtables]
-A INPUT -p IPv4 -j ACCEPT
```

You can write ACL rules for the system into multiple files under the default `/etc/cumulus/acl/policy.d/` directory. The ordering of rules during installation follows the sort order of the files based on their file names.

Use multiple files to stack rules. The example below shows two rules files separating rules for management and datapath traffic:

```
cumulus@switch:~$ ls /etc/cumulus/acl/policy.d/
00sample_mgmt.rules 01sample_datapath.rules
cumulus@switch:~$ cat /etc/cumulus/acl/policy.d/00sample_mgmt.rules

INGRESS_INTF = swp+
```

```

INGRESS_CHAIN = INPUT

[iptables]
# protect the switch management
-A $INGRESS_CHAIN --in-interface $INGRESS_INTF -s 10.0.14.2 -d
10.0.15.8 -p tcp -j ACCEPT
-A $INGRESS_CHAIN --in-interface $INGRESS_INTF -s 10.0.11.2 -d
10.0.12.8 -p tcp -j ACCEPT
-A $INGRESS_CHAIN --in-interface $INGRESS_INTF -d 10.0.16.8 -p udp -j
DROP

cumulus@switch:~$ cat /etc/cumulus/acl/policy.d/01sample_datapath.
rules
INGRESS_INTF = swp+
INGRESS_CHAIN = INPUT, FORWARD

[iptables]
-A $INGRESS_CHAIN --in-interface $INGRESS_INTF -s 192.0.2.5 -p icmp -
-j ACCEPT
-A $INGRESS_CHAIN --in-interface $INGRESS_INTF -s 192.0.2.6 -d
192.0.2.4 -j DROP
-A $INGRESS_CHAIN --in-interface $INGRESS_INTF -s 192.0.2.2 -d
192.0.2.8 -j DROP

```

Install all ACL policies under a directory:

```

cumulus@switch:~$ sudo cl-acltool -i -P ./rules
Reading files under rules
Reading rule file ./rules/01_http_rules.txt ...
Processing rules in file ./rules/01_http_rules.txt ...
Installing acl policy ...
Done.

```

Install all rules and policies included in /etc/cumulus/acl/policy.conf:

```

cumulus@switch:~$ sudo cl-acltool -i

```

## Specify the Policy Files to Install

By default, Cumulus Linux installs any .rules file you configure in /etc/cumulus/acl/policy.d/. To add other policy files to an ACL, you need to include them in /etc/cumulus/acl/policy.conf. For example, for Cumulus Linux to install a rule in a policy file called 01\_new.datapathacl, add include /etc/cumulus/acl/policy.d/01\_new.rules to policy.conf, as in this example:

```

cumulus@switch:~$ sudo nano /etc/cumulus/acl/policy.conf
#

```

```
# This file is a master file for acl policy file inclusion
#
# Note: This is not a file where you list acl rules.
#
# This file can contain:
# - include lines with acl policy files
#   example:
#     include <filepath>
#
# see manpage cl-acltool(5) and cl-acltool(8) for how to write policy
files
#
include /etc/cumulus/acl/policy.d/01_new.datapathacl
```

## Hardware Limitations on Number of Rules

The maximum number of rules that can be handled in hardware is a function of the following factors:

- The platform type (switch silicon, like Tomahawk or Spectrum — see the [HCL](#) to determine which platform type applies to a particular switch).
- The mix of IPv4 and IPv6 rules; Cumulus Linux does not support the maximum number of rules for both IPv4 and IPv6 simultaneously.
- The number of default rules provided by Cumulus Linux.
- Whether the rules are applied on ingress or egress.
- Whether the rules are in atomic or nonatomic mode; nonatomic mode rules are used when nonatomic updates are enabled ([see above \(see page 150\)](#)).

If the maximum number of rules for a particular table is exceeded, `cl-acltool -i` generates the following error:

```
error: hw sync failed (sync_acl hardware installation failed) Rolling
back .. failed.
```

In the tables below, the default rules count toward the limits listed. The raw limits below assume only one ingress and one egress table are present.

### Broadcom Tomahawk Limits

<b>Direction</b>	<b>Atomic Mode IPv4 Rules</b>	<b>Atomic Mode IPv6 Rules</b>	<b>Nonatomic Mode IPv4 Rules</b>	<b>Nonatomic Mode IPv6 Rules</b>
Ingress raw limit	512	512	1024	1024
Ingress limit with default rules	256 (36 default)	256 (29 default)	768 (36 default)	768 (29 default)
Egress raw limit	256	0	512	0



Egress limit with default rules	256 (29 default)	0	512 (29 default)	0
---------------------------------	------------------	---	------------------	---

### Broadcom Trident II+ and Trident3 Limits

Direction	Atomic Mode IPv4 Rules	Atomic Mode IPv6 Rules	Nonatomic Mode IPv4 Rules	Nonatomic Mode IPv6 Rules
Ingress raw limit	4096	4096	8192	8192
Ingress limit with default rules	2048 (36 default)	3072 (29 default)	6144 (36 default)	6144 (29 default)
Egress raw limit	256	0	512	0
Egress limit with default rules	256 (29 default)	0	512 (29 default)	0

### Broadcom Trident II Limits

Direction	Atomic Mode IPv4 Rules	Atomic Mode IPv6 Rules	Nonatomic Mode IPv4 Rules	Nonatomic Mode IPv6 Rules
Ingress raw limit	1024	1024	2048	2048
Ingress limit with default rules	512 (36 default)	768 (29 default)	1536 (36 default)	1536 (29 default)
Egress raw limit	256	0	512	0
Egress limit with default rules	256 (29 default)	0	512 (29 default)	0

### Broadcom Helix4 Limits

Direction	Atomic Mode IPv4 Rules	Atomic Mode IPv6 Rules	Nonatomic Mode IPv4 Rules	Nonatomic Mode IPv6 Rules
Ingress raw limit	1024	512	2048	1024
	768 (36 default)	384 (29 default)	1792 (36 default)	896 (29 default)

<b>Direction</b>	<b>Atomic Mode IPv4 Rules</b>	<b>Atomic Mode IPv6 Rules</b>	<b>Nonatomic Mode IPv4 Rules</b>	<b>Nonatomic Mode IPv6 Rules</b>
Ingress limit with default rules				
Egress raw limit	256	0	512	0
Egress limit with default rules	256 (29 default)	0	512 (29 default)	0

### Mellanox Spectrum Limits

The Mellanox Spectrum ASIC has one common [TCAM](#) for both ingress and egress, which can be used for other non-ACL-related resources. However, the number of supported rules varies with the [TCAM profile](#) (see page 726) specified for the switch.

<b>Profile</b>	<b>Atomic Mode IPv4 Rules</b>	<b>Atomic Mode IPv6 Rules</b>	<b>Nonatomic Mode IPv4 Rules</b>	<b>Nonatomic Mode IPv6 Rules</b>
default	500	250	1000	500
ipmc-heavy	750	500	1500	1000
acl-heavy	1750	1000	3500	2000
ipmc-max	1000	500	2000	1000
ip-acl-heavy	7500	0	15000	0



Even though the table above specifies that zero IPv6 rules are supported with the ip-acl-heavy profile, Cumulus Networks does not prevent you from configuring IPv6 rules. However, there is no guarantee that IPv6 rules work under the ip-acl-heavy profile.

### Supported Rule Types

The `iptables`/`ip6tables`/`ebtables` construct tries to layer the Linux implementation on top of the underlying hardware but they are not always directly compatible. Here are the supported rules for chains in `iptables`, `ip6tables` and `ebtables`.



To learn more about any of the options shown in the tables below, run `iptables -h [name of option]`. The same help syntax works for options for `ip6tables` and `ebtables`.

[Click to see an example of help syntax for an ebttables target](#)

```
root@leaf1# ebttables -h tricolorpolice
<...snip...
tricolorpolice option:
  --set-color-mode STRING setting the mode in blind or aware
  --set-cir INT setting committed information rate in kbits per
second
  --set-cbs INT setting committed burst size in kbyte
  --set-pir INT setting peak information rate in kbits per
second
  --set-ebs INT setting excess burst size in kbyte
  --set-conform-action-dscp INT setting dscp value if the
action is accept for conforming packets
  --set-exceed-action-dscp INT setting dscp value if the action
is accept for exceeding packets
  --set-violate-action STRING setting the action (accept/drop)
for violating packets
  --set-violate-action-dscp INT setting dscp value if the
action is accept for violating packets
Supported chains for the filter table:
INPUT FORWARD OUTPUT
```

## *iptables/ip6tables Rule Support*

Rule Element	Supported	Unsupported
<b>Matches</b>	<ul style="list-style-type: none"> <li>Src/Dst, IP protocol</li> <li>In/out interface</li> <li>IPv4: icmp, ttl,</li> <li>IPv6: icmp6, frag, hl,</li> <li>IP common: tcp (<a href="#">with flags (see page 172)</a>), udp, multiport, DSCP, addrtype</li> </ul>	<ul style="list-style-type: none"> <li>Rules with input/output Ethernet interfaces are ignored</li> <li>Inverse matches</li> </ul>
<b>Standard Targets</b>	<ul style="list-style-type: none"> <li>ACCEPT, DROP</li> </ul>	<ul style="list-style-type: none"> <li>RETURN, QUEUE, STOP, Fall Thru, Jump</li> </ul>
<b>Extended Targets</b>	<ul style="list-style-type: none"> <li>LOG (IPv4/IPv6); UID is not supported for LOG</li> <li>TCP SEQ, TCP options or IP options</li> <li>ULOG</li> </ul>	



Rule Element	Supported	Unsupported
	<ul style="list-style-type: none"><li>• SETQOS</li><li>• DSCP</li></ul> <p><i>Unique to Cumulus Linux:</i></p> <ul style="list-style-type: none"><li>• SPAN</li><li>• ERSPAN (IPv4/IPv6)</li><li>• POLICE</li><li>• TRICOLORPOLICE</li><li>• SETCLASS</li></ul>	

### *ebtables Rule Support*

Rule Element	Supported	Unsupported
<b>Matches</b>	<ul style="list-style-type: none"><li>• ether type</li><li>• input interface/wildcard</li><li>• output interface/wildcard</li><li>• src/dst MAC</li><li>• IP: src, dest, tos, proto, sport, dport</li><li>• IPv6: tclass, icmp6: type, icmp6: code range, src /dst addr, sport, dport</li><li>• 802.1p (CoS)</li><li>• VLAN</li></ul>	<ul style="list-style-type: none"><li>• Inverse matches</li><li>• Proto length</li></ul>
<b>Standard Targets</b>	<ul style="list-style-type: none"><li>• ACCEPT, DROP</li></ul>	<ul style="list-style-type: none"><li>• Return, Continue, Jump, Fall Thru</li></ul>
<b>Extended Targets</b>	<ul style="list-style-type: none"><li>• Ulog</li><li>• log</li></ul> <p><i>Unique to Cumulus Linux:</i></p> <ul style="list-style-type: none"><li>• span</li><li>• erspan</li><li>• police</li><li>• tricolorpolice</li><li>• setclass</li></ul>	



## Other Unsupported Rules

- Rules that have no matches and accept all packets in a chain are currently ignored.
- Chain default rules (that are ACCEPT) are also ignored.

## IPv6 Egress Rules on Broadcom Switches

Cumulus Linux 3.7.2 and later supports IPv6 egress rules in `ip6tables` on Broadcom switches. Because there are no slices to allocate in the egress TCAM for IPv6, the matches are implemented using a combination of the ingress IPv6 slice and the existing egress IPv4 MAC slice:

- Cumulus Linux compares all the match fields in the IPv6 ingress slice, except the `--out-interface` field, and marks the packet with a `classid`.
- The egress IPv4 MAC slice matches on the `classid` and the `out-interface`, and performs the actions.

For example, the `-A FORWARD --out-interface vlan100 -p icmp6 -j ACCEPT` rule is split into the following:

- IPv6 ingress: `-A FORWARD -p icmp6` action mark (for example, `classid 4`)
- IPv4 MAC egress: `<match mark 4>` and `--out-interface vlan100 -j ACCEPT`



- IPv6 egress rules in `ip6tables` are not supported on Hurricane2 switches.
- You cannot match both input and output interfaces in the same rule.
- The egress TCAM IPv4 MAC slice is shared with other rules, which constrains the scale to a much lower limit.

## Caveats

Splitting rules across the ingress TCAM and the egress TCAM causes the ingress IPv6 part of the rule to match packets going to all destinations, which can interfere with the regular expected linear rule match in a sequence.

### Examples

A higher rule can prevent a lower rule from being matched unexpectedly:

Rule 1: `-A FORWARD --out-interface vlan100 -p icmp6 -j ACCEPT`  
Rule 2: `-A FORWARD --out-interface vlan101 -p icmp6 -s 01::02 -j ACCEPT`  
Rule 1 matches all icmp6 packets from to all out interfaces in the ingress TCAM.  
This prevents rule 2 from getting matched, which is more specific but with a different out interface.

Make sure to put more specific matches above more general matches even if the output interfaces are different.

When you have two rules with the same output interface, the lower rule might match unexpectedly depending on the presence of the previous rules.

Rule 1: `-A FORWARD --out-interface vlan100 -p icmp6 -j ACCEPT`  
Rule 2: `-A FORWARD --out-interface vlan101 -s 00::01 -j DROP`



## Examples

Rule 3: -A FORWARD --out -interface vlan101 -p icmp6 -j ACCEPT

Rule 3 still matches for an icmp6 packet with sip 00:01 going out of vlan101. Rule 1 interferes with the normal function of rule 2 and/or rule 3.

When you have two adjacent rules with the same match and different output interfaces, such as:

Rule 1: -A FORWARD --out-interface vlan100 -p icmp6 -j ACCEPT

Rule 2: -A FORWARD --out-interface vlan101 -p icmp6 -j DROP

Rule 2 will never be match on ingress. Both rules share the same mark.

## Matching Untagged Packets (Trident3 Switches)

Untagged packets do not have an associated VLAN to match on egress; therefore, the match must be on the underlying layer 2 port. For example, for a bridge configured with pvid 100, member port swp1s0 and swp1s1, and SVI vlan100, the output interface match on vlan100 has to be expanded into each member port. The -A FORWARD -o vlan100 -p icmp6 -j ACCEPT rule must be specified as two rules:

Rule 1: -A FORWARD -o swp1s0 -p icmp6 -J ACCEPT

Rule 2: -A FORWARD -o swp1s1 -p icmp6 -j ACCEPT

Matching on an egress port matches all packets egressing the port, tagged as well as untagged. Therefore, to match only untagged traffic on the port, you must specify additional rules above this rule to prevent tagged packets matching the rule. This is true for bridge member ports as well as regular layer 2 ports. In the example rule above, if vlan101 is also present on the bridge, add a rule above rule 1 and rule 2 to protect vlan101 tagged traffic:

Rule 0: -A FORWARD -o vlan101 -p icmp6 -j ACCEPT

Rule 1: -A FORWARD -o swp1s0 -p icmp6 -j ACCEPT

Rule 2: -A FORWARD -o swp1s1 -p icmp6 -j ACCEPT

For a standalone port or subinterface on swp1s2:

Rule 0: -A FORWARD -o swp1s2.101 -p icmp6 -j ACCEPT

Rule 1: -A FORWARD -o swp1s2 -p icmp6 -j ACCEPT

## Common Examples

### Control Plane and Data Plane Traffic

You can configure quality of service for traffic on both the control plane and the data plane. By using QoS policers, you can rate limit traffic so incoming packets get dropped if they exceed specified thresholds.



Counters on POLICE ACL rules in `iptables` do not currently show the packets that are dropped due to those rules.

Use the `POLICE` target with `iptables`. `POLICE` takes these arguments:

- `--set-class value` sets the system internal class of service queue configuration to `value`.
- `--set-rate value` specifies the maximum rate in kilobytes (KB) or packets.

- `--set-burst value` specifies the number of packets or kilobytes (KB) allowed to arrive sequentially.
- `--set-mode string` sets the mode in *KB* (kilobytes) or *pkt* (packets) for rate and burst size.

For example, to rate limit the incoming traffic on `swp1` to 400 packets per second with a burst of 100 packets per second and set the class of the queue for the policed traffic as 0, set this rule in your appropriate `.rules` file:

```
-A INPUT --in-interface swp1 -j POLICE --set-mode pkt --set-rate 400
--set-burst 100 --set-class 0
```

Here is another example of control plane ACL rules to lock down the switch. You specify them in `/etc/cumulus/acl/policy.d/00control_plane.rules`:

#### [View the contents of the file ...](#)

```
INGRESS_INTF = swp+
INGRESS_CHAIN = INPUT
INNFWD_CHAIN = INPUT,FORWARD
MARTIAN_SOURCES_4 = "240.0.0.0/5,127.0.0.0/8,224.0.0.0/8,
255.255.255.255/32"
MARTIAN_SOURCES_6 = "ff00::/8,::128,::ffff:0.0.0.0/96,::1/128"
# Custom Policy Section
SSH_SOURCES_4 = "192.168.0.0/24"
NTP_SERVERS_4 = "192.168.0.1/32,192.168.0.4/32"
DNS_SERVERS_4 = "192.168.0.1/32,192.168.0.4/32"
SNMP_SERVERS_4 = "192.168.0.1/32"
[iptables]
-A $INNFWD_CHAIN --in-interface $INGRESS_INTF -s $MARTIAN_SOURCES_4 -
j DROP
-A $INGRESS_CHAIN --in-interface $INGRESS_INTF -p ospf -j POLICE --
set-mode pkt --set-rate 2000 --set-burst 2000 --set-class 7
-A $INGRESS_CHAIN --in-interface $INGRESS_INTF -p tcp --dport bgp -j
POLICE --set-mode pkt --set-rate 2000 --set-burst 2000 --set-class 7
-A $INGRESS_CHAIN --in-interface $INGRESS_INTF -p tcp --sport bgp -j
POLICE --set-mode pkt --set-rate 2000 --set-burst 2000 --set-class 7
-A $INGRESS_CHAIN --in-interface $INGRESS_INTF -p icmp -j POLICE --
set-mode pkt --set-rate 100 --set-burst 40 --set-class 2
-A $INGRESS_CHAIN --in-interface $INGRESS_INTF -p udp --dport bootps:
bootpc -j POLICE --set-mode pkt --set-rate 100 --set-burst 100 --set-
class 2
-A $INGRESS_CHAIN --in-interface $INGRESS_INTF -p tcp --dport bootps:
bootpc -j POLICE --set-mode pkt --set-rate 100 --set-burst 100 --set-
class 2
-A $INGRESS_CHAIN --in-interface $INGRESS_INTF -p igmp -j POLICE --
set-mode pkt --set-rate 300 --set-burst 100 --set-class 6
# Custom policy
-A $INGRESS_CHAIN --in-interface $INGRESS_INTF -p tcp --dport 22 -s
$SSH_SOURCES_4 -j ACCEPT
```



```
-A $INGRESS_CHAIN --in-interface $INGRESS_INTF -p udp --sport 123 -s $NTP_SERVERS_4 -j ACCEPT
-A $INGRESS_CHAIN --in-interface $INGRESS_INTF -p udp --sport 53 -s $DNS_SERVERS_4 -j ACCEPT
-A $INGRESS_CHAIN --in-interface $INGRESS_INTF -p udp --dport 161 -s $SNMP_SERVERS_4 -j ACCEPT
# Allow UDP traceroute when we are the current TTL expired hop
-A $INGRESS_CHAIN --in-interface $INGRESS_INTF -p udp --dport 1024:65535 -m ttl --ttl-eq 1 -j ACCEPT
-A $INGRESS_CHAIN --in-interface $INGRESS_INTF -j DROP
```

### Set DSCP on Transit Traffic

The examples here use the *mangle* table to modify the packet as it transits the switch. DSCP is expressed in [decimal notation](#) in the examples below.

```
[iptables]

#Set SSH as high priority traffic.
-t mangle -A FORWARD -p tcp --dport 22 -j DSCP --set-dscp 46

#Set everything coming in SWP1 as AF13
-t mangle -A FORWARD --in-interface swp1 -j DSCP --set-dscp 14

#Set Packets destined for 10.0.100.27 as best effort
-t mangle -A FORWARD -d 10.0.100.27/32 -j DSCP --set-dscp 0

#Example using a range of ports for TCP traffic
-t mangle -A FORWARD -p tcp -s 10.0.0.17/32 --sport 10000:20000 -d 10.0.100.27/32 --dport 10000:20000 -j DSCP --set-dscp 34
```

### Verify DSCP Values on Transit Traffic

The examples here use the DSCP match criteria in combination with other IP, TCP, and interface matches to identify traffic and count the number of packets.

```
[iptables]

#Match and count the packets that match SSH traffic with DSCP EF
-A FORWARD -p tcp --dport 22 -m dscp --dscp 46 -j ACCEPT

#Match and count the packets coming in SWP1 as AF13
-A FORWARD --in-interface swp1 -m dscp --dscp 14 -j ACCEPT
#Match and count the packets with a destination 10.0.0.17 marked best effort
-A FORWARD -d 10.0.100.27/32 -m dscp --dscp 0 -j ACCEPT

#Match and count the packets in a port range with DSCP AF41
```

```
-A FORWARD -p tcp -s 10.0.0.17/32 --sport 10000:20000 -d 10.0.100.27
/32 --dport 10000:20000 -m dscp --dscp 34 -j ACCEPT
```

### *Check the Packet and Byte Counters for ACL Rules*

To verify the counters using the above example rules, first send test traffic matching the patterns through the network. The following example generates traffic with [mz](#), which can be installed on host servers or even on Cumulus Linux switches. After traffic is sent to validate the counters, they are matched on switch1 use `cl-acltool`.



**Note:** Policing counters do not increment on switches with the Spectrum ASIC.

```
# Send 100 TCP packets on host1 with a DSCP value of EF with a
destination of host2 TCP port 22:

cumulus@host1$ mz eth1 -A 10.0.0.17 -B 10.0.100.27 -c 100 -v -t tcp
"dp=22,dscp=46"
    IP:  ver=4, len=40, tos=184, id=0, frag=0, ttl=255, proto=6, sum=0,
SA=10.0.0.17, DA=10.0.100.27,
        payload=[see next layer]
    TCP:  sp=0, dp=22, S=42, A=42, flags=0, win=10000, len=20, sum=0,
        payload=

# Verify the 100 packets are matched on switch1

cumulus@switch1$ sudo cl-acltool -L ip
-----
Listing rules of type iptables:
-----
TABLE filter :
Chain INPUT (policy ACCEPT 9314 packets, 753K bytes)
  pkts bytes target     prot opt in      out      source
destination
Chain FORWARD (policy ACCEPT 0 packets, 0 bytes)
  pkts bytes target     prot opt in      out      source
destination
      100   6400 ACCEPT      tcp  --  any     any     anywhere
anywhere          tcp dpt:ssh DSCP match 0x2e
      0       0 ACCEPT      all  --  swp1    any     anywhere
anywhere          DSCP match 0x0e
      0       0 ACCEPT      all  --  any     any      10.0.0.17
anywhere          DSCP match 0x00
      0       0 ACCEPT      tcp  --  any     any      10.0.0.17
10.0.100.27          tcp spts:webmin:20000 dpts:webmin:2002
```



```
# Send 100 packets with a small payload on host1 with a DSCP value of AF13 with a destination of host2:
```

```
cumulus@host1$ mz eth1 -A 10.0.0.17 -B 10.0.100.27 -c 100 -v -t ip
  IP: ver=4, len=20, tos=0, id=0, frag=0, ttl=255, proto=0, sum=0,
  SA=10.0.0.17, DA=10.0.100.27,
    payload=
```

```
# Verify the 100 packets are matched on switch1
```

```
cumulus@switch1$ sudo cl-acltool -L ip
-----
Listing rules of type iptables:
-----
TABLE filter :
Chain INPUT (policy ACCEPT 9314 packets, 753K bytes)
  pkts bytes target      prot opt in     out      source
destination
Chain FORWARD (policy ACCEPT 0 packets, 0 bytes)
  pkts bytes target      prot opt in     out      source
destination
    100   6400 ACCEPT      tcp  --  any      any      anywhere
anywhere          tcp dpt:ssh DSCP match 0x2e
    100   7000 ACCEPT      all  --  swp3     any      anywhere
anywhere          DSCP match 0x0e
    100   6400 ACCEPT      all  --  any      any      10.0.0.17
anywhere          DSCP match 0x00
        0     0 ACCEPT      tcp  --  any      any      10.0.0.17
10.0.100.27       tcp spts:webmin:20000 dpts:webmin:2002
```

```
# Send 100 packets on host1 with a destination of host2:
```

```
cumulus@host1$ mz eth1 -A 10.0.0.17 -B 10.0.100.27 -c 100 -v -t ip
  IP: ver=4, len=20, tos=56, id=0, frag=0, ttl=255, proto=0, sum=0,
  SA=10.0.0.17, DA=10.0.100.27,
    payload=
```

```
# Verify the 100 packets are matched on switch1
```

```
cumulus@switch1$ sudo cl-acltool -L ip
-----
Listing rules of type iptables:
-----
TABLE filter :
Chain INPUT (policy ACCEPT 9314 packets, 753K bytes)
  pkts bytes target      prot opt in     out      source
destination
Chain FORWARD (policy ACCEPT 0 packets, 0 bytes)
  pkts bytes target      prot opt in     out      source
destination
```

```

100  6400  ACCEPT      tcp   --  any    any    anywhere
anywhere
          tcp dpt:ssh  DSCP match 0x2e
100  7000  ACCEPT      all   --  swp3   any    anywhere
anywhere
          DSCP match 0x0e
          all   --  any    any    10.0.0.17
          DSCP match 0x00
          0     0  ACCEPT      tcp   --  any    any    10.0.0.17
10.0.100.27
          0     0  ACCEPT      tcp spts:webmin:20000 dpts:webmin:2002still
working

```

### *Filter Specific TCP Flags*

The example solution below creates rules on the INPUT and FORWARD chains to drop ingress IPv4 and IPv6 TCP packets when the SYN bit is set and the RST, ACK, and FIN bits are reset. The default for the INPUT and FORWARD chains allows all other packets. The ACL is applied to ports swp20 and swp21. After configuring this ACL, new TCP sessions that originate from ingress ports swp20 and swp21 are not allowed. TCP sessions that originate from any other port are allowed.

```

INGRESS_INTF = swp20,swp21

[iptables]
-A INPUT, FORWARD --in-interface $INGRESS_INTF -p tcp --syn -j DROP
[ip6tables]
-A INPUT, FORWARD --in-interface $INGRESS_INTF -p tcp --syn -j DROP

```

The `--syn` flag in the above rule matches packets with the SYN bit set and the ACK, RST, and FIN bits are cleared. It is equivalent to using `-tcp-flags SYN,RST,ACK,FIN SYN`. For example, you can write the above rule as:

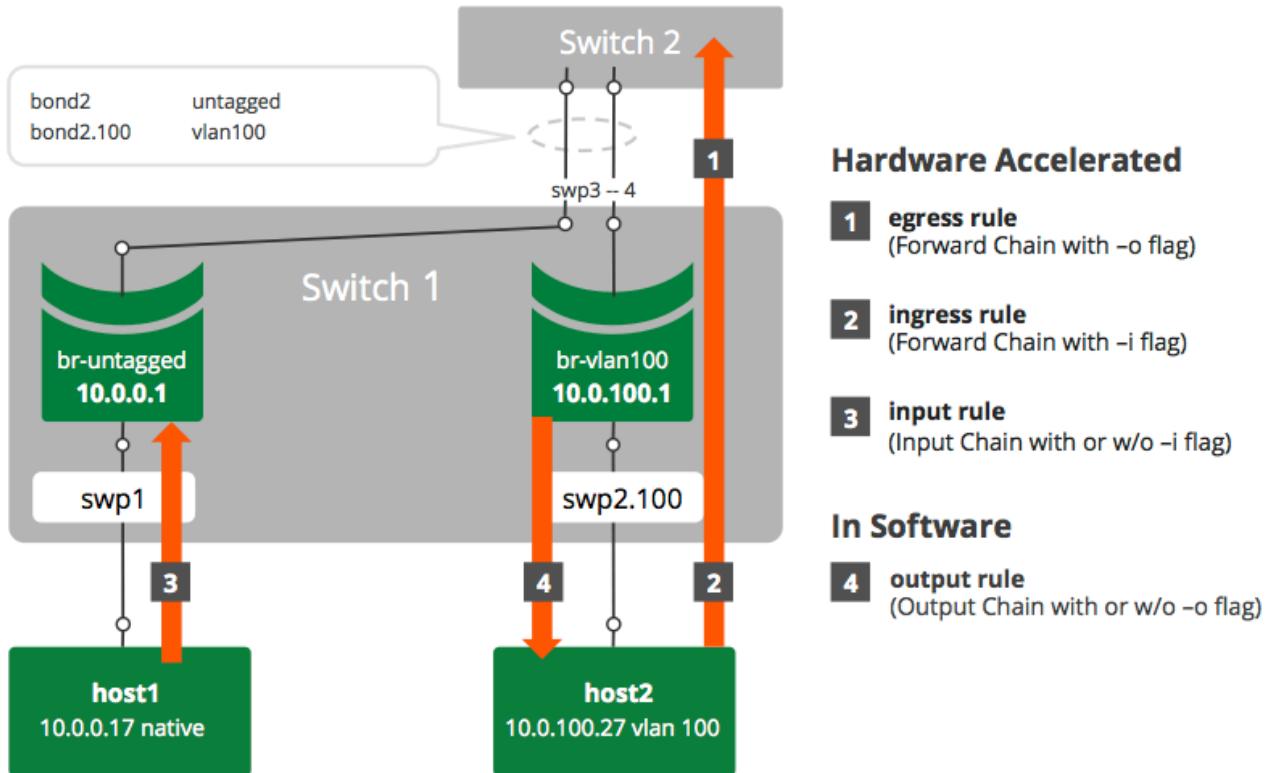
```

-A INPUT, FORWARD --in-interface $INGRESS_INTF -p tcp --tcp-flags SYN,
RST,ACK,FIN SYN -j DROP

```

## Example Scenario

The following example scenario demonstrates how several different rules are applied.



Following are the configurations for the two switches used in these examples. The configuration for each switch appears in `/etc/network/interfaces` on that switch.

### Switch 1 Configuration

```
cumulus@switch1:~$ net show configuration files

...
/etc/network/interfaces
=====

auto swp1
iface swp1

auto swp2
iface swp2

auto swp3
iface swp3
```



```
auto swp4
iface swp4

auto bond2
iface bond2
    bond-slaves swp3 swp4

auto br-untagged
iface br-untagged
    address 10.0.0.1/24
    bridge_ports swp1 bond2
    bridge_stp on

auto br-tag100
iface br-tag100
    address 10.0.100.1/24
    bridge_ports swp2.100 bond2.100
    bridge_stp on

...
```

## Switch 2 Configuration

```
cumulus@switch2:~$ net show configuration files

...
/etc/network/interfaces
=====

auto swp3
iface swp3

auto swp4
iface swp4

auto br-untagged
iface br-untagged
    address 10.0.0.2/24
    bridge_ports bond2
    bridge_stp on

auto br-tag100
iface br-tag100
    address 10.0.100.2/24
    bridge_ports bond2.100
    bridge_stp on

auto bond2
```



```
iface bond2  
    bond-slaves swp3 swp4  
  
...
```

### Egress Rule

The following rule blocks any TCP traffic with destination port 200 going from host1 or host2 through the switch (corresponding to rule 1 in the diagram above).

```
[iptables] -A FORWARD -o bond2 -p tcp --dport 200 -j DROP
```

### Ingress Rule

The following rule blocks any UDP traffic with source port 200 going from host1 through the switch (corresponding to rule 2 in the diagram above).

```
[iptables] -A FORWARD -i swp2 -p udp --sport 200 -j DROP
```

### Input Rule

The following rule blocks any UDP traffic with source port 200 and destination port 50 going from host1 to the switch (corresponding to rule 3 in the diagram above).

```
[iptables] -A INPUT -i swp1 -p udp --sport 200 --dport 50 -j DROP
```

### Output Rule

The following rule blocks any TCP traffic with source port 123 and destination port 123 going from Switch 1 to host2 (corresponding to rule 4 in the diagram above).

```
[iptables] -A OUTPUT -o br-tag100 -p tcp --sport 123 --dport 123 -j  
DROP
```

### Combined Rules

The following rule blocks any TCP traffic with source port 123 and destination port 123 going from any switch port egress or generated from Switch 1 to host1 or host2 (corresponding to rules 1 and 4 in the diagram above).

```
[iptables] -A OUTPUT, FORWARD -o swp+ -p tcp --sport 123 --dport 123 -  
j DROP
```



This also becomes two ACLs and is the same as:

```
[iptables]
-A FORWARD -o swp+ -p tcp --sport 123 --dport 123 -j DROP
-A OUTPUT -o swp+ -p tcp --sport 123 --dport 123 -j DROP
```

### *Layer 2-only Rules/ebtables*

The following rule blocks any traffic with source MAC address 00:00:00:00:00:12 and destination MAC address 08:9e:01:ce:e2:04 going from any switch port egress/ingress.

```
[ebtables] -A FORWARD -s 00:00:00:00:00:12 -d 08:9e:01:ce:e2:04 -j
DROP
```

## **Useful Links**

- [www.netfilter.org](http://www.netfilter.org)
- Netfilter.org packet filtering how-to

## **Caveats and Errata**

### *Not All Rules Supported*

Not all `iptables`, `ip6tables`, or `ebtables` rules are supported. Refer to the [Supported Rules](#) section (see page 163) above for specific rule support.

### *ACL Log Policer Limits Traffic*

To protect the CPU from overloading, traffic copied to the CPU is limited to 1 pkt/s by an ACL Log Policer.

### *Bridge Traffic Limitations*

Bridge traffic that matches LOG ACTION rules are not logged in syslog; the kernel and hardware identify packets using different information.

### *Log Actions Cannot Be Forwarded*

Logged packets cannot be forwarded. The hardware cannot both forward a packet and send the packet to the control plane (or kernel) for logging. To emphasize this, a log action must also have a drop action.

### *Broadcom Range Checker Limitations*

Broadcom platforms have only 24 range checkers. This is a separate resource from the total number of ACLs allowed. If you are creating a large ACL configuration, use port ranges for large ranges of more than 5 ports.



## *Inbound LOG Actions Only for Broadcom Switches*

On Broadcom-based switches, LOG actions can only be done on inbound interfaces (the ingress direction), not on outbound interfaces (the egress direction).

## *SPAN Sessions that Reference an Outgoing Interface*

SPAN sessions that reference an outgoing interface create mirrored packets based on the ingress interface before the routing/switiching decision. For an example, see the [SPAN Sessions that Reference an Outgoing Interface \(see page 1013\)](#) in the Network Troubleshooting chapter.

## *Tomahawk Hardware Limitations*

### *Rate Limiting per Pipeline, Not Global*

On Tomahawk switches, the field processor (FP) polices on a per-pipeline basis instead of globally, as with a Trident II switch. If packets come in to different switch ports that are on different pipelines on the ASIC, they might be rate limited differently.

For example, your switch is set so BFD is rate limited to 2000 packets per second. When the BFD packets are received on port1/pipeline1 and port2/pipeline2, they are each rate limited at 2000 pps; the switch is rate limiting at 4000 pps overall. Because there are four pipelines on a Tomahawk switch, you might see a fourfold increase of your configured rate limits.

### *Atomic Update Mode Enabled by Default*

In Cumulus Linux, atomic update mode is enabled by default. If you have Tomahawk switches and plan to use SPAN and/or mangle rules, you must disable atomic update mode.

To do so, enable nonatomic update mode by setting the value for `acl.non_atomic_update_mode` to `TRUE` in `/etc/cumulus/switchd.conf`, then [restart switchd](#).

```
acl.non_atomic_update_mode = TRUE
```

## *Packets Undercounted during ACL Updates*

On Tomahawk switches, when updating egress FP rules, some packets do not get counted. This results in an underreporting of counts during ping-pong or incremental switchover.

## *Trident II+ Hardware Limitations*

On a Trident II+ switch, the TCAM allocation for ACLs is limited to 2048 rules in atomic mode for a default setup instead of 4096, as advertised for ingress rules.



## *Trident3 Hardware Limitations*

### *TCAM Allocation*

On a Trident3 switch, the TCAM allocation for ACLs is limited to 2048 rules in atomic mode for a default setup instead of 4096, as advertised for ingress rules.

### *Enable Nonatomic Mode*

On a Trident3 switch, you must enable nonatomic update mode before you can configure ERSPAN. To do so, set the value for `acl.non_atomic_update_mode` to TRUE in `/etc/cumulus/switchd.conf`, then [restart `switchd`](#).

```
acl.non_atomic_update_mode = TRUE
```

### *Egress ACL Rules*

On Trident3 switches, egress ACL rules matching on the output SVI interface match layer 3 routed packets only, not bridged packets. To match layer 2 traffic, use egress bridge member port-based rules.

### *iptables Interactions with cl-acltool*

Because Cumulus Linux is a Linux operating system, the `iptables` commands can be used directly. However, consider using `cl-acltool` instead because:

- Without using `cl-acltool`, rules are not installed into hardware.
- Running `cl-acltool -i` (the installation command) resets all rules and deletes anything that is not stored in `/etc/cumulus/acl/policy.conf`.

For example, running the following command works:

```
cumulus@switch:~$ sudo iptables -A INPUT -p icmp --icmp-type echo-request -j DROP
```

And the rules appear when you run `cl-acltool -L`:

```
cumulus@switch:~$ sudo cl-acltool -L ip
-----
Listing rules of type iptables:
-----
TABLE filter :
Chain INPUT (policy ACCEPT 72 packets, 5236 bytes)
 pkts bytes target  prot opt in     out     source      destination
          0     0  DROP    icmp --   any   any     anywhere  anywhere
          0     0  icmp echo-request
```



However, running `cl-acltool -i` or `reboot` removes them. To ensure all rules that can be in hardware are hardware accelerated, place them in the `/etc/cumulus/acl/policy.conf` file, then run `cl-acltool -i`.

### Mellanox Spectrum Hardware Limitations

Due to hardware limitations in the Spectrum ASIC, [BFD policers](#) (see page 821) are shared between all BFD-related control plane rules. Specifically the following default rules share the same policer in the `00control_plan.rules` file:

```
[iptables]
-A $INGRESS_CHAIN -p udp --dport $BFD_ECHO_PORT -j POLICE --set-mode
pkt --set-rate 2000 --set-burst 2000
-A $INGRESS_CHAIN -p udp --dport $BFD_PORT -j POLICE --set-mode pkt --
set-rate 2000 --set-burst 2000
-A $INGRESS_CHAIN -p udp --dport $BFD_MH_PORT -j POLICE --set-mode
pkt --set-rate 2000 --set-burst 2000

[ip6tables]
-A $INGRESS_CHAIN --in-interface $INGRESS_INTF -p udp --dport
$BFD_ECHO_PORT -j POLICE --set-mode pkt --set-rate 2000 --set-burst
2000 --set-class 7
-A $INGRESS_CHAIN --in-interface $INGRESS_INTF -p udp --dport
$BFD_PORT -j POLICE --set-mode pkt --set-rate 2000 --set-burst 2000 --
set-class 7
-A $INGRESS_CHAIN --in-interface $INGRESS_INTF -p udp --dport
$BFD_MH_PORT -j POLICE --set-mode pkt --set-rate 2000 --set-burst
2000 --set-class 7
```

To work around this limitation, set the rate and burst of all 6 of these rules to the same values, using the `--set-rate` and `--set-burst` options.

### Where to Assign Rules

- If a switch port is assigned to a bond, any egress rules must be assigned to the bond.
- When using the OUTPUT chain, rules must be assigned to the source. For example, if a rule is assigned to the switch port in the direction of traffic but the source is a bridge (VLAN), the traffic is not affected by the rule and must be applied to the bridge.
- If all transit traffic needs to have a rule applied, use the FORWARD chain, not the OUTPUT chain.

### Generic Error Message Displayed after ACL Rule Installation Failure

After an ACL rule installation failure, a generic error message like the following is displayed:

```
cumulus@switch:$ sudo cl-acltool -i -p 00control_plane.rules
Using user provided rule file 00control_plane.rules
Reading rule file 00control_plane.rules ...
```



```
Processing rules in file 00control_plane.rules ...
error: hw sync failed (sync_acl hardware installation failed)
Installing acl policy... Rolling back ..
failed.
```

### Dell S3048-ON Supports only 24K MAC Addresses

The Dell S3048-ON has a limit of 24576 MAC address entries instead of 32K for other 1G switches.

### Mellanox Spectrum Switches and INPUT Chain Rules

On Mellanox Spectrum switches, INPUT chain rules are implemented using a trap mechanism. Packets headed to the CPU are assigned trap IDs. The default INPUT chain rules are mapped to these trap IDs. However, if a packet matches multiple traps, they are resolved by an internal priority mechanism that might be different from the rule priorities. Packets might not get policed by the default expected rule, but by another rule instead. For example, ICMP packets headed to the CPU are policed by the LOCAL rule instead of the ICMP rule. Also, multiple rules might share the same trap. In this case the policer that is applied is the largest of the policer values.

To work around this issue, create rules on the INPUT and FORWARD chains (INPUT,FORWARD).

### Hardware Policing of Packets in the Input Chain

On certain platforms, there are limitations on hardware policing of packets in the INPUT chain. To work around these limitations, Cumulus Linux supports kernel based policing of these packets in software using limit/hashlimit matches. Rules with these matches are not hardware offloaded, but are ignored during hardware install.

## Default Cumulus Linux ACL Configuration

The Cumulus Linux default ACL configuration is split into three parts, as outlined in the [netfilter ACL documentation \(see page 142\)](#): IP tables, IPv6 tables, and EB tables. The sections below describe the default configurations for each part. You can see the default file by clicking the Default ACL Configuration link:

### Default ACL Configuration

```
cumulus@switch:~$ sudo cl-acltool -L all
-----
Listing rules of type iptables:
-----
TABLE filter :
Chain INPUT (policy ACCEPT 167 packets, 16481 bytes)
  pkts bytes target     prot opt in     out     source
destination
      0     0  DROP      all   --  swp+    any    240.0.0.0/5
anywhere
      0     0  DROP      all   --  swp+    any    loopback/8
anywhere
      0     0  DROP      all   --  swp+    any    base-address.mcast.net
/8  anywhere
```



0	0	DROP	all	--	swp+	any	255.255.255.255
anywhere							
0	0	SETCLASS	udp	--	swp+	any	anywhere
anywhere			udp	dpt:3785	SETCLASS	class:7	
0	0	POLICE	udp	--	any	any	anywhere
anywhere			udp	dpt:3785	POLICE	mode:pkt rate:2000 burst:	
2000							
0	0	SETCLASS	udp	--	swp+	any	anywhere
anywhere			udp	dpt:3784	SETCLASS	class:7	
0	0	POLICE	udp	--	any	any	anywhere
anywhere			udp	dpt:3784	POLICE	mode:pkt rate:2000 burst:	
2000							
0	0	SETCLASS	udp	--	swp+	any	anywhere
anywhere			udp	dpt:4784	SETCLASS	class:7	
0	0	POLICE	udp	--	any	any	anywhere
anywhere			udp	dpt:4784	POLICE	mode:pkt rate:2000 burst:	
2000							
0	0	SETCLASS	ospf	--	swp+	any	anywhere
anywhere					SETCLASS	class:7	
0	0	POLICE	ospf	--	any	any	anywhere
anywhere			POLICE	mode:pkt rate:2000 burst:2000			
0	0	SETCLASS	tcp	--	swp+	any	anywhere
anywhere			tcp	dpt:bgp	SETCLASS	class:7	
0	0	POLICE	tcp	--	any	any	anywhere
anywhere			tcp	dpt:bgp	POLICE	mode:pkt rate:2000 burst:2000	
0	0	SETCLASS	tcp	--	swp+	any	anywhere
anywhere			tcp	spt:bgp	SETCLASS	class:7	
0	0	POLICE	tcp	--	any	any	anywhere
anywhere			tcp	spt:bgp	POLICE	mode:pkt rate:2000 burst:2000	
0	0	SETCLASS	tcp	--	swp+	any	anywhere
anywhere			tcp	dpt:5342	SETCLASS	class:7	
0	0	POLICE	tcp	--	any	any	anywhere
anywhere			tcp	dpt:5342	POLICE	mode:pkt rate:2000 burst:	
2000							
0	0	SETCLASS	tcp	--	swp+	any	anywhere
anywhere			tcp	spt:5342	SETCLASS	class:7	
0	0	POLICE	tcp	--	any	any	anywhere
anywhere			tcp	spt:5342	POLICE	mode:pkt rate:2000 burst:	
2000							
0	0	SETCLASS	icmp	--	swp+	any	anywhere
anywhere					SETCLASS	class:2	
1	84	POLICE	icmp	--	any	any	anywhere
anywhere			POLICE	mode:pkt rate:100 burst:40			
0	0	SETCLASS	udp	--	swp+	any	anywhere
anywhere			udp	dpts:bootps:bootpc	SETCLASS	class:2	
0	0	POLICE	udp	--	any	any	anywhere
anywhere			udp	dpt:bootps	POLICE	mode:pkt rate:100 burst:	
100							
0	0	POLICE	udp	--	any	any	anywhere
anywhere			udp	dpt:bootpc	POLICE	mode:pkt rate:100 burst:	
100							

```

      0      0 SETCLASS    tcp   --  swp+   any     anywhere
anywhere          tcp dpts:bootps:bootpc SETCLASS  class:2
      0      0 POLICE     tcp   --  any     any     anywhere
anywhere          tcp dpt:bootps POLICE  mode:pkt rate:100 burst:
100
      0      0 POLICE     tcp   --  any     any     anywhere
anywhere          tcp dpt:bootpc POLICE  mode:pkt rate:100 burst:
100
      0      0 SETCLASS    udp   --  swp+   any     anywhere
anywhere          udp dpt:10001 SETCLASS  class:3
      0      0 POLICE     udp   --  any     any     anywhere
anywhere          udp dpt:10001 POLICE  mode:pkt rate:2000 burst:
2000
      0      0 SETCLASS    igmp  --  swp+   any     anywhere
anywhere          SETCLASS  class:6
      1      32 POLICE    igmp  --  any     any     anywhere
anywhere          POLICE  mode:pkt rate:300 burst:100
      0      0 POLICE    all   --  swp+   any     anywhere
anywhere          ADDRTYPE match dst-type LOCAL POLICE  mode:pkt
rate:1000 burst:1000 class:0
      0      0 POLICE    all   --  swp+   any     anywhere
anywhere          ADDRTYPE match dst-type IPROUTER POLICE  mode:
pkt rate:400 burst:100 class:0
      0      0 SETCLASS    all   --  swp+   any     anywhere
anywhere          SETCLASS  class:0
Chain FORWARD (policy ACCEPT 0 packets, 0 bytes)
  pkts bytes target     prot opt in     out     source
destination
      0      0 DROP       all   --  swp+   any     240.0.0.0/5
anywhere
      0      0 DROP       all   --  swp+   any     loopback/8
anywhere
      0      0 DROP       all   --  swp+   any     base-address.mcast.net
/8 anywhere
      0      0 DROP       all   --  swp+   any     255.255.255.255
anywhere
Chain OUTPUT (policy ACCEPT 107 packets, 12590 bytes)
  pkts bytes target     prot opt in     out     source
destination
TABLE mangle :
Chain PREROUTING (policy ACCEPT 172 packets, 17871 bytes)
  pkts bytes target     prot opt in     out     source
destination
Chain INPUT (policy ACCEPT 172 packets, 17871 bytes)
  pkts bytes target     prot opt in     out     source
destination
Chain FORWARD (policy ACCEPT 0 packets, 0 bytes)
  pkts bytes target     prot opt in     out     source
destination
Chain OUTPUT (policy ACCEPT 111 packets, 18134 bytes)
  pkts bytes target     prot opt in     out     source
destination

```



```
Chain POSTROUTING (policy ACCEPT 111 packets, 18134 bytes)
  pkts bytes target     prot opt in     out     source
destination
TABLE raw :
Chain PREROUTING (policy ACCEPT 173 packets, 17923 bytes)
  pkts bytes target     prot opt in     out     source
destination
Chain OUTPUT (policy ACCEPT 112 packets, 18978 bytes)
  pkts bytes target     prot opt in     out     source
destination
-----
Listing rules of type ip6tables:
-----
TABLE filter :
Chain INPUT (policy ACCEPT 0 packets, 0 bytes)
  pkts bytes target     prot opt in     out     source
destination
      0      0 DROP       all      swp+   any    ip6-mcastprefix/8
anywhere
      0      0 DROP       all      swp+   any    ::/128
anywhere
      0      0 DROP       all      swp+   any    ::ffff:0.0.0.0/96
anywhere
      0      0 DROP       all      swp+   any    localhost/128
anywhere
      0      0 POLICE    udp     swp+   any    anywhere
anywhere
      0      0 POLICE    udp     dpt:3785 POLICE mode:pkt rate:2000 burst:
2000 class:7
      0      0 POLICE    udp     dpt:3784 POLICE mode:pkt rate:2000 burst:
2000 class:7
      0      0 POLICE    udp     swp+   any    anywhere
anywhere
      0      0 POLICE    udp     dpt:4784 POLICE mode:pkt rate:2000 burst:
2000 class:7
      0      0 POLICE    ospf    swp+   any    anywhere
anywhere
      0      0 POLICE    tcp     swp+   any    anywhere
anywhere
      0      0 POLICE    tcp     dpt:bgp POLICE mode:pkt rate:2000 burst:
2000 class:7
      0      0 POLICE    tcp     swp+   any    anywhere
anywhere
      0      0 POLICE    tcp     spt:bgp POLICE mode:pkt rate:2000 burst:
2000 class:7
      0      0 POLICE    ipv6-icmp swp+   any    anywhere
anywhere
      0      0 POLICE    ipv6-icmp router-
solicitation POLICE mode:pkt rate:100 burst:100 class:2
      0      0 POLICE    ipv6-icmp swp+   any    anywhere
anywhere
      0      0 POLICE    ipv6-icmp router-
advertisement POLICE mode:pkt rate:500 burst:500 class:2
      0      0 POLICE    ipv6-icmp swp+   any    anywhere
anywhere
      0      0 POLICE    ipv6-icmp router-
solicitation POLICE mode:pkt rate:400 burst:400 class:2
```

```

      0      0 POLICE      ipv6-icmp      swp+    any
anywhere          anywhere          ipv6-icmp neighbour-
advertisement POLICE mode:pkt rate:400 burst:400 class:2
      0      0 POLICE      ipv6-icmp      swp+    any
anywhere          anywhere          ipv6-icmptype 130 POLICE
mode:pkt rate:200 burst:100 class:6
      0      0 POLICE      ipv6-icmp      swp+    any
anywhere          anywhere          ipv6-icmptype 131 POLICE
mode:pkt rate:200 burst:100 class:6
      0      0 POLICE      ipv6-icmp      swp+    any
anywhere          anywhere          ipv6-icmptype 132 POLICE
mode:pkt rate:200 burst:100 class:6
      0      0 POLICE      ipv6-icmp      swp+    any
anywhere          anywhere          ipv6-icmptype 143 POLICE
mode:pkt rate:200 burst:100 class:6
      0      0 POLICE      ipv6-icmp      swp+    any
anywhere          anywhere          POLICE mode:pkt rate:64
burst:40 class:2
      0      0 POLICE      udp       swp+    any     anywhere
anywhere          udp dpts:dhcpv6-client:dhcpv6-server POLICE
mode:pkt rate:100 burst:100 class:2
      0      0 POLICE      tcp       swp+    any     anywhere
anywhere          tcp dpts:dhcpv6-client:dhcpv6-server POLICE
mode:pkt rate:100 burst:100 class:2
      0      0 POLICE      all      swp+    any     anywhere
anywhere          ADDRTYPE match dst-type LOCAL POLICE mode:pkt
rate:1000 burst:1000 class:0
      0      0 POLICE      all      swp+    any     anywhere
anywhere          ADDRTYPE match dst-type IPROUTER POLICE mode:
pkt rate:400 burst:100 class:0
      0      0 SETCLASS     all      swp+    any     anywhere
anywhere          SETCLASS class:0
Chain FORWARD (policy ACCEPT 0 packets, 0 bytes)
  pkts bytes target      prot opt in      out      source
destination
      0      0 DROP        all      swp+    any     ip6-mcastprefix/8
anywhere
      0      0 DROP        all      swp+    any     ::/128
anywhere
      0      0 DROP        all      swp+    any     ::ffff:0.0.0.0/96
anywhere
      0      0 DROP        all      swp+    any     localhost/128
anywhere
Chain OUTPUT (policy ACCEPT 5 packets, 408 bytes)
  pkts bytes target      prot opt in      out      source
destination
TABLE mangle :
Chain PREROUTING (policy ACCEPT 7 packets, 718 bytes)
  pkts bytes target      prot opt in      out      source
destination
Chain INPUT (policy ACCEPT 0 packets, 0 bytes)

```



```
pkts bytes target      prot opt in      out      source
destination
Chain FORWARD (policy ACCEPT 0 packets, 0 bytes)
  pkts bytes target      prot opt in      out      source
destination
Chain OUTPUT (policy ACCEPT 0 packets, 0 bytes)
  pkts bytes target      prot opt in      out      source
destination
Chain POSTROUTING (policy ACCEPT 0 packets, 0 bytes)
  pkts bytes target      prot opt in      out      source
destination
TABLE raw :
Chain PREROUTING (policy ACCEPT 7 packets, 718 bytes)
  pkts bytes target      prot opt in      out      source
destination
Chain OUTPUT (policy ACCEPT 0 packets, 0 bytes)
  pkts bytes target      prot opt in      out      source
destination
-----
Listing rules of type ebtables:
-----
TABLE filter :
Bridge table: filter
Bridge chain: INPUT, entries: 16, policy: ACCEPT
-d BGA -i swp+ -j setclass --class 7 , pcnt = 0 -- bcnt = 0
-d BGA -j police --set-mode pkt --set-rate 2000 --set-burst 2000 ,
pcnt = 0 -- bcnt = 0
-d 1:80:c2:0:0:2 -i swp+ -j setclass --class 7 , pcnt = 0 -- bcnt = 0
-d 1:80:c2:0:0:2 -j police --set-mode pkt --set-rate 2000 --set-burst
2000 , pcnt = 0 -- bcnt = 0
-d 1:80:c2:0:0:e -i swp+ -j setclass --class 6 , pcnt = 0 -- bcnt = 0
-d 1:80:c2:0:0:e -j police --set-mode pkt --set-rate 200 --set-burst
200 , pcnt = 0 -- bcnt = 0
-d 1:0:c:cc:cc:cc -i swp+ -j setclass --class 6 , pcnt = 0 -- bcnt = 0
-d 1:0:c:cc:cc:cc -j police --set-mode pkt --set-rate 200 --set-burst
200 , pcnt = 0 -- bcnt = 0
-p ARP -i swp+ -j setclass --class 2 , pcnt = 0 -- bcnt = 0
-p ARP -j police --set-mode pkt --set-rate 400 --set-burst 100 , pcnt
= 0 -- bcnt = 0
-d 1:0:c:cc:cc:cd -i swp+ -j setclass --class 7 , pcnt = 0 -- bcnt = 0
-d 1:0:c:cc:cc:cd -j police --set-mode pkt --set-rate 2000 --set-
burst 2000 , pcnt = 0 -- bcnt = 0
-p IPv4 -i swp+ -j ACCEPT , pcnt = 0 -- bcnt = 0
-p IPv6 -i swp+ -j ACCEPT , pcnt = 0 -- bcnt = 0
-i swp+ -j setclass --class 0 , pcnt = 0 -- bcnt = 0
-j police --set-mode pkt --set-rate 100 --set-burst 100 , pcnt = 0 --
bcnt = 0
Bridge chain: FORWARD, entries: 0, policy: ACCEPT
Bridge chain: OUTPUT, entries: 0, policy: ACCEPT
```



## IP Tables

Action/Value	Protocol/IP Address
Drop Destination IP: Any	Source IPv4: <ul style="list-style-type: none"><li>• 240.0.0.0/5</li><li>• loopback/8</li><li>• 224.0.0.0/4</li><li>• 255.255.255.255</li></ul>
Set class: 7 Police: Packet rate 2000 burst 2000 Source IP: Any Destination IP: Any	Protocol: <ul style="list-style-type: none"><li>• UDP/BFD Echo</li><li>• UDP/BFD Control</li><li>• UDP BFD Multihop Control</li><li>• OSPF</li><li>• TCP/BGP (spt dpt 179)</li><li>• TCP/MLAG (spt dpt 5342)</li></ul>
Set Class: 6 Police: Rate 300 burst 100 Source IP: Any Destination IP: Any	Protocol: <ul style="list-style-type: none"><li>• IGMP</li></ul>
Set class: 2 Police: Rate 100 burst 40 Source IP : Any Destination IP: Any	Protocol: <ul style="list-style-type: none"><li>• ICMP</li></ul>
Set class: 2 Police: Rate 100 burst 100 Source IP: Any Destination IP: Any	Protocol: <ul style="list-style-type: none"><li>• UDP/bootpc, bootps</li></ul>
Set class: 3 Police: Rate 2000 burst:2000	Protocol: <ul style="list-style-type: none"><li>• UDP/LNV</li></ul>



Action/Value	Protocol/IP Address
Source IP: Any Destination IP: Any	
Set class: 0  Police: Rate 1000 burst 1000  Source IP: Any Destination IP: Any	ADDRTYPE match dst-type LOCAL  ⚠ LOCAL is any local address -> Receiving a packet with a destination matching a local IP address on the switch will go to the CPU.
Set class: 0  Police: Rate 400 burst 100  Source IP: Any Destination IP: Any	ADDRTYPE match dst-type IPROUTER  ⚠ IPROUTER is any unresolved address -> On a l2/l3 boundary receiving a packet from L3 and needs to go to CPU in order to ARP for the destination.
Set class 0	All



⚠ Set class is internal to the switch - it does not set any precedence bits.

## IPv6 Tables

Action/Value	Protocol/IP Address
Drop	Source IPv6: <ul style="list-style-type: none"><li>ff00::/8</li><li>::</li><li>::ffff:0.0.0.0/96</li><li>localhost</li></ul>
Set class: 7  Police: Packet rate 2000 burst 2000  Source IPv6: Any Destination IPv6: Any	Protocol: <ul style="list-style-type: none"><li>UDP/BFD Echo</li><li>UDP/BFD Control</li><li>UDP BFD Multihop Control</li><li>OSPF</li><li>TCP/BGP (spt dpt 179)</li></ul>



Action/Value	Protocol/IP Address
Set class: 6 Police: Packet Rte: 200 burst 100 Source IPv6: Any Destination IPv6: Any	Protocol: <ul style="list-style-type: none"><li>• Multicast Listener Query (MLD)</li><li>• Multicast Listener Report (MLD)</li><li>• Multicast Listener Done (MLD)</li><li>• Multicast Listener Report V2</li></ul>
Set class: 2 Police: Packet rate: 100 burst 100 Source IPv6: Any Destination IPv6: Any	Protocol: <ul style="list-style-type: none"><li>• ipv6-icmp router-solicitation</li></ul>
Set class: 2 Police: Packet rate: 500 burst 500 Source IPv6: Any Destination IPv6: Any	Protocol: <ul style="list-style-type: none"><li>• ipv6-icmp router-advertisement POLICE</li></ul>
Set class: 2 Police: Packet rate: 400 burst 400 Source IPv6: Any Destination IPv6: Any	Protocol: <ul style="list-style-type: none"><li>• ipv6-icmp neighbour-solicitation</li><li>• ipv6-icmp neighbour-advertisement</li></ul>
Set class: 2 Police: Packet rate: 64 burst: 40 Source IPv6: Any Destination IPv6: Any	Protocol: <ul style="list-style-type: none"><li>• Ipv6 icmp</li></ul>
Set class: 2 Police: Packet rate: 100 burst: 100	Protocol: UDP/dhcpv6-client:dhcpv6-server (Spts & dpts)



Action/Value	Protocol/IP Address
Source IPv6: Any Destination IPv6: Any	
Police: Packet rate: 1000 burst 1000  Source IPv6: Any Destination IPv6: Any	ADDRTYPE match dst-type LOCAL  ⚠ LOCAL is any local address -> Receiving a packet with a destination matching a local IPv6 address on the switch will go to the CPU.
Set class: 0  Police: Packet rate: 400 burst 100	ADDRTYPE match dst-type IPROUTER  ⚠ IPROUTER is an unresolved address -> On a l2/l3 boundary receiving a packet from L3 and needs to go to CPU in order to ARP for the destination.
Set class 0	All



Set class is internal to the switch - it does not set any precedence bits.

## EB Tables

Action/Value	Protocol/MAC Address
Set Class: 7  Police: packet rate: 2000 burst rate:2000  Any switchport input interface	BDPU  LACP  Cisco PVST
Set Class: 6  Police: packet rate: 200 burst rate: 200  Any switchport input interface	LLDP  CDP
Set Class: 2  Police: packet rate: 400 burst rate: 100  Any switchport input interface	ARP
Catch All:  Allow all traffic	IPv4  IPv6

Action/Value	Protocol/MAC Address
Any switchport input interface	
Catch All (applied at end): Set class: 0 Police: packet rate 100 burst rate 100 Any switchport	ALL OTHER



Set class is internal to the switch. It does not set any precedence bits.

## Filtering Learned MAC Addresses

On Broadcom switches, a MAC address is learned on a bridge regardless of whether or not a received packet is dropped by an [ACL \(see page 142\)](#). This is due to how the hardware learns MAC addresses and occurs before the ACL lookup. This can be a security or resource problem as the MAC address table has the potential to get filled with bogus MAC addresses; a malfunctioning host, network error, loop, or malicious attack on a shared layer 2 platform can create an outage for other hosts if the same MAC address is learned on another port.

To prevent this from happening, Cumulus Linux filters frames before MAC learning occurs. Because MAC addresses and their port/VLAN associations are known at configuration time, you can create static MAC addresses, then create ingress ACLs to whitelist traffic from these MAC addresses and drop traffic otherwise.



This feature is specific to switches on the Broadcom platform only; on Mellanox Spectrum switches, the input port ACL does not have these issues when learning MAC addresses.

Create a configuration similar to the following, where you associate a port and VLAN with a given MAC address, adding each one to the bridge:

```
cumulus@switch:~$ net add bridge bridge vids 100,200,300
cumulus@switch:~$ net add bridge bridge pvid 1
cumulus@switch:~$ net add bridge bridge ports swp1-3
cumulus@switch:~$ net add bridge pre-up bridge fdb add 00:00:00:00:00:00
11 dev swp1 master static vlan 100
cumulus@switch:~$ net add bridge pre-up bridge fdb add 00:00:00:00:00:00
22 dev swp2 master static vlan 200
cumulus@switch:~$ net add bridge pre-up bridge fdb add 00:00:00:00:00:00
33 dev swp3 master static vlan 300
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands create the following configuration in the `/etc/network/interfaces` file:



```
auto swp1
iface swp1

auto swp2
iface swp2

auto swp3
iface swp3

auto bridge
iface bridge
    bridge-ports swp1 swp2 swp3
    bridge-pvid 1
    bridge-vids 100 200 300
    bridge-vlan-aware yes
    pre-up bridge fdb add 00:00:00:00:00:11 dev swp1 master static
    vlan 100
    pre-up bridge fdb add 00:00:00:00:00:22 dev swp2 master static
    vlan 200
    pre-up bridge fdb add 00:00:00:00:00:33 dev swp3 master static
    vlan 300
```

If you need to list many MAC addresses, you can run a script to create the same configuration. For example, create a script called `macs.txt` and put in the `bridge fdb add` commands for each MAC address you need to configure:

```
cumulus@switch:~$ cat /etc/networks/macs.txt
#!/bin/bash
bridge fdb add 00:00:00:00:00:11 dev swp1 master static vlan 100
bridge fdb add 00:00:00:00:00:22 dev swp2 master static vlan 200
bridge fdb add 00:00:00:00:00:33 dev swp3 master static vlan 300
bridge fdb add 00:00:00:00:00:44 dev swp4 master static vlan 400
bridge fdb add 00:00:00:00:00:55 dev swp5 master static vlan 500
bridge fdb add 00:00:00:00:00:66 dev swp6 master static vlan 600
```

Then create the configuration using [NCLU](#) (see page 88):

```
cumulus@switch:~$ net add bridge bridge vids 100,200,300
cumulus@switch:~$ net add bridge bridge pvid 1
cumulus@switch:~$ net add bridge bridge ports swp1-3
cumulus@switch:~$ net add bridge pre-up /etc/networks/macs.txt
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands create the following configuration in the `/etc/network/interfaces` file:



```
auto swp1
iface swp1

auto swp2
iface swp2

auto swp3
iface swp3

auto swp4
iface swp4

auto swp5
iface swp5

auto swp6
iface swp6

auto bridge
iface bridge
    bridge-ports swp1 swp2 swp3 swp4 swp5 swp6
    bridge-pvid 1
    bridge-vids 100 200 300
    bridge-vlan-aware yes
    pre-up bridge fdb add 00:00:00:00:00:11 dev swp1 master static
    vlan 100
    pre-up bridge fdb add 00:00:00:00:00:22 dev swp2 master static
    vlan 200
    pre-up bridge fdb add 00:00:00:00:00:33 dev swp3 master static
    vlan 300
    pre-up bridge fdb add 00:00:00:00:00:44 dev swp4 master static
    vlan 400
    pre-up bridge fdb add 00:00:00:00:00:55 dev swp5 master static
    vlan 500
    pre-up bridge fdb add 00:00:00:00:00:66 dev swp6 master static
    vlan 600
```

### Interactions with EVPN

If you are using [EVPN](#) (see page 501), local static MAC addresses added to the local FDB are exported as static MAC addresses to remote switches. Remote MAC addresses are added as MAC addresses to the remote FDB.

## Services and Daemons in Cumulus Linux

Services (also known as *daemons*) and *processes* are at the heart of how a Linux system functions. Most of the time a service takes care of itself; you just enable and start it, then let it run. However, because a Cumulus Linux switch is a Linux system, you have the ability to dig deeper if you like. Services may start multiple processes as they run. Services tend to be the most important things to monitor on a Cumulus Linux switch.



You manage services in Cumulus Linux in the following ways:

- Identify currently active or stopped services
- Identify boot time state of a specific service
- Disable or enable a specific service
- Identify active listener ports

## Contents

This topic describes ...

- [systemd and the systemctl Command \(see page 193\)](#)
  - [systemctl Subcommands \(see page 195\)](#)
  - [Ensure a Service Starts after Multiple Restarts \(see page 196\)](#)
  - [Keep systemd Services from Hanging after Starting \(see page 196\)](#)
- [Identify Active Listener Ports for IPv4 and IPv6 \(see page 196\)](#)
- [Identify Services Currently Active or Stopped \(see page 197\)](#)
- [Identify Essential Services \(see page 202\)](#)
  - [Important Services \(see page 203\)](#)

## systemd and the systemctl Command

In general, you manage services using `systemd` via the `systemctl` command. You use it with any service on the switch to start, stop, restart, reload, enable, disable, reenable, or get the status of the service.

```
cumulus@switch:~$ sudo systemctl start | stop | restart | status |
reload | enable | disable | reenable SERVICENAME.service
```

For example to restart networking, run the command:

```
cumulus@switch:~$ sudo systemctl restart networking.service
```



Unlike the `service` command in Debian Wheezy, the service name is written **after** the `systemctl` subcommand, not before it.

To see all the currently running services, run:

```
cumulus@switch:~$ sudo systemctl status
switch
    State: running
      Jobs: 0 queued
 Failed: 0 units
 Since: Thu 2019-01-10 00:19:34 UTC; 23h ago
```



```
CGroup: /
  1 /sbin/init
  system.slice
    dbus.service
      403 /usr/bin/dbus-daemon --system --address=systemd: --
nofork --nopidfile --systemd-activation
    uuidd.service
      669 /usr/sbin/uuidd --socket-activation
  cron.service
    381 /usr/sbin/cron -f -L 38
  smond.service
    606 /usr/bin/python /usr/sbin/smond
  switchd.service
    587 /usr/sbin/switchd -vx
  ledmgrd.service
    613 /usr/bin/python /usr/sbin/ledmgrd
  wd_keepalive.service
    433 /usr/sbin/wd_keepalive
  netq-agent.service
    915 /usr/bin/python /usr/sbin/netq-agent
  ptmd.service
    914 /usr/sbin/ptmd -l INFO
  networking.service
    729 /sbin/dhclient -pf /run/dhclient.vagrant.pid -lf
/var/lib/dhcp/dhclient.vagrant.leases vagrant
    828 /sbin/dhclient -pf /run/dhclient.eth0.pid -lf /var
/lib/dhcp/dhclient.eth0.leases eth0
  nginx.service
    449 nginx: master process /usr/sbin/nginx -g daemon on;
master_process on
    450 nginx: worker process
    451 nginx: worker process
    452 nginx: worker process
    453 nginx: worker process
  sysmonitor.service
    847 /bin/bash /usr/lib/cumulus/sysmonitor
    7717 sleep 60
  system-serial\x2dgetty.slice
    serial-getty@ttyS0.service
      920 /sbin/agetty --keep-baud 115200 38400 9600 ttyS0
vt102
  neighmgrd.service
    844 /usr/bin/python /usr/bin/neighmgrd
  systemd-journald.service
    252 /lib/systemd/systemd-journald
  netqd.service
    846 /usr/bin/python /usr/sbin/netqd --daemon
  auditd.service
    337 /sbin/auditd -n
  pwmd.service
    614 /usr/bin/python /usr/sbin/pwmd
  netd.service
```



```
845 /usr/bin/python -O /usr/sbin/netd -d
ssh.service
937 /usr/sbin/sshd -D
6893 sshd: cumulus [priv]
6911 sshd: cumulus@pts/0
6912 -bash
7747 sudo systemctl status
7752 systemctl status
7753 pager
systemd-logind.service
405 /lib/systemd/systemd-logind
system-getty.slice
getty@tty1.service
435 /sbin/agetty --noclear tty1 linux
systemd-udevd.service
254 /lib/systemd/systemd-udevd
mcelog.service
438 /usr/sbin/mcelog --ignorenodenv --daemon --foreground
portwd.service
603 /usr/bin/python /usr/sbin/portwd
lldpd.service
911 lldpd: monitor.
936 lldpd: connected to oob-mgmt-switch
rsyslog.service
392 /usr/sbin/rsyslogd -n
ntp.service
912 /usr/sbin/ntp -n -u ntp:ntp -g
acpid.service
390 /usr/sbin/acpid
mstpd.service
436 /sbin/mstpd -d -v2
```

## systemctl Subcommands

systemctl has a number of subcommands that perform a specific operation on a given service.

- **status:** Returns the status of the specified service.
- **start:** Starts the service.
- **stop:** Stops the service.
- **restart:** Stops, then starts the service, all the while maintaining state. So if there are dependent services or services that mark the restarted service as *Required*, the other services also get restarted. For example, running `systemctl restart frr.service` restarts any of the routing protocol services that are enabled and running, such as `bgpd` or `ospfd`.
- **reload:** Reloads a service's configuration.
- **enable:** Enables the service to start when the system boots, but does not start it unless you use the `systemctl start SERVICENAME.service` command or reboot the switch.
- **disable:** Disables the service, but does not stop it unless you use the `systemctl stop SERVICENAME.service` command or reboot the switch. A disabled service can still be started or stopped.

- **reenable:** Disables, then enables a service. You might need to do this so that any new *Wants* or *WantedBy* lines create the symlinks necessary for ordering. This has no side effects on other services.

There is often little reason to interact with the services directly using these commands. If a critical service should happen to crash or hit an error it will be automatically respawned by systemd. Systemd is effectively the caretaker of services in modern Linux systems and is responsible for starting all the necessary services at boot time.

### *Ensure a Service Starts after Multiple Restarts*

By default, `systemd` is configured to try to restart a particular service only a certain number of times within a given interval before the service fails to start at all. The settings for this are stored in the service script. The settings are *StartLimitInterval* (which defaults to 10 seconds) and *StartBurstLimit* (which defaults to 5 attempts), but many services override these defaults, sometimes with much longer times. `switchd.service`, for example, sets *StartLimitInterval=10m* and *StartBurstLimit=3*, which means if you restart `switchd` more than 3 times in 10 minutes, it does not start.

When the restart fails for this reason, a message similar to the following appears:

```
Job for switchd.service failed. See 'systemctl status switchd.service' and 'journalctl -xn' for details.
```

And `systemctl status switchd.service` shows output similar to:

```
Active: failed (Result: start-limit) since Thu 2016-04-07 21:55:14 UTC; 15s ago
```

To clear this error, run `systemctl reset-failed switchd.service`. If you know you are going to restart frequently (multiple times within the *StartLimitInterval*), you can run the same command before you issue the restart request. This also applies to stop followed by start.

### *Keep systemd Services from Hanging after Starting*

If you start, restart, or reload any `systemd` service that can be started from another `systemd` service, you must use the `--no-block` option with `systemctl`. Otherwise, that service or even the switch itself might hang after starting or restarting.

## **Identify Active Listener Ports for IPv4 and IPv6**

You can identify the active listener ports under both IPv4 and IPv6 using the `netstat` command:

```
cumulus@switch:~$ netstat -nlp --inet --inet6
Active Internet connections (only servers)
Proto Recv-Q Send-Q Local Address          Foreign Address
State      PID/Program name
tcp        0      0 0.0.0.0:53              0.0.0.0:*
LISTEN     444/dnsmasq
```



tcp	0	0 0.0.0.0:22	0.0.0.0:*
LISTEN	874/sshd		
tcp6	0	0 ::::53	::::*
LISTEN	444/dnsmasq		
tcp6	0	0 ::::22	::::*
LISTEN	874/sshd		
udp	0	0 0.0.0.0:28450	0.0.0.0:
*		839/dhclient	
udp	0	0 0.0.0.0:53	0.0.0.0:
*		444/dnsmasq	
udp	0	0 0.0.0.0:68	0.0.0.0:
*		839/dhclient	
udp	0	0 192.168.0.42:123	0.0.0.0:
*		907/ntpd	
udp	0	0 127.0.0.1:123	0.0.0.0:
*		907/ntpd	
udp	0	0 0.0.0.0:123	0.0.0.0:
*		907/ntpd	
udp	0	0 0.0.0.0:4784	0.0.0.0:
*		909/ptmd	
udp	0	0 0.0.0.0:3784	0.0.0.0:
*		909/ptmd	
udp	0	0 0.0.0.0:3785	0.0.0.0:
*		909/ptmd	
udp6	0	0 ::::58352	:::
*		839/dhclient	
udp6	0	0 ::::53	:::
*		444/dnsmasq	
udp6	0	0 fe80::a200:ff:fe00::123 :::	
*		907/ntpd	
udp6	0	0 ::1:123	:::
*		907/ntpd	
udp6	0	0 ::::123	:::
*		907/ntpd	
udp6	0	0 ::::4784	:::
*		909/ptmd	
udp6	0	0 ::::3784	:::
*		909/ptmd	

## Identify Services Currently Active or Stopped

To determine which services are currently active or stopped, run the `cl-service-summary` command:

```
cumulus@switch:~$ cl-service-summary
Service cron           enabled   active
Service ssh            enabled   active
Service syslog          enabled   active
Service asic-monitor    enabled   inactive
Service clagd           enabled   inactive
```

Service cumulus-poe		inactive
Service lldpd	enabled	active
Service mstpd	enabled	active
Service neighmgrd	enabled	active
Service netd	enabled	active
Service netq-agent	enabled	active
Service ntp	enabled	active
Service portwd	enabled	active
Service ptmd	enabled	active
Service pwmd	enabled	active
Service smond	enabled	active
Service switchd	enabled	active
Service sysmonitor	enabled	active
Service vxrd	disabled	inactive
Service vxsnd	disabled	inactive
Service rdnbrd	disabled	inactive
Service frr	enabled	inactive
Service bgpd	disabled	inactive
Service eigrpd	disabled	inactive
Service isisd	disabled	inactive
Service ldpd	disabled	inactive
Service nhrpdp	disabled	inactive
Service ospf6d	disabled	inactive
Service ospfd	disabled	inactive
Service pbrd	disabled	inactive
Service pimd	disabled	inactive
Service ripd	disabled	inactive
Service ripngd	disabled	inactive
Service zebra	disabled	inactive

You can also run the `systemctl list-unit-files --type service` command to list all services on the switch and see which ones are enabled:

[Click here to see output of this command ...](#)

```
cumulus@switch:~$ systemctl list-unit-files --type service
UNIT FILE                                     STATE
aclinit.service                                enabled
acltool.service                                enabled
acpid.service                                  disabled
asic-monitor.service                           enabled
auditd.service                                 enabled
autovt@.service                               disabled
bmcd.service                                   disabled
bootlog.service                                enabled
bootlogd.service                              masked
bootlogs.service                             masked
bootmisc.service                            masked
checkfs.service                               masked
checkroot-bootclean.service                  masked
checkroot.service                            masked
```



clagd.service	enabled
console-getty.service	disabled
console-shell.service	disabled
container-getty@.service	static
cron.service	enabled
cryptdisks-early.service	masked
cryptdisks.service	masked
cumulus-aclcheck.service	static
cumulus-chassis-ssh.service	disabled
cumulus-chassisd.service	disabled
cumulus-core.service	static
cumulus-fastfailover.service	enabled
cumulus-firstboot.service	disabled
cumulus-hyperconverged.service	disabled
cumulus-platform.service	enabled
cumulus-support.service	static
dbus-org.freedesktop.hostname1.service	static
dbus-org.freedesktop.locale1.service	static
dbus-org.freedesktop.login1.service	static
dbus-org.freedesktop.machine1.service	static
dbus-org.freedesktop.timedate1.service	static
dbus.service	static
debian-fixup.service	static
debug-shell.service	disabled
decode-syseeprom.service	static
dhcpd.service	disabled
dhcpd6.service	disabled
dhcpd6@.service	disabled
dhcpd@.service	disabled
dhcrelay.service	disabled
dhcrelay6.service	disabled
dhcrelay6@.service	disabled
dhcrelay@.service	disabled
dm-event.service	disabled
dns-watcher.service	disabled
dnsmasq.service	disabled
emergency.service	static
frr.service	enabled
fuse.service	masked
getty-static.service	static
getty@.service	enabled
halt-local.service	static
halt.service	masked
heartbeat-failed@.service	static
hostapd.service	disabled
hostname.service	masked
hsflowd.service	disabled
hsflowd@.service	disabled
hwclock-save.service	enabled
hwclock.service	masked
hwclockfirst.service	masked
ifup@.service	static

initrd-cleanup.service	static
initrd-parse-etc.service	static
initrd-switch-root.service	static
initrd-udevadm-cleanup-db.service	static
ipmievdevd.service	disabled
killprocs.service	masked
kmod-static-nodes.service	static
kmod.service	static
ledmgrd.service	enabled
lldpd.service	enabled
lm-sensors.service	enabled
lvm2-activation-early.service	enabled
lvm2-activation.service	enabled
lvm2-lvmetad.service	static
lvm2-monitor.service	enabled
lvm2-pvscan@.service	static
lvm2.service	disabled
mcelog.service	enabled
module-init-tools.service	static
motd.service	masked
mountall-bootclean.service	masked
mountall.service	masked
mountdevsubfs.service	masked
mountkernfs.service	masked
mountnfs-bootclean.service	masked
mountnfs.service	masked
mstp_bridge.service	enabled
mstpd.service	enabled
neighmgrd.service	enabled
netd.service	enabled
netq-agent.service	enabled
netq-agent@.service	disabled
netq-notifier.service	disabled
netq-notifier@.service	disabled
netqd.service	enabled
netqd@.service	disabled
networking.service	enabled
nginx.service	enabled
ntp.service	enabled
ntp@.service	disabled
open-vm-tools.service	enabled
openvswitch-vtep.service	disabled
phc2sys.service	disabled
phy-ucode-update.service	enabled
portwd.service	enabled
procps.service	static
ptmd.service	enabled
ptp4l.service	disabled
pwmmd.service	enabled
quotaon.service	static
rc-local.service	static
rc.local.service	static



rdnbd.service	disabled
reboot.service	masked
rescue.service	static
restserver.service	disabled
rmnologin.service	masked
rsyslog.service	enabled
screen-cleanup.service	masked
sendsigs.service	masked
serial-getty@.service	disabled
single.service	masked
smartd.service	masked
smartmontools.service	disabled
smond.service	enabled
snmpd.service	disabled
snmpd@.service	disabled
snmptrapd.service	disabled
snmptrapd@.service	disabled
ssh.service	enabled
ssh@.service	disabled
sshd.service	enabled
stop-bootlogd-single.service	masked
stop-bootlogd.service	masked
stopssh.service	enabled
sudo.service	disabled
switchd-diag.service	static
switchd.service	enabled
syslog.service	enabled
sysmonitor.service	enabled
systemd-ask-password-console.service	static
systemd-ask-password-wall.service	static
systemd-backlight@.service	static
systemd-binfmt.service	static
systemd-fsck-root.service	static
systemd-fsck@.service	static
systemd-halt.service	static
systemd-hibernate.service	static
systemd-hostnamed.service	static
systemd-hybrid-sleep.service	static
systemd-initctl.service	static
systemd-journal-flush.service	static
systemd-journald.service	static
systemd-kexec.service	static
systemd-locale.service	static
systemd-logind.service	static
systemd-machined.service	static
systemd-modules-load.service	static
systemd-networkd-wait-online.service	disabled
systemd-networkd.service	disabled
systemd-nspawn@.service	disabled
systemd-poweroff.service	static
systemd-quotacheck.service	static
systemd-random-seed.service	static

systemd-readahead-collect.service	disabled
systemd-readahead-done.service	static
systemd-readahead-drop.service	disabled
systemd-readahead-replay.service	disabled
systemd-reboot.service	static
systemd-remount-fs.service	static
systemd-resolved.service	disabled
systemd-rfkill@.service	static
systemd-setup-dgram-qlen.service	static
systemd-shutdownd.service	static
systemd-suspend.service	static
systemd-sysctl.service	static
systemd-timedated.service	static
systemd-timesyncd.service	disabled
systemd-tmpfiles-clean.service	static
systemd-tmpfiles-setup-dev.service	static
systemd-tmpfiles-setup.service	static
systemd-udev-settle.service	static
systemd-udev-trigger.service	static
systemd-udevd.service	static
systemd-update-utmp-runlevel.service	static
systemd-update-utmp.service	static
systemd-user-sessions.service	static
udev-finish.service	static
udev.service	static
umountfs.service	masked
umountnfs.service	masked
umountroot.service	masked
update-ports.service	enabled
urandom.service	static
user@.service	static
uuidd.service	static
vboxadd-service.service	enabled
vboxadd-x11.service	enabled
vboxadd.service	enabled
vxrd.service	disabled
vxsnd.service	disabled
wd_keepalive.service	enabled
x11-common.service	masked
ztp.service	disabled
210 unit files listed.	
lines 165-213/213 (END)	

## Identify Essential Services

If you need to know which services are required to run when the switch boots, run:

```
cumulus@switch:~$ systemctl list-dependencies --before basic.target
```



To see which services are needed for networking, run:

```
cumulus@switch:~$ systemctl list-dependencies --after network.  
target  
  
switchd.service  
wd_keepalive.service  
network-pre.target
```

To identify the services needed for a multi-user environment, run:

```
cumulus@switch:~$ systemctl list-dependencies --before multi-user.  
target  
  
bootlog.service  
systemd-readahead-done.service  
systemd-readahead-done.timer  
systemd-update-utmp-runlevel.service  
graphical.target  
systemd-update-utmp-runlevel.service
```

## Important Services

The following table lists the most important services in Cumulus Linux.

Service Name	Description	Affects Forwarding?
switchd	Hardware abstraction daemon, synchronizes the kernel with the ASIC.	YES
sx_sdk	Only on Mellanox switches, interfaces with the Spectrum ASIC.	YES
portwd	Reads pluggable information over the I2C bus. Identifies and classifies the optics that are inserted into the system. Sets interface speeds and capabilities to match the optics.	YES, eventually, if optics are added /removed
frr	FRRouting (see page 731), handles routing protocols. There are separate processes for each routing protocol, like bgpd and ospfd.	YES if routing
clag	Cumulus link aggregation daemon, handles MLAG (see page 440).	YES if using MLAG
neighmgrd	Synchronizes MAC address information when MLAG is in use.	



Service Name	Description	Affects Forwarding?
		YES if using MLAG
mstpd	Spanning tree protocol (see page 372) daemon.	YES if using layer 2
ptmd	Prescriptive Topology Manager (see page 360), verifies cabling based on LLDP (see page 390) output, also sets up BFD (see page 821) sessions.	YES if using BFD
netd	NCLU (see page 88) back end.	NO
rsyslog	Handles logging of syslog messages.	NO
ntp	Network time protocol (see page 99).	NO
ledmgrd	LED manager (see page 950), reads the state of system LEDs.	NO
sysmonitor	Watches and logs critical system load (free memory, disk, CPU).	NO
lldpd	Handles Tx/Rx of LLDP (see page 390) information.	NO
smond	Reads platform sensors and fan information (see page 944) from pwmd.	NO
pwmd	Reads and sets fan speeds.	NO

## Configuring switchd

`switchd` is the daemon at the heart of Cumulus Linux. It communicates between the switch and Cumulus Linux, and all the applications running on Cumulus Linux.

The `switchd` configuration is stored in `/etc/cumulus/switchd.conf`.

### Contents

#### This topic describes ...

- The `switchd` File System (see page 205)
- Configure `switchd` Parameters (see page 206)
- Restart `switchd` (see page 207)



## The switchd File System

switchd also exports a file system, mounted on `/cumulus/switchd`, that presents all the switchd configuration options as a series of files arranged in a tree structure. You can see the contents by parsing the switchd tree; run `tree /cumulus/switchd`. The output below is for a switch with one switch port configured:

```
cumulus@switch:~$ sudo tree /cumulus/switchd/
/cumulus/switchd/
|-- config
|   |-- acl
|   |   |-- non_atomic_update_mode
|   |   `-- optimize_hw
|   |-- arp
|   |   `-- next_hops
|   |-- buf_util
|   |   |-- measure_interval
|   |   `-- poll_interval
|   |-- coalesce
|   |   |-- reducer
|   |   `-- timeout
|   |-- disable_internal_restart
|   |-- ignore_non_swps
|   |-- interface
|   |   |-- swp1
|   |   |   |-- storm_control
|   |   |   |   |-- broadcast
|   |   |   |   |-- multicast
|   |   |   |   `-- unknown_unicast
|   |   |-- logging
|   |   |-- route
|   |   |   |-- host_max_percent
|   |   |   `-- table
|   |   |-- stats
|   |   |   `-- poll_interval
|   |-- ctrl
|   |   |-- acl
|   |   |-- hal
|   |   |   `-- resync
|   |   |-- logger
|   |   |-- netlink
|   |   |   `-- resync
|   |   |-- resync
|   |   `-- sample
|       `-- ulog_channel
|-- run
`-- route_info
    |-- ecmp_nh
        |-- count
```

```

    |   |   '-- max
    |   '-- max_per_route
    '-- host
        |   '-- count
        |   '-- count_v4
        |   '-- count_v6
        '-- max
    '-- mac
        |   '-- count
        '-- max
    '-- route
        |   '-- count_0
        |   '-- count_1
        |   '-- count_total
        |   '-- count_v4
        |   '-- count_v6
        '-- mask_limit
        '-- max_0
        '-- max_1
        '-- max_total
-- version

```

## Configure switchd Parameters

You can use `cl-cfg` to configure many `switchd` parameters at runtime (like ACLs, interfaces, and route table utilization), which minimizes disruption to your running switch. However, some options are read only and cannot be configured at runtime.

For example, to see data related to routes, run:

```
cumulus@switch:~$ sudo cl-cfg -a switchd | grep route
route.table = 254
route.host_max_percent = 50
cumulus@cumulus:~$
```

To modify the configuration, run `cl-cfg -w`. For example, to set the buffer utilization measurement interval to 1 minute, run:

```
cumulus@switch:~$ sudo cl-cfg -w switchd buf_util.measure_interval=1
```

To verify that the value changed, use `grep`:

```
cumulus@switch:~$ cl-cfg -a switchd | grep buf
buf_util.poll_interval = 0
buf_util.measure_interval = 1
```



You can get some of this information by running `cl-resource-query`; though you cannot update the `switchd` configuration with it.

## Restart `switchd`

Whenever you modify any `switchd` hardware configuration file (typically changing any `*.conf` file that requires making a change to the switching hardware, like `/etc/cumulus/datapath/traffic.conf`), you must restart `switchd` for the change to take effect:

```
cumulus@switch:~$ sudo systemctl restart switchd.service
```



You do not have to restart the `switchd` service when you update a network interface configuration (that is, edit `/etc/network/interfaces`).



Restarting `switchd` causes all network ports to reset in addition to resetting the switch hardware configuration.

## Power over Ethernet - PoE

Cumulus Linux supports Power over Ethernet (PoE) and PoE+, so certain Cumulus Linux switches can supply power from Ethernet switch ports to enabled devices over the Ethernet cables that connect them. Power over Ethernet (PoE) is capable of powering devices up to 15W, while PoE+ can power devices up to 30W.

The [currently supported platform](#) is the Edge-Core AS4610-54P, which supports PoE and PoE+ and configuration over Ethernet layer 2 LLDP for power negotiation.

## Contents

### This topic describes ...

- PoE Basics (see page 208)
- Configure PoE (see page 208)
- Troubleshooting (see page 213)
  - Verify the Link Is Up (see page 213)
  - View LLDP Information Using `lldpcli` (see page 213)
  - View LLDP Information Using `tcpdump` (see page 214)
  - Log poed Events in `syslog` (see page 215)

## PoE Basics

PoE functionality is provided by the `cumulus-poe` package. When a powered device is connected to the switch via an Ethernet cable:

- If the available power is greater than the power required by the connected device, power is supplied to the switch port, and the device powers on
- If available power is less than the power required by the connected device and the switch port's priority is less than the port priority set on all powered ports, power is **not** supplied to the port
- If available power is less than the power required by the connected device and the switch port's priority is greater than the priority of a currently powered port, power is removed from lower priority port(s) and power is supplied to the port
- If the total consumed power exceeds the configured power limit of the power source, low priority ports are turned off. In the case of a tie, the port with the lower port number gets priority

Power is available as follows:

<b>PSU 1</b>	<b>PSU 2</b>	<b>PoE Power Budget</b>
920W	x	750W
x	920W	750W
920W	920W	1650W

The AS4610-54P has an LED on the front panel to indicate PoE status:

- Green: The `poed` daemon is running and no errors are detected
- Yellow: One or more errors are detected or the `poed` daemon is not running



Link state and PoE state are completely independent of each other. When a link is brought down on a particular port using `ip link <port> down`, power on that port is not turned off; however, LLDP negotiation is not possible.

## Configure PoE

You use the `poectl` command utility to configure PoE on a [switch that supports](#) the feature. You can:

- Enable or disable PoE for a given switch port
- Set a switch port's PoE priority to one of three values: *low*, *high* or *critical*

The PoE configuration resides in `/etc/cumulus/poe.conf`. The file lists all the switch ports, whether PoE is enabled for those ports and the priority for each port.

### Sample `poe.conf` file ...

```
[enable]
swp1 = enable
```

```
swp2 = enable
swp3 = enable
swp4 = enable
swp5 = enable
swp6 = enable
swp7 = enable
swp8 = enable
swp9 = enable
swp10 = enable
swp11 = enable
swp12 = enable
swp13 = enable
swp14 = enable
swp15 = enable
swp16 = enable
swp17 = enable
swp18 = enable
swp19 = enable
swp20 = enable
swp21 = enable
swp22 = enable
swp23 = enable
swp24 = enable
swp25 = enable
swp26 = enable
swp27 = enable
swp28 = enable
swp29 = enable
swp30 = enable
swp31 = enable
swp32 = enable
swp33 = enable
swp34 = enable
swp35 = enable
swp36 = enable
swp37 = enable
swp38 = enable
swp39 = enable
swp40 = enable
swp41 = enable
swp42 = enable
swp43 = enable
swp44 = enable
swp45 = enable
swp46 = enable
swp47 = enable
swp48 = enable
[priority]
swp1 = low
swp2 = low
swp3 = low
swp4 = low
```



```
swp5 = low
swp6 = low
swp7 = low
swp8 = low
swp9 = low
swp10 = low
swp11 = low
swp12 = low
swp13 = low
swp14 = low
swp15 = low
swp16 = low
swp17 = low
swp18 = low
swp19 = low
swp20 = low
swp21 = low
swp22 = low
swp23 = low
swp24 = low
swp25 = low
swp26 = low
swp27 = low
swp28 = low
swp29 = low
swp30 = low
swp31 = low
swp32 = low
swp33 = low
swp34 = low
swp35 = low
swp36 = low
swp37 = low
swp38 = low
swp39 = low
swp40 = low
swp41 = low
swp42 = low
swp43 = low
swp44 = low
swp45 = low
swp46 = low
swp47 = low
swp48 = low
```

By default, PoE and PoE+ are enabled on all Ethernet/1G switch ports, and these ports are set with a low priority. Switch ports can have low, high or critical priority.

There is no additional configuration for PoE+.

To change the priority for one or more switch ports, run `poectl -p swp# [low|high|critical]`. For example:



```
cumulus@switch:~$ sudo poectl -p swp1-swp5,swp7 high
```

To disable PoE for one or more ports, run `poectl -d [port_numbers]`:

```
cumulus@switch:~$ sudo poectl -d swp1-swp5,swp7
```

To display PoE information for a set of switch ports, run `poectl -i [port_numbers]`:

```
cumulus@switch:~$ sudo poectl -i swp10-swp13
Port          Status           Allocated    Priority   PD type
PD class     Voltage   Current      Power
-----  -----  -----  -----
-----  -----  -----  -----
swp10  connected      negotiating  low        IEEE802.3at
4       53.5 V      25 mA      3.9 W
swp11  searching      n/a        low        IEEE802.3at
none   0.0 V       0 mA      0.0 W
swp12  connected      n/a        low        IEEE802.3at
2       53.5 V      25 mA      1.4 W
swp13  connected      51.0 W     low        IEEE802.3at
4       53.6 V      72 mA      3.8 W
```

The **Status** can be one of the following:

- **searching:** PoE is enabled but no device has been detected.
- **disabled:** The PoE port has been configured as disabled.
- **connected:** A powered device is connected and receiving power.
- **power-denied:** There is insufficient PoE power available to enable the connected device.

The **Allocated** column displays how much PoE power has been allocated to the port, which can be one of the following:

- **n/a:** No device is connected or the connected device does not support LLDP negotiation.
- **negotiating:** An LLDP-capable device is connected and is negotiating for PoE power.
- **XX.X W:** An LLDP-capable device has negotiated for XX.X watts of power (for example, 51.0 watts for swp13 above).

To see all the PoE information for a switch, run `poectl -s`:

```
cumulus@switch:~$ poectl -s
System power:
  Total:      730.0 W
  Used:       11.0 W
  Available:  719.0 W
Connected ports:
  swp11, swp24, swp27, swp48
```

The set commands (priority, enable, disable) either succeed silently or display an error message if the command fails.

The `poectl` command takes the following arguments:

<b>Argument</b>	<b>Description</b>
<code>-h, --help</code>	Show this help message and exit
<code>-i, --port-info</code> <code>PORT_LIST</code>	Returns detailed information for the specified ports. You can specify a range of ports. For example: <code>-i swp1-swp5,swp10</code> <div style="border: 2px solid #f0a; padding: 10px; margin-top: 10px;"> <span style="color: yellow;"><b>⚠</b></span> On an Edge-Core AS4610-54P switch, the voltage reported by the <code>poectl -i</code> command and measured through a power meter connected to the device varies by 5V. The current and power readings are correct and no difference is seen for them.       </div>
<code>-a, --all</code>	Returns PoE status and detailed information for all ports.
<code>-p, --priority</code> <code>PORT_LIST</code> <code>PRIORITY</code>	Sets priority for the specified ports: low, high, critical.
<code>-d, --disable-ports</code> <code>PORT_LIST</code>	Disables PoE operation on the specified ports.
<code>-e, --enable-ports</code> <code>PORT_LIST</code>	Enables PoE operation on the specified ports.
<code>-s, --system</code>	Returns PoE status for the entire switch.
<code>-r, --reset</code> <code>PORT_LIST</code>	Performs a hardware reset on the specified ports. Use this if one or more ports are stuck in an error state. This does not reset any configuration settings for the specified ports.
<code>-v, --version</code>	Displays version information.
<code>-j, --json</code>	Displays output in JSON format.
<code>--save</code>	Saves the current configuration. The saved configuration is automatically loaded on system boot.



Argument	Description
--load	Loads and applies the saved configuration.

## Troubleshooting

You can troubleshoot PoE and PoE+ using the following utilities and files:

- `poectl -s`, as described above.
- The Cumulus Linux `cl-support` script, which includes PoE-related output from `poed.conf`, `syslog`, `poectl --diag-info` and `lldpctl`.
- `lldpcli show neighbors ports <swp> protocol lldp hidden details`
- `tcpdump -v -v -i <swp> ether proto 0x88cc`
- The contents of the PoE/PoE+ `/etc/lldpd.d/poed.conf` configuration file, as described above.

### Verify the Link Is Up

LLDP requires network connectivity, so verify that the link is up.

```
cumulus@switch:~$ net show interface swp20
      Name      MAC              Speed      MTU      Mode
      --  -----  -----  -----  -----
UP    swp20   44:38:39:00:00:04  1G        1500  Access/L2
```

### View LLDP Information Using `lldpcli`

You can run `lldpcli` to view the LLDP information that has been received on a switch port. For example:

```
cumulus@switch:~$ sudo lldpcli show neighbors ports swp20 protocol
lldp hidden details
-----
-----
LLDP neighbors:
-----
-----
Interface:      swp20, via: LLDP, RID: 2, Time: 0 day, 00:03:34
  Chassis:
    ChassisID:      mac 68:c9:0b:25:54:7c
    SysName:        ihm-ubuntu
    SysDescr:       Ubuntu 14.04.2 LTS Linux 3.14.4+ #1 SMP Thu Jun 26
00:54:44 UTC 2014 armv7l
    MgmtIP:         fe80::6ac9:bff:fe25:547c
    Capability:    Bridge, off
    Capability:    Router, off
    Capability:    Wlan, off
```



```
Capability: Station, on
Port:
  PortID:          mac 68:c9:0b:25:54:7c
  PortDescr:       eth0
  PMD autoneg:    supported: yes, enabled: yes
    Adv:           10Base-T, HD: yes, FD: yes
    Adv:           100Base-TX, HD: yes, FD: yes
  MAU oper type:  100BasetXFD - 2 pair category 5 UTP, full duplex
mode
  MDI Power:      supported: yes, enabled: yes, pair control: no
  Device type:    PD
  Power pairs:   spare
  Class:          class 4
  Power type:    2
  Power Source:  Primary power source
  Power Priority: low
  PD requested power Value: 51000
  PSE allocated power Value: 51000
UnknownTLVs:
  TLV:            OUI: 00,01,42, SubType: 1, Len: 1 05
  TLV:            OUI: 00,01,42, SubType: 1, Len: 1 0D
-----
```

## *View LLDP Information Using tcpdump*

You can use `tcpdump` to view the LLDP frames being transmitted and received. For example:

```
cumulus@switch:~$ sudo tcpdump -v -v -i swp20 ether proto 0x88cc
tcpdump: listening on swp20, link-type EN10MB (Ethernet), capture
size 262144 bytes
18:41:47.559022 LLDP, length 211
  Chassis ID TLV (1), length 7
    Subtype MAC address (4): 00:30:ab:f2:d7:a5 (oui Unknown)
    0x0000: 0400 30ab f2d7 a5
  Port ID TLV (2), length 6
    Subtype Interface Name (5): swp20
    0x0000: 0573 7770 3230
  Time to Live TLV (3), length 2: TTL 120s
    0x0000: 0078
  System Name TLV (5), length 13: dni-3048up-09
    0x0000: 646e 692d 3330 3438 7570 2d30 39
  System Description TLV (6), length 68
    Cumulus Linux version 3.0.1~1466303042.2265c10 running on dni
3048up
    0x0000: 4375 6d75 6c75 7320 4c69 6e75 7820 7665
    0x0010: 7273 696f 6e20 332e 302e 317e 3134 3636
    0x0020: 3330 3330 3432 2e32 3236 3563 3130 2072
    0x0030: 756e 6e69 6e67 206f 6e20 646e 6920 3330
```



```
0x0040: 3438 7570
System Capabilities TLV (7), length 4
    System Capabilities [Bridge, Router] (0x0014)
    Enabled Capabilities [Router] (0x0010)
    0x0000: 0014 0010
Management Address TLV (8), length 12
    Management Address length 5, AFI IPv4 (1): 10.0.3.190
    Interface Index Interface Numbering (2): 2
    0x0000: 0501 0a00 03be 0200 0000 0200
Management Address TLV (8), length 24
    Management Address length 17, AFI IPv6 (2): fe80::230:abff:fef2:
d7a5
    Interface Index Interface Numbering (2): 2
    0x0000: 1102 fe80 0000 0000 0000 0230 abff fef2
    0x0010: d7a5 0200 0000 0200
Port Description TLV (4), length 5: swp20
    0x0000: 7377 7032 30
Organization specific TLV (127), length 9: OUI IEEE 802.3 Private
(0x00120f)
    Link aggregation Subtype (3)
        aggregation status [supported], aggregation port ID 0
        0x0000: 0012 0f03 0100 0000 00
    Organization specific TLV (127), length 9: OUI IEEE 802.3 Private
(0x00120f)
        MAC/PHY configuration/status Subtype (1)
            autonegotiation [supported, enabled] (0x03)
            PMD autoneg capability [10BASE-T fdx, 100BASE-TX fdx,
1000BASE-T fdx] (0x2401)
            MAU type 100BASEFX fdx (0x0012)
            0x0000: 0012 0f01 0324 0100 12
    Organization specific TLV (127), length 12: OUI IEEE 802.3
Private (0x00120f)
        Power via MDI Subtype (2)
            MDI power support [PSE, supported, enabled], power pair
spare, power class class4
            0x0000: 0012 0f02 0702 0513 01fe 01fe
    Organization specific TLV (127), length 5: OUI Unknown (0x000142)
        0x0000: 0001 4201 0d
    Organization specific TLV (127), length 5: OUI Unknown (0x000142)
        0x0000: 0001 4201 01
End TLV (0), length 0
```

## *Log poed Events in syslog*

The poed service logs the following events to `syslog` when:

- A switch provides power to a powered device.
- A device that was receiving power is removed.
- The power available to the switch changes.
- Errors are detected.



## Configuring a Global Proxy

You configure [global HTTP and HTTPS proxies](#) in the `/etc/profile.d/` directory of Cumulus Linux. To do so, set the `http_proxy` and `https_proxy` variables, which tells the switch the address of the proxy server to use to fetch URLs on the command line. This is useful for programs such as `apt/apt-get`, `curl` and `wget`, which can all use this proxy.

1. In a terminal, create a new file in the `/etc/profile.d/` directory. In the code example below, the file is called `proxy.sh`, and is created using the text editor `nano`.

```
cumulus@switch:~$ sudo nano /etc/profile.d/proxy.sh
```

2. Add a line to the file to configure either an HTTP or an HTTPS proxy, or both:

- HTTP proxy:

```
http_proxy=http://myproxy.domain.com:8080
export http_proxy
```

- HTTPS proxy:

```
https_proxy=https://myproxy.domain.com:8080
export https_proxy
```

3. Create a file in the `/etc/apt/apt.conf.d` directory and add the following lines to the file for acquiring the HTTP and HTTPS proxies; the example below uses `http_proxy` as the file name:

```
cumulus@switch:~$ sudo nano /etc/apt/apt.conf.d/http_proxy
Acquire::http::Proxy "http://myproxy.domain.com:8080";
Acquire::https::Proxy "https://myproxy.domain.com:8080";
```

4. Add the proxy addresses to `/etc/wgetrc`; you may have to uncomment the `http_proxy` and `https_proxy` lines:

```
cumulus@switch:~$ sudo nano /etc/wgetrc
...
https_proxy = https://myproxy.domain.com:8080
http_proxy = http://myproxy.domain.com:8080
...
```

5. Run the `source` command, to execute the file in the current environment:



```
cumulus@switch:~$ source /etc/profile.d/proxy.sh
```

The proxy is now configured. The echo command can be used to confirm a proxy is set up correctly:

- HTTP proxy:

```
cumulus@switch:~$ echo $http_proxy  
http://myproxy.domain.com:8080
```

- HTTPS proxy:

```
cumulus@switch:~$ echo $https_proxy  
https://myproxy.domain.com:8080
```

## Related Information

- Setting up an apt package cache

## HTTP API

Cumulus Linux implements an HTTP application programming interface to [OpenStack ML2 driver \(see page 1125\)](#) and [NCLU \(see page 88\)](#). Rather than accessing Cumulus Linux using SSH, you can interact with the switch using an HTTP client, such as cURL, HTTPie or a web browser.



The HTTP API service is enabled by default on chassis hardware only. However, the associated server is configured to only listen to traffic originating from within the chassis.

The service is not enabled by default on non-chassis hardware.

## Contents

### This topic describes ...

- [HTTP API Basics \(see page 217\)](#)
- [Configuration \(see page 218\)](#)
  - [Enable External Traffic on a Chassis \(see page 218\)](#)
  - [IP and Port Settings \(see page 219\)](#)
- [Security \(see page 219\)](#)
  - [Authentication \(see page 219\)](#)
  - [Transport Layer Security \(see page 219\)](#)
- [cURL Examples \(see page 220\)](#)



## HTTP API Basics



If you are upgrading from a version of Cumulus Linux earlier than 3.4.0, the supporting software for the API may not be installed. Install the required software with the following command.

```
cumulus@switch:~$ sudo apt-get install python-cumulus-restapi
```

Then restart the `nginx` service to apply the API configuration.

```
cumulus@switch:~$ sudo systemctl restart nginx
```

To enable the HTTP API service, run the following `systemd` command:

```
cumulus@switch:~$ sudo systemctl enable restserver
```

Use the `systemctl start` and `systemctl stop` commands to start/stop the HTTP API service:

```
cumulus@switch:~$ sudo systemctl start restserver
cumulus@switch:~$ sudo systemctl stop restserver
```



Each service runs as a background daemon once started.

## Configuration

There are two configuration files associated with the HTTP API services:

- `/etc/nginx/sites-available/nginx-restapi.conf`
- `/etc/nginx/sites-available/nginx-restapi-chassis.conf`

The first configuration file is used for non-chassis hardware; the second, for chassis hardware.

Generally, only the configuration file relevant to your hardware needs to be edited, as the associated services determine the appropriate configuration file to use at run time.

## Enable External Traffic on a Chassis

The HTTP API services are configured to listen on port 8080 for chassis hardware by default. However, only HTTP traffic originating from internal link local management IPv6s will be allowed. To configure the services to also accept HTTP requests originating from external sources:

1. Open `/etc/nginx/sites-available/nginx-restapi-chassis.conf` in a text editor.
2. Uncomment the `server` block lines near the end of the file.



3. Change the port on the now uncommented `listen` line if the default value, 8080, is not the preferred port, and save the configuration file.
4. Verify the configuration file is still valid:

```
cumulus@switch:~$ sudo nginx -c /etc/nginx/sites-available/nginx-restapi-chassis.conf -t
```

If the configuration file is not valid, return to step 1; review any changes that were made, and correct the errors.

5. Restart the daemons:

```
cumulus@switch:~$ sudo systemctl restart restserver
```

## *IP and Port Settings*

The IP:port combinations that services listen to can be modified by changing the parameters of the `listen` directive(s). By default, `nginx-restapi.conf` has only one `listen` parameter, whereas `/etc/nginx/sites-available/nginx-restapi-chassis.conf` has two independently configurable `server` blocks, each with a `listen` directive. One server block is for external traffic, and the other for internal traffic.



All URLs must use HTTPS, rather than HTTP.

For more information on the `listen` directive, refer to the [NGINX documentation](#).



Do not set the same listening port for internal and external chassis traffic.

## *Security*

### *Authentication*

The default configuration requires all HTTP requests from external sources (not internal switch traffic) to set the HTTP Basic Authentication header.

The user and password should correspond to a user on the host switch.

### *Transport Layer Security*

All traffic must be secured in transport using TLSv1.2 by default. Cumulus Linux contains a self-signed certificate and private key used server-side in this application so that it works out of the box, but Cumulus Networks recommends you use your own certificates and keys. Certificates must be in the PEM format.

For step by step documentation for generating self-signed certificates and keys, and installing them to the switch, refer to the [Ubuntu Certificates and Security documentation](#).



**!** Do not copy the `cumulus.pem` or `cumulus.key` files. After installation, edit the "ssl\_certificate" and "ssl\_certificate\_key" values in the configuration file for your hardware.

## *curl Examples*

This section contains several example cURL commands for sending HTTP requests to a non-chassis host. The following settings are used for these examples:

- Username: `user`
- Password: `pw`
- IP: `192.168.0.32`
- Port: `8080`

**!** Requests for NCLU require setting the Content-Type request header to be set to `application/json`.

**i** cURL's `-k` flag is necessary when the server uses a self-signed certificate. This is the default configuration (see the [Security section \(see page 219\)](#)). To display the response headers, include `-D` flag in the command.

To retrieve a list of all available HTTP endpoints:

```
cumulus@switch:~$ curl -X GET -k -u user:pw https://192.168.0.32:8080
```

To run `net show counters` on the host as a remote procedure call:

```
cumulus@switch:~$ curl -X POST -k -u user:pw -H "Content-Type: application/json" -d '{"cmd": "show counters"}' https://192.168.0.32:8080/nclu/v1/rpc
```

To add a bridge using ML2:

```
cumulus@switch:~$ curl -X PUT -k -u user:pw https://192.168.0.32:8080/ml2/v1/bridge/"br1"/200
```



# Layer 1 and Switch Ports

## Interface Configuration and Management

`ifupdown` is the network interface manager for Cumulus Linux. Cumulus Linux uses an updated version of this tool, `ifupdown2`.

For more information on network interfaces, see [Switch Port Attributes \(see page 239\)](#).



By default, `ifupdown` is quiet; use the verbose option `-v` when you want to know what is going on when bringing an interface down or up.

## Contents

### This topic describes ...

- Basic Commands (see page 221)
- `ifupdown2` Interface Classes (see page 222)
- Configure a Loopback Interface (see page 224)
- `ifupdown` Behavior with Child Interfaces (see page 224)
- `ifupdown2` Interface Dependencies (see page 225)
- Subinterfaces (see page 228)
- `ifup` and `Upper` (Parent) Interfaces (see page 228)
- Configure IP Addresses (see page 229)
  - Specify IP Address Scope (see page 230)
  - Purge Existing IP Addresses on an Interface (see page 232)
- Specify User Commands (see page 232)
- Source Interface File Snippets (see page 233)
- Use Globs for Port Lists (see page 234)
- Use Templates (see page 235)
- Run `ifupdown` Scripts under `/etc/network/` with `ifupdown2` (see page 236)
- Add Descriptions to Interfaces (see page 236)
- Caveats and Errata (see page 237)
  - `ifupdown2` and `sysctl` (see page 238)
  - Long Interface Names (see page 238)
- Related Information (see page 238)

## Basic Commands

To bring up an interface or apply changes to an existing interface, run:



```
cumulus@switch:~$ sudo ifup <ifname>
```

To bring down a single interface, run:

```
cumulus@switch:~$ sudo ifdown <ifname>
```



`ifdown` always deletes logical interfaces after bringing them down. Use the `--admin-state` option if you only want to administratively bring the interface up or down.

To see the link and administrative state, use the `ip link show` command:

```
cumulus@switch:~$ ip link show dev swp1
3: swp1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast
state UP mode DEFAULT qlen 500
    link/ether 44:38:39:00:03:c1 brd ff:ff:ff:ff:ff:ff
```

In this example, `swp1` is administratively UP and the physical link is UP (`LOWER_UP` flag). More information on interface administrative state and physical state can be found in [this knowledge base article](#).

To put an interface into an admin down state. The interface remains down after any future reboots or applying configuration changes with `ifreload -a`. For example:

```
cumulus@switch:~$ net add interface swp1 link down
```

These commands create the following configuration in the `/etc/network/interfaces` file:

```
auto swp1
iface swp1
    link-down yes
```

## ifupdown2 Interface Classes

`ifupdown2` provides for the grouping of interfaces into separate classes, where a class is a user-defined label that groups interfaces sharing a common function (like uplink, downlink or compute). You specify classes in the `/etc/network/interfaces` file.

The most common class is `auto`, which you configure like this:

```
auto swp1
iface swp1
```

You can add other classes using the *allow* prefix. For example, if you have multiple interfaces used for uplinks, you can make up a class called *uplinks*:

```
auto swp1
allow-uplink swp1
iface swp1 inet static
    address 10.1.1.1/31

auto swp2
allow-uplink swp2
iface swp2 inet static
    address 10.1.1.3/31
```

This allows you to perform operations on only these interfaces using the `--allow=uplinks` option, or still use the `-a` options since these interfaces are also in the `auto` class:

```
cumulus@switch:~$ sudo ifup --allow=uplinks
cumulus@switch:~$ sudo ifreload -a
```

If you are using [Management VRF \(see page 877\)](#), you can use the special interface class called *mgmt*, and put the management interface into that class.

 The *mgmt* interface class is not supported if you are configuring Cumulus Linux using [NCLU \(see page 88\)](#).

```
allow-mgmt eth0
iface eth0 inet dhcp
    vrf mgmt

allow-mgmt mgmt
iface mgmt
    address 127.0.0.1/8
    vrf-table auto
```

All `ifupdown2` commands (`ifup`, `ifdown`, `ifquery`, `ifreload`) can take a class. Include the `--allow=<class>` option when you run the command. For example, to reload the configuration for the management interface described above, run:

```
cumulus@switch:~$ sudo ifreload --allow=mgmt
```

You can easily bring up or down all interfaces marked with the common `auto` class in `/etc/network/interfaces`. Use the `-a` option. For further details, see individual man pages for `ifup(8)`, `ifdown(8)`, `ifreload(8)`.

To administratively bring up all interfaces marked auto, run:

```
cumulus@switch:~$ sudo ifup -a
```

To administratively bring down all interfaces marked auto, run:

```
cumulus@switch:~$ sudo ifdown -a
```

To reload all network interfaces marked auto, use the `ifreload` command, which is equivalent to running `ifdown` then `ifup`, the one difference being that `ifreload` skips any configurations that didn't change):

```
cumulus@switch:~$ sudo ifreload -a
```

- ✓ Some syntax checks are done by default, however it may be safer to apply the configs only if the syntax check passes, using the following compound command:

```
cumulus@switch:~$ sudo bash -c "ifreload -s -a && ifreload -a"
```

## Configure a Loopback Interface

Cumulus Linux has a loopback preconfigured in `/etc/network/interfaces`. When the switch boots up, it has a loopback interface, called `lo`, which is up and assigned an IP address of 127.0.0.1.

- ✓ The loopback interface `lo` must always be specified in `/etc/network/interfaces` and must always be up.

## ifupdown Behavior with Child Interfaces

By default, `ifupdown` recognizes and uses any interface present on the system — whether a VLAN, bond or physical interface — that is listed as a dependent of an interface. You are not required to list them in the `interfaces` file unless they need a specific configuration, for [MTU, link speed, and so forth](#) (see page 239). And if you need to delete a child interface, you should delete all references to that interface from the `interfaces` file.

For this example, `swp1` and `swp2` below do not need an entry in the `interfaces` file. The following stanzas defined in `/etc/network/interfaces` provide the exact same configuration:

With Child Interfaces Defined	Without Child Interfaces Defined
<code>With Child Interfaces Defined</code>	<code>Without Child Interfaces Defined</code>



```
auto swp1
iface swp1

auto swp2
iface swp2

auto bridge
iface bridge
    bridge-vlan-aware yes
    bridge-ports swp1
swp2
    bridge-vids 1-100
    bridge-pvid 1
    bridge-stp on
```

```
auto bridge
iface bridge
    bridge-vlan-aware yes
    bridge-ports swp1
swp2
    bridge-vids 1-100
    bridge-pvid 1
    bridge-stp on
```

### Bridge in Traditional Mode - Example

For this example, swp1.100 and swp2.100 below do not need an entry in the `interfaces` file. The following stanzas defined in `/etc/network/interfaces` provide the exact same configuration:

#### With Child Interfaces Defined

```
auto swp1.100
iface swp1.100
auto swp2.100
iface swp2.100
auto br-100
iface br-100
    address 10.0.12.2/24
    address 2001:dad:beef::3/64
    bridge-ports swp1.100 swp2.
100
    bridge-stp on
```

#### Without Child Interfaces Defined

```
auto br-100
iface br-100
    address 10.0.12.2/24
    address 2001:dad:beef::3/64
    bridge-ports swp1.100 swp2.
100
    bridge-stp on
```

For more information on the bridge in traditional mode vs the bridge in VLAN-aware mode, please read [this knowledge base article](#).

## ifupdown2 Interface Dependencies

`ifupdown2` understands interface dependency relationships. When `ifup` and `ifdown` are run with all interfaces, they always run with all interfaces in dependency order. When run with the interface list on the command line, the default behavior is to not run with dependents. But if there are any built-in dependents, they will be brought up or down.

To run with dependents when you specify the interface list, use the `--with-dependents` option. `--with-dependents` walks through all dependents in the dependency tree rooted at the interface you specify. Consider the following example configuration:

```

auto bond1
iface bond1
    address 100.0.0.2/16
    bond-slaves swp29 swp30

auto bond2
iface bond2
    address 100.0.0.5/16
    bond-slaves swp31 swp32

auto br2001
iface br2001
    address 12.0.1.3/24
    bridge-ports bond1.2001 bond2.2001
    bridge-stp on

```

Using `ifup --with-dependents br2001` brings up all dependents of `br2001`: `bond1.2001`, `bond2.2001`, `bond1`, `bond2`, `bond1.2001`, `bond2.2001`, `swp29`, `swp30`, `swp31`, `swp32`.

```
cumulus@switch:~$ sudo ifup --with-dependents br2001
```

Similarly, specifying `ifdown --with-dependents br2001` brings down all dependents of `br2001`: `bond1.2001`, `bond2.2001`, `bond1`, `bond2`, `bond1.2001`, `bond2.2001`, `swp29`, `swp30`, `swp31`, `swp32`.

```
cumulus@switch:~$ sudo ifdown --with-dependents br2001
```

- ! As mentioned earlier, `ifdown2` always deletes logical interfaces after bringing them down. Use the `--admin-state` option if you only want to administratively bring the interface up or down. In terms of the above example, `ifdown br2001` deletes `br2001`.

To guide you through which interfaces will be brought down and up, use the `--print-dependency` option to get the list of dependents.

Use `ifquery --print-dependency=list -a` to get the dependency list of all interfaces:

```
cumulus@switch:~$ sudo ifquery --print-dependency=list -a
lo : None
eth0 : None
bond0 : ['swp25', 'swp26']
bond1 : ['swp29', 'swp30']
bond2 : ['swp31', 'swp32']
br0 : ['bond1', 'bond2']
bond1.2000 : ['bond1']
bond2.2000 : ['bond2']
br2000 : ['bond1.2000', 'bond2.2000']
bond1.2001 : ['bond1']
```

```

bond2.2001 : ['bond2']
br2001 : ['bond1.2001', 'bond2.2001']
swp40 : None
swp25 : None
swp26 : None
swp29 : None
swp30 : None
swp31 : None
swp32 : None
    
```

To print the dependency list of a single interface, use:

```

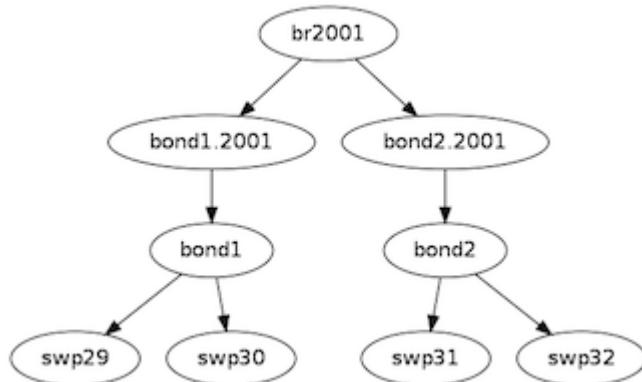
cumulus@switch:~$ sudo ifquery --print-dependency=list br2001
br2001 : ['bond1.2001', 'bond2.2001']
bond1.2001 : ['bond1']
bond2.2001 : ['bond2']
bond1 : ['swp29', 'swp30']
bond2 : ['swp31', 'swp32']
swp29 : None
swp30 : None
swp31 : None
swp32 : None
    
```

To print the dependency information of an interface in dot format:

```

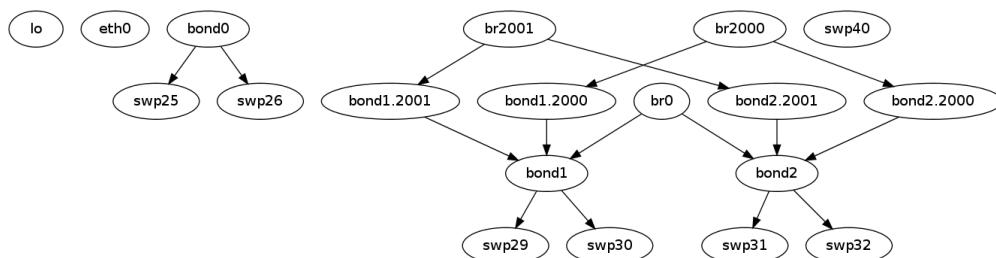
cumulus@switch:~$ sudo ifquery --print-dependency=dot br2001
/* Generated by GvGen v.0.9 (http://software.inl.fr/trac/wiki/GvGen)
 */
digraph G {
    compound=true;
    node1 [label="br2001"];
    node2 [label="bond1.2001"];
    node3 [label="bond2.2001"];
    node4 [label="bond1"];
    node5 [label="bond2"];
    node6 [label="swp29"];
    node7 [label="swp30"];
    node8 [label="swp31"];
    node9 [label="swp32"];
    node1->node2;
    node1->node3;
    node2->node4;
    node3->node5;
    node4->node6;
    node4->node7;
    node5->node8;
    node5->node9;
}
    
```

You can use `dot` to render the graph on an external system where `dot` is installed.



To print the dependency information of the entire `interfaces` file:

```
cumulus@switch:~$ sudo ifquery --print-dependency=dot -a
>interfaces_all.dot
```



## Subinterfaces

On Linux an *interface* is a network device, and can be either a physical device like switch port (such as `swp1`), or virtual, like a VLAN (`vlan100`). A *VLAN subinterface* is a VLAN device on an interface, and the VLAN ID is appended to the parent interface using dot (.) VLAN notation. For example, a VLAN with ID 100 that is a subinterface of `swp1` is named `swp1.100` in Cumulus Linux. The dot VLAN notation for a VLAN device name is a standard way to specify a VLAN device on Linux. Many Linux configuration tools, most notably `ifupdown2` and its predecessor `ifupdown`, recognize such a name as a VLAN interface name.

A VLAN subinterface only receives traffic [tagged \(see page 433\)](#) for that VLAN, so `swp1.100` only receives packets tagged with VLAN 100 on switch port `swp1`. Similarly, any transmits from `swp1.100` result in tagging the packet with VLAN 100.

For an [MLAG \(see page 440\)](#) deployment, the peerlink interface that connects the two switches in the MLAG pair has a VLAN subinterface named 4094 by default, provided you configured the subinterface with [NCLU \(see page 88\)](#). The `peerlink.4094` subinterface only receives traffic tagged for VLAN 4094.

## ifup and Upper (Parent) Interfaces

When you run `ifup` on a logical interface (like a bridge, bond or VLAN interface), if the `ifup` resulted in the creation of the logical interface, by default it implicitly tries to execute on the interface's upper (or parent) interfaces as well. This helps in most cases, especially when a bond is brought down and up, as in the example below. This section describes the behavior of bringing up the upper interfaces.

Consider this example configuration:



```
auto br100
iface br100
    bridge-ports bond1.100 bond2.100

auto bond1
iface bond1
    bond-slaves swp1 swp2
```

If you run `ifdown bond1`, `ifdown` deletes bond1 and the VLAN interface on bond1 (bond1.100); it also removes bond1 from the bridge br100. Next, when you run `ifup bond1`, it creates bond1 and the VLAN interface on bond1 (bond1.100); it also executes `ifup br100` to add the bond VLAN interface (bond1.100) to the bridge br100.

As you can see above, implicitly bringing up the upper interface helps, but there can be cases where an upper interface (like br100) is not in the right state, which can result in warnings. The warnings are mostly harmless.

If you want to disable these warnings, you can disable the implicit upper interface handling by setting `skip_upperinterfaces=1` in `/etc/network/ifupdown2/ifupdown2.conf`.

With `skip_upperinterfaces=1`, you will have to explicitly execute `ifup` on the upper interfaces. In this case, you will have to run `ifup br100` after an `ifup bond1` to add bond1 back to bridge br100.



Although specifying a subinterface like `swp1.100` and then running `ifup swp1.100` will also result in the automatic creation of the `swp1` interface in the kernel, Cumulus Networks recommends you specify the parent interface `swp1` as well. A parent interface is one where any physical layer configuration can reside, such as `link-speed 1000` or `link-duplex full`.

It's important to note that if you only create `swp1.100` and not `swp1`, then you cannot run `ifup swp1` since you did not specify it.

## Configure IP Addresses

IP addresses are configured with the `net add interface` command.



### Example IP Address Configuration

The following commands configure three IP addresses for `swp1`: two IPv4 addresses, and one IPv6 address.

```
cumulus@switch:~$ net add interface swp1 ip address 12.0.0.1/30
cumulus@switch:~$ net add interface swp1 ip address 12.0.0.2/30
cumulus@switch:~$ net add interface swp1 ipv6 address 2001:DB8::1/126
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands create the following code snippet:

```
auto swp1
iface swp1
    address 12.0.0.1/30
    address 12.0.0.2/30
    address 2001:DB8::1/126
```



You can specify both IPv4 and IPv6 addresses for the same interface.

For IPv6 addresses, you can create or modify the IP address for an interface using either ":" or "0:0:0" notation. Both of the following examples are valid:

```
cumulus@switch:~$ net add bgp neighbor 2620:149:43:c109:
0:0:0:5 remote-as internal
cumulus@switch:~$
cumulus@switch:~$ net add interface swp1 ipv6 address
2001:DB8::1/126
```



The address method and address family are added by NCLU when needed, specifically when you are creating DHCP or loopback interfaces.

```
auto lo
iface lo inet loopback
```

To show the assigned address on an interface, use `ip addr show`:

```
cumulus@switch:~$ ip addr show dev swp1
3: swp1: <BROADCAST,MULTICAST,SLAVE,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP qlen 500
    link/ether 44:38:39:00:03:c1 brd ff:ff:ff:ff:ff:ff
    inet 192.0.2.1/30 scope global swp1
        inet 192.0.2.2/30 scope global swp1
        inet6 2001:DB8::1/126 scope global tentative
            valid_lft forever preferred_lft forever
```

## Specify IP Address Scope

`ifupdown2` does not honor the configured IP address scope setting in `/etc/network/interfaces`, treating all addresses as global. It does not report an error. Consider this example configuration:



```
auto swp2
iface swp2
    address 35.21.30.5/30
    address 3101:21:20::31/80
    scope link
```

When you run `ifreload -a` on this configuration, `ifupdown2` considers all IP addresses as global.

```
cumulus@switch:~$ ip addr show swp2
5: swp2: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast
state UP group default qlen 1000
link/ether 74:e6:e2:f5:62:82 brd ff:ff:ff:ff:ff:ff
inet 35.21.30.5/30 scope global swp2
    valid_lft forever preferred_lft forever
    inet6 3101:21:20::31/80 scope global
        valid_lft forever preferred_lft forever
        inet6 fe80::76e6:e2ff:fef5:6282/64 scope link
            valid_lft forever preferred_lft forever
```

To work around this issue, configure the IP address scope:

## ⓘ Example post-up Configuration

```
cumulus@switch:~$ net add interface swp6 post-up ip address
add 71.21.21.20/32 dev swp6 scope site
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands create the following code snippet in the `/etc/network/interfaces` file:

```
auto swp6
iface swp6
    post-up ip address add 71.21.21.20/32 dev swp6 scope site
```

Now it has the correct scope:

```
cumulus@switch:~$ ip addr show swp6
9: swp6: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast
state UP group default qlen 1000
link/ether 74:e6:e2:f5:62:86 brd ff:ff:ff:ff:ff:ff
inet 71.21.21.20/32 scope site swp6
    valid_lft forever preferred_lft forever
    inet6 fe80::76e6:e2ff:fef5:6286/64 scope link
```



```
valid_lft forever preferred_lft forever
```

### Purge Existing IP Addresses on an Interface

By default, `ifupdown2` purges existing IP addresses on an interface. If you have other processes that manage IP addresses for an interface, you can disable this feature including the `address-purge` setting in the interface's configuration.

```
cumulus@switch:~$ net add interface swp1 address-purge no
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands create the following configuration snippet in the `/etc/network/interfaces` file:

```
auto swp1
iface swp1
    address-purge no
```



Purging existing addresses on interfaces with multiple `iface` stanzas is not supported. Doing so can result in the configuration of multiple addresses for an interface after you change an interface address and reload the configuration with `ifreload -a`. If this happens, you must shut down and restart the interface with `ifup` and `ifdown`, or manually delete superfluous addresses with `ip address delete specify.ip.address.here/mask dev DEVICE`. See also the [Caveats and Errata \(see page\)](#) section below for some cautions about using multiple `iface` stanzas for the same interface.

## Specify User Commands

You can specify additional user commands in the `interfaces` file. As shown in the example below, the interface stanzas in `/etc/network/interfaces` can have a command that runs at pre-up, up, post-up, pre-down, down, and post-down:

```
cumulus@switch:~$ net add interface swp1 post-up /sbin/foo bar
cumulus@switch:~$ net add interface ip address 12.0.0.1/30
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands create the following configuration in the `/etc/network/interfaces` file:

```
auto swp1
iface swp1
    address 12.0.0.1/30
```



```
post-up /sbin/foo bar
```

Any valid command can be hooked in the sequencing of bringing an interface up or down, although commands should be limited in scope to network-related commands associated with the particular interface.

For example, it wouldn't make sense to install some Debian package on `ifup` of `swp1`, even though that is technically possible. See `man interfaces` for more details.



If your `post-up` command also starts, restarts or reloads any `systemd` service, you must use the `--no-block` option with `systemctl`. Otherwise, that service or even the switch itself may hang after starting or restarting.

For example, to restart the `dhcrelay` service after bringing up VLAN 100, first run:

```
cumulus@switch:~$ net add vlan 100 post-up systemctl --no-block restart dhcrelay.service
```

This command creates the following configuration in the `/etc/network/interfaces` file:

```
auto bridge
iface bridge
    bridge-vids 100
    bridge-vlan-aware yes

auto vlan100
iface vlan100
    post-up systemctl --no-block restart dhcrelay.service
    vlan-id 100
    vlan-raw-device bridge
```

## Source Interface File Snippets

Sourcing interface files helps organize and manage the `interfaces` file. For example:

```
cumulus@switch:~$ cat /etc/network/interfaces
# The loopback network interface
auto lo
iface lo inet loopback

# The primary network interface
auto eth0
iface eth0 inet dhcp

source /etc/network/interfaces.d/bond0
```



The contents of the sourced file used above are:

```
cumulus@switch:~$ cat /etc/network/interfaces.d/bond0
auto bond0
iface bond0
    address 14.0.0.9/30
    address 2001:ded:beef:2::1/64
    bond-slaves swp25 swp26
```

## Use Globs for Port Lists

NCLU supports globs to define port lists (that is, a range of ports). The `glob` keyword is implied when you specify bridge ports and bond slaves:

```
cumulus@switch:~$ net add bridge bridge ports swp1-4,6,10-12
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```



While you must use commas to separate different ranges of ports in the NCLU command, the `/etc/network/interfaces` file renders the list of ports individually, as in the example output below.

These commands produce the following snippet in the `/etc/network/interfaces` file:

```
...
auto bridge
iface bridge
    bridge-ports swp1 swp2 swp3 swp4 swp6 swp10 swp11 swp12
    bridge-vlan-aware yes
auto swp1
iface swp1

auto swp2
iface swp2

auto swp3
iface swp3

auto swp4
iface swp4

auto swp6
iface swp6

auto swp10
```

```
iface swp10

auto swp11
iface swp11

auto swp12
iface swp12
```

## Use Templates

`ifupdown2` supports [Mako-style templates](#). The Mako template engine is run over the `interfaces` file before parsing.

Use the template to declare cookie-cutter bridges in the `interfaces` file:

```
%for v in [11,12]:
auto vlan${v}
iface vlan${v}
    address 10.20.${v}.3/24
    bridge-ports glob swp19-20.${v}
    bridge-stp on
%endfor
```

And use it to declare addresses in the `interfaces` file:

```
%for i in [1,12]:
auto swp${i}
iface swp${i}
    address 10.20.${i}.3/24
```



Regarding Mako syntax, use square brackets ([1,12]) to specify a list of individual numbers (in this case, 1 and 12). Use `range(1,12)` to specify a range of interfaces.



You can test your template and confirm it evaluates correctly by running `mako-render /etc/network/interfaces`.



For more examples of configuring Mako templates, read this [knowledge base article](#).

To comment out content in Mako templates, use double hash marks (##). For example:

```
## % for i in range(1, 4):
```



```
## auto swp${i}
## iface swp${i}
## % endfor
##
```

## Run ifupdown Scripts under /etc/network/ with ifupdown2

Unlike the traditional `ifupdown` system, `ifupdown2` does not run scripts installed in `/etc/network/*` automatically to configure network interfaces.

To enable or disable `ifupdown2` scripting, edit the `addon_scripts_support` line in the `/etc/network/ifupdown2/ifupdown2.conf` file. 1 enables scripting and 2 disables scripting. The following example enables scripting.

```
cumulus@switch:~$ sudo nano /etc/network/ifupdown2/ifupdown2.conf
# Support executing of ifupdown style scripts.
# Note that by default python addon modules override scripts with the
same name
addon_scripts_support=1
```

`ifupdown2` sets the following environment variables when executing commands:

- `$IFACE` represents the physical name of the interface being processed; for example, `br0` or `vxlan42`. The name is obtained from the `/etc/network/interfaces` file.
- `$LOGICAL` represents the logical name (configuration name) of the interface being processed.
- `$METHOD` represents the address method; for example, `loopback`, `DHCP`, `DHCP6`, `manual`, `static`, and so on.
- `$ADDRFAM` represents the address families associated with the interface, formatted in a comma-separated list; for example, `"inet,inet6"`.

## Add Descriptions to Interfaces

You can add descriptions to the interfaces configured in `/etc/network/interfaces` by using the `alias` keyword.

### ⓘ Example Alias Configuration

The following commands create an alias for `swp1`:

```
cumulus@switch:~$ net add interface swp1 alias
hypervisor_port_1
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands create the following code snippet:



```
auto swp1
iface swp1
    alias hypervisor_port_1
```

You can query the interface description using NCLU:

```
cumulus@switch$ net show interface swp1
  Name      MAC                Speed      MTU      Mode
  --  -----  -----  -----
  UP   swp1   44:38:39:00:00:04  1G        1500     Access/L2
Alias
-----
hypervisor_port_1
```

Interface descriptions also appear in the [SNMP \(see page 1024\)](#) OID `IF-MIB::ifAlias`.



Aliases are limited to 256 characters.

To show the interface description (alias) for all interfaces on the switch, run the `net show interface alias` command. For example:

```
cumulus@switch:~$ net show interface alias
  State    Name          Mode           Alias
  -----  -----
  UP      bond01        LACP
  UP      bond02        LACP
  UP      bridge         Bridge/L2
  UP      eth0          Mgmt
  UP      lo            Loopback       loopback interface
  UP      mgmt          Interface/L3
  UP      peerlink       LACP
  UP      peerlink.4094 SubInt/L3
  UP      swp1          BondMember     hypervisor_port_1
  UP      swp2          BondMember     to Server02
  ...
```

To show the interface description for all interfaces on the switch in JSON format, run the `net show interface alias json` command.

## Caveats and Errata

While `ifupdown2` supports the inclusion of multiple `iface` stanzas for the same interface, Cumulus Networks recommends you use a single `iface` stanza for each interface, if possible.

There are cases where you must specify more than one `iface` stanza for the same interface. For example, the configuration for a single interface can come from many places, like a template or a sourced file.



If you do specify multiple `iface` stanzas for the same interface, make sure the stanzas do not specify the same interface attributes. Otherwise, unexpected behavior can result.

For example, `swp1` is configured in two places:

```
cumulus@switch:~$ cat /etc/network/interfaces
source /etc/network/interfaces.d/speed_settings

auto swp1
iface swp1
    address 10.0.14.2/24
```

As well as `/etc/network/interfaces.d/speed_settings`

```
cumulus@switch:~$ cat /etc/network/interfaces.d/speed_settings

auto swp1
iface swp1
    link-speed 1000
    link-duplex full
```

`ifupdown2` correctly parses a configuration like this because the same attributes are not specified in multiple `iface` stanzas.

And, as stated in the note above, you cannot purge existing addresses on interfaces with multiple `iface` stanzas.

### *ifupdown2 and sysctl*

For `sysctl` commands in the `pre-up`, `up`, `post-up`, `pre-down`, `down`, and `post-down` lines that use the `$IFACE` variable, if the interface name contains a dot (.), `ifupdown2` does not change the name to work with `sysctl`. For example, the interface name `bridge.1` is not converted to `bridge/1`.

### *Long Interface Names*

The Linux kernel limits interface names to 15 characters in length and cannot have a number as the first character. Longer interface names can result in errors. To work around this issue, remove the interface from the `/etc/network/interfaces` file, then restart the `networking.service`.

```
cumulus@switch:~$ sudo vi /etc/network/interfaces
cumulus@switch:~$ sudo systemctl restart networking.service
```

## Related Information

- [Debian - Network Configuration](#)
- [Linux Foundation - Bonds](#)



- [Linux Foundation - VLANs](#)
- [man ifdown\(8\)](#)
- [man ifquery\(8\)](#)
- [man ifreload](#)
- [man ifup\(8\)](#)
- [man ifupdown-addons-interfaces\(5\)](#)
- [man interfaces\(5\)](#)

## Switch Port Attributes

Cumulus Linux exposes network interfaces for several types of physical and logical devices:

- `lo`, network loopback device
- `ethN`, switch management port(s), for out of band management only
- `swpN`, switch front panel ports
- (optional) `brN`, bridges (IEEE 802.1Q VLANs)
- (optional) `bondN`, bonds (IEEE 802.3ad link aggregation trunks, or port channels)

Each physical network interface has a number of configurable settings:

- [Auto-negotiation](#)
- [Duplex](#)
- [FEC](#) (Forward error correction)
- Link speed
- MTU, or [maximum transmission unit](#)

Most of these settings are configured automatically for you, depending upon your switch ASIC, although you must always set MTU manually.



You can only set MTU for logical interfaces. If you try to set auto-negotiation, duplex mode, or link speed for a logical interface, an unsupported error is shown.

For **Mellanox switches**, MTU is the only port attribute you can directly configure. The Mellanox firmware configures FEC, link speed, duplex mode and auto-negotiation automatically, following a predefined list of parameter settings until the link comes up. However, you can disable FEC if necessary, which forces the firmware to not try any FEC options.

For **Broadcom-based switches**, Cumulus Networks recommends that you enable auto-negotiation on each port. When enabled, Cumulus Linux automatically configures the best link parameter settings based on the module type (speed, duplex, auto-negotiation, and FEC where supported). To understand the default configuration for the various port and cable types, see the [table below \(see page 250\)](#). If you need to troubleshoot further to bring the link up, follow the sections below to set the specific link parameters.

## Contents

### This topic describes ...

- [Auto-negotiation \(see page 240\)](#)
- [Port Speed and Duplex Mode \(see page 241\)](#)



- MTU (see page 242)
  - Set a Policy for Global System MTU (see page 243)
  - MTU for a Bridge (see page 243)
  - Bring Down an Interface for a Bridge Member (see page 245)
- FEC (see page 245)
  - Determine Cable Class of 100G and 25G DACs (see page 246)
  - How Does Cumulus Linux use FEC? (see page 247)
  - Show the Current FEC Mode (see page 248)
  - Enable or Disable FEC (see page 248)
- Interface Configuration Recommendations for Broadcom Platforms (see page 250)
- Default Policies for Interface Settings (see page 260)
- Breakout Ports (see page 261)
  - Break out a 100G Port to Four 10G Ports (see page 263)
  - Remove a Breakout Port (see page 263)
  - Combine Four 10G Ports into One 40G Port (see page 264)
- Logical Switch Port Limitations (see page 265)
  - Mellanox Logical Port Limits and Breakout Configurations (see page 266)
- Configure Interfaces with ethtool (see page 266)
- Verification and Troubleshooting Commands (see page 267)
  - Statistics (see page 267)
  - Query SFP Port Information (see page 268)
- Caveats and Errata (see page 268)
  - Port Speed and the ifreload -a Command (see page 268)
  - 10G and 1G SFPs Inserted in a 25G Port (see page 269)
  - Timeout Error on Quanta LY8 and LY9 Switches (see page 270)
  - swp33 and swp34 Disabled on Some Switches (see page 270)
  - 200G Interfaces on the Dell S5248F Switch (see page 270)
  - QSFP+ Ports on the Dell S5232F Switch (see page )
  - QSFP+ Ports on the Dell S4148T Switch (see page )
  - Link Speed on the EdgeCore AS7326-56X Switch (see page 271)
  - ethtool Shows Incorrect Port Speed on 100G Mellanox Switches (see page 272)
  - Delay in Reporting Interface as Operational Down (see page 272)
- Related Information (see page 272)

## *Auto-negotiation*

To configure auto-negotiation for a Broadcom-based switch, set `link-autoneg` to `on` for all the switch ports. For example, to enable auto-negotiation for `swp1` through `swp52`:



```
cumulus@switch:~$ net add interface swp1-52 link autoneg on  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

Any time you enable auto-negotiation, Cumulus Linux restores the default configuration settings specified in the [table below \(see page 250\)](#).

By default on a Broadcom-based switch, auto-negotiation is disabled — except on 10G and 1000BASE-T fixed copper switch ports, where it is required for links to work. For RJ-45 SFP adapters, you need to manually configure the desired link speed and auto-negotiation as described in the [default settings table below \(see page 250\)](#).

If you disable auto-negotiation later or never enable it, then you have to configure any settings that deviate from the port default — such as duplex mode, FEC, and link speed settings.



Some module types support auto-negotiation while others do not. To enable a simpler configuration, Cumulus Linux allows you to configure auto-negotiation on all port types on Broadcom switches; the port configuration software then configures the underlying hardware according to its capabilities.

If you do decide to disable auto-negotiation, be aware of the following:

- You must manually set any non-default link speed, duplex, pause, and FEC.
- Disabling auto-negotiation on a 1G optical cable prevents detection of single fiber breaks.
- You cannot disable auto-negotiation on 1GT or 10GT fixed copper switch ports.

For 1000BASE-T RJ-45 SFP adapters, auto-negotiation is automatically done on the SFP PHY, so enabling auto-negotiation on the port settings is not required. You must manually configure these ports using the [settings below \(see page 250\)](#).

Depending upon the connector used for a port, enabling auto-negotiation also enables forward error correction (FEC), if the cable requires it (see the [table below \(see page 250\)](#)). The correct FEC mode is set based on the speed of the cable when auto-negotiation is enabled.

## Port Speed and Duplex Mode

Cumulus Linux supports both half- and [full-duplex](#) configurations. The duplex mode setting defaults to *full*. You only need to specify `link duplex` if you want half-duplex mode.

Supported port speeds include 100M, 1G, 10G, 25G, 40G, 50G and 100G. If you need to manually set the speed on a Broadcom-based switch, set it in terms of Mbps, where the setting for 1G is 1000, 40G is 40000 and 100G is 100000, for example.

You can configure ports to one speed less than their maximum speed.

Switch Port Type	Lowest Configurable Speed
1G	100 Mb
10G	1 Gigabit (1000 Mb)
40G	10G*



Switch Port Type	Lowest Configurable Speed
100G	50G* & 40G (with or without breakout port), 25G*, 10G*

\*Requires the port to be converted into a breakout port. See [Configuring Breakout Ports \(see page 261\)](#) below.

## ⓘ Example Port Speed and Duplexing Configuration

The following NCLU commands configure the port speed for the swp1 interface:

```
cumulus@switch:~$ net add interface swp1 link speed 10000  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

The above commands create the following /etc/network/interfaces code snippet:

```
auto swp1  
iface swp1  
    link-speed 10000
```

## ⚠ Platform Limitations

- On Lenovo NE25720 switches, swp1 thru swp8 only support 25G speed.
- For 10G and 1G SFPs inserted in a 25G port on a Broadcom platform, you must edit the /etc/cumulus/ports.conf file and configure the four ports in the same core to be 10G. See [Caveats and Errata \(see page 268\)](#) below.

## MTU

Interface MTU ([maximum transmission unit](#)) applies to traffic traversing the management port, front panel /switch ports, bridge, VLAN subinterfaces and bonds — in other words, both physical and logical interfaces.

MTU is the only interface setting that you must set manually.

In Cumulus Linux, ifupdown2 assigns 1500 as the default MTU setting. To change the setting, run:

```
cumulus@switch:~$ net add interface swp1 mtu 9000  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```





Some switches might not support the same maximum MTU setting in hardware for both the management interface (eth0) and the data plane ports.

### *Set a Policy for Global System MTU*

For a global policy to set MTU, create a policy document (called `mtu.json` here) like the following:

```
cat /etc/network/ifupdown2/policy.d/mtu.json
{
  "address": { "defaults": { "mtu": "9216" } }
}
```



If your platform does not support a high MTU on eth0, you can set a lower MTU with the following command:

```
cumulus@switch:~$ net add interface eth0 mtu 1500
cumulus@switch:~$ net commit
```



The policies and attributes in any file in `/etc/network/ifupdown2/policy.d/` override the default policies and attributes in `/var/lib/ifupdown2/policy.d/`.

### *MTU for a Bridge*

The MTU setting is the lowest MTU setting of any interface that is a member of that bridge (every interface specified in `bridge-ports` in the bridge configuration in the `interfaces` file), even if another bridge member has a higher MTU value. There is **no** need to specify an MTU on the bridge. Consider this bridge configuration:

```
auto bridge
iface bridge
  bridge-ports bond1 bond2 bond3 bond4 peer5
  bridge-vids 100-110
  bridge-vlan-aware yes
```

For `bridge` to have an MTU of 9000, set the MTU for each of the member interfaces (bond1 to bond 4, and peer5), to 9000 at minimum.



**Use MTU 9216 for a bridge**

Two common MTUs for jumbo frames are 9216 and 9000 bytes. The corresponding MTUs for the VNIs would be 9166 and 8950.

When configuring MTU for a bond, configure the MTU value directly under the bond interface; the configured value is inherited by member links/slave interfaces. If you need a different MTU on the bond, set it on the bond interface, as this ensures the slave interfaces pick it up. There is no need to specify MTU on the slave interfaces.

VLAN interfaces inherit their MTU settings from their physical devices or their lower interface; for example, swp1.100 inherits its MTU setting from swp1. Therefore, specifying an MTU on swp1 ensures that swp1.100 inherits the MTU setting for swp1.

If you are working with [VXLANs](#) (see page 490), the MTU for a virtual network interface (VNI) must be 50 bytes smaller than the MTU of the physical interfaces on the switch, as those 50 bytes are required for various headers and other data. Also, consider setting the MTU much higher than the default 1500.

## ⓘ Example MTU Configuration

In general, the policy file specified above handles default MTU settings for all interfaces on the switch. If you need to configure a different MTU setting for a subset of interfaces, use [NCLU](#) (see page 88).

The following commands configure an MTU minimum value of 9000 on swp1:

```
cumulus@switch:~$ net add interface swp1 mtu 9000
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands create the following code snippet:

```
auto swp1
iface swp1
    mtu 9000
```

**!** You must take care to ensure there are no MTU mismatches in the conversation path. MTU mismatches result in dropped or truncated packets, degrading or blocking network performance.

**!** The MTU for an SVI interface, such as vlan100, is derived from the bridge. When you use NCLU to change the MTU for an SVI and the MTU setting is higher than it is for the other bridge member interfaces, the MTU for all bridge member interfaces changes to the new setting. If you need to use a mixed MTU configuration for SVIs, for example, if some SVIs have a higher MTU and some lower, then set the MTU for all member interfaces to the maximum value, then set the MTU on the specific SVIs that need to run at a lower MTU.

To view the MTU setting, run the `net show interface <interface>` command:

```
cumulus@switch:~$ net show interface swp1
      Name      MAC              Speed      MTU      Mode
--  -----
UP    swp1    44:38:39:00:00:04   1G        1500  Access/L2
```

### *Bring Down an Interface for a Bridge Member*

When you bring down an interface for a bridge member, the MTU for the interface and the MTU for the bridge are both set to the default value of 1500. To work around this, run `ifdown` on the interface, then run the `sudo ip link set dev <interface> mtu <mtu>` command.

For example:

```
sudo ifdown swp3
sudo ip link set dev swp3 mtu 9192
```

As an alternative, add a `post-down` command in the `/etc/network/interfaces` file to reset the MTU of the interface. For example:

```
auto swp3
iface swp3
    alias BNBYLAB-PD01HV-01_Port3
    bridge-vids 106 109 119 141 150-151
    mtu 9192
    post-down /sbin/ip link set dev swp3 mtu 9192
```

### FEC

**Forward Error Correction (FEC)** is an encoding and decoding layer that enables the switch to detect and correct bit errors introduced over the cable between two interfaces. Because 25G transmission speeds can introduce a higher than acceptable bit error rate (BER) on a link, FEC is required or recommended for 25G, 4x25G, and 100G link speeds. In order for the link to come up, the two interfaces on each end must use the same FEC setting.



There is a very small latency overhead required for FEC. For most applications, this small amount of latency is preferable to error packet retransmission latency.

There are two FEC types:

- Reed Solomon (**RS**), IEEE 802.3 Clause 108 (CL108) on individual 25G channels and Clause 91 on 100G (4channels). This is the highest FEC algorithm, providing the best bit-error correction.
- Base-R (**BaseR**), Fire Code (FC), IEEE 802.3 Clause 74 (CL74). Base-R provides less protection from bit errors than RS FEC but adds less latency.

There are additional FEC options for Cumulus Linux configuration:



- Auto FEC instructs the hardware to select the best FEC. For copper DAC, FEC can be negotiated with the remote end. However, optical modules do not have auto-negotiation capability; if the device chooses a preferred mode, it might not match the remote end. This is the current default on a Mellanox switch.
- No FEC (no error correction is done). This is the current default on a Broadcom switch.

### **Important**

The Tomahawk switch does not support RS FEC or auto-negotiation of FEC on 25G lanes that are broken out (Tomahawk pre-dates 802.3by). If you are using a 4x25G breakout DAC or AOC on a Tomahawk switch, you can configure either Base-R FEC or no FEC, and choose cables appropriate for that limitation (CA-25G-S, CA-25G-N or fiber).

Tomahawk+, Tomahawk2, Trident3, and Maverick switches do not have this limitation.

### 

You cannot set RS FEC on any Trident II switch with either NCLU or by directly editing the `/etc/network/interfaces` file.

For **25G DAC, 4x25G Breakouts DAC and 100G DAC cables**, the IEEE 802.3by specification creates 3 classes:

- CA-25G-L (long cables - achievable cable length of at least 5m) dB loss less or equal to 22.48. Requires RS FEC and expects BER of 10-5 or better with RS FEC enabled.
- CA-25G-S (short cables - achievable cable length of at least 3m) dB loss less or equal to 16.48. Requires Base-R FEC and expects BER of 10-8 or better with Base-R FEC enabled.
- CA-25G-N (no FEC - achievable cable length of at least 3m) dB loss less or equal to 12.98. Does not require FEC. Expects BER 10-12 or better with no FEC.

The IEEE classification is based on various dB loss measurements and minimum achievable cable length. You can build longer and shorter cables if they comply to the dB loss and BER requirements.

If a cable is manufactured to CA-25G-S classification and FEC is not enabled, the BER might be unacceptable in a production network. It is important to set the FEC according to the cable class (or better) to have acceptable bit error rates. See [Determining Cable Class \(see page 246\)](#) below.

You can check bit errors using `c1-netstat` (`RX_ERR` column) or `ethtool -S` (`HwIfInErrors` counter) after a large amount of traffic has passed through the link. A non-zero value indicates bit errors. Expect error packets to be zero or extremely low compared to good packets. If a cable has an unacceptable rate of errors with FEC enabled, replace the cable.

For **25G, 4x25G Breakout, and 100G Fiber modules and AOCs**, there is no classification of 25G cable types for dB loss, BER or length. FEC is recommended but might not be required if the BER is low enough.

### *Determine Cable Class of 100G and 25G DACs*

You can determine the cable class for 100G and 25G DACs from the Extended Specification Compliance Code field (SFP28: 0Ah, byte 35, QSFP28: Page 0, byte 192) in the cable EEPROM programming.

For 100G DACs, most manufacturers use the 0x0Bh `100GBASE-CR4` or `25GBASE-CR CA-L` value (the 100G DAC specification predates the IEEE 802.3by 25G DAC specification). RS FEC is the expected setting for 100G DAC but might not be required with shorter or better cables.





A manufacturer's EEPROM setting might not match the dB loss on a cable or the actual bit error rates that a particular cable introduces. Use the designation as a guide, but set FEC according to the bit error rate tolerance in the design criteria for the network. For most applications, the highest mutual FEC ability of both end devices is the best choice.

You can determine for which grade the manufacturer has designated the cable as follows.

For the **SFP28 DAC**, run the following command:

```
cumulus@switch:~$ sudo ethtool -m swp35 hex on | grep 0020 | awk '{  
print $6}'  
0c
```

The values at location 0x0024 are:

- 0x0b : CA-L (long cable - RS FEC required)
- 0x0c : CA-S (short cable - BaseR or better FEC required)
- 0x0d : CA-N (no FEC required)

For the **QSFP28 DAC**, run the following command:

```
cumulus@switch:~$ sudo ethtool -m swp51s0 hex on | grep 00c0 | awk  
'{print $2}'  
0b
```

The values at 0x00c0 are:

- 0x0b : CA-L (long cable - RS FEC required) or 100G CR4
- 0x0c : CA-S (short cable - BaseR or better FEC required)
- 0x0d : CA-N (no FEC required)

In each example below, the *Compliance* field is derived using the method described above and is not visible in the `ethtool -m` output.



#### **Cable Class Example 1:** 3meter cable that does not require FEC (CA-N)

Cost : More expensive

Cable size : 26AWG (Note that AWG does not necessarily correspond to overall dB loss or BER performance)

Compliance Code : 25GBASE-CR CA-N



#### **Cable Class Example 2:** 3meter cable that requires Base-R FEC (CA-S)

Cost: Less expensive

Cable size : 26AWG

Compliance Code : 25GBASE-CR CA-S

When in doubt, consult the manufacturer directly to determine the cable classification.

## How Does Cumulus Linux use FEC?

This depends upon the make of the switch you are using.

A Mellanox switch enables FEC automatically when it powers up; that is, the setting is `fec auto`. The port firmware tests and determines the correct FEC mode to bring the link up with the neighbor. It is possible to get a link up to a Mellanox switch without enabling FEC on the remote device as the switch eventually finds a working combination to the neighbor without FEC.

On a Broadcom switch, Cumulus Linux does not enable FEC by default; that is, the setting is `fec off`. Cumulus Networks recommends you configure FEC explicitly to match the configured FEC on the link neighbor. On 100G DACs, you can configure `link-autoneg` so that the port attempts to negotiate FEC settings with the remote peer.

The following sections describe how to show the current FEC mode, and to enable and disable FEC.

### Show the Current FEC Mode

Cumulus Linux returns different output for the `ethtool --show-fec` command, depending upon whether you are using a Broadcom or Mellanox switch.

On a Broadcom switch, the `--show-fec` output tells you exactly what you configured, even if the link is down due to a FEC mismatch with the neighbor.

On a Mellanox switch, the `--show-fec` output tells you the current active state of FEC **only if the link is up**; that is, if the FEC modes matches that of the neighbor. If the link is not up, the value displays *None*, which is not valid.

To display the FEC mode currently enabled on a given switch port, run the following command:

```
cumulus@switch:~$ sudo ethtool --show-fec swp23
FEC parameters for swp23:
FEC encodings : None
```

### Enable or Disable FEC

To enable **Reed Solomon (RS) FEC** on a link, run the following NCLU commands:

```
cumulus@switch:~$ sudo net add interface swp23 link fec rs
cumulus@switch:~$ sudo net commit
```

To review the FEC setting on the link, run the following command:

```
cumulus@switch:~$ sudo ethtool --show-fec swp23
FEC parameters for swp23:
FEC encodings : RS
```

To enable **Base-R/FireCode FEC** on a link, run the following NCLU commands:

```
cumulus@switch:~$ sudo net add interface swp23 link fec baser
```



```
cumulus@switch:~$ sudo net commit
```

To review the FEC setting on the link, run the following command:

```
cumulus@switch:~$ sudo ethtool --show-fec swp23
FEC parameters for swp23:
FEC encodings : BaseR
```



FEC with auto-negotiation is supported on DACs only.

To enable FEC with auto-negotiation, run the following NCLU commands:

```
cumulus@switch:~$ sudo net add interface swp12 link autoneg on
cumulus@switch:~$ sudo net commit
```

To view the FEC and auto-negotiation settings, run the following command:

```
cumulus@switch:~$ sudo ethtool swp12 | egrep 'FEC|auto'
Supports auto-negotiation: Yes
Supported FEC modes: RS
Advertised auto-negotiation: Yes
Advertised FEC modes: RS
Link partner advertised auto-negotiation: Yes
Link partner advertised FEC modes: Not reported
```

```
cumulus@switch:~$ sudo ethtool --show-fec swp12
FEC parameters for swp12:
FEC encodings : RS
```

To disable FEC on a link, run the following NCLU commands:

```
cumulus@switch:~$ sudo net add interface swp23 link fec off
cumulus@switch:~$ sudo net commit
```

To review the FEC setting on the link, run the following command:

```
cumulus@switch:~$ sudo ethtool --show-fec swp23
FEC parameters for swp23:
FEC encodings : None
```

## *Interface Configuration Recommendations for Broadcom Platforms*

The recommended configuration for each type of interface is described in the following table. These are the link settings that are applied to the port hardware when auto-negotiation is enabled on a Broadcom-based switches. If further troubleshooting is required to bring a link up, use the table below as a guide to set the link parameters.

Except as noted below, the settings for both sides of the link are expected to be the same.



Mellanox switches automatically configure these settings following a predefined list of parameter settings until the link comes up.



If the other side of the link is running a version of Cumulus Linux earlier than 3.2, depending upon the interface type, auto-negotiation may not work on that switch. Cumulus Networks recommends you use the recommended settings as show below on this switch in this case.

Speed /Type	Auto-negotiation	FEC Setting	Manual Configuration Steps	Notes
100BASE-T (RJ-45 SFP Module)	Off	N/A (does not apply at this speed)	<pre>\$ net add interface swp1 link speed 100 \$ net add interface swp1 link autoneg off</pre> <p><b>Configuration in /etc/network/interfaces</b></p> <pre>auto swp1 iface swp1     link-     autoneg off     link-speed     100</pre>	<ul style="list-style-type: none"> <li>The module has two sets of electronics — the port side, which communicates to the switch ASIC, and the RJ-45 adapter side.</li> <li>Auto-negotiation is always used on the RJ-45 adapter side of the link by the PHY built into the module. This is independent of the switch setting. Set link-autoneg to off.</li> <li>Auto-negotiation needs to be enabled on the server side in this scenario.</li> </ul>
	On	N/A	<pre>\$ net add interface</pre>	<ul style="list-style-type: none"> <li>10M or 100M speeds are possible with auto-negotiation OFF on both sides. Testing on an</li> </ul>



Speed /Type	Auto-negotiation	FEC Setting	Manual Configuration Steps	Notes
100BASE-T on a 1G fixed copper port			<pre>swp1 link speed 100 \$ net add interface swp1 link autoneg on</pre> <b>Configuration in /etc/network/interfaces</b>  <pre>auto swp1 iface swp1     link-     autoneg on     link-speed     100</pre>	<p>Edgecore AS4610-54P revealed the ASIC reporting auto-negotiation as ON.</p> <ul style="list-style-type: none"><li>● Power over Ethernet (see page 207) may require auto-negotiation to be ON.</li></ul>
1000BASE-T (RJ-45 SFP Module)	Off	N/A	<pre>\$ net add interface swp1 link speed 1000 \$ net add interface swp1 link autoneg off</pre> <b>Configuration in /etc/network/interfaces</b>  <pre>auto swp1 iface swp1     link-     autoneg off     link-speed     1000</pre>	<ul style="list-style-type: none"><li>● The module has two sets of electronics — the port side, which communicates to the switch ASIC, and the RJ-45 side.</li><li>● Auto-negotiation is always used on the RJ-45 side of the link by the PHY built into the module. This is independent of the switch setting. Set link-autoneg to off.</li><li>● Auto-negotiation needs to be enabled on the server side.</li></ul>



Speed /Type	Auto-negotiation	FEC Setting	Manual Configuration Steps	Notes
1000BASE-T on a 1G fixed copper port	On	N/A	<pre>\$ net add interface swp1 link speed 1000 \$ net add interface swp1 link autoneg on</pre> <b>Configuration in /etc/network/interfaces</b>  <pre>auto swp1 iface swp1     link-     autoneg on     link-speed     1000</pre>	
1000BASE-T on a 10G fixed copper port	On	N/A	<pre>\$ net add interface swp1 link speed 1000 \$ net add interface swp1 link autoneg on</pre> <b>Configuration in /etc/network/interfaces</b>  <pre>auto swp1 iface swp1     link-     autoneg on</pre>	



Speed /Type	Auto-negotiation	FEC Setting	Manual Configuration Steps	Notes
			<pre>link-speed 1000</pre>	
1000BASE-SX, 1000BASE-LX, (1G Fiber)	Recommended On	N/A	<pre>\$ net add interface swp1 link speed 1000 \$ net add interface swp1 link autoneg on</pre> <b>Configuration in /etc /network /interfaces</b>  <pre>auto swp1 iface swp1 link- autoneg on link-speed 1000</pre>	<ul style="list-style-type: none"><li>Without auto-negotiation, the link stays up when there is a single fiber break.</li></ul> <p>See the limitation discussed in <a href="#">10G and 1G SFPs Inserted in a 25G Port (see page 269)</a>, below</p>
10GBASE-T (RJ-45 SFP Module)	Off	N/A	<pre>\$ net add interface swp1 link speed 10000 \$ net add interface swp1 link autoneg off</pre> <b>Configuration in /etc /network /interfaces</b>	<ul style="list-style-type: none"><li>The module has two sets of electronics — the port side, which communicates to the switch ASIC and the RJ-45 side.</li><li>Auto-negotiation is always used on the RJ-45 side of the link by the PHY built into the module. This is independent of the switch setting. Set link-autoneg to off.</li><li>Auto-negotiation needs to be enabled on the server side.</li></ul>



Speed /Type	Auto-negotiation	FEC Setting	Manual Configuration Steps	Notes
			<pre>auto swp1 iface swp1     link-     autoneg off     link-speed     10000</pre>	
10GBASE-T fixed copper port	On	N/A	<pre>\$ net add interface swp1 link speed 10000 \$ net add interface swp1 link autoneg on</pre> <p><b>Configuration in /etc/network/interfaces</b></p> <pre>auto swp1 iface swp1     link-     autoneg on     link-speed     10000</pre>	
10GBASE-CR, 10GBASE-LR, 10GBASE-SR, 10G AOC	Off	N/A	<pre>\$ net add interface swp1 link speed 10000 \$ net add interface swp1 link autoneg off</pre>	



Speed /Type	Auto-negotiation	FEC Setting	Manual Configuration Steps	Notes
			<p><b>Configuration in /etc/network/interfaces</b></p> <pre>auto swp1 iface swp1     link-     autoneg off     link-speed     10000</pre>	
40GBASE-CR4	Recommended On	Disable it	<pre>\$ net add interface swp1 link speed 40000 \$ net add interface swp1 link autoneg on</pre> <p><b>Configuration in /etc/network/interfaces</b></p> <pre>auto swp1 iface swp1     link-     autoneg on     link-speed     40000</pre>	<ul style="list-style-type: none"><li>• 40G standards mandate auto-negotiation should be enabled for DAC connections.</li></ul>
40GBASE-SR4, 40GBASE-LR4, 40G AOC	Off	Disable it	<pre>\$ net add interface swp1 link speed 40000 \$ net add interface</pre>	



Speed /Type	Auto-negotiation	FEC Setting	Manual Configuration Steps	Notes
			<pre>swp1 link autoneg off</pre>  <b>Configuration in /etc/network/interfaces</b>  <pre>auto swp1 iface swp1     link-     autoneg off     link-speed     40000</pre>	
100GBASE-CR4	On	auto-negotiated	<pre>\$ net add interface swp1 link speed 100000 \$ net add interface swp1 link autoneg on</pre>  <b>Configuration in /etc/network/interfaces</b>  <pre>auto swp1 iface swp1     link-     autoneg on     link-speed     100000</pre>	
100GBASE-SR4, 100G AOC	Off	RS	<pre>\$ net add interface</pre>	



Speed /Type	Auto-negotiation	FEC Setting	Manual Configuration Steps	Notes
			<pre>swp1 link speed 100000 \$ net add interface swp1 link autoneg off \$ net add interface swp1 link fec rs</pre> <b>Configuration in /etc /network /interfaces</b>  <pre>auto swp1 iface swp1     link-     autoneg off     link-speed     100000     link-fec rs</pre>	
100GBASE-LR4	Off	None stated	<pre>\$ net add interface swp1 link speed 100000 \$ net add interface swp1 link autoneg off \$ net add interface swp1 link fec off</pre> <b>Configuration in /etc /network /interfaces</b>	



Speed /Type	Auto-negotiation	FEC Setting	Manual Configuration Steps	Notes
			<pre>auto swp1 iface swp1     link-     autoneg off     link-speed     100000     link-fec     off</pre>	
25GBASE-CR	On	auto-negotiated*	<pre>\$ net add interface swp1 link speed 25000 \$ net add interface swp1 link autoneg on</pre> <b>Configuration in /etc/network/interfaces</b> <pre>auto swp1 iface swp1     link-     autoneg on     link-speed     25000</pre>	
25GBASE-SR	Off	RS*	<pre>\$ net add interface swp1 link speed 25000 \$ net add interface swp1 link autoneg off \$ net add interface</pre>	<ul style="list-style-type: none"><li>Tomahawk cannot do RS on a single channel, only BASE-R/FC/FireCode /Type74, which violates the 802.3by specification for 25G.</li></ul>



Speed /Type	Auto-negotiation	FEC Setting	Manual Configuration Steps	Notes
			<pre>swp1 link fec baser</pre>  <b>Configuration in /etc/network/interfaces</b>  <pre>auto swp1 iface swp1     link-     autoneg off     link-speed     25000     link-fec     baser</pre>	
25GBASE-LR	Off	None stated	<pre>\$ net add interface swp1 link speed 25000 \$ net add interface swp1 link autoneg off \$ net add interface swp1 link fec off</pre>	  <b>Configuration in /etc/network/interfaces</b>  <pre>auto swp1 iface swp1     link-     autoneg off     link-speed     25000</pre>

Speed /Type	Auto-negotiation	FEC Setting	Manual Configuration Steps	Notes
			link-fec off	

### *Default Policies for Interface Settings*

Instead of configuring these settings for each individual interface, you can specify a policy for all interfaces on a switch, or tailor custom settings for each interface. Create a file in `/etc/network/ifupdown2/policy.d/` and populate the settings accordingly. The following example shows a file called `address.json`.

```
cumulus@switch:~$ cat /etc/network/ifupdown2/policy.d/address.json
{
    "ethtool": {
        "defaults": {
            "link-duplex": "full"
        },
        "iface_defaults": {
            "swp1": {
                "link-autoneg": "on",
                "link-speed": "1000"
            },
            "swp16": {
                "link-autoneg": "off",
                "link-speed": "10000"
            },
            "swp50": {
                "link-autoneg": "off",
                "link-speed": "100000",
                "link-fec": "rs"
            }
        }
    },
    "address": {
        "defaults": { "mtu": "9000" }
        "iface_defaults": {
            "eth0": { "mtu": "1500" }
        }
    }
}
```



Setting the default MTU also applies to the management interface. Be sure to add the `iface_defaults` to override the MTU for `eth0`, to remain at 1500.



## Breakout Ports

Cumulus Linux has the ability to:

- Break out 100G switch ports into the following with breakout cables:
  - 2x50G, 2x40G, 4x25G, 4x10G
- Break out 40G switch ports into four separate 10G ports for use with breakout cables.
- Combine (also called *aggregating* or *ganging*) four 10G switch ports into one 40G port for use with a breakout cable ([not to be confused with a bond \(see page 399\)](#)).

To configure a 4x25G breakout port, first configure the port to break out then set the link speed:

```
cumulus@switch:~$ net add interface swp3 breakout 4x25G  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```



On Mellanox switches, you need to disable the next port (see below). In this example, you must run the following before committing the update with `net commit`:

```
cumulus@switch:~$ net add interface swp4 breakout disabled
```

Also, [see below \(see page 266\)](#) for how to configure breakout ports on Mellanox switches.

These commands break out the 100G interfaces to 4x25G interfaces in the `/etc/cumulus/ports.conf` file, restart the `switchd` process to reconfigure the ports and create four interfaces in the `/etc/network/interfaces` file named as follows:

```
cumulus@switch:~$ cat /etc/network/interfaces  
  
...  
  
auto swp3s0  
iface swp3s0  
  
auto swp3s1  
iface swp3s1  
  
auto swp3s2  
iface swp3s2  
  
auto swp3s3  
iface swp3s3  
  
...
```



When you commit your change configuring the breakout ports, `switchd` restarts to apply the changes. The restart [interrupts network services \(see page 207\)](#).

The breakout port configuration is stored in the `/etc/cumulus/ports.conf` file.



The `/etc/cumulus/ports.conf` file varies across different hardware platforms. Check the current list of supported platforms on [the hardware compatibility list](#).

A snippet from the `/etc/cumulus/ports.conf` file on a Dell S6000 switch (with a Trident II+ ASIC) where `swp6` is broken out looks like this:

```
cumulus@switch:~$ cat /etc/cumulus/ports.conf
# ports.conf --
#
# This file controls port aggregation and subdivision.  For
example, QSFP+
# ports are typically configurable as either one 40G interface
or four
# 10G/1000/100 interfaces.  This file sets the number of
interfaces per port
# while /etc/network/interfaces and ethtool configure the link
speed for each
# interface.
#
# You must restart switchd for changes to take effect.
#
# The DELL S6000 has:
#     32 QSFP ports numbered 1-32
#     These ports are configurable as 40G, split into 4x10G
ports or
#     disabled.
#
#     The X pipeline covers QSFP ports 1 through 16 and the Y
pipeline
#     covers QSFP ports 17 through 32.
#
#     The Trident2 chip can only handle 52 logical ports per
pipeline.
#
#     This means 13 is the maximum number of 40G ports you can
ungang
#     per pipeline, with the remaining three 40G ports set to
#     "disabled".  The 13 40G ports become 52 unganged 10G
ports, which
#     totals 52 logical ports for that pipeline.
#
# QSFP+ ports
#
# <port label 1-32> = [4x10G|40G|disabled]
```



```
1=40G  
2=40G  
3=40G  
4=40G  
5=40G  
6=4x  
7=40G  
8=40G  
9=40G  
10=40G  
11=40G  
12=40G  
13=40G  
14=40G  
15=40G  
16=40G  
17=40G  
18=40G  
19=40G  
20=40G  
21=40G  
22=40G  
23=40G  
24=40G  
25=40G  
26=40G  
27=40G  
28=40G  
29=40G  
30=40G  
31=40G  
32=40G
```

### *Break out a 100G Port to Four 10G Ports*

If you want to support 10G speed modules or cables on 100G ports you must set up the port in 10G mode first by configuring breakout ports on the 100G ports using the following NCLU commands:

```
cumulus@switch:~$ net add interface swp25 breakout 4x10G  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

### *Remove a Breakout Port*

To remove a breakout port, you need to do the following:

1. Remove the breakout port interfaces using NCLU, then commit the change. Continuing with the original example:



```
cumulus@switch:~$ net del interface swp3s0
cumulus@switch:~$ net del interface swp3s1
cumulus@switch:~$ net del interface swp3s2
cumulus@switch:~$ net del interface swp3s3
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

2. Manually edit the `/etc/cumulus/ports.conf` file to configure the interface for the original speed, then save your changes:

```
cumulus@switch:~$ sudo nano /etc/cumulus/ports.conf
...
2=100G
3=100G
4=100G
...
...
```

3. Restart `switchd` (see page 207).

### Combine Four 10G Ports into One 40G Port

You can *gang* (aggregate) four 10G ports into one 40G port for use with a breakout cable, provided you follow these requirements:

- You must gang four 10G ports in sequential order. For example, you cannot gang `swp1`, `swp10`, `swp20` and `swp40` together.
- The ports must be in increments of four, with the starting port being `swp1` (or `swp5`, `swp9`, or so forth); so you cannot gang `swp2`, `swp3`, `swp4` and `swp5` together.

For example, to gang `swp1` through `swp4` into a 40G port, run:

```
cumulus@switch:~$ net add int swp1-4 breakout /4
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands create the following configuration snippet in the `/etc/cumulus/ports.conf` file:

```
# SFP+ ports#
# <port label 1-48> = [10G|40G/4]
1=40G/4
2=40G/4
3=40G/4
```

4=40G/4  
5=10G

## Logical Switch Port Limitations

100G and 40G switches can support a certain number of logical ports, depending upon the manufacturer; these include:

- Mellanox SN2700, SN2700B, SN2410 and SN2410B switches
- Switches with Broadcom Tomahawk, Trident II, Trident II+ and Trident3 chipsets (check the [HCL](#))

You *cannot* have more than 128 total logical ports on a Broadcom switch.

The Mellanox SN2700, SN2700B, SN2410 and SN2410B switches all have a limit of 64 logical ports in total.

Before you configure any logical/unganged ports on a switch, check the limitations listed in `/etc/cumulus/ports.conf`; this file is specific to each manufacturer.

For example, the Dell S6000 `ports.conf` file indicates the logical port limitation like this:

```
# ports.conf --
#
# This file controls port aggregation and subdivision.  For example,
QSFP+
# ports are typically configurable as either one 40G interface or four
# 10G/1000/100 interfaces.  This file sets the number of interfaces
per port
# while /etc/network/interfaces and ethtool configure the link speed
for each
# interface.
#
# You must restart switchd for changes to take effect.
#
# The DELL S6000 has:
#      32 QSFP ports numbered 1-32
#      These ports are configurable as 40G, split into 4x10G ports or
#      disabled.
#
#      The X pipeline covers QSFP ports 1 through 16 and the Y pipeline
#      covers QSFP ports 17 through 32.
#
#      The Trident2 chip can only handle 52 logical ports per pipeline.
#
#      This means 13 is the maximum number of 40G ports you can ungang
#      per pipeline, with the remaining three 40G ports set to
#      "disabled".  The 13 40G ports become 52 unganged 10G ports, which
#      totals 52 logical ports for that pipeline.
```

The means the maximum number of ports for this Dell S6000 is 104.



## Mellanox Logical Port Limits and Breakout Configurations

The Mellanox SN2700, SN2700B, SN2410 and SN2410B switches all have a limit of 64 logical ports in total. However, if you want to break out to 4x25G or 4x10G, you must configure the logical ports as follows:

- You can only break out odd-numbered ports into 4 logical ports.
- You must disable the next even-numbered port.

These restrictions do not apply to a 2x50G breakout configuration.

For example, if you have a 100G Mellanox SN2700 switch and break out port 11 into 4 logical ports, you must disable port 12 by running `net add interface swp12 breakout disabled`, which results in this configuration in `/etc/cumulus/ports.conf`:

```
...
11=4x
12=disabled
...
```

There is no limitation on any port if interfaces are configured in 2x50G mode.



Here is an example showing how to configure breakout cables for the [Mellanox Spectrum SN2700](#).

## Configure Interfaces with ethtool

The Cumulus Linux `ethtool` command is an alternative for configuring interfaces as well as viewing and troubleshooting them.

For example, to manually set link speed, auto-negotiation, duplex mode and FEC on `swp1`, run:

```
cumulus@switch:~$ sudo ethtool -s swp1 speed 25000 autoneg off duplex full
cumulus@switch:~$ sudo ethtool --set-fec swp1 encoding off
```

To view the FEC setting on an interface, run:

```
cumulus@switch:~$ sudo ethtool --show-fec swp1FEC parameters for swp1:
Auto-negotiation: off
FEC encodings : RS
```



## Verification and Troubleshooting Commands

### Statistics

High-level interface statistics are available with the `net show interface` command:

```
cumulus@switch:~$ net show interface swp1

      Name      MAC                      Speed      MTU      Mode
---  -----  -----
UP   swp1    44:38:39:00:00:04    1G          1500  Access/L2

Vlans in disabled State
-----
br0

Counters      TX      RX
-----  -----
errors        0       0
unicast       0       0
broadcast     0       0
multicast     0       0

LLDP
-----
swp1      ===  44:38:39:00:00:03(server01)
```

Low-level interface statistics are available with `ethtool`:

```
cumulus@switch:~$ sudo ethtool -S swp1
NIC statistics:
  HwIfInOctets: 21870
  HwIfInUcastPkts: 0
  HwIfInBcastPkts: 0
  HwIfInMcastPkts: 243
  HwIfOutOctets: 1148217
  HwIfOutUcastPkts: 0
  HwIfOutMcastPkts: 11353
  HwIfOutBcastPkts: 0
  HwIfInDiscards: 0
  HwIfInL3Drops: 0
  HwIfInBufferDrops: 0
  HwIfInAclDrops: 0
  HwIfInBlackholeDrops: 0
```



```
HwIfInDot3LengthErrors: 0
HwIfInErrors: 0
SoftInErrors: 0
SoftInDrops: 0
SoftInFrameErrors: 0
HwIfOutDiscards: 0
HwIfOutErrors: 0
HwIfOutQDrops: 0
HwIfOutNonQDrops: 0
SoftOutErrors: 0
SoftOutDrops: 0
SoftOutTxFifoFull: 0
HwIfOutQLen: 0
```

### Query SFP Port Information

You can verify SFP settings using `ethtool -m` (see page 990). The following example shows the vendor, type and power output for the swp4 interface.

```
cumulus@switch:~$ sudo ethtool -m swp4 | egrep 'Vendor|type|power\s+:'
Transceiver type : 10G Ethernet: 10G
Base-LR
    Vendor name : FINISAR CORP.
    Vendor OUI : 00:90:65
    Vendor PN : FTLX2071D327
    Vendor rev : A
    Vendor SN : UY30DTX
    Laser output power : 0.5230 mW / -2.81
dBm
    Receiver signal average optical power : 0.7285 mW / -1.38
dBm
```

### Caveats and Errata

#### Port Speed and the ifreload -a Command

When configuring port speed or break outs in the `/etc/cumulus/ports.conf` file, you need to run the `ifreload -a` command to reload the configuration after restarting `switchd` in the following cases:

- If you configure, or configure then remove, the port speed in the `/etc/cumulus/ports.conf` file and you also set or remove the speed on the same physical port or breakouts of that port in the `/etc/network/interfaces` file since the last time you restarted `switchd`.
- If you break out a switch port or remove a break out port and the port speed is set in both the `/etc/cumulus/ports.conf` file and the `/etc/network/interfaces` file.



## 10G and 1G SFPs Inserted in a 25G Port

For 10G and 1G SFPs inserted in a 25G port on a Broadcom platform, you must configure the four ports in the same core to be 10G. Each set of four 25G ports are controlled by a single core; therefore, each core must run at the same clock speed. The four ports must be in sequential order; for example, swp1, swp2, swp3, and swp4.

1. Edit the `/etc/cumulus/ports.conf` file and configure the four ports to be 10G. 1G SFPs are clocked at 10G speeds; therefore, for 1G SFPs, the `/etc/cumulus/ports.conf` file entry must also specify 10G. Currently, you cannot use NCLU commands for this step.

```
...
# SFP28 ports
#
# <port label 1-48> = [25G|10G|100G/4|40G/4]
1=25G
2=25G
3=25G
4=25G
5=10G
6=10G
7=10G
8=10G
9=25G
...
```

2. [Restart `switchd`](#).
3. If you want to set the speed of any SFPs to 1G, set the port speed to 1000 Mbps using NCLU commands; this is *not* necessary for 10G SFPs. You don't need to set the port speed to 1G for all four ports. For example, if you intend only for swp5 and swp6 to use 1G SFPs, do the following:

```
cumulus@switch:~$ net add interface swp5-swp6 link speed 1000
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```



100G switch ASICs do not support 1000Base-X auto-negotiation (Clause 37), which is recommended for 1G fiber optical modules. As a result, single fiber breaks cannot be detected when using 1G optical modules on these switches.

The auto-negotiation setting must be the same on both sides of the connection. If using 1G fiber modules in 25G SFP28 ports, ensure auto-negotiation is disabled on the link partner interface as well.



## Timeout Error on Quanta LY8 and LY9 Switches

On Quanta T5048-LY8 and T3048-LY9 switches, an *Operation timed out* error occurs while removing and reinserting QSFP module.

You cannot remove the QSFPx2 module while the switch is powered on, as it is not hot-swappable. However, if an *Operation timed out* error occurs, you can get the link to come up by [restarting switchd](#) (see [page 207](#)); however, this disrupts your network.

On the T3048-LY9, run the following commands:

```
cumulus@switch:~$ sudo echo 0 > qsfpd_power_enable/value
cumulus@switch:~$ sudo rmmod quanta_ly9_rangeley_platform
cumulus@switch:~$ sudo modprobe quanta_ly9_rangeley_platform
cumulus@switch:~$ sudo systemctl restart switchd.service
```

On the T5048-LY8, run the following commands:

```
cumulus@switch:~$ sudo echo 0 > qsfpd_power_enable/value
cumulus@switch:~$ sudo systemctl restart switchd.service
```

## *swp33 and swp34 Disabled on Some Switches*

The front SFP+ ports (swp33 and swp34) are disabled in Cumulus Linux on the following switches:

- Dell Z9100-ON
- Penguin Arctica 3200-series switches (the 3200C, 3200XL and 3200XLP)
- Supermicro SSE-C3632S

These ports appear as disabled in the `/etc/cumulus/ports.conf` file.

## *200G Interfaces on the Dell S5248F Switch*

On the Dell S5248F switch, the 2x200G QSFP-DD interfaces labeled 49/50 and 51/52 are not supported natively at 200G speeds. The interfaces are supported with 100G cables; however, you can only use one 100G cable from each QSFP-DD port. The upper QSFP-DD port is named `swp49` and the lower QSFP-DD port is named `swp52`.

## *QSFP+ Ports on the Dell S5232F Switch*

Cumulus Linux does not support the 2x10G QSFP+ ports on the Dell S5232F switch.

## *QSFP+ Ports on the Dell S4148T Switch*

On the Dell S4148T switch, the two QSFP+ ports are set to `disabled` by default and the four QSFP28 ports are configured for 100G. The following example shows the default settings in the `/etc/cumulus/ports.conf` file for this switch:

```
cumulus@switch:~$ sudo cat /etc/cumulus/ports.conf
...
# QSFP+ ports
#
# <port label 27-28> = [4x10G|40G]
27=disabled
28=disabled
# QSFP28 ports
#
# <port label 25-26, 29-30> = [4x10G|4x25G|2x50G|40G|50G|100G]
25=100G
26=100G
29=100G
30=100G
```

To enable the two QSFP+ ports, you *must* configure all four QSFP28 ports for either 40G or 4x10G. You cannot use either of the QSFP+ ports if any of the QSFP28 ports are configured for 100G.

The following example shows the `/etc/cumulus/ports.conf` file with all four QSFP28 ports configured for 40G and both QSFP+ ports enabled:

```
cumulus@switch:~$ sudo cat /etc/cumulus/ports.conf
...
# QSFP+ ports
#
# <port label 27-28> = [4x10G|40G]
27=40G
28=40G
# QSFP28 ports
#
# <port label 25-26, 29-30> = [4x10G|4x25G|2x50G|40G|50G|100G]
25=40G
26=40G
29=40G
30=40G
```



To disable the QSFP+ ports, you must set the ports to `disabled`. Do not comment out the lines as this prevents `switchd` from restarting.

### Link Speed on the EdgeCore AS7326-56X Switch

On the EdgeCore AS7326-56X switch, all four switch ports in each port group must be set to the same link speed; otherwise, the links do not come up. These ports are set to 25G by default, but can also be set to 10G. The port groups on this switch are as follows, where each row is a port group:

- 1 2 3 6\*
- 4 5 7\* 9
- 8 10 11\* 12



- 13 14 15 18\*
- 16 17 19\* 21
- 20 22 23\* 24
- 25 26 27 30\*
- 28 29 31\* 33
- 32 34 35\* 36
- 37 38 39 42\*
- 40\* 41 43 45
- 44\* 46 47 48

For example, if you configure port 19 for 10G, you must also configure ports 16, 17 and 21 for 10G.

Additionally, you can gang each port group together as a 100G or 40G port. When ganged together, one port (based on the arrangement of the ports) is designated as the gang leader. This port's number is used to configure the ganged ports and is marked with an asterisk ( \* ) above.



The EdgeCore AS7326-56X is a 48x25G + 8x100G + 2x10G switch. The dedicated 10G ports are not currently supported in Cumulus Linux. However, you can configure all other ports to run at 10G speeds.

### *ethtool Shows Incorrect Port Speed on 100G Mellanox Switches*

After setting the interface speed to 40G by editing the `ports.conf` file on a Mellanox switch, `ethtool` still shows the speed as 100G.

This is a known issue where `ethtool` does not update after restarting `switchd`, so it continues to display the outdated port speed.

To correctly set the port speed, use [NCLU \(see page 88\)](#) or `ethtool` to set the speed instead of manually editing the `ports.conf` file.

For example, to set the speed to 40G using NCLU:

```
cumulus@switch:~$ net add interface swp1 link speed 40000
```

Or using `ethtool`:

```
cumulus@switch:~$ sudo ethtool -s swp1 speed 40000
```

### *Delay in Reporting Interface as Operational Down*

When you remove two transceivers simultaneously from a switch, both interfaces show the `carrier down` status immediately. However, it takes one second for the second interface to show the `operational down` status. In addition, the services on this interface also take an extra second to come down.



## Related Information

- [Debian - Network Configuration](#)
- [Linux Foundation - VLANs](#)
- [Linux Foundation - Bonds](#)

## ifplugd

`ifplugd` is an Ethernet link-state monitoring daemon, that can execute user-specified scripts to configure an Ethernet device when a cable is plugged in, or automatically unconfigure it when a cable is removed.

Follow the steps below to install and configure the `ifplugd` daemon.

## Contents

### This topic describes ...

- [Install ifplugd \(see page 273\)](#)
- [Configure ifplugd \(see page 273\)](#)
- [Caveats and Errata \(see page 275\)](#)

## Install ifplugd

1. Update the switch before installing the daemon:

```
cumulus@switch:~$ sudo -E apt-get update
```

2. Install the `ifplugd` package:

```
cumulus@switch:~$ sudo -E apt-get install ifplugd
```

## Configure ifplugd

Once `ifplugd` is installed, two configuration files must be edited to set up `ifplugd`:

- `/etc/default/ifplugd`
- `/etc/ifplugd/action.d/ifupdown`

## Example ifplugd Configuration

The example `ifplugd` configuration below show that `ifplugd` has been configured to bring down all uplinks when the peerbond goes down in an MLAG environment.



`ifplugd` is configured on both both the primary and secondary [MLAG \(see page 440\)](#) switches in this example.

1. Open /etc/default/ifplugd in a text editor.
2. Configure the file as appropriate, and add the peerbond name, before saving:

```
INTERFACES="peerbond"
HOTPLUG_INTERFACES=""
ARGS="-q -f -u0 -d1 -w -I"
SUSPEND_ACTION="stop"
```

3. Open /etc/ifplugd/action.d/ifupdown in a text editor.
4. Configure the script, and save the file.

```
#!/bin/sh
set -e
case "$2" in
up)
    clagrole=$(clagctl | grep "Our Priority" | awk '{print $8}')
    if [ "$clagrole" = "secondary" ]
    then
        #List all the interfaces below to bring up when
        #clag peerbond comes up.
        for interface in swp1 bond1 bond3 bond4
        do
            echo "bringing up : $interface"
            ip link set $interface up
        done
    fi
    ;;
down)
    clagrole=$(clagctl | grep "Our Priority" | awk '{print $8}')
    if [ "$clagrole" = "secondary" ]
    then
        #List all the interfaces below to bring down
        #when clag peerbond goes down.
        for interface in swp1 bond1 bond3 bond4
        do
            echo "bringing down : $interface"
            ip link set $interface down
        done
    fi
    ;;
esac
```

5. Restart ifplugd to implement the changes:

```
cumulus@switch:$ sudo systemctl restart ifplugd.service
```

## Caveats and Errata

The default shell for `ifplugd` is `dash` (`/bin/sh`), rather than `bash`, as it provides a faster and more nimble shell. However, it contains less features than `bash` (such as being unable to handle multiple uplinks).

## Buffer and Queue Management

Hardware datapath configuration manages packet buffering, queueing and scheduling in hardware. There are two configuration input files:

- `/etc/cumulus/datapath/traffic.conf`, which describes priority groups and assigns the scheduling algorithm and weights
- `/usr/lib/python2.7/dist-packages/cumulus/__chip_config/[bcm|mlx]/datapath.conf`, which assigns buffer space and egress queues



While it's possible to change the buffer limits in the `datapath.conf` file, Cumulus Networks strongly recommends you [work with a Cumulus support engineer](#) to do so.

Each packet is assigned to an ASIC Class of Service (CoS) value based on the packet's priority value stored in the 802.1p (Class of Service) or DSCP (Differentiated Services Code Point) header field. The choice to schedule packets based on COS or DSCP is a configurable option in the `/etc/cumulus/datapath/traffic.conf` file.

Priority groups include:

- *Control*: Highest priority traffic
- *Service*: Second-highest priority traffic
- *Bulk*: All remaining traffic

The scheduler is configured to use a hybrid scheduling algorithm. It applies strict priority to control traffic queues and a weighted round robin selection from the remaining queues. Unicast packets and multicast packets with the same priority value are assigned to separate queues, which are assigned equal scheduling weights.

Datapath configuration takes effect when you initialize `switchd`. Changes to the `traffic.conf` file require you to [restart the `switchd` \(see page 207\)](#) service.



You can configure Quality of Service (QoS) for switches on the following platforms only:

- Broadcom Helix4, Tomahawk, Trident II, Trident II+ and Trident3
- Mellanox Spectrum

## Contents

This topic describes ...



- [Commands \(see page 276\)](#)
- [Example Configuration File \(see page 276\)](#)
- [Configure Traffic Marking through ACL Rules \(see page 280\)](#)
- [Configure Priority Flow Control \(see page 281\)](#)
- [Port Groups \(see page 283\)](#)
- [Configure Link Pause \(see page 284\)](#)
- [Configure Cut-through Mode and Store and Forward Switching \(see page 285\)](#)
- [Configure Explicit Congestion Notification \(see page 286\)](#)
- [Check Interface Buffer Status \(see page 288\)](#)
- [Related Information \(see page 288\)](#)

## Commands

If you modify the configuration in the `/etc/cumulus/datapath/traffic.conf` file, you must [restart switchd](#) (see page 207) for the changes to take effect:

```
cumulus@switch:~$ sudo systemctl restart switchd.service
```

## Example Configuration File

The following example `/etc/cumulus/datapath/traffic.conf` datapath configuration file applies to 10G, 40G, and 100G switches on Broadcom Tomahawk, Trident II, Trident II+, or Trident3 and Mellanox Spectrum [platforms](#) only. However, see the note above for all the supported ASICs.

Keep in mind the following about the configuration:

- Regarding the default source packet fields and mapping, each selected packet field should have a block of mapped values. Any packet field value that is not specified in the configuration is assigned to a default internal switch priority. The configuration applies to every forwarding port unless a custom remark configuration is defined for that port (see below).
- Regarding the default remark packet fields and mapping, each selected packet field should have a block of mapped values. Any internal switch priority value that is not specified in the configuration is assigned to a default packet field value. The configuration applies to every forwarding port unless a custom remark configuration is defined for that port (see below).
- Per-port source packet fields and mapping apply to the designated set of ports.
- Per-port remark packet fields and mapping apply to the designated set of ports.

[Click to view sample traffic.conf file ...](#)

```
cumulus@switch:~$ cat /etc/cumulus/datapath/traffic.conf
#
# /etc/cumulus/datapath/traffic.conf
#
# packet header field used to determine the packet priority
level
# fields include {802.1p, dscp}
```



```
traffic.packet_priority_source_set = [802.1p,
dscp]
# remark packet priority
value
# fields include {802.1p,
none}
# remark packet priority value
# fields include {802.1p, dscp}
traffic.packet_priority_remark_set = [802.1p,dscp]
# packet priority remark values assigned from each internal cos value
# internal cos values {cos_0..cos_7}
# (internal cos 3 has been reserved for CPU-generated traffic)
#
# 802.1p values = {0..7}
traffic.cos_0.priority_remark.8021p = [1]
traffic.cos_1.priority_remark.8021p = [0]
traffic.cos_2.priority_remark.8021p = [3]
traffic.cos_3.priority_remark.8021p = [2]
traffic.cos_4.priority_remark.8021p = [4]
traffic.cos_5.priority_remark.8021p = [5]
traffic.cos_6.priority_remark.8021p = [7]
traffic.cos_7.priority_remark.8021p = [6]
# dscp values = {0..63}
traffic.cos_0.priority_remark.dscp = [1]
traffic.cos_1.priority_remark.dscp = [9]
traffic.cos_2.priority_remark.dscp = [17]
traffic.cos_3.priority_remark.dscp = [25]
traffic.cos_4.priority_remark.dscp = [33]
traffic.cos_5.priority_remark.dscp = [41]
traffic.cos_6.priority_remark.dscp = [49]
traffic.cos_7.priority_remark.dscp = [57]
# Per-port remark packet fields and mapping: applies to the
designated set of ports.
remark.port_group_list = [remark_port_group]
remark.remark_port_group.packet_priority_remark_set = [802.1p,dscp]
remark.remark_port_group.port_set = swp1-swp4,swp6
remark.remark_port_group.cos_0.priority_remark.dscp = [2]
remark.remark_port_group.cos_1.priority_remark.dscp = [10]
remark.remark_port_group.cos_2.priority_remark.dscp = [18]
remark.remark_port_group.cos_3.priority_remark.dscp = [26]
remark.remark_port_group.cos_4.priority_remark.dscp = [34]
remark.remark_port_group.cos_5.priority_remark.dscp = [42]
remark.remark_port_group.cos_6.priority_remark.dscp = [50]
remark.remark_port_group.cos_7.priority_remark.dscp =
[58]
# packet priority values assigned to each internal cos
value
# internal cos values {cos_0..
cos_7}
# (internal cos 3 has been reserved for CPU-generated traffic)
#
# 802.1p values = {0..7}
```



```
traffic.cos_0.priority_source.8021p = [0]
traffic.cos_1.priority_source.8021p = [1]
traffic.cos_2.priority_source.8021p = [2]
traffic.cos_3.priority_source.8021p = []
traffic.cos_4.priority_source.8021p = [3,4]
traffic.cos_5.priority_source.8021p = [5]
traffic.cos_6.priority_source.8021p = [6]
traffic.cos_7.priority_source.8021p = [7]
# dscp values = {0..63}
traffic.cos_0.priority_source.dscp = [0,1,2,3,4,5,6,7]
traffic.cos_1.priority_source.dscp = [8,9,10,11,12,13,14,15]
traffic.cos_2.priority_source.dscp = []
traffic.cos_3.priority_source.dscp = []
traffic.cos_4.priority_source.dscp = []
traffic.cos_5.priority_source.dscp = []
traffic.cos_6.priority_source.dscp = []
traffic.cos_7.priority_source.dscp =
[56,57,58,59,60,61,62,63]
# Per-port source packet fields and mapping: applies to the
designated set of ports.
source.port_group_list = [source_port_group]
source.source_port_group.packet_priority_source_set = [802.1p,dscp]
source.source_port_group.port_set = swp1-swp4,swp6
source.source_port_group.cos_0.priority_source.8021p = [7]
source.source_port_group.cos_1.priority_source.8021p = [6]
source.source_port_group.cos_2.priority_source.8021p = [5]
source.source_port_group.cos_3.priority_source.8021p = [4]
source.source_port_group.cos_4.priority_source.8021p = [3]
source.source_port_group.cos_5.priority_source.8021p = [2]
source.source_port_group.cos_6.priority_source.8021p = [1]
source.source_port_group.cos_7.priority_source.8021p = [0]
# priority groups
traffic.priority_group_list = [control, service, bulk]
# internal cos values assigned to each priority group
# each cos value should be assigned exactly once
# internal cos values {0..7}
priority_group.control.cos_list = [7]
priority_group.service.cos_list = [2]
priority_group.bulk.cos_list = [0,1,3,4,5,6]
# to configure priority flow control on a group of ports:
# -- assign cos value(s) to the cos list
# -- add or replace a port group names in the port group list
# -- for each port group in the list
#   -- populate the port set, e.g.
#     swp1-swp4,swp8,swp50s0-swp50s3
#   -- set a PFC buffer size in bytes for each port in the group
#   -- set the xoff byte limit (buffer limit that triggers PFC frame
transmit to start)
#   -- set the xon byte delta (buffer limit that triggers PFC frame
transmit to stop)
#   -- enable PFC frame transmit and/or PFC frame receive
# priority flow control
```

```

# pfc.port_group_list = [pfc_port_group]
# pfc.pfc_port_group.cos_list = []
# pfc.pfc_port_group.port_set = swp1-swp4,swp6
# pfc.pfc_port_group.port_buffer_bytes = 25000
# pfc.pfc_port_group.xoff_size = 10000
# pfc.pfc_port_group.xon_delta = 2000
# pfc.pfc_port_group.tx_enable = true
# pfc.pfc_port_group.rx_enable = true
# to configure pause on a group of ports:
# -- add or replace port group names in the port group list
# -- for each port group in the list
#   -- populate the port set, e.g.
#       swp1-swp4,swp8,swp50s0-swp50s3
#   -- set a pause buffer size in bytes for each port in the group
#   -- set the xoff byte limit (buffer limit that triggers pause
frames transmit to start)
#   -- set the xon byte delta (buffer limit that triggers pause
frames transmit to stop)
# link pause
# link_pause.port_group_list = [pause_port_group]
# link_pause.pause_port_group.port_set = swp1-swp4,swp6
# link_pause.pause_port_group.port_buffer_bytes = 25000
# link_pause.pause_port_group.xoff_size = 10000
# link_pause.pause_port_group.xon_delta = 2000
# link_pause.pause_port_group.rx_enable = true
# link_pause.pause_port_group.tx_enable = true
# scheduling algorithm: algorithm values = {dwrr}
scheduling.algorithm = dwrr
# traffic group scheduling weight
# weight values = {0..127}
# '0' indicates strict priority
priority_group.control.weight = 0
priority_group.service.weight = 32
priority_group.bulk.weight = 16
# To turn on/off Denial of service (DOS) prevention checks
dos_enable = false
# Cut-through is disabled by default on all chips with the exception
of
# Spectrum. On Spectrum cut-through cannot be disabled.
#cut_through_enable = false
# Enable resilient hashing
#resilient_hash_enable = FALSE
# Resilient hashing flowset entries per ECMP group
# Valid values - 64, 128, 256, 512, 1024
#resilient_hash_entries_ecmp = 128
# Enable symmetric hashing
#symmetric_hash_enable = TRUE
# Set sflow/sample ingress cpu packet rate and burst in packets/sec
# Values: {0..16384}
#sflow.rate = 16384
#sflow.burst = 16384
#Specify the maximum number of paths per route entry.

```

```

# Maximum paths supported is 200.
# Default value 0 takes the number of physical ports as the max path
size.
#ecmp_max_paths = 0
#Specify the hash seed for Equal cost multipath entries
# Default value 0
# Value Rang: {0..4294967295}
#ecmp_hash_seed = 42
# Specify the forwarding table resource allocation profile, applicable
# only on platforms that support universal forwarding resources.
#
# /usr/cumulus/sbin/cl-rsource-query reports the allocated table sizes
# based on the profile setting.
#
# Values: one of {'default', 'l2-heavy', 'v4-lpm-heavy', 'v6-lpm-
heavy'}
# Default value: 'default'
# Note: some devices may support more modes, please consult user
#       guide for more details
#
#forwarding_table.profile = default

```



On Mellanox Spectrum switches, packet priority remark must be enabled on the **ingress** port. A packet received on a remark-enabled port is remarked according to the priority mapping configured on the **egress** port. If packet priority remark is configured the same way on every port, the default configuration example above is correct. However, per-port customized configurations require two port groups: one for the ingress ports and one for the egress ports, as below:

```

remark.port_group_list = [ingress_remark_group,
egress_remark_group]
remark.ingress_remark_group.packet_priority_remark_set = [dscp]
remark.remark_port_group.port_set = swp1-swp4,swp6
remark.egress_remark_group.port_set = swp10-swp20
remark.egress_remark_group.cos_0.priority_remark.dscp = [2]
remark.egress_remark_group.cos_1.priority_remark.dscp = [10]
remark.egress_remark_group.cos_2.priority_remark.dscp = [18]
remark.egress_remark_group.cos_3.priority_remark.dscp = [26]
remark.egress_remark_group.cos_4.priority_remark.dscp = [34]
remark.egress_remark_group.cos_5.priority_remark.dscp = [42]
remark.egress_remark_group.cos_6.priority_remark.dscp = [50]
remark.egress_remark_group.cos_7.priority_remark.dscp = [58]

```

## Configure Traffic Marking through ACL Rules

You can mark traffic for egress packets through `iptables` or `ip6tables` rule classifications. To enable these rules, you do one of the following:



- Mark DSCP values in egress packets.
- Mark 802.1p CoS values in egress packets.

To enable traffic marking, use `c1-acltool`. Add the `-p` option to specify the location of the policy file. By default, if you don't include the `-p` option, `c1-acltool` looks for the policy file in `/etc/cumulus/acl/policy.d/`.

The `iptables`-`/ip6tables`-based marking is supported via the following action extension:

```
-j SETQOS --set-dscp 10 --set-cos 5
```

For `ebtables`, the `setqos` keyword must be in lowercase, as in:

```
[ebtables]
-A FORWARD -o swp5 -j setqos --set-cos 5
```

You can specify one of the following targets for `SETQOS`/`setqos`:

Option	Description
--set-cos INT	Sets the datapath resource/queuing class value. Values are defined in <a href="#">IEEE_P802.1p</a> .
--set-dscp value	Sets the DSCP field in packet header to a value, which can be either a decimal or hex value.
--set-dscp-class class	Sets the DSCP field in the packet header to the value represented by the DiffServ class value. This class can be EF, BE or any of the CSxx or AFxx classes.



You can specify either `--set-dscp` or `--set-dscp-class`, but not both.

Here are two example rules:

```
[iptables]
-t mangle -A FORWARD --in-interface swp+ -p tcp --dport bgp -j SETQOS
--set-dscp 10 --set-cos 5

[ip6tables]
-t mangle -A FORWARD --in-interface swp+ -j SETQOS --set-dscp 10
```

You can put the rule in either the `mangle` table or the default `filter` table; the `mangle` table and `filter` table are put into separate TCAM slices in the hardware.

To put the rule in the `mangle` table, include `-t mangle`; to put the rule in the `filter` table, omit `-t mangle`.

## Configure Priority Flow Control

Priority flow control, as defined in the [IEEE 802.1Qbb standard](#), provides a link-level flow control mechanism that can be controlled independently for each Class of Service (CoS) with the intention to ensure no data frames are lost when congestion occurs in a bridged network.



PFC is not supported on switches with the Helix4 ASIC.

PFC is a layer 2 mechanism that prevents congestion by throttling packet transmission. When PFC is enabled for received packets on a set of switch ports, the switch detects congestion in the ingress buffer of the receiving port and signals the upstream switch to stop sending traffic. If the upstream switch has PFC enabled for packet transmission on the designated priorities, it responds to the downstream switch and stops sending those packets for a period of time.

PFC operates between two adjacent neighbor switches; it does not provide end-to-end flow control. However, when an upstream neighbor throttles packet transmission, it could build up packet congestion and propagate PFC frames further upstream: eventually the sending server could receive PFC frames and stop sending traffic for a time.

The PFC mechanism can be enabled for individual switch priorities on specific switch ports for RX and/or TX traffic. The switch port's ingress buffer occupancy is used to measure congestion. If congestion is present, the switch transmits flow control frames to the upstream switch. Packets with priority values that do not have PFC configured are not counted during congestion detection; neither do they get throttled by the upstream switch when it receives flow control frames.

PFC congestion detection is implemented on the switch using xoff and xon threshold values for the specific ingress buffer which is used by the targeted switch priorities. When a packet enters the buffer and the buffer occupancy is above the xoff threshold, the switch transmits an Ethernet PFC frame to the upstream switch to signal packet transmission should stop. When the buffer occupancy drops below the xon threshold, the switch sends another PFC frame upstream to signal that packet transmission can resume. (PFC frames contain a quanta value to indicate a timeout value for the upstream switch: packet transmission can resume after the timer has expired, or when a PFC frame with quanta == 0 is received from the downstream switch.)

After the downstream switch has sent a PFC frame upstream, it continues to receive packets until the upstream switch receives and responds to the PFC frame. The downstream ingress buffer must be large enough to store those additional packets after the xoff threshold has been reached.



Before Cumulus Linux 3.1.1, PFC was designated as a *lossless* priority group. The lossless priority group has been removed from Cumulus Linux.

Priority flow control is fully supported on both [Broadcom](#) and [Mellanox switches](#).

PFC is disabled by default in Cumulus Linux. Enabling priority flow control (PFC) requires configuring the following settings in `/etc/cumulus/datapath/traffic.conf` on the switch:

- Specifying the name of the port group in `pfc.port_group_list` in brackets; for example, `pfc.port_group_list = [pfc_port_group]`.
- Assigning a CoS value to the port group in `pfc.pfc_port_group.cos_list` setting. Note that `pfc_port_group` is the name of a port group you specified above and is used throughout the following settings.
- Populating the port group with its member ports in `pfc.pfc_port_group.port_set`.



- Setting a PFC buffer size in `pfc.pfc_port_group.port_buffer_bytes`. This is the maximum number of bytes allocated for storing bursts of packets, guaranteed at the ingress port. The default is 25000 bytes.
- Setting the xoff byte limit in `pfc.pfc_port_group.xoff_size`. This is a threshold for the PFC buffer; when this limit is reached, an xoff transition is initiated, signaling the upstream port to stop sending traffic, during which time packets continue to arrive due to the latency of the communication. The default is 10000 bytes.
- Setting the xon delta limit in `pfc.pfc_port_group.xon_delta`. This is the number of bytes to subtract from the xoff limit, which results in a second threshold at which the egress port resumes sending traffic. After the xoff limit is reached and the upstream port stops sending traffic, the buffer begins to drain. When the buffer reaches 8000 bytes (assuming default xoff and xon settings), the egress port signals that it can start receiving traffic again. The default is 2000 bytes.
- Enabling the egress port to signal the upstream port to stop sending traffic (`pfc.pfc_port_group.tx_enable`). The default is `true`.
- Enabling the egress port to receive notifications and act on them (`pfc.pfc_port_group.rx_enable`). The default is `true`.
- The switch priority value(s) are mapped to the specific ingress buffer for each targeted switch port. Cumulus Linux looks at either the 802.1p bits or the IP layer DSCP bits depending on which is configured in the `traffic.conf` file to map packets to internal switch priority values.

The following configuration example shows PFC configured for ports swp1 through swp4 and swp6:

```
# to configure priority flow control on a group of ports:  
# -- assign cos value(s) to the cos list  
# -- add or replace a port group names in the port group list  
# -- for each port group in the list  
#     -- populate the port set, e.g.  
#         swp1-swp4,swp8,swp50s0-swp50s3  
#     -- set a PFC buffer size in bytes for each port in the group  
#     -- set the xoff byte limit (buffer limit that triggers PFC frame  
transmit to start)  
#     -- set the xon byte delta (buffer limit that triggers PFC frame  
transmit to stop)  
#     -- enable PFC frame transmit and/or PFC frame receive  
# priority flow control  
pfc.port_group_list = [pfc_port_group]  
pfc.pfc_port_group.cos_list = []  
pfc.pfc_port_group.port_set = swp1-swp4,swp6  
pfc.pfc_port_group.port_buffer_bytes = 25000  
pfc.pfc_port_group.xoff_size = 10000  
pfc.pfc_port_group.xon_delta = 2000  
pfc.pfc_port_group.tx_enable = true  
pfc.pfc_port_group.rx_enable = true
```

## Port Groups

A *port group* refers to one or more sequences of contiguous ports. Multiple port groups can be defined by:

- Adding a comma-separated list of port group names to the `port_group_list`.



- Adding the port\_set, rx\_enable, and tx\_enable configuration lines for each port group.

You can specify the set of ports in a port group in comma-separated sequences of contiguous ports; you can see which ports are contiguous in `/var/lib/cumulus/porttab`. The syntax supports:

- A single port (`swp1s0` or `swp5`)
- A sequence of regular swp ports (`swp2-swp5`)
- A sequence within a breakout swp port (`swp6s0-swp6s3`)
- A sequence of regular and breakout ports, provided they are all in a contiguous range. For example:

```
...
swp2
swp3
swp4
swp5
swp6s0
swp6s1
swp6s2
swp6s3
swp7
...
```

Restart `switchd` (see page 207) to allow the PFC configuration changes to take effect:

```
cumulus@switch:~$ sudo systemctl restart switchd.service
```

## Configure Link Pause

The PAUSE frame is a flow control mechanism that halts the transmission of the transmitter for a specified period of time. A server or other network node within the data center may be receiving traffic faster than it can handle it, thus the PAUSE frame. In Cumulus Linux, individual ports can be configured to execute link pause by:

- Transmitting pause frames when its ingress buffers become congested (TX pause enable) and/or
- Responding to received pause frames (RX pause enable).

Link pause is disabled by default. Enabling link pause requires configuring settings in `/etc/cumulus/datapath/traffic.conf`, similar to how you configure [priority flow control \(see page 275\)](#). The settings are explained in that section as well.



What's the difference between link pause and priority flow control?

Priority flow control is applied to an individual priority group for a specific ingress port.

Link pause (also known as port pause or global pause) is applied to all the traffic for a specific ingress port.

Here is an example configuration that enables both types of link pause for `swp1` through `swp4` and `swp6`:



```
# to configure pause on a group of ports:  
# -- add or replace port group names in the port group list  
# -- for each port group in the list  
#   -- populate the port set, e.g.  
#       swp1-swp4,swp8,swp50s0-swp50s3  
#   -- set a pause buffer size in bytes for each port in the group  
#   -- set the xoff byte limit (buffer limit that triggers pause  
frames transmit to start)  
#   -- set the xon byte delta (buffer limit that triggers pause  
frames transmit to stop)  
  
# link pause  
link_pause.port_group_list = [pause_port_group]  
link_pause.pause_port_group.port_set = swp1-swp4,swp6  
link_pause.pause_port_group.port_buffer_bytes = 25000  
link_pause.pause_port_group.xoff_size = 10000  
link_pause.pause_port_group.xon_delta = 2000  
link_pause.pause_port_group.rx_enable = true  
link_pause.pause_port_group.tx_enable = true
```

Restart `switchd` (see page 207) to allow link pause configuration changes to take effect:

```
cumulus@switch:~$ sudo systemctl restart switchd.service
```

## Configure Cut-through Mode and Store and Forward Switching

Cut-through mode is disabled in Cumulus Linux by default on switches with Broadcom ASICs. With cut-through mode enabled and link pause is asserted, Cumulus Linux generates a TOVR and TUFL ERROR; certain error counters increment on a given physical port.

```
cumulus@switch:~$ sudo ethtool -S swp49 | grep Error  
HwIfInDot3LengthErrors: 0  
HwIfInErrors: 0  
HwIfInDot3FrameErrors: 0  
SoftInErrors: 0  
SoftInFrameErrors: 0  
HwIfOutErrors: 35495749  
SoftOutErrors: 0  
  
cumulus@switch:~$ sudo ethtool -S swp50 | grep Error  
HwIfInDot3LengthErrors: 3038098  
HwIfInErrors: 297595762  
HwIfInDot3FrameErrors: 293710518
```

To work around this issue, disable link pause or disable cut-through mode in `/etc/cumulus/datapath/traffic.conf`.

To disable link pause, comment out the `link_pause*` section in `/etc/cumulus/datapath/traffic.conf`:

```
cumulus@switch:~$ sudo nano /etc/cumulus/datapath/traffic.conf
#link_pause.port_group_list = [port_group_0]
#link_pause.port_group_0.port_set = swp45-swp54
#link_pause.port_group_0.rx_enable = true
#link_pause.port_group_0.tx_enable = true
```

To enable store and forward switching, set `cut_through_enable` to `false` in `/etc/cumulus/datapath/traffic.conf`:

```
cumulus@switch:~$ sudo nano /etc/cumulus/datapath/traffic.conf
cut_through_enable = false
```



On switches using Broadcom Tomahawk, Trident II, Trident II+, and Trident3 ASICs, Cumulus Linux supports store and forward switching but does **not** support cut-through mode.

On switches using Mellanox Spectrum ASICs, Cumulus Linux supports cut-through mode but does **not** support store and forward switching.

## Configure Explicit Congestion Notification

*Explicit Congestion Notification (ECN)* is defined by [RFC 3168](#). ECN gives a Cumulus Linux switch the ability to mark a packet to signal impending congestion instead of dropping the packet outright, which is how TCP typically behaves when ECN is not enabled.

ECN is a layer 3 end-to-end congestion notification mechanism only. Packets can be marked as *ECN-capable transport* (ECT) by the sending server. If congestion is observed by any switch while the packet is getting forwarded, the ECT-enabled packet can be marked by the switch to indicate the congestion. The end receiver can respond to the ECN-marked packets by signaling the sending server to slow down transmission. The sending server marks a packet *ECT* by setting the least 2 significant bits in an IP header `DiffServ` (ToS) field to `01` or `10`. A packet that has the least 2 significant bits set to `00` indicates a non-ECT-enabled packet.

The ECN mechanism on a switch only marks packets to notify the end receiver. It does not take any other action or change packet handling in any way, nor does it respond to packets that have already been marked ECN by an upstream switch.



**On Trident II switches only**, if ECN is enabled on a specific queue, the ASIC also enables RED on the same queue. If the packet is ECT marked (the ECN bits are `01` or `10`), the ECN mechanism executes as described above. However, if it is entering an ECN-enabled queue but is not ECT marked (the ECN bits are `00`), then the RED mechanism uses the same threshold and probability values to decide whether to drop the packet. Packets entering a non-ECN-enabled queue do not get marked or dropped due to ECN or RED in any case.



ECN is implemented on the switch using minimum and maximum threshold values for the egress queue length. When a packet enters the queue and the average queue length is between the minimum and maximum threshold values, a configurable probability value will determine whether the packet will be marked. If the average queue length is above the maximum threshold value, the packet is always marked.

The downstream switches with ECN enabled perform the same actions as the traffic is received. If the ECN bits are set, they remain set. The only way to overwrite ECN bits is to enable it — that is, set the ECN bits to 11.

ECN is supported on [Broadcom Tomahawk, Tomahawk2, Trident II, Trident II+ and Trident3, and Mellanox Spectrum switches](#).

### **Click to learn how to configure ECN ...**

ECN is disabled by default in Cumulus Linux. You can enable ECN for individual switch priorities on specific switch ports. ECN requires configuring the following settings in `/etc/cumulus/datapath/traffic.conf` on the switch:

- Specifying the name of the port group in `ecn.port_group_list` in brackets; for example, `ecn.port_group_list = [ecn_port_group]`.
- Assigning a CoS value to the port group in `ecn.ecn_port_group.cos_list`. If the CoS value of a packet matches the value of this setting, then ECN is applied. Note that `ecn_port_group` is the name of a port group you specified above.
- Populating the port group with its member ports (`ecn.ecn_port_group.port_set`), where `ecn_port_group` is the name of the port group you specified above. Congestion is measured on the egress port queue for the ports listed here, using the average queue length: if congestion is present, a packet entering the queue may be marked to indicate that congestion was observed. Marking a packet involves setting the least 2 significant bits in the IP header DiffServ (ToS) field to 11.
- The switch priority value(s) are mapped to specific egress queues for the target switch ports.
- The `ecn.ecn_port_group.probability` value indicates the probability of a packet being marked if congestion is experienced.

The following configuration example shows ECN configured for ports swp1 through swp4 and swp6:

```
# Explicit Congestion Notification
# to configure ECN on a group of ports:
# -- add or replace port group names in the port group list
# -- assign cos value(s) to the cos list *ECN will only be applied
to traffic matching this COS*
# -- for each port group in the list
#     -- populate the port set, e.g.
#         swp1-swp4,swp8,swp50s0-swp50s3
ecn.port_group_list = [ecn_port_group]
ecn.ecn_port_group.cos_list = [0]
ecn.ecn_port_group.port_set = swp1-swp4,swp6
ecn.ecn_port_group.min_threshold_bytes = 40000
ecn.ecn_port_group.max_threshold_bytes = 200000
ecn.ecn_port_group.probability = 100
```

Restart `switchd` (see page 207) to allow the ECN configuration changes to take effect:

```
cumulus@switch:~$ sudo systemctl restart switchd.service
```



## Check Interface Buffer Status

On Mellanox switches, you can collect a fine-grained history of queue lengths using histograms maintained by the ASIC; see the [ASIC monitoring chapter \(see page 957\)](#) for details.

On Broadcom switches, the buffer status is not visible currently.

## Related Information

- [iptables-extensions man page](#)

## Hardware-enabled DDOS Protection

It is crucial to also protect a switch's control plane to ensure the proper control plane applications have access to the switch's CPU. Failure to do so could increase vulnerabilities to a Denial of Service (DOS) attack. Cumulus Linux provides control plane protection by default. It also offers a DDOS protection mechanism, which protects data plane, control plane and management plane traffic in the switch. It drops any packets that match one or more of the following criteria while incurring no performance impact:

- Source IP address matches the destination address for IPv4 and IPv6 packets
- Source MAC address matches the destination MAC address
- Unfragmented or first fragment SYN packets with a source port of 0-1023
- TCP packets with control flags =0 and seq number == 0
- TCP packets with FIN, URG and PSH bits set and seq number == 0
- TCP packets with both SYN and FIN bits set
- TCP source PORT matches the destination PORT
- UDP source PORT matches the destination PORT
- First TCP fragment with partial TCP header
- TCP header has fragment offset value of 1
- ICMPv6 ping packets payload larger than programmed value of ICMP max size
- ICMPv4 ping packets payload larger than programmed value of ICMP max size
- Fragmented ICMP packet
- IPv6 fragment lower than programmed minimum IPv6 packet size

## Supported ASICs

DDOS protection is available for the following Broadcom ASICs:

- Helix4
- Maverick
- Tomahawk
- Tomahawk+
- Trident
- Trident-II
- Trident-II+



- Trident3

Cumulus Networks recommends enabling this feature when deploying a switch with one of the above mentioned ASICs, as hardware-based DDOS protection is disabled by default. Although Cumulus recommends enabling all of the above criteria, they can be individually enabled if desired. None of them are enabled by default.

DDOS protection is not supported on Broadcom Hurricane2 and Mellanox Spectrum ASICs.

### Configure Persistent DDOS Protection

1. Open the `/etc/cumulus/datapath/traffic.conf` file in a text editor.
2. Enable DOS prevention checks by changing the following value to `true`, and save the file:

```
# To turn on/off Denial of Service (DOS) prevention checks
dos_enable = true
```

3. Open the `/usr/lib/python2.7/dist-packages/cumulus/__chip_config/bcm/datapath.conf` file in a text editor and set the following checks to `true`, and save the file:

```
cumulus@switch:~$ sudo nano /usr/lib/python2.7/dist-packages
/cumulus/__chip_config/bcm/datapath.conf
# Enabling/disabling Denial of service (DOS) prevention checks
# To change the default configuration:
# enable/disable the individual DOS checks.
dos.sip_eq_dip = true
dos.smac_eq_dmac = true
dos.tcp_hdr_partial = true
dos.tcp_syn_frag = true
dos.tcp_ports_eq = true
dos.tcp_flags_syn_fin = true
dos.tcp_flags_fup_seq0 = true
dos.tcp_offset1 = true
dos.tcp_ctrl0_seq0 = true
dos.udp_ports_eq = true
dos.icmp_frag = true
dos.icmpv4_length = true
dos.icmpv6_length = true
dos.ipv6_min_frag = true
```



Configuring any of the following settings affects the [BFD echo \(see page 821\)](#) function. For example, if you enable `dos.udp_ports_eq`, all the BFD packets will get dropped because the BFD protocol uses the same source and destination UDP ports.

```
dos.sip_eq_dip
dos.smac_eq_dmac
dos.tcp_ctrl0_seq0
```

- dos.tcp\_flags\_fup\_seq0
- dos.tcp\_flags\_syn\_fin
- dos.tcp\_ports\_eq
- dos.tcp\_syn\_frag
- dos.udp\_ports\_eq

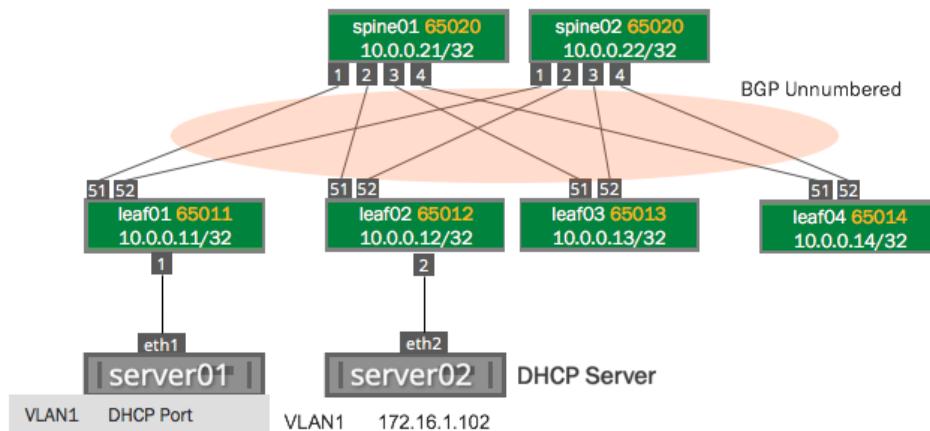
4. Restart `switchd` to enable DDOS protection:

```
cumulus@switch:~$ sudo systemctl restart switchd.service
```

## DHCP Relays

You can configure DHCP relays for IPv4 and IPv6.

To run DHCP for both IPv4 and IPv6, initiate the DHCP relay once for IPv4 and once for IPv6. Following are the configurations on the server hosts, DHCP relay, and DHCP server using the following topology:



The `dhcpd` and `dhcrelay` services are disabled by default. After you finish configuring the DHCP relays and servers, you need to start those services. If you intend to run these services within a VRF (see page 847), including the management VRF (see page 877), follow these steps (see page 879) for configuring them. See also the VRF chapter (see page ).

## Contents

This topic describes ...

- Configure IPv4 DHCP Relays (see page 291)
  - DHCP Option 82 (see page 292)
  - Control the Gateway IP Address with RFC 3527 (see page 292)
- Configure IPv6 DHCP Relays (see page 294)

- Configure Multiple DHCP Relays (see page 295)
- Configure a DHCP Relay with VRR (see page 296)
- Configure the DHCP Relay Service Manually (Advanced) (see page 296)
- Use the Gateway IP Address as the Source IP for Relayed DHCP Packets (Advanced) (see page 297)
- Troubleshooting (see page 297)
  - Configuration Errors (see page 298)

## Configure IPv4 DHCP Relays

Configure `isc-dhcp-relay` using [NCLU \(see page 88\)](#), specifying the IP addresses to each DHCP server and the interfaces that are used as the uplinks.

In the examples below, the DHCP server IP address is 172.16.1.102, VLAN 1 (the SVI is `vlan1`) and the uplinks are `swp51` and `swp52`.



You configure a DHCP relay on a per-VLAN basis, specifying the SVI, not the parent bridge; in our example, you would specify `vlan1` as the SVI for VLAN 1; do not specify the bridge named `bridge` in this case.

As per [RFC 3046](#), you can specify as many server IP addresses that can fit in 255 octets, specifying each address only once.

```
cumulus@leaf01:~$ net add dhcp relay interface swp51
cumulus@leaf01:~$ net add dhcp relay interface swp52
cumulus@leaf01:~$ net add dhcp relay interface vlan1
cumulus@leaf01:~$ net add dhcp relay server 172.16.1.102
cumulus@leaf01:~$ net pending
cumulus@leaf01:~$ net commit
```

These commands create the following configuration in the `/etc/default/isc-dhcp-relay` file:

```
cumulus@leaf01:~$ cat /etc/default/isc-dhcp-relay
SERVERS="172.16.1.102"
INTF_CMD="-i vlan1 -i swp51 -i swp52"
OPTIONS=""
```

After you finish configuring DHCP relay, restart then enable the `dhcrelay` service so the configuration persists between reboots:

```
cumulus@leaf01:~$ sudo systemctl restart dhcrelay.service
cumulus@leaf01:~$ sudo systemctl enable dhcrelay.service
```

To see the DHCP relay status, use the `systemctl status dhcrelay.service` command:

```
cumulus@leaf01:~$ sudo systemctl status dhcrelay.service
dhcrelay.service - DHCPv4 Relay Agent Daemon
   Loaded: loaded (/lib/systemd/system/dhcrelay.service; enabled)
   Active: active (running) since Fri 2016-12-02 17:09:10 UTC; 2min
          16s ago
     Docs: man:dhcrelay(8)
 Main PID: 1997 (dhcrelay)
    CGroup: /system.slice/dhcrelay.service
              1997 /usr/sbin/dhcrelay --nl -d -q -i vlan1 -i swp51 -i
              swp52 172.16.1.102
```

## DHCP Option 82

You can configure DHCP relays to inject the `circuit-id` field with the `-a` option, which you add to the `OPTIONS` line in the `/etc/default/isc-dhcp-relay` file. By default, the ingress SVI interface against which the relayed DHCP discover packet is processed is injected into this field. You can change this behavior by adding the `--use-pif-circuit-id` option. With this option, the physical switch port (swp) on which the discover packet arrives is placed in the `circuit-id` field.

## Control the Gateway IP Address with RFC 3527

When DHCP relay is required in an environment that relies on an anycast gateway (such as EVPN), a unique IP address is necessary on each device for return traffic. By default, in a BGP unnumbered environment with DHCP relay, the source IP address is set to the loopback IP address and the gateway IP address (`giaddr`) is set as the SVI IP address. However with anycast traffic, the SVI IP address is not unique to each rack; it is typically shared amongst all racks. Most EVPN ToR deployments only possess a single unique IP address, which is the loopback IP address.

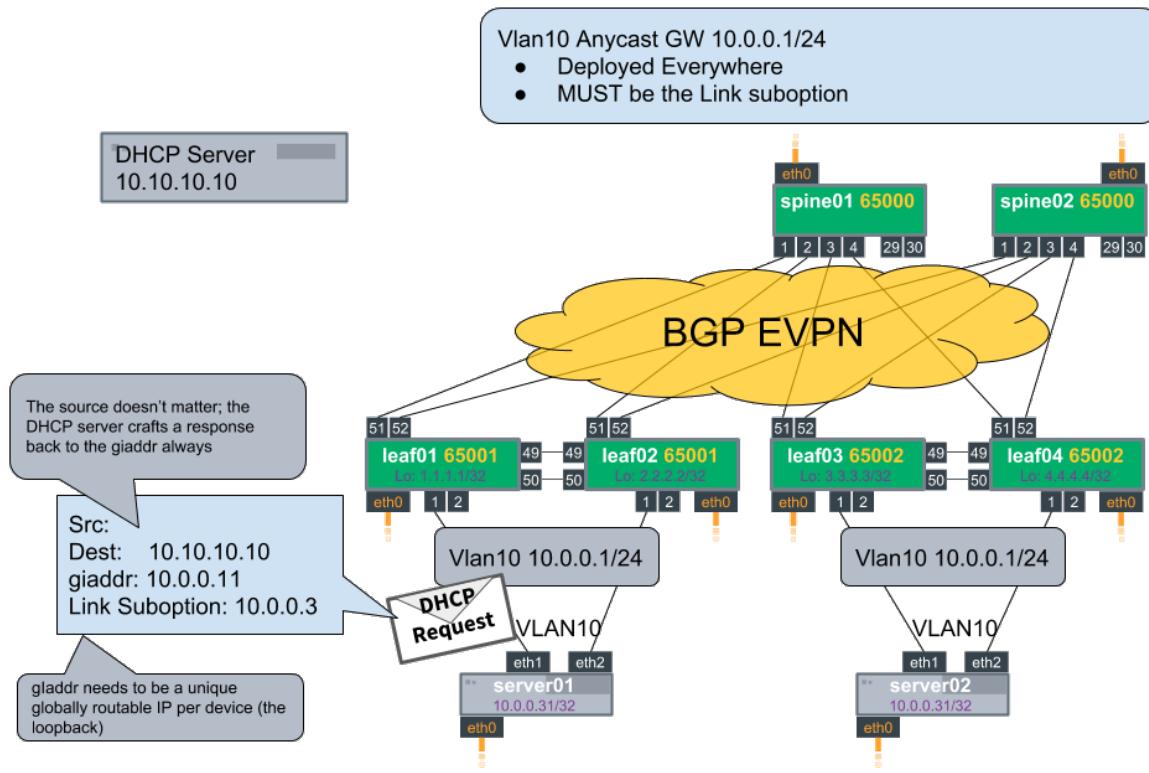
[RFC 3527](#) enables the DHCP server to react to these environments by introducing a new parameter to the DHCP header called the *link selection sub-option*, which is built by the DHCP relay agent. The link selection sub-option takes on the normal role of the `giaddr` in relaying to the DHCP server which subnet is correlated to the DHCP request. When using this sub-option, the `giaddr` continues to be present but only relays the return IP address that is to be used by the DHCP server; the `giaddr` becomes the unique loopback IP address.

When enabling RFC 3527 support, you can specify an interface, such as the loopback interface or a switchport interface to be used as the `giaddr`. The relay picks the first IP address on that interface. If the interface has multiple IP addresses, you can specify a specific IP address for the interface.



RFC 3527 is supported for IPv4 DHCP relays only.

The following illustration demonstrates how you can control the `giaddr` with RFC 3527.



To enable RFC 3527 support and control the giaddr, run the `net add dhcp relay giaddr-interface` command with interface/IP address you want to use.

The following example uses the first IP address on the loopback interface as the giaddr:

```
cumulus@leaf01:~$ net add dhcp relay giaddr-interface lo
```

The above command creates the following configuration in the `/etc/default/isc-dhcp-relay` file:

```
cumulus@leaf01:~$ cat /etc/default/isc-dhcp-relay
...
# Additional options that are passed to the DHCP relay daemon?
OPTIONS="-U lo"
```



The first IP address on the loopback interface is typically the 127.0.0.1 address; Cumulus Networks recommends that you use more specific syntax, as shown in the next example.

The following example uses IP address 10.0.0.1 on the loopback interface as the giaddr:

```
cumulus@leaf01:~$ net add dhcp relay giaddr-interface lo 10.0.0.1
```

The above command creates the following configuration in the `/etc/default/isc-dhcp-relay` file:



```
cumulus@leaf01:~$ cat /etc/default/isc-dhcp-relay
...
# Additional options that are passed to the DHCP relay daemon?
OPTIONS="-U 10.0.0.1%lo"
```

The following example uses the first IP address on swp2 as the giaddr:

```
cumulus@leaf01:~$ net add dhcp relay giaddr-interface swp2
```

The above command creates the following configuration in the `/etc/default/isc-dhcp-relay` file:

```
cumulus@leaf01:~$ cat /etc/default/isc-dhcp-relay
...
# Additional options that are passed to the DHCP relay daemon?
OPTIONS="-U swp2"
```

The following example uses IP address 10.0.0.3 on swp2 as the giaddr:

```
cumulus@leaf01:~$ net add dhcp relay giaddr-interface swp2 10.0.0.3
```

The above command creates the following configuration in the `/etc/default/isc-dhcp-relay` file:

```
cumulus@leaf01:~$ cat /etc/default/isc-dhcp-relay
...
# Additional options that are passed to the DHCP relay daemon?
OPTIONS="-U 10.0.0.3%swp2"
```

## Configure IPv6 DHCP Relays

If you are configuring IPv6, the `/etc/default/isc-dhcp-relay6` variables file has a different format than the `/etc/default/isc-dhcp-relay` file for IPv4 DHCP relays. Make sure to configure the variables appropriately by editing this file.



You cannot use NCLU to configure IPv6 relays.

```
cumulus@leaf01:$ sudo nano /etc/default/isc-dhcp-relay6
SERVERS=" -u 2001:db8:100::2%swp51 -u 2001:db8:100::2%swp52"
INTF_CMD="-l vlan1"
```



After you finish configuring the DHCP relay, save your changes, restart the dhcrelay6 service, then enable the dhcrelay6 service so the configuration persists between reboots:

```
cumulus@leaf01:~$ sudo systemctl restart dhcrelay6.service
cumulus@leaf01:~$ sudo systemctl enable dhcrelay6.service
```

To see the status of the IPv6 DHCP relay, use the `systemctl status dhcrelay6.service` command:

```
cumulus@leaf01:~$ sudo systemctl status dhcrelay6.service
dhcrelay6.service - DHCPv6 Relay Agent Daemon
  Loaded: loaded (/lib/systemd/system/dhcrelay6.service; disabled)
  Active: active (running) since Fri 2016-12-02 21:00:26 UTC; 1s ago
    Docs: man:dhcrelay(8)
 Main PID: 6152 (dhcrelay)
   CGroup: /system.slice/dhcrelay6.service
           6152 /usr/sbin/dhcrelay -6 --nl -d -q -l vlan1 -u 2001:db8:
100::2 swp51 -u 2001:db8:100::2 swp52
```

## Configure Multiple DHCP Relays

Cumulus Linux supports multiple DHCP relay daemons on a switch to enable relaying of packets from different bridges to different upstreams.

To configure multiple DHCP relay daemons on a switch:

1. As the sudo user, open the `/etc/vrf/systemd.conf` file in a text editor and remove `dhcrelay`.
2. To reload the `systemd` files, run the following command:

```
cumulus@switch:~$ sudo systemctl daemon-reload
```

3. Create a config file in `/etc/default` using the following format for each `dhcrelay: isc-dhcp-relay-<dhcp-name>`. An example file is shown below:

```
# Defaults for isc-dhcp-relay initscript# sourced by /etc/init.d
#/isc-dhcp-relay
# installed at /etc/default/isc-dhcp-relay by the maintainer
scripts
#
# This is a POSIX shell fragment
#
# What servers should the DHCP relay forward requests to?
SERVERS="102.0.0.2"
# On what interfaces should the DHCP relay (dhcrelay) serve DHCP
requests?
# Always include the interface towards the DHCP server.
```



```
# This variable requires a -i for each interface configured above.  
# This will be used in the actual dhcrelay command  
# For example, "-i eth0 -i eth1"  
INTF_CMD="-i swp2s2 -i swp2s3"  
# Additional options that are passed to the DHCP relay daemon?  
OPTIONS=""
```

- Run the following command to start a dhcrelay instance. Replace `dhcp-name` with the instance name or number:

```
cumulus@switch:~$ sudo systemctl start dhcrelay@<dhcp-name>
```

## Configure a DHCP Relay with VRR

The configuration procedure for DHCP relay with VRR is the same as documented above. Note that DHCP relay must run on the SVI and not on the -v0 interface.

## Configure the DHCP Relay Service Manually (Advanced)

### Configuring the DHCP service manually ...

By default, Cumulus Linux configures the DHCP relay service automatically. However, in older versions of Cumulus Linux, you needed to edit the `dhcrelay.service` file as described below. The IPv4 `dhcrelay.service` *Unit* script calls `/etc/default/isc-dhcp-relay` to find launch variables.

```
cumulus@switch:~$ cat /lib/systemd/system/dhcrelay.service  
[Unit]  
Description=DHCPv4 Relay Agent Daemon  
Documentation=man:dhcrelay(8)  
After=network-online.target networking.service syslog.service  
[Service]  
Type=simple  
EnvironmentFile=/etc/default/isc-dhcp-relay  
# Here, we are expecting the INTF_CMD to contain  
# the -i for each interface specified,  
# e.g. "-i eth0 -i swp1"  
ExecStart=/usr/sbin/dhcrelay -d -q $INTF_CMD $SERVERS $OPTIONS  
[Install]  
WantedBy=multi-user.target
```

The `/etc/default/isc-dhcp-relay` variables file needs to reference both interfaces participating in DHCP relay (facing the server and facing the client) and the IP address of the server. If the client-facing interface is a bridge port, specify the switch virtual interface (SVI) name if you are using a [VLAN-aware bridge](#) (see page 415) (for example, `vlan100`), or the bridge name if you are using traditional bridging (for example, `br100`).



## Use the Gateway IP Address as the Source IP for Relayed DHCP Packets (Advanced)

### Using the gateway IP address as the source IP for relayed DHCP packets

You can configure the `dhcrelay` service to forward IPv4 (only) DHCP packets to a server and ensure that the source IP address of the relayed packet is the same as the gateway IP address. You do this by enabling the `giaddr-src` option; when set, `dhcrelay` attempts to set the source IP address of the packet to be the gateway IP address.

This option impacts all relayed packets globally.

To enable this feature:

```
cumulus@leaf:~$ net add dhcp relay use-giaddr-as-src  
cumulus@leaf:~$ net pending  
cumulus@leaf:~$ net commit
```

These commands create the following configuration in the `/etc/default/isc-dhcp-relay` file:

```
cumulus@leaf01:~$ cat /etc/default/isc-dhcp-relay  
# Defaults for isc-dhcp-relay initscript  
# sourced by /etc/init.d/isc-dhcp-relay  
# installed at /etc/default/isc-dhcp-relay by the maintainer scripts  
#  
# This is a POSIX shell fragment  
#  
# What servers should the DHCP relay forward requests to?  
SERVERS=""  
# On what interfaces should the DHCP relay (dhrelay) serve DHCP  
# requests?  
# Always include the interface towards the DHCP server.  
# This variable requires a -i for each interface configured above.  
# This will be used in the actual dhcrelay command  
# For example, "-i eth0 -i eth1"  
INTF_CMD=""  
# Additional options that are passed to the DHCP relay daemon?  
OPTIONS="--giaddr-src"
```

## Troubleshooting

If you are experiencing issues with the DHCP relay, run the following commands to determine if the issue is with `systemd`. The following commands manually activate the DHCP relay process and they do not persist when you reboot the switch:

```
cumulus@switch:~$ /usr/sbin/dhcrelay -4 -i <interface_facing_host>  
<ip_address_dhcp_server> -i <interface_facing_dhcp_server>
```

```
cumulus@switch:~$ /usr/sbin/dhcrelay -6 -l <interface_facing_host> -u <ip_address_dhcp_server>%<interface_facing_dhcp_server>
```

For example:

```
cumulus@leaf01:~$ /usr/sbin/dhcrelay -4 -i vlan1 172.16.1.102 -i swp51  
cumulus@leaf01:~$ /usr/sbin/dhcrelay -6 -l vlan1 -u 2001:db8:100::2%  
swp51
```

See `man dhcrelay` for more information.

Use the `journalctl` command to look at the behavior on the Cumulus Linux switch that is providing the DHCP relay functionality:

```
cumulus@leaf01:~$ sudo journalctl -l -n 20 | grep dhcrelay  
Dec 05 20:58:55 leaf01 dhcrelay[6152]: sending upstream swp52  
Dec 05 20:58:55 leaf01 dhcrelay[6152]: sending upstream swp51  
Dec 05 20:58:55 leaf01 dhcrelay[6152]: Relaying Reply to fe80::4638:  
39ff:fe00:3 port 546 down.  
Dec 05 20:58:55 leaf01 dhcrelay[6152]: Relaying Reply to fe80::4638:  
39ff:fe00:3 port 546 down.  
Dec 05 21:03:55 leaf01 dhcrelay[6152]: Relaying Renew from fe80::4638:  
39ff:fe00:3 port 546 going up.  
Dec 05 21:03:55 leaf01 dhcrelay[6152]: sending upstream swp52  
Dec 05 21:03:55 leaf01 dhcrelay[6152]: sending upstream swp51  
Dec 05 21:03:55 leaf01 dhcrelay[6152]: Relaying Reply to fe80::4638:  
39ff:fe00:3 port 546 down.  
Dec 05 21:03:55 leaf01 dhcrelay[6152]: Relaying Reply to fe80::4638:  
39ff:fe00:3 port 546 down.
```

You can run the `journalctl` command with the `--since` flag to specify a time period:

```
cumulus@leaf01:~$ sudo journalctl -l --since "2 minutes ago" | grep  
dhcrelay  
Dec 05 21:08:55 leaf01 dhcrelay[6152]: Relaying Renew from fe80::4638:  
39ff:fe00:3 port 546 going up.  
Dec 05 21:08:55 leaf01 dhcrelay[6152]: sending upstream swp52  
Dec 05 21:08:55 leaf01 dhcrelay[6152]: sending upstream swp51
```

## Configuration Errors

If you configure DHCP relays by editing the `/etc/default/isc-dhcp-relay` file manually instead of running NCLU commands, you might introduce configuration errors that can cause the switch to crash.

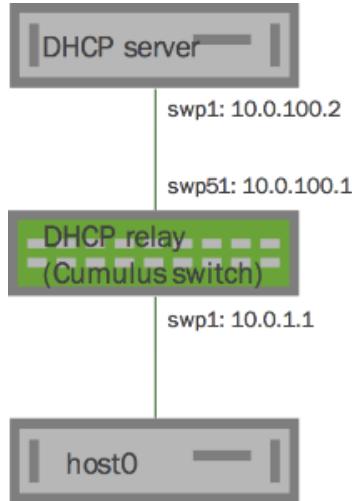
For example, if you see an error similar to the following, there might be a space between the DHCP server address and the interface used as the uplink.

```
Core was generated by `/usr/sbin/dhcrelay --nl -d -i vx-40 -i vlan100
10.0.0.4 -U 10.0.1.2 %vlan120'.
Program terminated with signal SIGSEGV, Segmentation fault.
```

To resolve the issue, manually edit the `/etc/default/isc-dhcp-relay` file to remove the space, then run the `sudo systemctl restart dhcrelay.service` command to restart the `dhcrelay` service and apply the configuration change.

## DHCP Servers

To run DHCP for both IPv4 and IPv6, you need to initiate the DHCP server twice: once for IPv4 and once for IPv6. The following configuration uses the following topology for the host, DHCP relay and DHCP server:



For the configurations used in this chapter, the DHCP server is a switch running Cumulus Linux; however, the DHCP server can also be located on a dedicated server in your environment.



The `dhcpd` and `dhcrelay` services are disabled by default. After you finish configuring the DHCP relays and servers, you need to start those services. If you intend to run these services within a VRF (see page 847), including the management VRF (see page 877), follow these steps (see page 879) for configuring them. See also the VRF chapter (see page ).

## Contents

### This topic describes ...

- Configure the DHCP Server on Cumulus Linux Switches (see page 300)
  - Configure the IPv4 DHCP Server (see page 300)
  - Configure the IPv6 DHCP Server (see page 300)
- Assign Port-Based IP Addresses (see page 301)
- Troubleshooting (see page 301)



## Configure the DHCP Server on Cumulus Linux Switches

You can use the following sample configurations for `dhcp.conf` and `dhcpd6.conf` to start both an IPv4 and an IPv6 DHCP server. The configuration files for the two DHCP server instances need to have two pools:

- Pool 1: Subnet overlaps interfaces
- Pool 2: Subnet that includes the addresses

### Configure the IPv4 DHCP Server

In a text editor, edit the `dhcpd.conf` file with a configuration similar to the following:

```
cumulus@switch:~$ cat /etc/dhcp/dhcpd.conf
ddns-update-style none;

default-lease-time 600;
max-lease-time 7200;

subnet 10.0.100.0 netmask 255.255.255.0 {
}
subnet 10.0.1.0 netmask 255.255.255.0 {
    range 10.0.1.50 10.0.1.60;
}
```

Just as you did with the DHCP relay scripts, edit the DHCP server configuration file so it can launch the DHCP server when the system boots. Here is a sample configuration:

```
cumulus@switch:~$ cat /etc/default/isc-dhcp-server
DHCPD_CONF="-cf /etc/dhcp/dhcpd.conf"

INTERFACES="swp1"
```

After you've finished configuring the DHCP server, enable and start the `dhcpd` service immediately:

```
cumulus@switch:~$ sudo systemctl enable dhcpcd.service
cumulus@switch:~$ sudo systemctl start dhcpcd.service
```

### Configure the IPv6 DHCP Server

In a text editor, edit the `dhcpd6.conf` file with a configuration similar to the following:

```
cumulus@switch:~$ cat /etc/dhcp/dhcpd6.conf
ddns-update-style none;

default-lease-time 600;
```



```
max-lease-time 7200;

subnet6 2001:db8:100::/64 {
}
subnet6 2001:db8:1::/64 {
    range6 2001:db8:1::100 2001:db8:1::200;
}
```

Just as you did with the DHCP relay scripts, edit the DHCP server configuration file so it can launch the DHCP server when the system boots. Here is a sample configuration:

```
cumulus@switch:~$ cat /etc/default/isc-dhcp-server6
DHCPD_CONF="-cf /etc/dhcp/dhcpd6.conf"

INTERFACES="swp1"
```



You cannot use NCLU to configure IPv6 DHCP servers.

After you've finished configuring the DHCP server, enable and start the `dhcpd6` service immediately:

```
cumulus@switch:~$ sudo systemctl enable dhcpd6.service
cumulus@switch:~$ sudo systemctl start dhcpd6.service
```

## Assign Port-Based IP Addresses

You can assign an IP address and other DHCP options based on physical location or port regardless of MAC address to clients that are attached directly to the Cumulus Linux switch through a switch port. This is helpful when swapping out switches and servers; you can avoid the inconvenience of collecting the MAC address and sending it to the network administrator to modify the DHCP server configuration.

Edit the `/etc/dhcp/dhcpd.conf` file and add the interface name `ifname` to assign an IP address through DHCP. The following provides an example:

```
host myhost {
    ifname = "swp1" ;
    fixed_address = 10.10.10.10 ;
}
```

## Troubleshooting

The DHCP server knows whether a DHCP request is a relay or a non-relay DHCP request. On `isc-dhcp-server`, for example, it is possible to tail the log and look at the behavior firsthand:

```
cumulus@server02:~$ sudo tail /var/log/syslog | grep dhcpd
```

```
2016-12-05T19:03:35.379633+00:00 server02 dhcpcd: Relay-forward  
message from 2001:db8:101::1 port 547, link address 2001:db8:101::1,  
peer address fe80::4638:39ff:fe00:3  
2016-12-05T19:03:35.380081+00:00 server02 dhcpcd: Advertise NA:  
address 2001:db8:1::110 to client with duid 00:01:00:01:1f:d8:75:3a:  
44:38:39:00:00:03 iaid = 956301315 valid for 600 seconds  
2016-12-05T19:03:35.380470+00:00 server02 dhcpcd: Sending Relay-reply  
to 2001:db8:101::1 port 547
```

## Facebook Voyager Optical Interfaces

Facebook Voyager is a Broadcom Tomahawk-based switch with added Dense Wave Division Multiplexing (DWDM) ports that can connect to another switch thousands of kilometers away by adding transponders. DWDM allows many separate connections on one fiber pair by sending them over different wavelengths. Although the wavelengths are sent on the same physical fiber, they do not interact with each other, similar to VLANs on a trunk. Each wavelength can transport very high speeds over very long distances.

## Contents

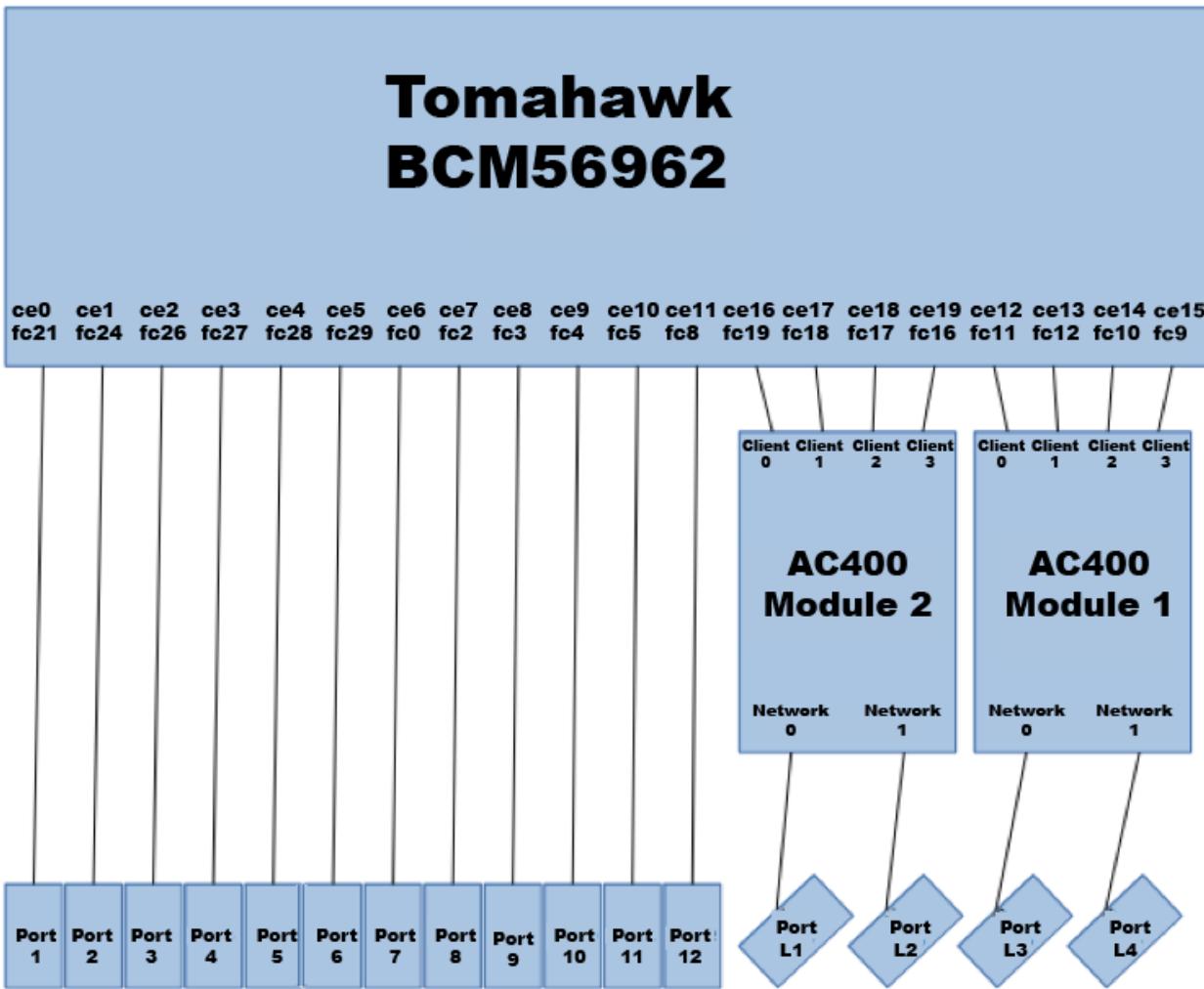
### This topic describes ...

- The Voyager Platform (see page 302)
  - Inside the AC400 (see page 303)
  - Client to Network Connection (see page 304)
- Configure the Voyager Ports (see page 305)
- Configure the Transponder Modules (see page 306)
  - Set the Transponder State (see page 306)
  - Disable the Transmitter (see page 307)
  - Change the Grid Spacing (see page 308)
  - Set the Channel Frequency (see page 309)
  - Set the Transmit Power (see page 310)
  - Change the Modulation (see page 310)
  - Set the Differential Encoding (see page 311)
  - Change Forward Error Correction (see page 312)
  - Configure a Line Side Loopback (see page 313)
  - Display the Transponder Status (see page 313)
  - Display Available Channel Frequencies (see page 317)
  - Display the Current Transponder Configuration (see page 318)
  - Edit the `transponders.ini` File (see page 319)
  - Initiate a Hardware Update (see page 336)

## The Voyager Platform

The Voyager platform has 16 ports on the front of the switch:

- Twelve **QSFP28 ethernet ports** labeled 1 thru 12. These are standard 100G ports that you configure like ports on other platforms with a Tomahawk ASIC. The `ports.conf` file defines the breakout configuration and the `/etc/network/interfaces` file defines the other port parameters. When not broken out they are named `swp1` thru `swp12`.
- Four **duplex LC ports** labeled L1 thru L4. L1 and L2 connect to AC400 module 2. L3 and L4 connect to AC400 module 1. Each AC400 module connects to four Tomahawk ASIC ports.



The `fc` designations on the Tomahawk stand for Falcon Core. Each AC400 module has four 100G interfaces connected to the Tomahawk and two interfaces connected to the front of the box.

### *Inside the AC400*

The way in which the client ports are mapped to the network ports in an AC400 depends on the modulation format and coupling mode. Cumulus Linux supports five different modulation and coupling mode options on each AC400 module.

Network 0 Modulation	Network 1 Modulation	Independent/Coupled
QPSK	QPSK	Independent

Network 0 Modulation	Network 1 Modulation	Independent/Coupled
16-QAM	16-QAM	Independent
QPSK	16-QAM	Independent
16-QAM	QPSK	Independent
8-QAM	8-QAM	Coupled

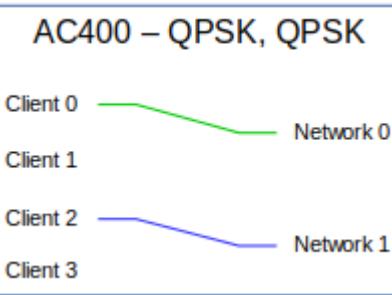
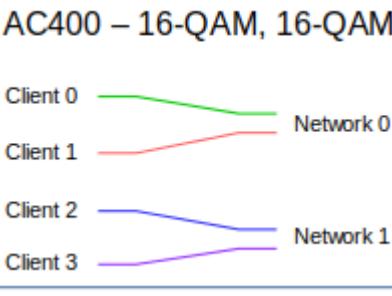
QPSK—[Quadrature phase shift keying](#). When a network interface is using QPSK modulation, it carries 100Gbps and is therefore connected to only one client interface.

16-QAM—[Quadrature amplitude modulation](#) with 4 bits per symbol. When a network interface is using 16-QAM modulation, it carries 200Gbps and is therefore connected to two client interfaces. Each of the two client interfaces carried on a network interface is called a tributary. The AC400 adds extra information so that these tributaries can be sorted out at the far end and delivered to the appropriate client interface.

8-QAM—[Quadrature amplitude modulation](#) with 3 bits per symbol. When a network interface is using 8-QAM modulation, it carries 150Gbps. In this case, the two network interfaces in an AC400 module must be coupled, so that the total bandwidth carried by the two interfaces is 300Gbps. Three client interfaces are used with this modulation format. However, unlike other modulation formats that use independent mode, the coupled mode means that data from each client interface is carried on both of the network interfaces.

### *Client to Network Connection*

For each of the five supported modulation configurations, the client interface to network interface connections are as follows:

<b>AC400 – QPSK, QPSK</b> 	In this configuration, two client interfaces, 0 and 2, are mapped to the two network interfaces. Client interfaces 1 and 3 are not used.
<b>AC400 – 16-QAM, 16-QAM</b> 	In this configuration, two client interfaces are mapped to each network interface. Each network interface, therefore, has two tributaries.
	These configurations are combinations of the previous two.

<p><b>AC400 – QPSK, 16-QAM</b></p>	<p>The network interface configured for QPSK connects to one client interface and the network interface configured for 16-QAM connects to two client interfaces.</p>
<p><b>AC400 – 16-QAM, QPSK</b></p>	
<p><b>AC400 – 8-QAM, 8-QAM</b></p>	<p>This configuration uses three client interfaces, for a total of 300Gbps; 150Gbps on each network interface. Because the network interfaces are coupled, they cannot be connected to different far-end systems. Each network interface carries three tributaries.</p>

## Configure the Voyager Ports

To configure the five modulation and coupling configurations described above, edit the `/etc/cumulus/ports.conf` file. The ports do not exist until you configure them.

The file has lines for the 12 QSPF28 ports. The four DWDM Line ports are labeled **L1** thru **L4**. To program the AC400 modulation and coupling into the five configurations, configure these ports as follows:

ports.conf	L1 Modulation	L2 Modulation	Independent/Coupled
L1=1x L2=1x	QPSK	QPSK	Independent
L1=1x L2=2x	QPSK	16-QAM	Independent
L1=2x L2=1x	16-QAM	QPSK	Independent

<b>ports.conf</b>	<b>L1 Modulation</b>	<b>L2 Modulation</b>	<b>Independent/Coupled</b>
L1=2x L2=2x	16-QAM	16-QAM	Independent
L1=3/2 L2=3/2	8-QAM	8-QAM	Coupled

The following example `/etc/cumulus/ports.conf` file shows configuration for all of the modes.

```

1=1x      # Creates swp1
2=2x      # Creates swp2s0 and swp2s1
3=4x      # Creates four 25G ports: swp3s0, swp3s1, swp3s2, and swp3s3
4=1x40G  # Creates swp4
5=4x10G   # Creates four 10G ports: swp5s0, swp5s1, swp5s2, and swp5s3
6=1x
7=1x
8=1x
9=1x
10=1x
11=1x
12=1x
L1=2x    # Creates swpL1s0 and swpL1s1
L2=1x    # Creates swpL2
L3=3/2   # Creates swpL3s0, swpL3s1, and swpL3s2
L4=3/2   # Creates no "swpL4" ports since L4 is ganged with L3

```

## Configure the Transponder Modules

The Voyager platform contains two AC400 transponder modules, which you configure with NCLU commands.

Many commands include the `<trans-port>` parameter. This is the network interface of the transponder or the port, as printed on the front of the system; L1, L2, L3, or L4.



Using NCLU commands is the preferred way to configure the transponder modules. However, as an alternative, you can edit the `/etc/cumulus/transponders.ini` file to make configuration changes. See [Edit the transponder.ini file \(see page 319\)](#) below.

### Set the Transponder State

Each transponder module has a state, which is set to `ready` by default. The available transponder states are listed below.



Setting	Description
reset	The module is in the reset state. The module cannot be accessed and remains non-operational until the state is changed to one of the other states.
low-power	The module is in the low-power configuration state. The network interfaces are not powered up. This state can be used to configure the module before bringing it online.
tx-off	The receivers and transmitters are turned up, but there is nothing being transmitted.
ready	This is the fully operational state of the module.

To change the state of the module, run the `net add interface <trans-port> state (reset|low-power|tx-off|ready)` command. For example, to change the state of the transponder module to low power for L2, run the following command:

```
cumulus@switch:~$ net add interface L2 state low-power
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

This command creates the following configuration snippet in the `/etc/cumulus/transponders.ini` file:

```
cumulus@switch:~$ cat /etc/cumulus/transponders.ini
...
[AC400_2]
Location = 2
NetworkMode = independent
NetworkInterfaces = L1, L2
HostInterfaces = Host4, Host5, Host6, Host7
OperStatus = low_power
...
```



Use caution when changing the setting; although this command specifies a port, it affects an entire module. State changes on modules with multiple ports affect **all** ports on the module, not just the port specified.

## Disable the Transmitter

You can disable or enable the transmitter of an individual network interface.

To disable the transmitter of a network interface, run the `net add interface <trans-port> transmit-disable` command. The following example command disables the L1 transmitter:



```
cumulus@switch:~$ net add interface L1 transmit-disable  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

This command creates the following configuration snippet in the `/etc/cumulus/transponders.ini` file:

```
cumulus@switch:~$ cat /etc/cumulus/transponders.ini  
...  
[L1]  
Location = 0  
TxEnable = false  
...
```

To enable the transmitter of an individual network interface, run the `net del interface <trans-port> transmit-disable` command. The following example command enables the L1 transmitter:

```
cumulus@switch:~$ net del interface L1 transmit-disable  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

This command creates the following configuration snippet in the `/etc/cumulus/transponders.ini` file:

```
cumulus@switch:~$ cat /etc/cumulus/transponders.ini  
...  
[L1]  
Location = 0  
TxEnable = true  
...
```

### *Change the Grid Spacing*

You can set grid spacing between two adjacent channels (the distance between channel frequencies) to 12.5GHz or 50GHz. The default spacing is 50 GHz.

To change the grid spacing, run the `net add interface <trans-port> grid-spacing (12.5|50)` command. The following command sets the grid spacing on L2 to 12.5GHz:

```
cumulus@switch:~$ net add interface L2 grid-spacing 12.5  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

This command creates the following configuration snippet in the `/etc/cumulus/transponders.ini` file:



```
cumulus@switch:~$ cat /etc/cumulus/transponders.ini
...
[L2]
Location = 1
TxEnable = true
TxGridSpacing = 12.5ghz
...
```

### *Set the Channel Frequency*

To set the frequency used by the network interface, run the `net add interface <trans-port> frequency <trans-frequency>` command.

`<trans-frequency>` is a floating point number in THz. The transponders support 100 channels, from 191.15 THz to 196.10 THz. Tab-completion is supported on this command and shows the available frequencies, together with the corresponding channel number and wavelength.

The following example command sets the frequency used by L2 to 195.30:

```
cumulus@switch:~$ net add interface L2 frequency 195.30
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

This command creates the following configuration snippet in the `/etc/cumulus/transponders.ini` file:

```
cumulus@switch:~$ cat /etc/cumulus/transponders.ini
...
[L2]
Location = 1
TxEnable = true
TxGridSpacing = 50ghz
TxChannel = 84
...
```

The following example shows the command with the output when using tab completion:

```
cumulus@switch:~$ net add interface L1 frequency 195.<tab>
195.00 THz : Channel 78, Wavelength 1537.40 nm
195.05 THz : Channel 79, Wavelength 1537.00 nm
195.10 THz : Channel 80, Wavelength 1536.61 nm
195.15 THz : Channel 81, Wavelength 1536.22 nm
195.20 THz : Channel 82, Wavelength 1535.82 nm
195.25 THz : Channel 83, Wavelength 1535.43 nm
195.30 THz : Channel 84, Wavelength 1535.04 nm
195.35 THz : Channel 85, Wavelength 1534.64 nm
195.40 THz : Channel 86, Wavelength 1534.25 nm
```

```

195.45 THz : Channel 87, Wavelength 1533.86 nm
195.50 THz : Channel 88, Wavelength 1533.47 nm
195.55 THz : Channel 89, Wavelength 1533.07 nm
195.60 THz : Channel 90, Wavelength 1532.68 nm
195.65 THz : Channel 91, Wavelength 1532.29 nm
195.70 THz : Channel 92, Wavelength 1531.90 nm
195.75 THz : Channel 93, Wavelength 1531.51 nm
195.80 THz : Channel 94, Wavelength 1531.12 nm
195.85 THz : Channel 95, Wavelength 1530.72 nm
195.90 THz : Channel 96, Wavelength 1530.33 nm
195.95 THz : Channel 97, Wavelength 1529.94 nm

```

To see a complete list of the frequencies, channels, and wavelengths, run the `net show transponder frequency-map` command (described in [Display Available Frequencies \(see page 317\)](#)).

### *Set the Transmit Power*

To set the amount of transmit power for a network interface, run the `net add interface <trans-port> power <trans-dBm>` command.

`<trans-dBm>` is the power as a floating point number in units of dBm. This value can range from -35.0 to 10.0. The following example command sets the transmit power for L1 to 10.0 dBm.

```

cumulus@switch:~$ net add interface L1 power 10.0
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit

```

This command creates the following configuration snippet in the `/etc/cumulus/transponders.ini` file:

```

cumulus@switch:~$ cat /etc/cumulus/transponders.ini
...
[L1]
Location = 0
TxEnable = true
TxGridSpacing = 50ghz
TxChannel = 52
OutputPower = 10.0
...

```

### *Change the Modulation*

To change the modulation technique used on a network interface, run the `net add interface <trans-port> modulation (16-qam|8-qam|pm-qpsk)` command. The available modulation options are 16-qam, 8-qam, and pm-qpsk. The following example command changes the modulation on L1 to 8-qam:

```

cumulus@switch:~$ net add interface L1 modulation 8-qam

```



```
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

Changing the modulation also changes the Linux interfaces available in the system, removing existing interfaces and adding the new ones. Therefore, you must remove network interfaces with the `net del interface <swpLx...>` command before you change the modulation. The network interfaces created for each modulation are as follows (L1 is used as an example):

Modulation	Linux Interfaces
16-qam	<code>swpL1s0</code> and <code>swpL1s1</code>
8-qam	<code>swpL1s0</code> , <code>swpL1s1</code> , and <code>swpL1s2</code>
pm-qpsk	<code>swpL1</code>

Because 8-qam modulation requires both network interfaces on a module to operate together, changing the modulation on one interface also changes it on the other. Also, the network mode of the module changes automatically to `coupled` when changing to 8-qam and reverts to `independent` when leaving 8-qam modulation.

The only modulation format that allows the `15%_ac100` FEC mode is pm-qpsk. Attempting to change the modulation from pm-qpsk while `15%_ac100` FEC is configured is not allowed. First change the FEC mode to something other than `15%_ac100` and then the modulation.

### *Set the Differential Encoding*

To select non-differential encoding on the network interface, run the `net add interface <trans-port> non-differential` command. To revert to differential encoding (the default), run the `net del interface <trans-port> non-differential` command. The following example command selects non-differential encoding for L1:

```
cumulus@switch:~$ net add interface L1 non-differential  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

This command creates the following configuration snippet in the `/etc/cumulus/transponders.ini` file:

```
cumulus@switch:~$ cat /etc/cumulus/transponders.ini  
...  
[L1]  
Location = 0  
TxEnable = true  
TxGridSpacing = 50ghz  
TxChannel = 52  
OutputPower = 10.0  
TxFineTuneFrequency = 0  
MasterEnable = true
```



```
ModulationFormat = 16-qam
DifferentialEncoding = false
...
```

The following example command reverts to differential encoding (the default) for L1:

```
cumulus@switch:~$ net del interface L1 non-differential
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

This command creates the following configuration snippet in the `/etc/cumulus/transponders.ini` file:

```
cumulus@switch:~$ cat /etc/cumulus/transponders.ini
...
[L1]
Location = 0
TxEnable = true
TxGridSpacing = 50ghz
TxChannel = 52
OutputPower = 10.0
TxFineTuneFrequency = 0
MasterEnable = true
ModulationFormat = 16-qam
DifferentialEncoding = true
...
```

### *Change Forward Error Correction*

To select Forward Error Correction (FEC) mode, run the `net add interface <trans-port> fec (15% | 15%_ac100 | 25%)` command. The available modes are 15% (15% overhead SDFEC), 15%\_ac100 (15% overhead SDFEC compatible with AC100), and 25% (25% overhead SDFEC). The following example command sets FEC mode on L1 to 15%:

```
cumulus@switch:~$ net add interface L1 fec 15%
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

This command creates the following configuration snippet in the `/etc/cumulus/transponders.ini` file:

```
cumulus@switch:~$ cat /etc/cumulus/transponders.ini
...
[L1]
Location = 0
```

```
TxEnable = true
TxGridSpacing = 50ghz
TxChannel = 52
OutputPower = 10.0
TxFineTuneFrequency = 0
MasterEnable = true
ModulationFormat = 16-qam
DifferentialEncoding = true
FecMode = 15%
...
...
```

### Configure a Line Side Loopback

Line side loopback mode enables you to send and receive data from the same network interface port to verify that the port is operational.

To enable line side loopback mode, run the `net add interface <interface> facility-loopback` command. You can enable line side loopback mode on one or multiple interfaces. The following example enables loopback mode on the L1, L2, L3, and L4 network interfaces:

```
cumulus@switch:~$ net add interface L1-4 facility-loopback
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

To disable loopback mode, run the `net del interface <interface> facility-loopback` command. The following example disables loopback mode on the L1, L2, L3, and L4 network interfaces:

```
cumulus@switch:~$ net del interface L1-4 facility-loopback
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```



To enable loopback on the client interface (internal loopback for DWDM testing), edit the `/etc/cumulus/transponders.ini` file. See [Edit the transponder.ini file \(see page 319\)](#) below

### Display the Transponder Status

To display the current status of the transponder module, run the `net show transponder` command. The first two lines of command output displays the status of the module and the next section displays the status of the network interfaces. This is repeated for each module in the system.

```
cumulus@switch:~$ net show transponder
Module: 1 ready Acacia Comm Inc. AC400-004-330 S/N:170212599 53.88C
11.89V
    Laser: 191.15 THz - 196.10 THz, 6.00 GHz fine tune, independent
    lanes
```



Network

Interfaces

L4

-----

Modulation 16-qam 16-

qam Frequency 193.70 THz, Channel 52 193.70 THz,

Channel 52 Current BER 1.428e-04 1.387e-

05 Current OSNR 84.90dBm 84.80dBm

Current Chromatic Disp 13ps/nm 9ps/nm

TX/RX Power 0.99dBm/0.66dBm 1.00dBm/0.

43dBm Encoding differential

differential Alignment TX & RX TX &

RX Grid Spacing 50ghz

50ghz FEC Mode 25%

25% Uncorrectable FEC Errs 0

0 TX/RX Turn-up power\_adjusted/locked power\_adjusted

/locked

Module: 2 ready Acacia Comm Inc. AC400-004-330 S/N:170212585 55.00C  
11.90V

Laser: 191.15 THz - 196.10 THz, 6.00 GHz fine tune, independent lanes

Network

Interfaces

L2

-----

Modulation 16-qam 16-

qam Frequency 193.70 THz, Channel 52 193.70 THz,

Channel 52 Current BER 7.039e-05 7.404e-

05 Current OSNR 84.90dBm 84.80dBm

Current Chromatic Disp 13ps/nm 9ps/nm

TX/RX Power 0.98dBm/0.48dBm 0.99dBm/-0.78

dBm



```
        Encoding differential  
differential  
                Alignment TX & RX  
RX  
                Grid Spacing 50ghz  
50ghz  
                FEC Mode 25%  
25%  
Uncorrectable FEC Errs 0  
0  
        TX/RX Turn-up power_adjusted/locked  
/locked
```

TX &amp;

power\_adjusted

To display only the status of a particular module, use the `module <trans-module>` option, which specifies the transponder module number. The following example command displays the status of transponder module 1:

```
cumulus@switch:~$ net show transponder module 1  
Module: 1 ready Acacia Comm Inc. AC400-004-330 S/N:170212599 53.75C  
11.89V  
    Laser: 191.15 THz - 196.10 THz, 6.00 GHz fine tune, independent  
lanes  
  
                                Network  
Interfaces  
                                L3  
L4  
-----  
-----  
Channel 52  
    Modulation 16-qam  
    Frequency 193.70 THz, Channel 52  
    Current BER 1.626e-04  
    Current OSNR 84.90dBm  
    Current Chromatic Disp 13ps/nm  
    /nm  
    TX/RX Power 1.00dBm/0.67dBm  
    42dBm  
        Encoding differential  
differential  
                Alignment TX & RX  
RX  
                Grid Spacing 50ghz  
50ghz  
                FEC Mode 25%  
25%  
Uncorrectable FEC Errs 0  
0  
        TX/RX Turn-up power_adjusted/locked  
/locked
```

Network

Interfaces

L3

L4

-----

```
Modulation 16-qam  
Frequency 193.70 THz, Channel 52
```

```
16-qam  
193.70 THz,
```

Channel 52

Current BER 1.626e-04

1.343e-05

Current OSNR 84.90dBm

84.80dBm

Current Chromatic Disp 13ps/nm

9ps

/nm

TX/RX Power 1.00dBm/0.67dBm

0.99dBm/0.

42dBm

```
        Encoding differential  
differential
```

TX &amp;

RX

Grid Spacing 50ghz

50ghz

FEC Mode 25%

25%

Uncorrectable FEC Errs 0

0

```
        TX/RX Turn-up power_adjusted/locked  
/locked
```

power\_adjusted



To display more information, including the host interfaces, use the `verbose` option. The following example command displays more information about the transponder module:

```
cumulus@switch:~$ net show transponder module 1 verbose
```

To display all status information in JSON format, use the `json` option. The following example command displays all status information in JSON format:

```
cumulus@switch:~$ net show transponder json
{
    "modules" : [
        {
            "location" : "1",
            "vendor_name" : "Acacia Comm Inc.",
            "part_num" : "AC400-004-330",
            "serial_num" : "170212599",
            "fw_version_a" : 17.100000,
            "fw_version_b" : 17.100000,
            "min_laser_freq" : 1911500000000000,
            "max_laser_freq" : 1961000000000000,
            "fine_tune_freq" : 6000000000,
            "grid_support" : [ "50ghz", "12.5ghz" ],
            "max_channels" : 100,
            "oper_status" : "ready",
            "internal_temp" : 53.625000,
            "supply_voltage" : 11.903000,
            "num_host_ifs" : 4,
            "num_net_ifs" : 2,
            "net_mode" : "independent",
            "host_interfaces" : [
                {
                    "index" : 0,
                    "lane_fault_status" : [
                        [ "no_faults" ],
                        [ "no_faults" ],
                        [ "no_faults" ],
                        [ "no_faults" ]
                    ],
                    "tx_align_status" : [ "aligned" ],
                    "rate" : "100ge",
                    "enabled" : true,
                    "fec_decoding" : false,
                    "fec_encoding" : false,
                    "tx_reset" : false,
                    "rx_reset" : false,
                    "deserializer" : [ 1, 18, 0 ],
                    "serializer" : [ 3, 3, 6, 12, 6 ],
                    "indep_tributary" : 0,
                    "coupled_tributary" : 0,
                    "fec_rx_err" : 0
                }
            ]
        }
    ]
}
```



```
        "loopback" : false  
    },  
    ...
```

### Display Available Channel Frequencies

To display a map of available channel frequencies, numbers, and wavelengths, run the `net show transponder frequency-map [ json ]` command.

The following example command displays a map of available channel frequencies, numbers, and wavelengths.

```
cumulus@switch:~$ net show transponder frequency-map  
Frequency      Channel      Wavelength  
(THz)          (#)         (nm)  
-----  -----  
191.15          1            1568.36  
191.20          2            1567.95  
191.25          3            1567.54  
191.30          4            1567.13  
191.35          5            1566.72  
191.40          6            1566.31  
191.45          7            1565.90  
191.50          8            1565.50  
191.55          9            1565.09  
191.60         10            1564.68  
191.65         11            1564.27  
191.70         12            1563.86  
191.75         13            1563.45  
191.80         14            1563.05  
191.85         15            1562.64  
...  
...
```

The following example command displays a map of available channel frequencies, numbers, and wavelengths in JSON format.

```
cumulus@switch:~$ net show transponder frequency-map json  
[  
  [  
    [  
      1,  
      191.15,  
      1568.36  
    ],  
    [  
      2,  
      191.2,  
      1567.95  
    ],  
    [  
      3,  
      191.25,  
      1567.54  
    ],  
    [  
      4,  
      191.3,  
      1567.13  
    ],  
    [  
      5,  
      191.35,  
      1566.72  
    ],  
    [  
      6,  
      191.4,  
      1566.31  
    ],  
    [  
      7,  
      191.45,  
      1565.9  
    ],  
    [  
      8,  
      191.5,  
      1565.5  
    ],  
    [  
      9,  
      191.55,  
      1565.09  
    ],  
    [  
      10,  
      191.6,  
      1564.68  
    ],  
    [  
      11,  
      191.65,  
      1564.27  
    ],  
    [  
      12,  
      191.7,  
      1563.86  
    ],  
    [  
      13,  
      191.75,  
      1563.45  
    ],  
    [  
      14,  
      191.8,  
      1563.05  
    ],  
    [  
      15,  
      191.85,  
      1562.64  
    ]  
]
```



```
    3,  
    191.25,  
    1567.54  
],  
[  
    4,  
    191.3,  
    1567.13  
],  
...  
...
```

### *Display the Current Transponder Configuration*

To display the current configuration state of the transponders, run the following command:

```
cumulus@switch:~$ net show configuration transponders  
  
transponders  
  
AC400_1  
  
    Location  
        1  
  
    NetworkMode  
        independent  
  
    L3  
  
        Location  
            0  
  
        TxEnable  
            true  
  
        TxGridSpacing  
            50ghz  
  
        TxChannel  
            52  
  
        OutputPower  
            1  
  
        TxFineTuneFrequency  
            0  
  
        MasterEnable  
            true
```



```
ModulationFormat
    16-qam

DifferentialEncoding
    true

FecMode
    25%

Loopback
    false

TxTributaryIndependent
    0
    1

TxTributaryCoupled
    0
    1
    2
    15

...
```

### Edit the `transponders.ini` File

As an alternative to using NCLU commands to configure the transponder modules (described above), you can edit the `/etc/cumulus/transponders.ini` file, then [Initiate a hardware update \(see page 336\)](#).



Using NCLU commands to configure the transponder modules is the preferred method. However, not all configuration options are available with NCLU. If you want to change a transponder module configuration setting that does not have an NCLU command, you can change the setting manually in the `transponders.ini` file, then initiate the hardware update. Use caution when editing the `/etc/cumulus/transponders.ini` file.

The `/etc/cumulus/transponders.ini` file consists of groups of key-value pairs, interspersed with comments. Configuration groups start with a header line that contains the group name enclosed in square brackets (`[ ]`) and end implicitly by the start of the next group or the end of the file. Key-value pairs have the form `key=value`. Spaces before and after the `=` character are ignored. Lines beginning with `#` and blank lines are considered comments.

Here is an example `/etc/cumulus/transponders.ini` file:

```
# 
# Configuration file for Voyager transponder modules
#
[Modules]
Names=AC400_1,AC400_2

[AC400_1]
```



```
Location=1
NetworkMode=independent
NetworkInterfaces=L3,L4
HostInterfaces=Client0,Client1,Client2,Client3
OperStatus=ready

[AC400_2]
Location=2
NetworkMode=independent
NetworkInterfaces=L1,L2
HostInterfaces=Client4,Client5,Client6,Client7
OperStatus=ready

[L1]
Location=0
TxEnable=true
TxGridSpacing=50ghz
TxChannel=52
OutputPower=1
TxFineTuneFrequency=0
MasterEnable=true
ModulationFormat=16-qam
DifferentialEncoding=true
FecMode=25%
TxTributaryIndependent=0,1
TxTributaryCoupled=0,1,2,15
Loopback=false

[L2]
Location=1
TxEnable=true
TxGridSpacing=50ghz
TxChannel=52
OutputPower=1
TxFineTuneFrequency=0
MasterEnable=true
ModulationFormat=16-qam
DifferentialEncoding=true
FecMode=25%
TxTributaryIndependent=2,3
TxTributaryCoupled=0,1,2,15
Loopback=false

[L3]
Location=0
TxEnable=true
TxGridSpacing=50ghz
TxChannel=52
OutputPower=1
TxFineTuneFrequency=0
MasterEnable=true
ModulationFormat=16-qam
```

```
DifferentialEncoding=true  
FecMode=25%  
TxTributaryIndependent=0,1  
TxTributaryCoupled=0,1,2,15  
Loopback=false
```

```
[L4]  
Location=1  
TxEnable=true  
TxGridSpacing=50ghz  
TxChannel=52  
OutputPower=1  
TxFineTuneFrequency=0  
MasterEnable=true  
ModulationFormat=16-qam  
DifferentialEncoding=true  
FecMode=25%  
TxTributaryIndependent=2,3  
TxTributaryCoupled=0,1,2,15  
Loopback=false
```

```
[Client0]  
Location=0  
Rate=100ge  
Enable=true  
FecDecoder=false  
FecEncoder=false  
DeserialLfCtleGain=1  
DeserialCtleGain=18  
DeserialDfeCoeff=0  
SerialTap0Gain=3  
SerialTap0Delay=3  
SerialTap1Gain=6  
SerialTap2Gain=12  
SerialTap2Delay=6  
RxTributaryIndependent=0  
RxTributaryCoupled=0  
Loopback=false
```

```
[Client1]  
Location=1  
Rate=100ge  
Enable=true  
FecDecoder=false  
FecEncoder=false  
DeserialLfCtleGain=1  
DeserialCtleGain=18  
DeserialDfeCoeff=0  
SerialTap0Gain=3  
SerialTap0Delay=3  
SerialTap1Gain=6  
SerialTap2Gain=12
```



```
SerialTap2Delay=6
RxTributaryIndependent=1
RxTributaryCoupled=1
Loopback=false

[Client2]
Location=2
Rate=100ge
Enable=true
FecDecoder=false
FecEncoder=false
DeserialLfCtleGain=1
DeserialCtleGain=18
DeserialDfeCoeff=0
SerialTap0Gain=3
SerialTap0Delay=3
SerialTap1Gain=6
SerialTap2Gain=12
SerialTap2Delay=6
RxTributaryIndependent=2
RxTributaryCoupled=2
Loopback=false

[Client3]
Location=3
Rate=100ge
Enable=true
FecDecoder=false
FecEncoder=false
DeserialLfCtleGain=1
DeserialCtleGain=18
DeserialDfeCoeff=0
SerialTap0Gain=3
SerialTap0Delay=3
SerialTap1Gain=6
SerialTap2Gain=12
SerialTap2Delay=6
RxTributaryIndependent=3
RxTributaryCoupled=65535
Loopback=false

[Client4]
Location=0
Rate=100ge
Enable=true
FecDecoder=false
FecEncoder=false
DeserialLfCtleGain=1
DeserialCtleGain=18
DeserialDfeCoeff=0
SerialTap0Gain=3
SerialTap0Delay=3
```

```
SerialTap1Gain=5
SerialTap2Gain=9
SerialTap2Delay=5
RxTributaryIndependent=0
RxTributaryCoupled=0
Loopback=false
```

```
[Client5]
Location=1
Rate=100ge
Enable=true
FecDecoder=false
FecEncoder=false
DeserialLfCtleGain=1
DeserialCtleGain=18
DeserialDfeCoeff=0
SerialTap0Gain=3
SerialTap0Delay=3
SerialTap1Gain=5
SerialTap2Gain=9
SerialTap2Delay=5
RxTributaryIndependent=1
RxTributaryCoupled=1
Loopback=false
```

```
[Client6]
Location=2
Rate=100ge
Enable=true
FecDecoder=false
FecEncoder=false
DeserialLfCtleGain=1
DeserialCtleGain=18
DeserialDfeCoeff=0
SerialTap0Gain=3
SerialTap0Delay=3
SerialTap1Gain=5
SerialTap2Gain=9
SerialTap2Delay=5
RxTributaryIndependent=2
RxTributaryCoupled=2
Loopback=false
```

```
[Client7]
Location=3
Rate=100ge
Enable=true
FecDecoder=false
FecEncoder=false
DeserialLfCtleGain=1
DeserialCtleGain=18
DeserialDfeCoeff=0
```



```
SerialTap0Gain=3
SerialTap0Delay=3
SerialTap1Gain=5
SerialTap2Gain=9
SerialTap2Delay=5
RxTributaryIndependent=3
RxTributaryCoupled=65535
Loopback=false
```

The file contains four configuration groups:

- The Modules group
- The module groups
- The network interface groups
- The client interface groups

### Modules Group

The **Modules group** identifies the names of the other groups in the file. This is the *root* group from which all other groups are referenced; it must always be the first group in the file and must be named `Modules`.

There is only one key-value pair in this group. Each value in the list represents a transponder in the system. There must be a group within the file that has the same name as each value in the list.

The following example shows that there are two modules in the system named AC400\_1 and AC400\_2. The `transponders.ini` file must contain these two groups.

```
[Modules]
Names=AC400_1,AC400_2
```

### Module Groups

The **module groups** are individual groups for each of the predefined modules and define the attributes of the transponders in the system. The name of a module group is defined in the values of the `Names` key in the Modules group (shown above).

The following table describes the key-value pairs in the module groups.

Key	Value Type	Description
Location	Integer: 1 or 2	<p>The location or identifier of the module within Voyager. Voyager has two modules which are identified by indexes 1 and 2.</p> <ul style="list-style-type: none"><li>• Module 1 is connected to external network interfaces labeled L3 and L4.</li><li>• Module 2 is connected to L1 and L2.</li></ul>
NetworkMode	String: independent or coupled	<p>The overall mode of the two network interfaces on the module:</p> <ul style="list-style-type: none"><li>• In <b>coupled</b> mode, traffic from a client interface travels on both network interfaces.</li></ul>



Key	Value Type	Description
		<ul style="list-style-type: none"><li>In <code>independent</code> mode, traffic from a client interface travels on only one network interface.</li></ul> <p>The default value is <code>independent</code>.</p> <p><b>Note:</b> When network interfaces are configured in 8-qam mode, you must set this key to <code>coupled</code>.</p>
<code>NetworkInterfaces</code>	Comma-separated list of network interface group names	Each value in the list represents a network interface connected to this module. There must be a group within the file that has the same name as each value in the list. Network interfaces are the module interfaces that leave the Voyager platform and are labeled L1, L2, L3, and L4 on the front of the Voyager.  <b>Note:</b> Although you can use any string for the network interface group names, Cumulus Networks recommends that you use the labels on the front of the Voyager to avoid confusion.
<code>HostInterfaces</code>	Comma-separated list of client interface group names	Each value in this list represents a client interface connected to this module. There must be a group within the file that has the same name as each value in the list. Client interfaces are the module interfaces that connect to the Tomahawk switching ASIC.
<code>OperStatus</code>	String: <code>reset</code> , <code>low_power</code> , <code>tx_off</code> , or <code>ready</code>	The operational status of the module: <ul style="list-style-type: none"><li><code>reset</code> holds the module in the reset state.</li><li><code>low_power</code> configures the module before bringing the module to an operational state.</li><li><code>tx_off</code> means the module is fully functional, except that the transmitters on the network interfaces are turned off.</li><li><code>ready</code> means the module is fully functional.</li></ul>

The following example provides the configuration for module 1. The network interfaces are configured to operate independently and are defined in the `L3` and `L4` groups in the file. The client interfaces are defined in the `Client0`, `Client1`, `Client2`, and `Client3` groups in the file. The operational status of the module is `ready`.

```
[AC400_1]
Location=1
NetworkMode=independent
NetworkInterfaces=L3,L4
HostInterfaces=Client0,Client1,Client2,Client3
OperStatus=ready
```

## *Network Interface Groups*

The network interface groups define the attributes of the network interfaces on the module. The name of a network interface group is defined in the values of the `NetworkInterfaces` key in the module groups.

The following table describes the key-value pairs in the network interface groups.

Key	Value Type	Description															
Location	Integer: 0-1	<p>The location or index of the network interface within a module. The Voyager AC400 modules each have two network interfaces that are connected to the external ports as follows:</p> <table border="1"> <thead> <tr> <th>Module Location</th><th>Network Interface Location</th><th>External Port</th></tr> </thead> <tbody> <tr> <td>2</td><td>0</td><td>L1</td></tr> <tr> <td>2</td><td>1</td><td>L2</td></tr> <tr> <td>1</td><td>0</td><td>L3</td></tr> <tr> <td>1</td><td>1</td><td>L4</td></tr> </tbody> </table>	Module Location	Network Interface Location	External Port	2	0	L1	2	1	L2	1	0	L3	1	1	L4
Module Location	Network Interface Location	External Port															
2	0	L1															
2	1	L2															
1	0	L3															
1	1	L4															
TxEnable	Boolean: true or false	Enable (true) or disable (false) the transmission of data.															
TxGridSpacing	String: 100ghz, 50ghz, 33ghz, 25ghz, 12.5ghz, or 6.25 ghz	<p>Defines the channel spacing. The AC400 does not support variable-width channels; only different channel center frequencies.</p> <p>The default is 50ghz. Only 50ghz and 12.5ghz are supported.</p>															
TxChannel	Integer: 1-100	<p>The channel number upon which the network interface transmits and receives data.</p> <p><a href="#">Click here to see the frequency and wavelength per channel</a></p> <table border="1"> <thead> <tr> <th>Channel Number</th><th>Frequency (THz)</th><th>Wavelength (nm)</th></tr> </thead> </table>	Channel Number	Frequency (THz)	Wavelength (nm)												
Channel Number	Frequency (THz)	Wavelength (nm)															

Key	Value Type	Description		
		Channel Number	Frequency (THz)	Wavelength (nm)
		1	191.15	1,568.36
		2	191.20	1,567.95
		3	191.25	1,567.54
		4	191.30	1,567.13
		5	191.35	1,566.72
		6	191.40	1,566.31
		7	191.45	1,565.91
		8	191.50	1,565.50
		9	191.55	1,565.09
		10	191.60	1,564.68
		11	191.65	1,564.27
		12	191.70	1,563.86
		13	191.75	1,563.46
		14	191.80	1,563.05
		15	191.85	1,562.64
		16	191.90	1,562.23
		17	191.95	1,561.83
		18	192.00	1,561.42
		19	192.05	1,561.01
		20	192.10	1,560.61



Key	Value Type	Description		
		Channel Number	Frequency (THz)	Wavelength (nm)
		21	192.15	1,560.20
		22	192.20	1,559.79
		23	192.25	1,559.39
		24	192.30	1,558.98
		25	192.35	1,558.58
		26	192.40	1,558.17
		27	192.45	1,557.77
		28	192.50	1,557.36
		29	192.55	1,556.96
		30	192.60	1,556.56
		31	192.65	1,556.15
		32	192.70	1,555.75
		33	192.75	1,555.34
		34	192.80	1,554.94
		35	192.85	1,554.54
		36	192.90	1,554.13
		37	192.95	1,553.73
		38	193.00	1,553.33
		39	193.05	1,552.93



Key	Value Type	Description		
		Channel Number	Frequency (THz)	Wavelength (nm)
		40	193.10	1,552.52
		41	193.15	1,552.12
		42	193.20	1,551.72
		43	193.25	1,551.32
		44	193.30	1,550.92
		45	193.35	1,550.52
		46	193.40	1,550.12
		47	193.45	1,549.72
		48	193.50	1,549.32
		49	193.55	1,548.92
		50	193.60	1,548.52
		51	193.65	1,548.12
		52	193.70	1,547.72
		53	193.75	1,547.32
		54	193.80	1,546.92
		55	193.85	1,546.52
		56	193.90	1,546.12
		57	193.95	1,545.72
		58	194.00	1,545.32



Key	Value Type	Description		
		Channel Number	Frequency (THz)	Wavelength (nm)
		59	194.05	1,544.92
		60	194.10	1,544.53
		61	194.15	1,544.13
		62	194.20	1,543.73
		63	194.25	1,543.33
		64	194.30	1,542.94
		65	194.35	1,542.54
		66	194.40	1,542.14
		67	194.45	1,541.75
		68	194.50	1,541.35
		69	194.55	1,540.95
		70	194.60	1,540.56
		71	194.65	1,540.16
		72	194.70	1,539.77
		73	194.75	1,539.37
		74	194.80	1,538.98
		75	194.85	1,538.58
		76	194.90	1,538.19
		77	194.95	1,537.79

Key	Value Type	Description		
		Channel Number	Frequency (THz)	Wavelength (nm)
		78	195.00	1,537.40
		79	195.05	1,537.00
		80	195.10	1,536.61
		81	195.15	1,536.22
		82	195.20	1,535.82
		83	195.25	1,535.43
		84	195.30	1,535.04
		85	195.35	1,534.64
		86	195.40	1,534.25
		87	195.45	1,533.86
		88	195.50	1,533.47
		89	195.55	1,533.07
		90	195.60	1,532.68
		91	195.65	1,532.29
		92	195.70	1,531.90
		93	195.75	1,531.51
		94	195.80	1,531.12
		95	195.85	1,530.73
		96	195.90	1,530.33

Key	Value Type	Description															
		<table border="1"> <thead> <tr> <th>Channel Number</th><th>Frequency (THz)</th><th>Wavelength (nm)</th></tr> </thead> <tbody> <tr> <td>97</td><td>195.95</td><td>1,529.94</td></tr> <tr> <td>98</td><td>196.00</td><td>1,529.55</td></tr> <tr> <td>99</td><td>196.05</td><td>1,529.16</td></tr> <tr> <td>100</td><td>196.10</td><td>1,528.77</td></tr> </tbody> </table>	Channel Number	Frequency (THz)	Wavelength (nm)	97	195.95	1,529.94	98	196.00	1,529.55	99	196.05	1,529.16	100	196.10	1,528.77
Channel Number	Frequency (THz)	Wavelength (nm)															
97	195.95	1,529.94															
98	196.00	1,529.55															
99	196.05	1,529.16															
100	196.10	1,528.77															
OutputPower	Floating point number: 0 to +6	The output power of the network interface in dBm.															
TxFineTuneFrequency	Integer	The fine tune frequency of the laser in units of 1 Hz. The AC400 modules on Voyager are only capable of 1 MHz resolution; you must specify this value in multiples of 1,000,000. The default value is 0.															
MasterEnable	Boolean: true or false	Enables (true) or disables (false) the ability of the network lane modem to turn-up when leaving the low power state.															
ModulationFormat	String: 16-qam, 8-qam, or pm-qpsk	<p>Defines the modulation format used on the network interface:</p> <ul style="list-style-type: none"> <li>• 16-qam operates at 200G</li> <li>• 8-qam operates at 150G</li> <li>• pm-qpsk operates at 100G</li> </ul> <p><b>Note:</b> When selecting 8-qam, you must configure both network interfaces on a module for 8-qam and set the NetworkMode key of the module to coupled.</p>															
DifferentialEncoding	Boolean: true or false	Enables (true) or disables (false) differential encoding on the network interface.															
FecMode		<p>Selects the type of forward error correction used on the network interface.</p> <ul style="list-style-type: none"> <li>• 15% selects the 15% SDFEC</li> </ul>															



Key	Value Type	Description
	String: 15%, 15%_non_std, or 25%	<ul style="list-style-type: none"><li>• 25% selects the 25% SDFEC</li><li>• 15%_non_std selects the 15% overhead AC100 compatible SDFEC</li></ul>
TxTributaryIndependent	List of two comma-separated integers	Defines which client interfaces map to this network interface when <code>NetworkMode</code> for the network interface is set to <code>independent</code> . The integers in the list are the <code>Location</code> values of the client interfaces. When operating in pm-qpsk, only the first client interface in the list is used.  <b>Note:</b> Cumulus Networks STRONGLY recommends that you do not change this value. The Tomahawk switching ASIC should be configured to steer data to the appropriate network interface, not this attribute.
TxTributaryCoupled	List of four comma-separated integers	Defines which client interfaces map to this network interface when <code>NetworkMode</code> for the network interface is set to <code>coupled</code> . The integers in the list are the <code>Location</code> values of the client interfaces. When operating in 8-qam, only the first three client interfaces in the list are used and only the attribute on the network interface at location 0 is used.  <b>Note:</b> Cumulus Networks STRONGLY recommends that you do not change this value. The Tomahawk switching ASIC should be configured to steer data to the appropriate network interface, not this attribute.
Loopback	Boolean: <code>true</code> or <code>false</code>	Enables ( <code>true</code> ) or disables ( <code>false</code> ) line side loopback mode on a network interface. When enabled, you send and receive data from the same network interface port to verify that the port is operational.

The following example shows a network interface at `location 0`, which has transmission enabled and 50ghz channel spacing. Communication occurs on channel 52 with 1dBm of power. The network interface becomes operational when leaving the low power state. 16-qam encoding is used (200G) with differential encoding and 25% overhead SDFEC. The tributary mappings of the client interfaces is left unchanged. Loopback mode is disabled.

```
[l1]
Location=0
TxEnable=true
TxGridSpacing=50ghz
TxChannel=52
OutputPower=1
TxFineTuneFrequency=0
MasterEnable=true
ModulationFormat=16-qam
```

```
DifferentialEncoding=true
FecMode=25%
TxTributaryIndependent=0,1
TxTributaryCoupled=0,1,2,15
Loopback=false
```

## *Client Interface Groups*

The client interface groups define the attributes of the client interfaces on the module. The name of a client interface group is defined in the values of the `HostInterfaces` key of the module group.

The following table describes the key-value pairs in the client interface groups.

 **Important**

Because client interfaces are internal interfaces between the transponder module and the Tomahawk switching ASIC, the default values of these attributes do not typically need to be changed.

Key	Value Type	Description																											
Location	Integer: 0-3	<p>The location or index of the client interface within a module. The Voyager AC400 modules each have four network interfaces that are connected to the Tomahawk ASIC as follows:</p> <table border="1"> <thead> <tr> <th>Module Location</th><th>Network Interface Location</th><th>Tomahawk Falcon Core</th></tr> </thead> <tbody> <tr> <td>1</td><td>0</td><td>fc11</td></tr> <tr> <td>1</td><td>1</td><td>fc12</td></tr> <tr> <td>1</td><td>2</td><td>fc10</td></tr> <tr> <td>1</td><td>3</td><td>fc9</td></tr> <tr> <td>2</td><td>0</td><td>fc19</td></tr> <tr> <td>2</td><td>1</td><td>fc18</td></tr> <tr> <td>2</td><td>2</td><td>fc17</td></tr> <tr> <td>2</td><td>3</td><td>fc16</td></tr> </tbody> </table>	Module Location	Network Interface Location	Tomahawk Falcon Core	1	0	fc11	1	1	fc12	1	2	fc10	1	3	fc9	2	0	fc19	2	1	fc18	2	2	fc17	2	3	fc16
Module Location	Network Interface Location	Tomahawk Falcon Core																											
1	0	fc11																											
1	1	fc12																											
1	2	fc10																											
1	3	fc9																											
2	0	fc19																											
2	1	fc18																											
2	2	fc17																											
2	3	fc16																											



Key	Value Type	Description
Rate	String: otu4 or 100ge	The rate at which the client interface operates. Because the client interfaces on Voyager are always connected to a Tomahawk ASIC, always set this value to 100ge.
Enable	Boolean: true or false	Enables (true) or disables (false) the client interface.
FecDecoder	Boolean: true or false	Enables (true) or disables (false) FEC decoding for data received from the Tomahawk switching ASIC.
FecEncoder	Boolean: true or false	Enables (true) or disables (false) FEC encoding for data sent to the Tomahawk switching ASIC.
DeserialLfCtleGain	Integer: 0-8	These attributes configure the SERDES of the client interface. The values for these attributes have been carefully determined by hardware engineers; do not change them.
DeserialCtleGain	Integer: 0-20	
DeserialDfeCoeff	Integer: 0-63	
SerialTap0Gain	Integer: 0-7	
SerialTap0Delay	Integer: 0-7	
SerialTap1Gain	Integer: 0-7	
SerialTap2Gain	Integer: 0-15	
SerialTap2Delay	Integer: 0-7	
RxTributaryIndependent	Integer: 0-1	Defines which network interface maps to this client interface when <code>NetworkMode</code> for the client interface is set to <code>independent</code> . The integer is the <code>Location</code> value of the network interface.



Key	Value Type	Description
		<b>Note:</b> Cumulus Networks STRONGLY recommends that you do not change this value. The Tomahawk switching ASIC should be configured to steer data from the appropriate network interface, not this attribute.
RxTributaryCoupled	Integer: 0-1	Defines which network interface maps to this client interface when <code>NetworkMode</code> for the client interface is set to <code>coupled</code> . The integer is the <code>Location</code> value of the network interface.  <b>Note:</b> Cumulus Networks STRONGLY recommends that you do not change this value. The Tomahawk switching ASIC should be configured to steer data from the appropriate network interface, not this attribute.
Loopback	Boolean: <code>true</code> or <code>false</code>	Enables ( <code>true</code> ) or disables ( <code>false</code> ) terminal loopback mode on a client interface. When enabled, you send and receive data from the same client interface port to verify that the port is operational. This is useful for DWDM testing.

The following example shows a sample configuration for a client interface group.

```
[Client0]
Location=0
Rate=100ge
Enable=true
FecDecoder=false
FecEncoder=false
DeserialLfCtleGain=1
DeserialCtleGain=18
DeserialDfeCoeff=0
SerialTap0Gain=3
SerialTap0Delay=3
SerialTap1Gain=6
SerialTap2Gain=12
SerialTap2Delay=6
RxTributaryIndependent=0
RxTributaryCoupled=0
Loopback=false
```

### *Initiate a Hardware Update*

After making a change to the `transponders.ini` file, you must program the change into the hardware by issuing a `systemd reload` command:

```
sudo systemctl reload taihost.service
```



Depending on the configuration changes, programming the change into the hardware can take a long time to complete (several minutes). The `systemd reload` command initiates the configuration update and returns immediately. To monitor the progress of the configuration changes, review the syslog messages. The following is an example of the syslog messages.

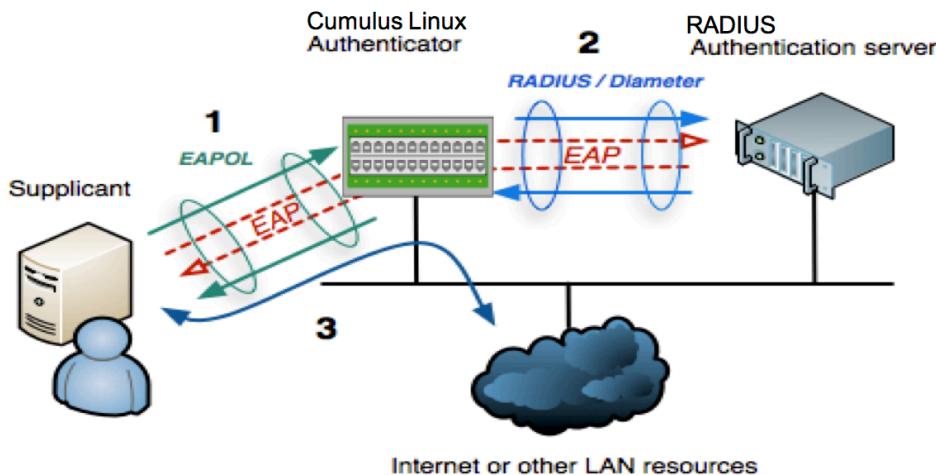
```
2018-04-24T18:18:49.847312+00:00 cumulus systemd[1]: Reloading TAI
host daemon.
2018-04-24T18:18:49.859649+00:00 cumulus voyager_tai_adapter[5793]:
SIGHUP received
2018-04-24T18:18:49.864101+00:00 cumulus voyager_tai_adapter[5793]:
Setting TxChannel (5) to 52, was 48
2018-04-24T18:18:49.867615+00:00 cumulus voyager_tai_adapter[5793]:
Setting OutputPower (6) to 1.000000, was 0.000000
2018-04-24T18:18:49.873785+00:00 cumulus voyager_tai_adapter[5793]:
Setting FecMode (268435464) to 3, was 1
2018-04-24T18:18:49.890446+00:00 cumulus voyager_tai_adapter[5793]:
Setting TxChannel (5) to 52, was 48
2018-04-24T18:18:49.893846+00:00 cumulus voyager_tai_adapter[5793]:
Setting OutputPower (6) to 1.000000, was 0.000000
2018-04-24T18:18:49.900383+00:00 cumulus voyager_tai_adapter[5793]:
Setting FecMode (268435464) to 3, was 1
2018-04-24T18:18:49.915172+00:00 cumulus voyager_tai_adapter[5793]:
Setting Rate (268435456) to 1, was 0
2018-04-24T18:18:49.920618+00:00 cumulus voyager_tai_adapter[5793]:
Setting FecDecoder (268435458) to false, was true
2018-04-24T18:18:49.924865+00:00 cumulus voyager_tai_adapter[5793]:
Setting FecEncoder (268435459) to false, was true
2018-04-24T18:18:49.929181+00:00 cumulus voyager_tai_adapter[5793]:
Setting DeserialLfCtleGain (268435462) to 1, was 5
2018-04-24T18:18:49.933236+00:00 cumulus voyager_tai_adapter[5793]:
Setting DeserialCtleGain (268435463) to 18, was 19
2018-04-24T18:18:49.937091+00:00 cumulus systemd[1]: Reloaded TAI
host daemon.
2018-04-24T18:18:49.941644+00:00 cumulus voyager_tai_adapter[5793]:
Setting SerialTap0Delay (268435466) to 3, was 5
2018-04-24T18:18:49.946020+00:00 cumulus voyager_tai_adapter[5793]:
Setting SerialTap1Gain (268435467) to 6, was 5
2018-04-24T18:18:49.948621+00:00 cumulus voyager_tai_adapter[5793]:
Setting SerialTap2Gain (268435468) to 12, was 8
2018-04-24T18:18:49.952036+00:00 cumulus voyager_tai_adapter[5793]:
Setting SerialTap2Delay (268435469) to 6, was 5
2018-04-24T18:18:49.957846+00:00 cumulus voyager_tai_adapter[5793]:
Setting Rate (268435456) to 1, was 0
2018-04-24T18:18:49.962431+00:00 cumulus voyager_tai_adapter[5793]:
Setting FecDecoder (268435458) to false, was true
2018-04-24T18:18:49.965701+00:00 cumulus voyager_tai_adapter[5793]:
Setting FecEncoder (268435459) to false, was true
...
2018-04-24T18:21:24.164981+00:00 cumulus voyager_tai_adapter[5793]:
Config has been reloaded
```

## 802.1X Interfaces

The [IEEE 802.1X protocol](#) provides a method of authenticating a client (called a *supplicant*) over wired media. It also provides access for individual MAC addresses on a switch (called the *authenticator*) after those MAC addresses have been authenticated by an authentication server — typically a [RADIUS](#) (see page 136) (Remote Authentication Dial In User Service, defined by [RFC 2865](#)) server.

A Cumulus Linux switch acts as an intermediary between the clients connected to the wired ports and the authentication server, which is reachable over the existing network. EAPOL (Extensible Authentication Protocol (EAP) over LAN — EtherType value of 0x888E, defined by [RFC 3748](#)) operates on top of the data link layer; the switch uses EAPOL to communicate with supplicants connected to the switch ports.

Cumulus Linux implements 802.1X through the Debian `hostapd` package, which has been modified to provide the PAE (port access entity).



## Contents

This topic describes ...

- Supported Features and Limitations (see page 339)
- Install the 802.1X Package (see page 340)
- Configure the RADIUS Server (see page 340)
- Configure 802.1X Interfaces (see page 340)
  - Configure 802.1X Interfaces for a VLAN-aware Bridge (see page 341)
  - Configure 802.1X Interfaces for a Traditional Mode Bridge (see page 342)
- Configure the Linux Supplicants (see page 344)
- Configure Accounting and Authentication Ports (see page 345)
- Configure MAC Authentication Bypass (see page 346)
- Configure a Parking VLAN (see page 347)
- Configure Dynamic VLAN Assignments (see page 349)
- Configure MAC Addresses per Port (see page 351)
- Configure EAP Requests from the Switch (see page 352)



- RADIUS Change of Authorization and Disconnect Requests (see page 352)
  - Configure DAS (see page 353)
  - Bounce a Port (see page 356)
- Troubleshooting (see page 357)
- Related Information (see page 359)

## Supported Features and Limitations

- 802.1X is supported on Broadcom-based switches (except the Hurricane2 switch). The Tomahawk, Tomahawk2, and Trident3 switch *must* be running in **nnonatomic mode** (see page 150).
- The protocol is supported on physical interfaces only (bridged/access only and routed interfaces) — such as swp1 or swp2s0; these interfaces cannot be part of a bond. However, 802.1X is **not** supported on eth0.
- Cumulus Linux 3.7.2 and later includes VRF support
- You can configure 802.1X interfaces for bridges in both **VLAN-aware mode** (see page 415) and **traditional mode** (see page 427) using the following features:
  - Parking VLAN
  - Dynamic VLAN
  - MAB (MAC-based authentication bypass)
- MAB, parking VLAN and dynamic VLAN all require a bridge access port.
- In traditional bridge mode, parking VLANs and dynamic VLANs both require the destination bridge to have a parking VLAN ID or dynamic VLAN ID tagged subinterface, respectively.
- Enabling or disabling the 802.1X capability on ports results in `hostapd` reloading. However, existing authorized sessions do not get reset.
- Changing any of the following RADIUS parameters restarts `hostapd`, which forces existing, authorized users to re-authenticate:
  - The RADIUS server IP address, shared secret, authentication port or accounting port
  - Parking VLAN ID
  - MAB activation delay
  - EAP reauthentication period
  - Removing all 802.1X interfaces



Changing the `interface dot1x`, `dot1x mab`, or `dot1x parking-vlan` settings do not reset existing authorized user ports.

- You can configure up to three RADIUS servers for failover purposes.
- Cumulus Networks performed tests with only a few `wpa_supplicant` (Debian), Windows 10 and Windows 7 supplicants.
- RADIUS authentication is supported with FreeRADIUS and Cisco ACS.
- Supports simple login/password, PEAP/MSCHAPv2 (Win7) and EAP-TLS (Debian).
- There is no support for Mako template-based configurations.



- Cumulus Linux 3.7.4 and later includes support for Multi Domain Authentication (MDA), where 802.1X is extended to allow authorization of multiple devices (a data and a voice device) on a single port and assign different VLANs to the devices based on authorization:
  - MDA is enabled by default; however, you need to assign a tagged VLAN for voice devices (see [Configure 802.1X Interfaces for a VLAN-aware Bridge \(see page 341\)](#)).
  - A maximum of four authorized devices (MAB + EAPOL) per port are supported.
  - The 802.1X enabled port must be a trunk port to allow tagged voice traffic from a phone; you cannot enable 802.1X on an access port.
  - Only one untagged VLAN and one tagged VLAN is supported on the 802.1X enabled ports
  - Multiple MAB (non voice) devices on a port are supported for VLAN-aware bridges only. Authorization of multiple MAB devices for different VLANs is not supported.
  - The MAB timer is not required (see [Configure MAC Authentication Bypass \(see page 346\)](#)).

## Install the 802.1X Package

If you upgraded Cumulus Linux from a version earlier than 3.3.0 instead of performing a full disk install, you need to install the `hostapd` package on your switch:

```
cumulus@switch:~$ sudo -E apt-get update
cumulus@switch:~$ sudo -E apt-get install hostapd
cumulus@switch:~$ sudo -E apt-get upgrade
```

## Configure the RADIUS Server

Before you configure any interfaces for 802.1X, configure the RADIUS server.



Do not use a Cumulus Linux switch as the RADIUS server.

To add a popular and freely available RADIUS server called FreeRADIUS on a Debian workstation, do the following:

```
root@radius:~# apt-get update
root@radius:~# apt-get install freeradius-utils freeradius-common
```

When installed and configured, the FreeRADIUS server can serve Cumulus Linux running `hostapd` as a RADIUS client.

For more information, see the [FreeRADIUS documentation](#).

## Configure 802.1X Interfaces

NCLU (see page 88) handles all the configuration of 802.1X interfaces, updating `hostapd` and other components so you do not have to manually modify configuration files. All the interfaces share the same RADIUS server settings.

The 802.1X-specific settings are:



- **accounting-port**: RADIUS accounting parameters, which defaults to 1813.
- **authentication-port**: RADIUS authentication port, which defaults to 1812.
- **server-ip**: RADIUS Server IPv4 or IPv6 address, which has no default, but is required. In Cumulus Linux 3.7.2 and later, you can also specify a VRF.
- **shared-secret**: RADIUS shared secret, which has no default, but is required.

## Configure 802.1X Interfaces for a VLAN-aware Bridge

Make sure you configure the RADIUS server before you configure the 802.1X interfaces. See [Configure the RADIUS Server \(see page 340\)](#), above for details.

1. Create a simple interface bridge configuration on the switch and add the switch ports that are members of the bridge. You can use glob syntax to add a range of interfaces. The MAB and parking VLAN configurations require interfaces to be bridge access ports. The VLAN-aware bridge must be named *bridge* and there can be only one VLAN-aware bridge on a switch.

```
cumulus@switch:~$ net add bridge bridge ports swp1-4
```

2. Configure the settings for the 802.1X RADIUS server, including its IP address and shared secret:

```
cumulus@switch:~$ net add dot1x radius server-ip 127.0.0.1
cumulus@switch:~$ net add dot1x radius shared-secret testing123
```

In Cumulus Linux 3.7.2 and later, you can specify a VRF for outgoing RADIUS accounting and authorization packets. The following example specifies a VRF called blue:

```
cumulus@switch:~$ net add dot1x radius server-ip 127.0.0.1 vrf
blue
cumulus@switch:~$ net add dot1x radius shared-secret mysecret
```

3. Enable 802.1X on interfaces.

```
cumulus@switch:~$ net add interface swp1-4 dot1x
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

In Cumulus Linux 3.7.4 and later, to assign a tagged VLAN for voice devices and assign different VLANs to the devices based on authorization, run these commands:

```
cumulus@switch:~$ net add interface swp1-4 dot1x voice-enable
cumulus@switch:~$ net add interface swp1-4 dot1x voice-enable
vlan 200
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```



These commands create the following configuration snippet in the `/etc/network/interfaces` file:

```
cumulus@switch:~$ cat /etc/network/interfaces

...
auto swp1
iface swp1
    bridge-learning off

auto swp2
iface swp2
    bridge-learning off

auto swp3
iface swp3
    bridge-learning off

auto swp4
iface swp4
    bridge-learning off
...

auto bridge
iface bridge
    bridge-ports swp1 swp2 swp3 swp4
    bridge-vlan-aware yes
```

Verify the 802.1X configuration, showing the configuration and its status:

```
cumulus@switch:~$ net show configuration commands | grep dot1x
dot1x radius server-ip 127.0.0.1
dot1x radius authentication-port 1812
dot1x radius accounting-port 1813
dot1x radius shared-secret testing123
interface swp2,swp3,swp1,swp4 dot1x

cumulus@switch:~$ net show dot1x status
IEEE802.1X Enabled Status: enabled
IEEE802.1X Active Status: active
```

## Configure 802.1X Interfaces for a Traditional Mode Bridge



NCLU and `hostapd` may change traditional mode configurations on the `bridge-ports` line in `/etc/network/interface` by adding or deleting special 802.1X traditional mode `bridge-ports` configuration stanzas in `/etc/network/interfaces.d/`. It is important that the



source configuration command in `/etc/network/interfaces` include these special configuration filenames. It should include at least `source /etc/network/interfaces.d/* .intf` in order to not prevent these files from being sourced during an `ifreload`.

1. Create some uplink ports. The following example uses bonds:

```
cumulus@switch:~$ net add bond bond1 bond slaves swp5-6  
cumulus@switch:~$ net add bond bond2 bond slaves swp7-8
```

2. Create a traditional mode bridge configuration on the switch and add the switch ports that are members of the bridge. Traditional bridge cannot be named `bridge` as that name is reserved for the single VLAN-aware bridge on the switch. You can use glob syntax to add a range of interfaces.

```
cumulus@switch:~$ net add bridge bridge1 ports swp1-4
```

3. Create bridge associations with the parking VLAN ID and the dynamic VLAN IDs. In this example, 600 is used for the parking VLAN ID and 700 is used for the dynamic VLAN ID:

```
cumulus@switch:~$ net add bridge br-vlan600 ports bond1.600  
cumulus@switch:~$ net add bridge br-vlan700 ports bond2.700
```

4. Configure the settings for the 802.1X RADIUS server, including its IP address and shared secret:

```
net add dot1x radius server-ip 127.0.0.1  
net add dot1x radius shared-secret testing123
```

In Cumulus Linux 3.7.2 and later, you can specify a VRF for outgoing RADIUS accounting and authorization packets. The following example specifies a VRF called blue:

```
cumulus@switch:~$ net add dot1x radius server-ip 127.0.0.1 vrf  
blue  
cumulus@switch:~$ net add dot1x radius shared-secret mysecret
```

5. Enable 802.1X on interfaces, then review and commit the new configuration.

```
cumulus@switch:~$ net add interface swp1-2 dot1x  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

Verify the 802.1X configuration, showing the configuration and its status:



```
cumulus@switch:~$ net show dot1x status

Hostapd IEEE 802.11 AP and IEEE 802.1X/WPA/WPA2/EAP Authenticator
Daemon
Attribute          Value
-----
Current Status     active (running)
Reload Status      enabled
Interfaces         swp1 swp2
MAB Interfaces
Parking VLAN Interfaces
Dynamic VLAN Status Disabled
```

```
cumulus@switch:~$ net show dot1x interface summary
```

Interface Type	MAC Address	Username	State	Authentication
MAB	VLAN			
swp1	00:02:00:00:00:01	host1	AUTHORIZED	
MD5		NO		
swp2	00:02:00:00:00:02	host2	AUTHORIZED	
MD5		NO		

## Configure the Linux Supplicants

A sample FreeRADIUS server configuration needs to contain the entries for users *host1* and *host2* on swp1 and swp2 for them to be placed in a VLAN.

```
host1 Cleartext-Password := "host1password"
host2 Cleartext-Password := "host2password"
```

After being configured, each supplicant needs the proper credentials:

```
user@host1:~# cat /etc/wpa_supplicant.conf

ctrl_interface=/var/run/wpa_supplicant
ctrl_interface_group=0
eapol_version=2
ap_scan=0
network={
    key_mgmt=IEEE8021X
    eap=TTLS MD5
    identity="host1"
    anonymous_identity="host1"
    password="host1password"
```



```
    phase1="auth=MD5"
    eapol_flags=0
}
```

```
user@host2:~# cat /etc/wpa_supplicant.conf

ctrl_interface=/var/run/wpa_supplicant
ctrl_interface_group=0
eapol_version=2
ap_scan=0
network={
    key_mgmt=IEEE8021X
    eap=TTLS MD5
    identity="host2"
    anonymous_identity="host2"
    password="host2password"
    phase1="auth=MD5"
    eapol_flags=0
}
```

To test that a supplicant (client) can communicate with the Cumulus Linux Authenticator switch, run the following command from the supplicant:

```
root@host1:/home/cumulus# wpa_supplicant -c /etc/wpa_supplicant.conf -
D wired -i swp1
Successfully initialized wpa_supplicant
swp1: Associated with 01:80:c2:00:00:03
swp1: CTRL-EVENT-EAP-STARTED EAP authentication started
swp1: CTRL-EVENT-EAP-PROPOSED-METHOD vendor=0 method=4
swp1: CTRL-EVENT-EAP-METHOD EAP vendor 0 method 4 (MD5) selected
swp1: CTRL-EVENT-EAP-SUCCESS EAP authentication completed successfully
swp1: CTRL-EVENT-CONNECTED - Connection to 01:80:c2:00:00:03 compl
```

Or from another supplicant:

```
root@host2:/home/cumulus# wpa_supplicant -c /etc/wpa_supplicant.conf -
D wired -i swp1
Successfully initialized wpa_supplicant
swp1: Associated with 01:80:c2:00:00:03
swp1: CTRL-EVENT-EAP-STARTED EAP authentication started
swp1: CTRL-EVENT-EAP-PROPOSED-METHOD vendor=0 method=4
swp1: CTRL-EVENT-EAP-METHOD EAP vendor 0 method 4 (MD5) selected
swp1: CTRL-EVENT-EAP-SUCCESS EAP authentication completed successfully
swp1: CTRL-EVENT-CONNECTED - Connection to 01:80:c2:00:00:03 comp
```

## Configure Accounting and Authentication Ports

You can configure the accounting and authentication ports in Cumulus Linux. The default values are `1813` for the accounting port and `1812` for the authentication port.

You can also change the reauthentication period for Extensible Authentication Protocol (EAP). The period defaults to `0` (no re-authentication is performed by the switch).

```
cumulus@switch:~$ net add dot1x radius authentication-port 2812
cumulus@switch:~$ net add dot1x radius accounting-port 2813
cumulus@switch:~$ net add dot1x eap-reauth-period 86400
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

## Configure MAC Authentication Bypass

MAC authentication bypass (MAB) enables bridge ports to allow devices to bypass authentication based on their MAC address. This is useful for devices that do not support PAE, such as printers or phones.



- In Cumulus Linux 3.7.3 and earlier, MAB supports one authenticated MAC address per port only. After a source MAC address is authenticated, the port exits MAB mode. Cumulus Linux 3.7.4 and later provides support for Multi Domain Authentication (MDA), where 802.1X is extended to allow authorization of multiple devices on a single port and assign different VLANs to the devices based on authorization.
- You must configure MAB on both the RADIUS server and the RADIUS client.
- When using a VLAN-aware bridge, the switch port must be part of bridge named bridge.

To configure MAB in Cumulus Linux 3.7.3 and earlier, enable a bridge port for MAB and change the MAB activation delay. You can change the MAB activation delay from the default of 30 seconds, but the delay must be between 5 and 30 seconds. After the delay limit is reached, the port enters MAB mode.

```
cumulus@switch:~$ net add dot1x mab-activation-delay 20
cumulus@switch:~$ net add interface swp1 dot1x mab
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

To configure MAB In Cumulus Linux 3.7.4 and later, enable a bridge port for MAB. The MAB activation delay is not used. For example:

```
cumulus@switch:~$ net add interface swp1 dot1x mab
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

To verify the configuration, run the `net show dot1x status` command:



```
cumulus@switch:~$ net show dot1x status

Hostapd IEEE 802.11 AP and IEEE 802.1X/WPA/WPA2/EAP Authenticator
Daemon
Attribute          Value
-----
Current Status     active (running)
Reload Status      enabled
Interfaces         swp1 swp2
MAB Interfaces    swp1
Parking VLAN Interfaces
Dynamic VLAN Status Disabled
```

```
cumulus@switch:~$ net show dot1x interface summary
```

Interface	MAC Address	Username	State
Authentication Type	MAB	VLAN	
swp1	00:02:00:00:00:08	000200000008	AUTHORIZED
unknown		YES	

## Configure a Parking VLAN

If a non-authorized supplicant tries to communicate with the switch, you can route traffic from that device to a different VLAN and associate that VLAN with one of the switch ports to which the supplicant is attached.

For VLAN-aware bridges, the parking VLAN is assigned by manipulating the PVID of the switch port. For traditional mode bridges, Cumulus Linux identifies the bridge associated with the parking VLAN ID and moves the switch port into that bridge. If an appropriate bridge is not found for the move, then the port remains in an unauthenticated state where no packets can be received or transmitted.

When using a VLAN-aware bridge, the switch port must be part of bridge named *bridge*.

```
cumulus@switch:~$ net add dot1x parking-vlan-id 777
cumulus@switch:~$ net add interface swp1 dot1x parking-vlan
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

If the authentication for swp1 fails, the port is moved to the parking VLAN:

```
cumulus@switch:~$ net show dot1x interface swp1 details

Interface  MAC Address          Attribute          Value
-----  -----  -----  -----
-----  -----  -----  -----
```

```

swp1      00:02:00:00:00:08  Status Flags
[ PARKED_VLAN ]
                                         Username          vlan60
                                         Authentication Type MD5
                                         VLAN             777
                                         Session Time (seconds) 24772
                                         EAPOL Frames RX    9
                                         EAPOL Frames TX    12
                                         EAPOL Start Frames RX 1
                                         EAPOL Logoff Frames RX 0
                                         EAPOL Response ID Frames RX 4
                                         EAPOL Response Frames RX 8
                                         EAPOL Request ID Frames TX 4
                                         EAPOL Request Frames TX 8
                                         EAPOL Invalid Frames RX 0
                                         EAPOL Length Error Frames Rx 0
                                         EAPOL Frame Version 2
                                         EAPOL Auth Last Frame Source 00:02:00:
00:00:08
                                         EAPOL Auth Backend Responses 8
                                         RADIUS Auth Session ID
                                         C2FED91A39D8D605

```

To verify the configuration, run the `net show dot1x interface summary` command:

```

cumulus@switch:~$ net show dot1x interface summary

Interface  MAC Address          Username          State
Authentication Type  MAB   VLAN
-----  -----  -----  -----
-----  -----  -----  -----
swp1      00:02:00:00:00:08  vlan60          PARKING VLAN
MD5           NO    777

```

The following output shows a parking VLAN association failure. VLAN association failure only occurs with traditional mode bridges when there is no traditional bridge available with a parking VLAN ID-tagged subinterface in it (notice the [UNKNOWN\_BR] status in the output):

```

cumulus@switch:~$ net show dot1x interface swp3 details

Interface  MAC Address          Attribute          Value
-----  -----  -----  -----
-----  -----  -----  -----
swp1      00:02:00:00:00:08  Status Flags
[ PARKED_VLAN ] [ UNKNOWN_BR ]
                                         Username          vlan60
                                         Authentication Type MD5
                                         VLAN             777
                                         Session Time (seconds) 24599

```



	EAPOL Frames RX	3
	EAPOL Frames TX	3
	EAPOL Start Frames RX	1
	EAPOL Logoff Frames RX	0
	EAPOL Response ID Frames RX	1
	EAPOL Response Frames RX	2
	EAPOL Request ID Frames TX	1
	EAPOL Request Frames TX	2
	EAPOL Invalid Frames RX	0
	EAPOL Length Error Frames Rx	0
	EAPOL Frame Version	2
00:00:08	EAPOL Auth Last Frame Source	00:02:00:
C2FED91A39D8D605	EAPOL Auth Backend Responses	2
	RADIUS Auth Session ID	

## Configure Dynamic VLAN Assignments

A common requirement for campus networks is to assign dynamic VLANs to specific users in combination with IEEE 802.1x. After authenticating a supplicant, the user is assigned a VLAN based on the RADIUS configuration.

For VLAN-aware bridges, the dynamic VLAN is assigned by manipulating the PVID of the switch port. For traditional mode bridges, Cumulus Linux identifies the bridge associated with the dynamic VLAN ID and moves the switch port into that bridge. If an appropriate bridge is not found for the move, then the port remains in an unauthenticated state where no packets can be received or transmitted.

To enable dynamic VLAN assignment globally, where VLAN attributes sent from the RADIUS server are applied to the bridge, do the following:

```
cumulus@switch:~$ net add dot1x dynamic-vlan
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

You can specify the `require` option in the command so that VLAN attributes are required. If VLAN attributes do not exist in the access response packet returned from the RADIUS server, the user is not authorized and has no connectivity. If the RADIUS server returns VLAN attributes but the user has an incorrect password, the user is placed in the parking VLAN (if you have configured parking VLAN).

```
cumulus@switch:~$ net add dot1x dynamic-vlan require
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

The following example shows a typical RADIUS configuration (shown for FreeRADIUS, not typically configured or run on the Cumulus Linux device) for a user with dynamic VLAN assignment:

```
# # VLAN 100 Client Configuration for Freeradius RADIUS Server.
# # This is not part of the CL configuration.
```



```
vlan100client Cleartext-Password := "client1password"
  Service-Type = Framed-User,
  Tunnel-Type = VLAN,
  Tunnel-Medium-Type = "IEEE-802",
  Tunnel-Private-Group-ID = 100
```

Verify the configuration (notice the [AUTHORIZED] status in the output):

```
cumulus@switch:~$ net show dot1x interface swp1 details

Interface  MAC Address          Attribute          Value
-----  -----
-----  -----
swp1      00:02:00:00:00:08  Status Flags
[DYNAMIC_VLAN][AUTHORIZED]
                                         Username        host1
                                         Authentication Type MD5
                                         VLAN           888
                                         Session Time (seconds) 799
                                         EAPOL Frames RX    3
                                         EAPOL Frames TX    3
                                         EAPOL Start Frames RX 1
                                         EAPOL Logoff Frames RX 0
                                         EAPOL Response ID Frames RX 1
                                         EAPOL Response Frames RX 2
                                         EAPOL Request ID Frames TX 1
                                         EAPOL Request Frames TX 2
                                         EAPOL Invalid Frames RX 0
                                         EAPOL Length Error Frames Rx 0
                                         EAPOL Frame Version 2
                                         EAPOL Auth Last Frame Source 00:02:00:
00:00:08
                                         EAPOL Auth Backend Responses 2
                                         RADIUS Auth Session ID
                                         939B1A53B624FC56
```

```
cumulus@switch:~$ net show dot1x interface summary

Interface  MAC Address          Username          State
Authentication Type  MAB   VLAN
-----  -----
-----  -----
swp1      00:02:00:00:00:08  000200000008  AUTHORIZED
unknown                NO    888
```

The following output shows a dynamic VLAN association failure. VLAN association failure only occurs with traditional mode bridges when there is no traditional bridge available with a parking VLAN ID-tagged subinterface in it (notice the [UNKNOWN\_BR] status in the output):



```
cumulus@switch:~$ net show dot1x interface swp1 details
```

Interface	MAC Address	Attribute	Value
swp1	00:02:00:00:00:08	Status Flags	
		[ DYNAMIC_VLAN ] [ AUTHORIZED ] [ UNKNOWN_BR ]	
		Username	host2
		Authentication Type	MD5
		VLAN	888
		Session Time (seconds)	11
		EAPOL Frames RX	3
		EAPOL Frames TX	3
		EAPOL Start Frames RX	1
		EAPOL Logoff Frames RX	0
		EAPOL Response ID Frames RX	1
		EAPOL Response Frames RX	2
		EAPOL Request ID Frames TX	1
		EAPOL Request Frames TX	2
		EAPOL Invalid Frames RX	0
		EAPOL Length Error Frames Rx	0
		EAPOL Frame Version	2
		EAPOL Auth Last Frame Source	00:02:00:
	00:00:08		
		EAPOL Auth Backend Responses	2
		RADIUS Auth Session ID	
	BDF731EF2B765B78		

To disable dynamic VLAN assignment, where VLAN attributes sent from the RADIUS server are ignored and users are authenticated based on existing credentials:

```
cumulus@switch:~$ net del dot1x dynamic-vlan
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```



Enabling or disabling dynamic VLAN assignment restarts `hostapd`, which forces existing, authorized users to re-authenticate.

## Configure MAC Addresses per Port

In Cumulus Linux 3.7.4 and later, you can specify the maximum number of authenticated MAC addresses allowed on a port with the `net add dot1x max-number-stations <value>` command. You can specify any number between 0 and 255. The default value is 4.

```
cumulus@switch:~$ net add dot1x max-number-stations 10
```



```
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

## Configure EAP Requests from the Switch

Cumulus Linux 3.7.3 and later provides the `send-eap-request-id` option, which you can use to trigger EAP packets to be sent from the host side of a connection. For example, this option is required in a configuration where a PC connected to a phone attempts to send EAP packets to the switch via the phone but the PC does not receive a response from the switch (the phone might not be ready to forward packets to the switch after a reboot). Because the switch does not receive EAP packets, it attempts to authorize the PC with MAB instead of waiting for the packets. In this case, the PC might be placed into a parking VLAN to isolate it. To remove the PC from the parking VLAN, the switch needs to send an EAP request to the PC to trigger EAP.

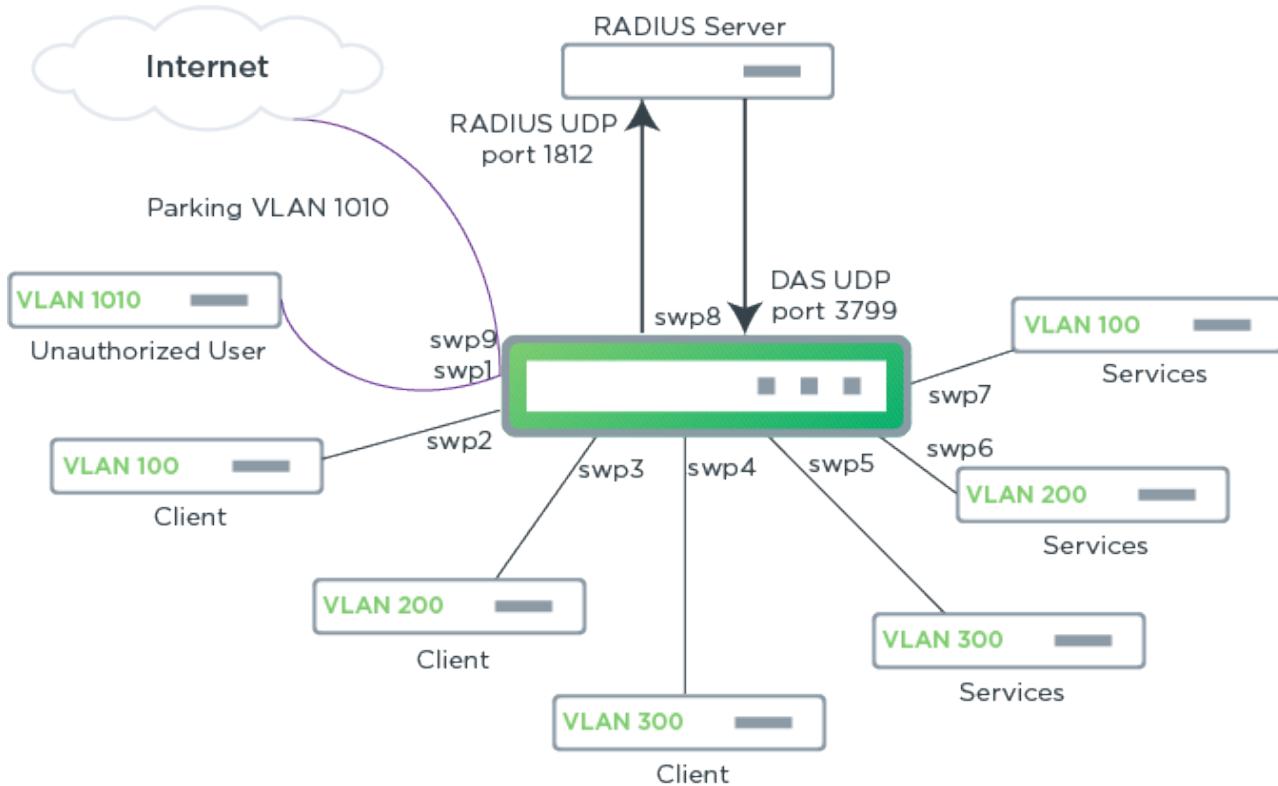
To configure the switch send an EAP request, run these commands:

```
cumulus@switch:~$ net add dot1x send-eap-request-id  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

The `net del dot1x send-eap-request-id` command disables this feature.

## RADIUS Change of Authorization and Disconnect Requests

Extensions to the RADIUS protocol (RFC 5176) enable the Cumulus Linux switch to act as a Dynamic Authorization Server (DAS) by listening for Change of Authorization (CoA) requests from the RADIUS server (Dynamic Authorization Client (DAC)) and taking action when needed, such as bouncing a port or terminating a user session. The IEEE 802.1x server (`hostapd`) running on Cumulus Linux has been adapted to handle these additional, unsolicited RADIUS requests.



## Configure DAS

To configure DAS, provide the UDP port (3799 is the default port), the IP address, and the secret key for the DAS client.

The following example commands set the UDP port to the default port, the IP address of the DAS client to 10.0.2.228, and the secret key to myclientsecret:

```
cumulus@switch:~$ net add dot1x radius das-port default
cumulus@switch:~$ net add dot1x radius das-client-ip 10.0.2.228 das-
client-secret myclientsecret
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

In Cumulus Linux 3.7.2 and later, you can specify a VRF so that incoming RADIUS disconnect and CoA commands are received and acknowledged on the correct interface when VRF is configured. The following example specifies VRF blue:

```
cumulus@switch:~$ net add dot1x radius das-port default
cumulus@switch:~$ net add dot1x radius das-client-ip 10.0.2.228 vrf
blue das-client-secret mysecret123
cumulus@switch:~$ net commit
```

In Cumulus Linux 3.7.4 and later, you can configure up to four DAS clients to be authorized to send CoA commands. For example:



```
cumulus@switch:~$ net add dot1x radius das-port default
cumulus@switch:~$ net add dot1x radius das-client-ip 10.20.250.53 das-
client-secret mysecret1
cumulus@switch:~$ net add dot1x radius das-client-ip 10.0.1.7 das-
client-secret mysecret2
cumulus@switch:~$ net add dot1x radius das-client-ip 10.20.250.99 das-
client-secret mysecret3
cumulus@switch:~$ net add dot1x radius das-client-ip 10.10.0.0.2 das-
client-secret mysecret4
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

You can disable DAS in Cumulus Linux at any time by running the following commands:

```
cumulus@switch:~$ net del dot1x radius das-port
cumulus@switch:~$ net del dot1x radius das-client-ip
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

To see DAS configuration information, run the `net show configuration dot1x` command. For example:

```
cumulus@switch:~$ net show configuration dot1x
...
dot1x
mab-activation-delay 5
eap-reauth-period 0
parking-vlan-id 100
dynamic-vlan
radius
client-source-ip 13.0.0.1
accounting-port 1813
das-client-ip 10.0.2.228
das-client-secret myclientsecret
authentication-port 1812
shared-secret testing123
server-ip 10.1.0.8
das-port 3799
```

### Terminate a User Session

From the DAC, users can create a disconnect message using the `radclient` utility (included in the Debian `freeradius-utils` package) on the RADIUS server or other authorized client. A disconnect message is sent as an unsolicited RADIUS Disconnect-Request packet to the switch to terminate a user session and discard all associated session context. The Disconnect-Request packet is used when the RADIUS server wants to disconnect the user after the session has been accepted by the RADIUS Access-Accept packet.

This is an example of a disconnect message created using the `radclient` utility:



```
$ echo "Acct-Session-Id=D91FE8E51802097" > disconnect-packet.txt
$ ## OPTIONAL ## echo "User-Name=somebody" >> disconnect-packet.txt
$ echo "Message-Authenticator=1" >> disconnect-packet.txt
$ echo "Event-Timestamp=1532974019" >> disconnect-packet.txt
# now send the packet with the radclient utility (from freeradius-
utils deb package)
$ cat disconnect-packet.txt | radclient -x 10.0.0.1:3799 disconnect
myclientsecret
```

To prevent unauthorized servers from disconnecting users, the Disconnect-Request packet must include certain identification attributes (described below). For a session to be disconnected, all parameters must match their expected values at the switch. If the parameters do not match, the switch discards the Disconnect-Request packet and sends a Disconnect-NAK (negative acknowledgment message).

- The `Message-Authenticator` attribute is required.
- If the packet comes from a different source IP address than the one defined by `das-client-ip`, the session is not disconnected and the `hostapd` logs the debug message: `DAS: Drop message from unknown client`.
- The `Event-Timestamp` attribute is required. If `Event-Timestamp` in the packet is outside the time window, a debug message is shown in the `hostapd` logs: `DAS: Unacceptable Event-Timestamp (1532978602; local time 1532979367) in packet from 10.10.0.21:45263 - drop`
- If the `Acct-Session-Id` attribute is omitted, the `User-Name` attribute is used to find the session. If the `User-Name` attribute is omitted, the `Acct-Session-Id` attribute is used. If both the `User-Name` and the `Acct-Session-Id` attributes are supplied, they must match the username provided by the supplicant with the `Acct-Session-Id` provided. If neither are given or there is no match, a Disconnect-NAK message is returned to the RADIUS server with `Error-Cause "Session-Context-Not-Found"` and the following debug message is shown in the log:  
RADIUS DAS: Acct-Session-Id match  
RADIUS DAS: No matches remaining after User-Name check  
hostapd\_das\_find\_global\_sta: checking ifname=swp2  
RADIUS DAS: No matches remaining after Acct-Session-Id check  
RADIUS DAS: No matching session found  
DAS: Session not found for request from 10.10.0.1:58385  
DAS: Reply to 10.10.0.1:58385

The following is an example of the Disconnect-Request packet received by the switch:

```
RADIUS Protocol
Code: Disconnect-Request (40)
Packet identifier: 0x4f (79)
Length: 53
Authenticator: c0e1fa75fdf594a1cfaf35151a43c6a7
Attribute Value Pairs
AVP: t=Acct-Session-Id(44) l=17 val=D91FE8E51802097
AVP: t=User-Name(1) l=10 val=somebody
AVP: t=Message-Authenticator(80) l=18
val=38cb3b6896623b4b7d32f116fa976cdc
AVP: t=Event-Timestamp(55) l=6 val=1532974019
AVP: t=NAS-IP-Address(4) l=6 val=10.0.0.1
```



## Bounce a Port

You can create a CoA bounce-host-port message from the RADIUS server using the `radclient` utility (included in the Debian `freeradius-utils` package). The bounce port can cause a link flap on an authentication port, which triggers DHCP renegotiation from one or more hosts connected to the port.

The following is an example of a Cisco AVPair CoA bounce-host-port message sent from the `radclient` utility:

```
$ echo "Acct-Session-Id=D91FE8E51802097" > bounce-packet.txt
$ ## OPTIONAL ## echo "User-Name=somebody" >> bounce-packet.txt
$ echo "Message-Authenticator=1" >> bounce-packet.txt
$ echo "Event-Timestamp=1532974019" >> bounce-packet.txt
$ echo "cisco-avpair='subscriber:command=bounce-host-port'" >>
bounce-packet.txt
$ cat bounce-packet.txt | radclient -x 10.0.0.1:3799 coa
myclientsecret
```

The message received by the switch is:

```
RADIUS Protocol
Code: CoA-Request (43)
Packet identifier: 0x3a (58)
Length: 96
Authenticator: 6480d710802329269d5cae6a59bcfb59
Attribute Value Pairs
AVP: t=Acct-Session-Id(44) l=17 val=D91FE8E51802097
Type: 44
Length: 17
Acct-Session-Id: D91FE8E51802097
AVP: t=User-Name(1) l=10 val=somebody
Type: 1
Length: 10
User-Name: somebody
AVP: t=NAS-IP-Address(4) l=6 val=10.0.0.1
Type: 4
Length: 6
NAS-IP-Address: 10.0.0.1
AVP: t=Vendor-Specific(26) l=43 vnd=ciscoSystems(9)
Type: 26
Length: 43
Vendor ID: ciscoSystems (9)
VSA: t=Cisco-AVPair(1) l=37 val=subscriber:command=bounce-host-port
Type: 1
Length: 37
Cisco-AVPair: subscriber:command=bounce-host-port
```



## Troubleshooting

To check connectivity between two supplicants, ping one host from the other:

```
root@host1:/home/cumulus# ping 198.150.0.2
PING 11.0.0.2 (11.0.0.2) 56(84) bytes of data.
64 bytes from 11.0.0.2: icmp_seq=1 ttl=64 time=0.604 ms
64 bytes from 11.0.0.2: icmp_seq=2 ttl=64 time=0.552 ms
^C
--- 11.0.0.2 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1000ms
rtt min/avg/max/mdev = 0.552/0.578/0
```

You can run `net show dot1x` with the following options for more data:

- `json`: Prints the command output in JSON format.
- `macs`: Displays MAC address information.
- `port-details`: Shows counters from the IEEE8021-PAE-MIB for ports.
- `radius-details`: Shows counters from the RADIUS-CLIENT MIB (RFC 2618) for ports.
- `status`: Displays the status of the daemon.

To check which MAC addresses are authorized by RADIUS:

```
cumulus@switch:~$ net show dot1x macs
Interface          Attribute      Value
-----            -----
swp1              MAC Addresses  00:02:00:00:00:01
swp2              No Data
swp3              No Data
swp4              No Data
```

To check the port detail counters:

```
cumulus@switch:~$ net show dot1x port-details
Interface          Attribute           Value
-----            -----
swp1              Mac Addresses       00:02:00:
00:00:01          authMultiSessionId
96703ADC82D77DF2
                    connected_time     182
                    dot1xAuthEapolFramesRx   3
                    dot1xAuthEapolFramesTx    3
                    dot1xAuthEapolLogoffFramesRx 0
                    dot1xAuthEapolReqFramesTx   2
```

	dot1xAuthEapolReqIdFramesTx	1
	dot1xAuthEapolRespFramesRx	2
	dot1xAuthEapolRespIdFramesRx	1
	dot1xAuthEapolStartFramesRx	1
00:01	dot1xAuthInvalidEapolFramesRx	0
	dot1xAuthLastEapolFrameSource	00:02:00:00:
	dot1xAuthLastEapolFrameVersion	2
	dot1xAuthPaeState	5
	dot1xAuthQuietPeriod	60
	dot1xAuthReAuthEnabled	FALSE
	dot1xAuthReAuthPeriod	0
	dot1xAuthServerTimeout	30
	dot1xAuthSessionAuthenticMethod	1
	dot1xAuthSessionId	
1B50FE8939FD9F5E		
	dot1xAuthSessionTerminateCause	999
	dot1xAuthSessionTime	182
	dot1xAuthSessionUserName	testing
	dot1xPaePortProtocolVersion	2
	last_eap_type_as	4 (MD5)
(MD5 )	last_eap_type_sta	4

To check RADIUS counters:

Interface	Attribute	Value
swp1	radiusAccClientRequests	1
	radiusAccClientResponses	1
	radiusAccClientServerPortNumber	1813
	radiusAccServerAddress	127.0.0.1
	radiusAuthClientAccessAccepts	1
	radiusAuthClientAccessChallenges	1
	radiusAuthClientAccessRejects	0
	radiusAuthClientAccessRequests	0
	radiusAuthClientServerPortNumber	1812
	radiusAuthServerAddress	127.0.0.1
	radiusAuthServerIndex	1
...		

You can also check logging with journalctl:

```
cumulus@switch-01:~$ sudo journalctl -f -u hostapd
Apr 19 22:17:11 switch-01 hostapd[12462]: swp1: interface state
UNINITIALIZED->ENABLED
Apr 19 22:17:11 switch-01 hostapd[12462]: swp1: AP-ENABLED
```



```
Apr 19 22:17:11 switch-01 hostapd[12462]: Reading rule file /etc/cumulus/acl/policy.d/00control_ps ...
Apr 19 22:17:11 switch-01 hostapd[12462]: Processing rules in file /etc/cumulus/acl/policy.d/00...
Apr 19 22:17:12 switch-01 hostapd[12462]: Reading rule file /etc/cumulus/acl/policy.d/100_dot1x...
Apr 19 22:17:12 switch-01 hostapd[12462]: Processing rules in file /etc/cumulus/acl/policy.d/100...
Apr 19 22:17:12 switch-01 hostapd[12462]: Reading rule file /etc/cumulus/acl/policy.d/99control
Apr 19 22:17:12 switch-01 hostapd[12462]: Processing rules in file /etc/cumulus/acl/policy.d/99
Apr 19 22:17:12 switch-01 hostapd[12462]: Installing acl policy
Apr 19 22:17:12 switch-01 hostapd[12462]: done.
```

To increase the debug level in hostapd, copy the hostapd service file, then add `-d`, `-dd` or `-ddd` to the `ExecStart` line in the `hostapd.service` file:

```
cumulus@switch:~$ cp /lib/systemd/system/hostapd.service /etc/systemd/system/hostapd.service
cumulus@switch:~$ sudo nano /etc/systemd/system/hostapd.service
...
ExecStart=/usr/sbin/hostapd -ddd -c /etc/hostapd.conf
...
```

To watch debugs with `journalctl` as supplicants attempt to connect:

```
cumulus@switch:~$ sudo journalctl -n 1000 -u hostapd      # see the
last 1000 lines of hostapd debug logging
cumulus@switch:~$ sudo journalctl -f -u hostapd          #
continuous tail of the hostapd daemon debug logging
```

To check ACL rules in `/etc/cumulus/acl/policy.d/100_dot1x_swpX.rules` before and after a supplicant attempts to authenticate:

```
cumulus@switch:~$ sudo cl-acltool -L eb | grep swpXX
cumulus@switch:~$ sudo cl-netstat | grep swpXX           # look at
interface counters
```

To check tc rules in `/var/lib/hostapd/acl/tc_swpX.rules`:

```
cumulus@switch:~$ sudo tc -s filter show dev swpXX parent 1:
cumulus@switch:~$ sudo tc -s filter show dev swpXX parent ffff:
```



## Related Information

Campus design feature set-up (6-part blog series)

# Prescriptive Topology Manager - PTM

In data center topologies, right cabling is a time-consuming endeavor and is error prone. Prescriptive Topology Manager (PTM) is a dynamic cabling verification tool to help detect and eliminate such errors. It takes a Graphviz-DOT specified network cabling plan (something many operators already generate), stored in a `topology.dot` file, and couples it with runtime information derived from LLDP to verify that the cabling matches the specification. The check is performed on every link transition on each node in the network.

You can customize the `topology.dot` file to control `ptmd` at both the global/network level and the node/port level.

PTM runs as a daemon, named `ptmd`.

For more information, see `man ptmd(8)`.

## Contents

This topic describes ...

- Supported Features (see page 361)
- Configure PTM (see page 361)
- Basic Topology Example (see page 361)
- `ptmd` Scripts (see page 362)
- Configuration Parameters (see page 362)
  - Host-only Parameters (see page 362)
  - Global Parameters (see page 363)
  - Per-port Parameters (see page 363)
  - Templates (see page 364)
  - Supported BFD and LLDP Parameters (see page 364)
- Bidirectional Forwarding Detection (BFD) (see page 365)
- Check Link State with FRRouting (see page 366)
- `ptmd` Service Commands (see page 367)
- `ptmctl` Commands (see page 367)
  - `ptmctl` Examples (see page 367)
  - `ptmctl` Error Outputs (see page 369)
- Caveats and Errata (see page 370)
- Related Information (see page 371)



## Supported Features

- Topology verification using LLDP. `ptmd` creates a client connection to the LLDP daemon, `lldpd`, and retrieves the neighbor relationship between the nodes/ports in the network and compares them against the prescribed topology specified in the `topology.dot` file.
- Only physical interfaces, like `swp1` or `eth0`, are currently supported. Cumulus Linux does not support specifying virtual interfaces like bonds or subinterfaces like `eth0.200` in the topology file.
- Forwarding path failure detection using [Bidirectional Forwarding Detection](#) (BFD); however, demand mode is not supported. For more information on how BFD operates in Cumulus Linux, read the [Bidirectional Forwarding Detection - BFD \(see page 821\)](#) chapter and read `man ptmd(8)`.
- Integration with FRRouting (PTM to FRRouting notification).
- Client management: `ptmd` creates an abstract named socket `/var/run/ptmd.socket` on startup. Other applications can connect to this socket to receive notifications and send commands.
- Event notifications: see Scripts below.
- User configuration via a `topology.dot` file; [see below \(see page 361\)](#).

## Configure PTM

`ptmd` verifies the physical network topology against a DOT-specified network graph file, `/etc/ptm.d/topology.dot`.

PTM supports [undirected graphs](#).

At startup, `ptmd` connects to `lldpd`, the LLDP daemon, over a Unix socket and retrieves the neighbor name and port information. It then compares the retrieved port information with the configuration information that it read from the topology file. If there is a match, then it is a PASS, else it is a FAIL.

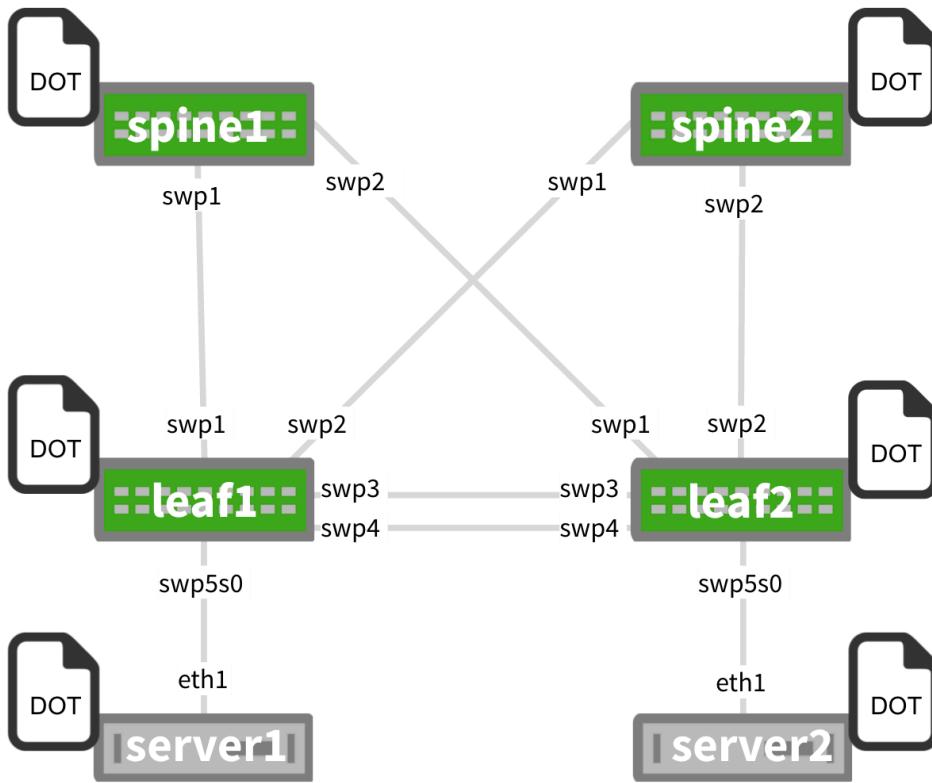


PTM performs its LLDP neighbor check using the PortID ifname TLV information. Previously, it used the PortID port description TLV information.

## Basic Topology Example

This is a basic example DOT file and its corresponding topology diagram. You should use the same `topology.dot` file on all switches, and don't split the file per device; this allows for easy automation by pushing/pulling the same exact file on each device!

```
graph G {
    "spine1":"swp1" -- "leaf1":"swp1";
    "spine1":"swp2" -- "leaf2":"swp1";
    "spine2":"swp1" -- "leaf1":"swp2";
    "spine2":"swp2" -- "leaf2":"swp2";
    "leaf1":"swp3" -- "leaf2":"swp3";
    "leaf1":"swp4" -- "leaf2":"swp4";
    "leaf1":"swp5s0" -- "server1":"eth1";
    "leaf2":"swp5s0" -- "server2":"eth1";
}
```



## ptmd Scripts

`ptmd` executes scripts at `/etc/ptm.d/if-topo-pass` and `/etc/ptm.d/if-topo-fail` for each interface that goes through a change, running `if-topo-pass` when an LLDP or BFD check passes and running `if-topo-fails` when the check fails. The scripts receive an argument string that is the result of the `ptmctl` command, described in the [ptmd commands section below](#) (see page 367).

You should modify these default scripts as needed.

## Configuration Parameters

You can configure `ptmd` parameters in the topology file. The parameters are classified as host-only, global, per-port/node and templates.

### Host-only Parameters

*Host-only parameters* apply to the entire host on which PTM is running. You can include the `hostnametype` host-only parameter, which specifies whether PTM should use only the host name (`hostname`) or the fully-qualified domain name (`fqdn`) while looking for the `self-node` in the graph file. For example, in the graph file below, PTM will ignore the FQDN and only look for `switch04`, since that is the host name of the switch it's running on:





It's a good idea to always wrap the hostname in double quotes, like "www.example.com". Otherwise, `ptmd` can fail if you specify a fully-qualified domain name as the hostname and do not wrap it in double quotes.

Further, to avoid errors when starting the `ptmd` process, make sure that `/etc/hosts` and `/etc/hostname` both reflect the hostname you are using in the `topology.dot` file.

```
graph G {
    hostnametype="hostname"
    BFD="upMinTx=150,requiredMinRx=250"
    "cumulus":"swp44" -- "switch04.cumulusnetworks.com": "swp20"
    "cumulus":"swp46" -- "switch04.cumulusnetworks.com": "swp22"
}
```

However, in this next example, PTM will compare using the FQDN and look for `switch05.cumulusnetworks.com`, which is the FQDN of the switch it's running on:

```
graph G {
    hostnametype="fqdn"
    "cumulus":"swp44" -- "switch05.cumulusnetworks.com": "swp20"
    "cumulus":"swp46" -- "switch05.cumulusnetworks.com": "swp22"
}
```

## Global Parameters

*Global parameters* apply to every port listed in the topology file. There are two global parameters: LLDP and BFD. LLDP is enabled by default; if no keyword is present, default values are used for all ports. However, BFD is disabled if no keyword is present, unless there is a per-port override configured. For example:

```
graph G {
    LLDP=""
    BFD="upMinTx=150,requiredMinRx=250,afi=both"
    "cumulus":"swp44" -- "qct-ly2-04": "swp20"
    "cumulus":"swp46" -- "qct-ly2-04": "swp22"
}
```

## Per-port Parameters

*Per-port parameters* provide finer-grained control at the port level. These parameters override any global or compiled defaults. For example:

```
graph G {
    LLDP=""
    BFD="upMinTx=300,requiredMinRx=100"
```

```

    "cumulus" :"swp44" -- "qct-ly2-04" :"swp20" [BFD="upMinTx=150,
requiredMinRx=250,afi=both"]
    "cumulus" :"swp46" -- "qct-ly2-04" :"swp22"
}

```

## *Templates*

*Templates* provide flexibility in choosing different parameter combinations and applying them to a given port. A template instructs `ptmd` to reference a named parameter string instead of a default one. There are two parameter strings `ptmd` supports:

- `bfdtmp1`, which specifies a custom parameter tuple for BFD.
- `lldptmp1`, which specifies a custom parameter tuple for LLDP.

For example:

```

graph G {
    LLDP=""
    BFD="upMinTx=300,requiredMinRx=100"
    BFD1="upMinTx=200,requiredMinRx=200"
    BFD2="upMinTx=100,requiredMinRx=300"
    LLDP1="match_type=ifname"
    LLDP2="match_type=portdescr"
    "cumulus" :"swp44" -- "qct-ly2-04" :"swp20" [BFD="
bfdtmpl=BFD1", LLDP="lldptmpl=LLDP1"]
    "cumulus" :"swp46" -- "qct-ly2-04" :"swp22" [BFD="
bfdtmpl=BFD2", LLDP="lldptmpl=LLDP2"]
    "cumulus" :"swp46" -- "qct-ly2-04" :"swp22"
}

```

In this template, `LLDP1` and `LLDP2` are templates for LLDP parameters while `BFD1` and `BFD2` are templates for BFD parameters.

## *Supported BFD and LLDP Parameters*

`ptmd` supports the following BFD parameters:

- `upMinTx`: the minimum transmit interval, which defaults to *300ms*, specified in milliseconds.
- `requiredMinRx`: the minimum interval between received BFD packets, which defaults to *300ms*, specified in milliseconds.
- `detectMult`: the detect multiplier, which defaults to *3*, and can be any non-zero value.
- `afi`: the address family to be supported for the edge. The address family must be one of the following:
  - *v4*: BFD sessions will be built for only IPv4 connected peer. This is the default value.
  - *v6*: BFD sessions will be built for only IPv6 connected peer.
  - *both*: BFD sessions will be built for both IPv4 and IPv6 connected peers.

The following is an example of a topology with BFD applied at the port level:



```
graph G {
    "cumulus-1": "swp44" -- "cumulus-2": "swp20" [BFD="upMinTx=300,
requiredMinRx=100,afi=v6"]
    "cumulus-1": "swp46" -- "cumulus-2": "swp22" [BFD=
detectMult=4]
}
```

`ptmd` supports the following LLDP parameters:

- `match_type`, which defaults to the interface name (`ifname`), but can accept a port description (`portdescr`) instead if you want `lldpd` to compare the topology against the port description instead of the interface name. You can set this parameter globally or at the per-port level.
- `match_hostname`, which defaults to the host name (`hostname`), but enables PTM to match the topology using the fully-qualified domain name (`fqdn`) supplied by LLDP.

The following is an example of a topology with LLDP applied at the port level:

```
graph G {
    "cumulus-1": "swp44" -- "cumulus-2": "swp20" [LLDP=
match_hostname=fqdn]
    "cumulus-1": "swp46" -- "cumulus-2": "swp22" [LLDP=
match_type=portdescr]
}
```



When you specify `match_hostname=fqdn`, `ptmd` will match the entire FQDN, like *cumulus-2.domain.com* in the example below. If you do not specify anything for `match_hostname`, `ptmd` will match based on hostname only, like *cumulus-3* below, and ignore the rest of the URL:

```
graph G {
    "cumulus-1": "swp44" -- "cumulus-2.domain.com": "swp20"
[LLDP="match_hostname=fqdn"]
    "cumulus-1": "swp46" -- "cumulus-3": "swp22" [LLDP=
match_type=portdescr]
}
```

## Bidirectional Forwarding Detection (BFD)

BFD provides low overhead and rapid detection of failures in the paths between two network devices. It provides a unified mechanism for link detection over all media and protocol layers. Use BFD to detect failures for IPv4 and IPv6 single or multihop paths between any two network devices, including unidirectional path failure detection. For information about configuring BFD using PTM, see the [BFD topic](#) (see page 821).



## Check Link State with FRRouting

The FRRouting routing suite enables additional checks to ensure that routing adjacencies are formed only on links that have connectivity conformant to the specification, as determined by `ptmd`.



You only need to do this to check link state; you do not need to enable PTM to determine BFD status.

When the global `ptm-enable` option is enabled, every interface has an implied `ptm-enable` line in the configuration stanza in the interfaces file.

To enable the global `ptm-enable` option, run the following FRRouting command:

```
cumulus@switch:~$ sudo vtysh

switch# configure terminal
switch(config)# ptm-enable
switch(config)# end
switch# write memory
switch# exit
cumulus@switch:~$
```

To disable the checks, delete the `ptm-enable` parameter from the interface. For example:

```
cumulus@switch:~$ net del interface swp51 ptm-enable
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

If you need to re-enable PTM for that interface, run:

```
cumulus@switch:~$ net add interface swp51 ptm-enable
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

With PTM enabled on an interface, the `zebra` daemon connects to `ptmd` over a Unix socket. Any time there is a change of status for an interface, `ptmd` sends notifications to `zebra`. `zebra` maintains a `ptm-status` flag per interface and evaluates routing adjacency based on this flag. To check the per-interface `ptm-status`:

```
cumulus@switch:~$ net show interface swp1

Interface swp1 is up, line protocol is up
  Link ups:      0    last: (never)
  Link downs:   0    last: (never)
```



```
PTM status: disabled
vrf: Default-IP-Routing-Table
index 3 metric 0 mtu 1550
flags: <UP,BROADCAST,RUNNING,MULTICAST>
HWaddr: c4:54:44:bd:01:41
```

## ptmd Service Commands

PTM sends client notifications in CSV format.

```
cumulus@switch:~$ sudo systemctl start|restart|force-reload ptmd.service
```

Starts or restarts the `ptmd` service. The `topology.dot` file must be present in order for the service to start.

```
cumulus@switch:~$ sudo systemctl reload ptmd.service
```

Instructs `ptmd` to read the `topology.dot` file again without restarting, applying the new configuration to the running state.

```
cumulus@switch:~$ sudo systemctl stop ptmd.service
```

Stops the `ptmd` service.

```
cumulus@switch:~$ sudo systemctl status ptmd.service
```

Retrieves the current running state of `ptmd`.

## ptmctl Commands

`ptmctl` is a client of `ptmd`; it retrieves the operational state of the ports configured on the switch and information about BFD sessions from `ptmd`. `ptmctl` parses the CSV notifications sent by `ptmd`.

See `man ptmctl` for more information.

### *ptmctl Examples*

The examples below contain the following keywords in the output of the `tbl` status column, which are described here:

tbl status Keyword	Definition
pass	The interface is defined in the topology file, LLDP information is received on the interface, and the LLDP information for the interface matches the information in the topology file.
fail	The interface is defined in the topology file, LLDP information is received on the interface, and the LLDP information for the interface does <b>not</b> match the information in the topology file.
N/A	The interface is defined in the topology file, but no LLDP information is received on the interface. The interface may be down or disconnected, or the neighbor is not sending LLDP packets.  The "N/A" and "fail" statuses may indicate a wiring problem to investigate.  The "N/A" status is not shown when using the <code>-1</code> option with <code>ptmctl</code> . If you specify the <code>-1</code> option, <code>ptmctl</code> displays only those interfaces that are receiving LLDP information.

For basic output, use `ptmctl` without any options:

```
cumulus@switch:~$ sudo ptmctl

-----
port  cbl      BFD      BFD
      status    status   peer
      local     type
-----
swp1  pass     pass     11.0.0.2
swp2  pass     N/A      N/A
swp3  pass     N/A      N/A
```

For more detailed output, use the **-d** option:

```
cumulus@switch:~$ sudo ptmctl -d

-----
port  cbl      exp      act      sysname  portID  portDescr  match
last   BFD      BFD
      status   nbr      nbr
      Type     state
      on

-----
swp45 pass     h1:swp1 h1:swp1  h1        swp1     swp1       IfName 5m:
5s    N/A      N/A
swp46 fail     h2:swp1 h2:swp1  h2        swp1     swp1       IfName 5m:
5s    N/A      N/A

#continuation of the output
-----

BFD      BFD      det_mult  tx_timeout  rx_timeout  echo_tx_timeout
echo_rx_timeout  max_hop_cnt
peer   DownDiag
-----

N/A     N/A      N/A      N/A        N/A        N/A        N
/A
N/A     N/A      N/A      N/A        N/A        N/A        N
/A
```

To return information on active BFD sessions **ptmd** is tracking, use the **-b** option:

```
cumulus@switch:~$ sudo ptmctl -b

-----
port  peer      state   local      type      diag
```



```
-----  
swp1 11.0.0.2    Up      N/A          singlehop  N/A  
N/A   12.12.12.1  Up      12.12.12.4  multihop   N/A
```

To return LLDP information, use the `-l` option. It returns only the active neighbors currently being tracked by `ptmd`.

```
cumulus@switch:~$ sudo ptmctl -l  
-----  
port  sysname  portID  port  match  last  
      descr    on     upd  
-----  
swp45 h1        swp1    swp1    IfName  5m:59s  
swp46 h2        swp1    swp1    IfName  5m:59s
```

To return detailed information on active BFD sessions `ptmd` is tracking, use the `-b` and `-d` options (results are for an IPv6-connected peer):

```
cumulus@switch:~$ sudo ptmctl -b -d  
-----  
port  peer                  state  local   type      diag  det  
tx_timeout rx_timeout  
  
mult  
-----  
swp1  fe80::202:ff:fe00:1  Up      N/A      singlehop  N/A   3  
300    900  
swp1  3101:abc:bcad::2    Up      N/A      singlehop  N/A   3  
300    900  
  
#continuation of output  
-----  
echo    echo      max      rx_ctrl  tx_ctrl  rx_echo  tx_echo  
tx_timeout rx_timeout hop_cnt  
-----  
0       0        N/A      187172  185986  0        0  
0       0        N/A      501     533     0        0
```

## *ptmctl Error Outputs*

If there are errors in the topology file or there isn't a session, PTM will return appropriate outputs. Typical error strings are:

```
Topology file error [/etc/ptm.d/topology.dot] [cannot find node
cumulus] -
please check /var/log/ptmd.log for more info
```

```
Topology file error [/etc/ptm.d/topology.dot] [cannot open file
(errno 2)] -
please check /var/log/ptmd.log for more info
```

```
No Hostname/MgmtIP found [Check LLDPD daemon status] -
please check /var/log/ptmd.log for more info
```

```
No BFD sessions . Check connections
```

```
No LLDP ports detected. Check connections
```

```
Unsupported command
```

For example:

```
cumulus@switch:~$ sudo ptmctl
-----
---  
cmd      error
-----
---  
get-status Topology file error [/etc/ptm.d/topology.dot]
[cannot open file (errno 2)] - please check /var/log/ptmd.
log
for more info
```



If you encounter errors with the `topology.dot` file, you can use `dot` (included in the Graphviz package) to validate the syntax of the topology file.

By simply opening the topology file with Graphviz, you can ensure that it is readable and that the file format is correct.

If you edit `topology.dot` file from a Windows system, be sure to double check the file formatting; there may be extra characters that keep the graph from working correctly.

## Caveats and Errata

- Prior to version 2.1, Cumulus Linux stored the `ptmd` configuration files in `/etc/cumulus/ptm.d`. When you upgrade to version 2.1 or later, all the existing `ptmd` files are copied from their original location to `/etc/ptm.d` with a `dpkg-old` extension, except for `topology.dot`, which gets copied to `/etc/ptm.d`.  
If you customized the `if-topo-pass` and `if-topo-fail` scripts, they are also copied to `dpkg-old`, and you must modify them so they can parse the CSV output correctly.



Sample `if-topo-pass` and `if-topo-fail` scripts are available in `/etc/ptm.d`. A sample `topology.dot` file is available in `/usr/share/doc/ptmd/examples`.

- When PTMD is incorrectly in a failure state and the Zebra interface is enabled, PIF BGP sessions are not establishing the route, but the subinterface on top of it does establish routes.

If the subinterface is configured on the physical interface and the physical interface is incorrectly marked as being in a PTM FAIL state, routes on the physical interface are not processed in Quagga, but the subinterface is working.

## Related Information

- [Bidirectional Forwarding Detection \(BFD\)](#)
- [Graphviz](#)
- [LLDP on Wikipedia](#)
- [PTMd GitHub repo](#)



# Layer 2

## Spanning Tree and Rapid Spanning Tree

Spanning tree protocol (STP) is always recommended in layer 2 topologies as it prevents bridge loops and broadcast radiation on a bridged network. STP also provides redundant links for automatic failover when an active link fails. STP is enabled by default in Cumulus Linux.

### Contents

This topic describes ...

- Supported Modes (see page 372)
  - STP for a VLAN-aware Bridge (see page 372)
  - STP within a Traditional Mode Bridge (see page 373)
- View Bridge and STP Status and Logs (see page 373)
- Customize Spanning Tree Protocol (see page 377)
  - Spanning Tree Priority (see page 377)
  - PortAdminEdge (PortFast Mode) (see page 378)
  - PortAutoEdge (see page 379)
  - BPDU Guard (see page 379)
  - Bridge Assurance (see page 382)
  - BPDU Filter (see page 382)
  - Storm Control (see page 383)
  - Spanning Tree Parameter List (see page 383)
  - Caveats and Errata (see page 390)
- Related Information (see page 390)

### Supported Modes

The STP modes Cumulus Linux supports vary depending upon whether the traditional or VLAN-aware bridge driver mode is in use.

- Bridges configured in *VLAN-aware* (see page 415) mode operate **only** in RSTP mode.
- Bridges configured in *traditional mode* (see page 427) operate in both PVST and PVRST mode. The default is set to PVRST. Each traditional bridge has its own separate STP instance.

### STP for a VLAN-aware Bridge

VLAN-aware bridges only operate in RSTP mode. STP bridge protocol data units (BPDUs) are transmitted on the native VLAN.

If a bridge running RSTP (802.1w) receives a common STP (802.1D) BPDU, it falls back to 802.1D operation automatically. RSTP interoperates with MST seamlessly, creating a single instance of spanning tree, which transmits BPDUs on the native VLAN. RSTP treats the MST domain as one giant switch.



When connecting a VLAN-aware bridge to a proprietary PVST+ switch using STP, VLAN 1 must be allowed on all 802.1Q trunks that interconnect them, regardless of the configured *native* VLAN . This is because only VLAN 1 enables the switches to address the BPDU frames to the IEEE multicast MAC address. The proprietary switch might be configured like this:

```
switchport trunk allowed vlan 1-100
```

### STP within a Traditional Mode Bridge

Per VLAN Spanning Tree (PVST) creates a spanning tree instance for a bridge. Rapid PVST (PVRST) supports RSTP enhancements for each spanning tree instance. To use PVRST with a traditional bridge, you must create a bridge corresponding to the untagged native VLAN and all the physical switch ports must be part of the same VLAN.



When connected to a switch that has a native VLAN configuration, the native VLAN **must** be configured to be VLAN 1 only for maximum interoperability.

## View Bridge and STP Status and Logs

To check STP status for a bridge, run the `net show bridge spanning-tree` command:

[Click to reveal the output ...](#)

```
cumulus@switch:~$ net show bridge spanning-tree
bridge CIST info
  enabled      yes
  bridge id    1.000.44:38:39:FF:40:90
  designated root 1.000.44:38:39:FF:40:90
  regional root 1.000.44:38:39:FF:40:90
  root port    none
  path cost    0          internal path cost  0
  max age     20         bridge max age    20
  forward delay 15        bridge forward delay 15
  tx hold count 6          max hops       20
  hello time   2          ageing time    300
  force protocol version  rstp
  time since topology change 253343s
  topology change count    4
  topology change          no
  topology change port     peerlink
  last topology change port leaf03-04
bridge:exit01-02 CIST info
  enabled      no
  Disabled
```

port id	8.004	state
<b>discarding</b>		
external port cost	305	admin external cost 0
internal port cost	305	admin internal cost 0
designated root	1.000.44:38:39:00:00:27	dsgn external cost 0
dsgn regional root	1.000.44:38:39:00:00:27	dsgn internal cost 0
designated bridge	1.000.44:38:39:00:00:27	designated port
<b>8.004</b>		
admin edge port	no	auto edge port yes
oper edge port	no	topology change ack no
point-to-point	yes	admin point-to-point auto
restricted role	no	restricted TCN no
port hello time	2	disputed no
bpduguard port	no	bpduguard error no
network port	no	BA inconsistent no
Num TX BPDU	2	Num TX TCN 0
Num RX BPDU	0	Num RX TCN 0
Num Transition FWD	0	Num Transition BLK 2
bpduguard port	no	
clag ISL	no	clag ISL Oper UP no
clag role	primary	clag dual conn mac 00:
00:00:00:00:00:00		
clag remote portID	F.FFF	clag system mac 44:
38:39:FF:40:90		
<b>bridge:leaf01-02 CIST info</b>		
enabled	yes	role
<b>Designated</b>		
port id	8.003	state
<b>forwarding</b>		
external port cost	10000	admin external cost 0
internal port cost	10000	admin internal cost 0
designated root	1.000.44:38:39:FF:40:90	dsgn external cost 0
dsgn regional root	1.000.44:38:39:FF:40:90	dsgn internal cost 0
designated bridge	1.000.44:38:39:FF:40:90	designated port
<b>8.003</b>		
admin edge port	no	auto edge port yes
oper edge port	no	topology change ack no
point-to-point	yes	admin point-to-point auto
restricted role	no	restricted TCN no
port hello time	2	disputed no
bpduguard port	no	bpduguard error no
network port	no	BA inconsistent no
Num TX BPDU	253558	Num TX TCN 2
Num RX BPDU	253373	Num RX TCN 4
Num Transition FWD	126675	Num Transition BLK
126694		
bpduguard port	no	
clag ISL	no	clag ISL Oper UP no
clag role	primary	clag dual conn mac 44:
38:39:FF:40:94		
clag remote portID	F.FFF	clag system mac 44:
38:39:FF:40:90		



```
bridge:leaf03-04 CIST info
  enabled          yes           role
Designated
  port id         8.001        state
forwarding
  external port cost 10000      admin external cost 0
  internal port cost 10000      admin internal cost 0
  designated root    1.000.44:38:39:FF:40:90 dsgn external cost 0
  dsgn regional root 1.000.44:38:39:FF:40:90 dsgn internal cost 0
  designated bridge  1.000.44:38:39:FF:40:90 designated port
8.001
  admin edge port   no           auto edge port     yes
  oper edge port    no           topology change ack no
  point-to-point    yes          admin point-to-point auto
  restricted role   no           restricted TCN      no
  port hello time   2            disputed           no
  bpdu guard port   no           bpdu guard error  no
  network port      no           BA inconsistent   no
  Num TX BPDU       130960      Num TX TCN        6
  Num RX BPDU       4            Num RX TCN        1
  Num Transition FWD 2          Num Transition BLK 1
  bpdulfILTER port no           clag ISL Oper UP  no
  clag role         primary      clag dual conn mac 44:
38:39:FF:40:93
  clag remote portID F.FFFF      clag system mac   44:
38:39:FF:40:90
bridge:peerlink CIST info
  enabled          yes           role
Designated
  port id         F.002        state
forwarding
  external port cost 10000      admin external cost 0
  internal port cost 10000      admin internal cost 0
  designated root    1.000.44:38:39:FF:40:90 dsgn external cost 0
  dsgn regional root 1.000.44:38:39:FF:40:90 dsgn internal cost 0
  designated bridge  1.000.44:38:39:FF:40:90 designated port  F.
002
  admin edge port   no           auto edge port     yes
  oper edge port    no           topology change ack no
  point-to-point    yes          admin point-to-point auto
  restricted role   no           restricted TCN      no
  port hello time   2            disputed           no
  bpdu guard port   no           bpdu guard error  no
  network port      no           BA inconsistent   no
  Num TX BPDU       126700      Num TX TCN        2
  Num RX BPDU       6            Num RX TCN        3
  Num Transition FWD 2          Num Transition BLK 1
  bpdulfILTER port no           clag ISL Oper UP  yes
  clag role         yes          clag dual conn mac 00:
00:00:00:00:00
```



```
clag remote portID F.FFF  
38:39:FF:40:90
```

```
clag system mac
```

44:

Use Linux to check spanning tree status (advanced):

### Using Linux to check STP status ...

`mstptcl` is the utility provided by the `mstpd` service to configure STP. The `mstpd` daemon is an open source project used by Cumulus Linux to implement IEEE802.1D 2004 and IEEE802.1Q 2011.

`mstpd` is started by default when the switch boots. `mstpd` logs and errors are located in `/var/log/syslog`.



`mstpd` is the preferred utility for interacting with STP on Cumulus Linux. `brctl` also provides certain methods for configuring STP; however, they are not as complete as the tools offered in `mstpd` and [output from brctl can be misleading](#) in some cases.

To get the bridge state, use:

```
cumulus@switch:~$ sudo brctl show  
bridge name      bridge id  
bridge          8000.001401010100      STP enabled  
                                yes      interfaces  
                                swp1  
                                swp4  
                                swp5
```

To show the `mstpd` bridge state, run this command:

```
cumulus@switch:~$ net show bridge spanning-tree  
bridge CIST info  
enabled          yes  
bridge id        F.000.00:14:01:01:01:00  
designated root   F.000.00:14:01:01:01:00  
regional root    F.000.00:14:01:01:01:00  
root port        none  
path cost        0          internal path cost  0  
max age          20         bridge max age     20  
forward delay    15         bridge forward delay 15  
tx hold count   6          max hops           20  
hello time       2          ageing time       200  
force protocol version  rstp  
time since topology change 90843s  
topology change count    4  
topology change      no  
topology change port   swp4  
last topology change port swp5
```

To show the `mstpd` bridge port state, run this command:



```
cumulus@switch:~$ sudo mstptctl showport bridge
E swp1 8.001 forw F.000.00:14:01:01:01:00 F.000.00:14:01:01:01:00
8.001 Desg
  swp4 8.002 forw F.000.00:14:01:01:01:00 F.000.00:14:01:01:01:00
8.002 Desg
  E swp5 8.003 forw F.000.00:14:01:01:01:00 F.000.00:14:01:01:01:00
8.003 Desg
cumulus@switch:~$ net show bridge spanning-tree
...
bridge:swp1 CIST info
  enabled      yes          role
Designated
  port id      8.001        state
forwarding
  external port cost 2000      admin external cost  0
  internal port cost 2000      admin internal cost 0
  designated root    F.000.00:14:01:01:01:00 dsgn external cost  0
  dsgn regional root F.000.00:14:01:01:01:00 dsgn internal cost 0
  designated bridge  F.000.00:14:01:01:01:00 designated port
8.001
  admin edge port no          auto edge port      yes
  oper edge port  yes         topology change ack no
  point-to-point yes         admin point-to-point auto
  restricted role no          restricted TCN       no
  port hello time 2           disputed            no
  bpdu guard port no         bpdu guard error   no
  network port    no          BA inconsistent     no
  Num TX BPDU    45772        Num TX TCN        4
  Num RX BPDU    0             Num RX TCN        0
  Num Transition FWD 2       Num Transition BLK 2
```

## Customize Spanning Tree Protocol

There are a number of ways you can customize STP in Cumulus Linux. Exercise extreme caution with many of the settings below to prevent malfunctions in STP loop avoidance.

### Spanning Tree Priority

If you have a multiple spanning tree instance (MSTI 0, also known as a common spanning tree, or CST), you can set the *tree priority* for a bridge. The bridge with the lowest priority is elected the *root bridge*. The priority must be a number between 0 and 61440 and must be a multiple of 4096; the default is 32768.

To set the tree priority, run:

```
cumulus@switch:~$ net add bridge stp treeprio 8192
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```



Cumulus Linux supports MSTI 0 only. It does not support MSTI 1 through 15.



## PortAdminEdge (PortFast Mode)

*PortAdminEdge* is equivalent to the PortFast feature offered by other vendors. It enables or disables the *initial edge state* of a port in a bridge.

All ports configured with PortAdminEdge bypass the listening and learning states to move immediately to forwarding.



Using PortAdminEdge mode has the potential to cause loops if it is not accompanied by the [BPDUGuard](#) (see page 379) feature.

While it is common for edge ports to be configured as access ports for a simple end host, this is not mandatory. In the data center, edge ports typically connect to servers, which might pass both tagged and untagged traffic.

## Example VLAN-aware Bridge Configuration

To configure PortAdminEdge mode, use the `bpduguard` and `portadminedge` NCLU configuration commands:

```
cumulus@switch:~$ net add interface swp5 stp bpduguard
cumulus@switch:~$ net add interface swp5 stp portadminedge
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

The NCLU commands above create the following code snippet:

```
auto swp5
iface swp5
    mstpctl-bpduguard yes
    mstpctl-portadminedge yes
```

## Example Traditional Bridge Configuration

For a bridge in [traditional mode](#) (see page 407), configure `PortAdminEdge` under the bridge stanza in `/etc/network/interfaces`:

```
auto br2
iface br2 inet static
    bridge-ports swp1 swp2 swp3 swp4
    mstpctl-bpduguard swp1=yes swp2=yes swp3=yes swp4=yes
    mstpctl-portadminedge swp1=yes swp2=yes swp3=yes swp4=yes
```



To load the new configuration, run `ifreload -a`:

```
cumulus@switch:~$ sudo ifreload -a
```

## PortAutoEdge

*PortAutoEdge* is an enhancement to the standard PortAdminEdge (PortFast) mode, which allows for the automatic detection of edge ports. PortAutoEdge enables and disables the *auto transition* to/from the edge state of a port in a bridge.



Edge ports and access ports are not the same thing. Edge ports transition directly to the forwarding state and skip the listening and learning stages. Upstream topology change notifications are not generated when an edge port's link changes state. Access ports only forward untagged traffic; however, there is no such restriction on edge ports, which can forward both tagged and untagged traffic.

When a BPDU is received on a port configured with portautoedge, the port ceases to be in the edge port state and transitions into a normal STP port. When BPDUs are no longer received on the interface, the port becomes an edge port, and transitions through the discarding and learning states before resuming forwarding.

PortAutoEdge is enabled by default in Cumulus Linux.

To disable PortAutoEdge for an interface, run the `net add interface <port> stp portautoedge no` command. The following example disables PortAutoEdge on swp1:

```
cumulus@switch:~$ net add interface swp1 stp portautoedge no
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

To re-enable PortAutoEdge for an interface, run the the `net del interface <port> stp portautoedge no` command. The following example re-enables PortAutoEdge on swp1:

```
cumulus@switch:~$ net del interface swp1 stp portautoedge no
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

## BPDU Guard

To protect the spanning tree topology from unauthorized switches affecting the forwarding path, you can configure *BPDU guard* (Bridge Protocol Data Unit). One very common example is when someone hooks up a new switch to an access port off of a leaf switch. If this new switch is configured with a low priority, it could become the new root switch and affect the forwarding path for the entire layer 2 topology.

## Example BPDU Guard Configuration

To configure BPDU guard, set the `bpduguard` value for the interface:

```
cumulus@switch:~$ net add interface swp5 stp bpduguard
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

This creates the following stanza in the `/etc/network/interfaces` file:

```
auto swp5
iface swp5
    mstpctl-bpduguard yes
```

### *Recover a Port Disabled by BPDU Guard*

If a BPDU is received on the port, STP will bring down the port and log an error in `/var/log/syslog`. The following is a sample error:

```
mstpd: error, MSTP_IN_rx_bpdu: bridge:bond0 Recvd BPDU on BPDU Guard
Port - Port Down
```

To determine whether BPDU guard is configured, or if a BPDU has been received, run:

```
cumulus@switch:~$ net show bridge spanning-tree | grep bpdu
bpdu guard port      yes          bpdu guard error      yes
```

The only way to recover a port that has been placed in the disabled state is to manually un-shut or bring up the port with `sudo ifup [port]`, as shown in the example below.



Bringing up the disabled port does not fix the problem if the configuration on the connected end-station has not been rectified.

```
cumulus@leaf2$ mstpctl showportdetail bridge bond0
bridge:bond0 CIST info
  enabled          no           role
Disabled
  port id        8.001         state
discarding
  external port cost 305      admin external cost  0
  internal port cost 305     admin internal cost  0
```



```
designated root      8.000.6C:64:1A:00:4F:9C dsgn external cost      0
dsgn regional root  8.000.6C:64:1A:00:4F:9C dsgn internal cost      0
designated bridge   8.000.6C:64:1A:00:4F:9C designated port

8.001
admin edge port     no                      auto edge port      yes
oper edge port      no                      topology change ack no
point-to-point       yes                     admin point-to-point auto
restricted role     no                      restricted TCN      no
port hello time    10                     disputed            no
bpdu guard port     yes                     bpdu guard error   yes
network port        no                      BA inconsistent    no
Num TX BPDU         3                      Num TX TCN        2
Num RX BPDU         488                    Num RX TCN        2
Num Transition FWD 1                      Num Transition BLK 2
bpdufilter port    no
clag ISL            no                      clag ISL Oper UP  no
clag role           unknown                 clag dual conn mac 0:0:
0:0:0:0
      clag remote portID F.FFF
0:0:0:0

cumulus@leaf2$ sudo ifup bond0
```

```
cumulus@leaf2$ mstpcctl showportdetail bridge bond0
bridge:bond0 CIST info
  enabled          yes             role          Root
  port id         8.001          state
forwarding
  external port cost 305          admin external cost 0
  internal port cost 305          admin internal cost 0
  designated root   8.000.6C:64:1A:00:4F:9C dsgn external cost 0
  dsgn regional root 8.000.6C:64:1A:00:4F:9C dsgn internal cost 0
  designated bridge 8.000.6C:64:1A:00:4F:9C designated port

8.001
  admin edge port     no                      auto edge port      yes
  oper edge port      no                      topology change ack no
  point-to-point       yes                     admin point-to-point auto
  restricted role     no                      restricted TCN      no
  port hello time    2                       disputed            no
  bpdu guard port    no                      bpdu guard error   no
  network port        no                     BA inconsistent    no
  Num TX BPDU         3                      Num TX TCN        2
  Num RX BPDU         43                     Num RX TCN        1
  Num Transition FWD 1                      Num Transition BLK 0
  bpdufilter port    no
  clag ISL            no                      clag ISL Oper UP  no
  clag role           unknown                 clag dual conn mac 0:0:
0:0:0:0
      clag remote portID F.FFF
0:0:0:0
```

## Bridge Assurance

On a point-to-point link where RSTP is running, if you want to detect unidirectional links and put the port in a discarding state (in error), you can enable bridge assurance on the port by enabling a port type network. The port would be in a bridge assurance inconsistent state until a BPDU is received from the peer. You need to configure the port type network on both the ends of the link in order for bridge assurance to operate properly.

The default setting for bridge assurance is off. This means that there is no difference between disabling bridge assurance on an interface and not configuring bridge assurance on an interface.

### Example Bridge Assurance Configuration

To enable bridge assurance on an interface, add the `portnetwork` option to the interface:

```
cumulus@switch:~$ net add interface swp1 stp portnetwork  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

This creates the following interface stanza:

```
auto swp1  
iface swp1  
    mstpctl-portnetwork yes
```

You can monitor logs for bridge assurance messages by doing the following:

```
cumulus@switch:~$ sudo grep -in assurance /var/log/syslog | grep mstp  
1365:Jun 25 18:03:17 mstpd: br1007:swp1.1007 Bridge assurance  
inconsistent
```

## BPDU Filter

You can enable `bpdufilter` on a switch port, which filters BPDUs in both directions. This effectively disables STP on the port as no BPDUs are transiting.



Using BDPU filter inappropriately can cause layer 2 loops. Use this feature deliberately and with extreme caution.

### Example BPDU Filter Configuration

To configure the BPDU filter, add the `portbpdufilter` option to the interface:

```
cumulus@switch:~$ net add interface swp6 stp portbpdufilter
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands create the following stanza in the `/etc/network/interfaces` file:

```
auto swp6
iface swp6
    mstpctl-portbpdufilter yes
```

### Storm Control

*Storm control* provides protection against excessive inbound BUM (broadcast, unknown unicast, multicast) traffic on layer 2 switch port interfaces, which can cause poor network performance.

You configure storm control for each physical port by [configuring `switchd` \(see page 204\)](#). For example, to enable unicast and multicast storm control at 400 packets per second (pps) and 3000 pps, respectively, for `swp1`, run the following:

```
cumulus@switch:~$ sudo sh -c 'echo 400 > /cumulus/switchd/config
/interface/swp1/storm_control/unknown_unicast'
cumulus@switch:~$ sudo sh -c 'echo 3000 > /cumulus/switchd/config
/interface/swp1/storm_control/multicast'
```

### Spanning Tree Parameter List

Spanning tree parameters are defined in the [IEEE 802.1D, 802.1Q](#) specifications.

The table below describes the STP configuration parameters available in Cumulus Linux. For a comparison of STP parameter configuration between `mstpctl` and other vendors, [read this knowledge base article](#).



Most of these parameters are blacklisted in the `ifupdown_blacklist` section of the `/etc/netd.conf` file. Before you configure these parameters, you must [edit the file \(see page 97\)](#) to remove them from the blacklist.

Parameter	NCLU Command	Description
<code>mstpctl-maxage</code>	<code>net add</code>	Sets the <i>maximum age</i> of the bridge in seconds. The default is 20. The maximum age must meet the condition $2 * (\text{Bridge Forward Delay} - 1 \text{ second}) \geq \text{Bridge Max Age}$ .



Parameter	NCLU Command	Description
	<pre>bridg e stp maxag e &lt;seco nds&gt;</pre>	
mstptcl- ageing	<pre>net add bridg e stp agein g &lt;seco nds&gt;</pre>	Sets the Ethernet (MAC) address <i>ageing time</i> for the bridge in seconds when the running version is STP, but not RSTP/MSTP. The default is 1800.
mstptcl- fdelay	<pre>net add bridg e stp fdela y &lt;seco nds&gt;</pre>	Sets the <i>bridge forward delay</i> time in seconds. The default value is 15. The bridge forward delay must meet the condition $2 * (\text{Bridge Forward Delay} - 1 \text{ second}) \geq \text{Bridge Max Age}$ .
mstptcl- maxhops	<pre>net add bridg e stp maxho ps &lt;max_ hops&gt;</pre>	Sets the <i>maximum hops</i> for the bridge. The default is 20.



Parameter	NCLU Command	Description
mstpctl- txholdcount	<pre>net add bridg e stp txhol dcoun t &lt;hold _coun t&gt;</pre>	Sets the <i>bridge transmit hold count</i> . The default value is 6.
mstpctl- forcevers	<pre>net add bridg e stp force vers RSTP   STP</pre>	Sets the <i>force STP version</i> of the bridge to either RSTP/STP. MSTP is not supported currently. The default is <i>RSTP</i> .
mstpctl- treepprio	<pre>net add bridg e stp treepp rio &lt;prio rity&gt;</pre>	Sets the <i>tree priority</i> of the bridge for an MSTI (multiple spanning tree instance). The priority value is a number between 0 and 61440 and must be a multiple of 4096. The bridge with the lowest priority is elected the <i>root bridge</i> . The default is 32768. <div style="border: 2px solid orange; padding: 10px; margin-top: 10px;"><span style="color: orange;">⚠️</span> Cumulus Linux supports MSTI 0 only. It does not support MSTI 1 through 15.</div>
mstpctl-hello	<pre>net add bridg e</pre>	Sets the <i>bridge hello time</i> in seconds. The default is 2.

Parameter	NCLU Command	Description
	<pre>stp hello &lt;seco nds&gt;</pre>	
mstptctl- portpathcost	<pre>net add inter face &lt;inte rface &gt; stp portp athco st &lt;cost &gt;</pre>	<p>Sets the <i>port cost</i> of the interface. The default is 0.  <code>mstpd</code> supports only long mode; 32 bits for the path cost.</p>
mstptctl- treeportprio	<pre>net add inter face &lt;inte rface &gt; stp treep ortpr io &lt;prio rity&gt;</pre>	<p>Sets the <i>priority</i> of the interface for the MSTI. The priority value is a number between 0 and 240 and must be a multiple of 16. The default is 128.</p> <div style="border: 2px solid #f0a000; padding: 5px; margin-top: 10px;"> <span style="color: #f0a000;">⚠</span> Cumulus Linux supports MSTI 0 only. It does not support MSTI 1 through 15.     </div>
mstptctl- portadminedge	<pre>net add inter face &lt;inte</pre>	<p>Enables or disables the <i>initial edge state</i> of the interface in the bridge. The default is <i>no</i>.</p>

Parameter	NCLU Command	Description
	<pre>rface &gt; stp porta dmine dge</pre>	
mstpcctl-portautoedge	<pre>net add inter face &lt;inte rface &gt; stp porta utoed ge no</pre>	<p>Enables or disables the <i>auto transition</i> to and from the edge state of the interface in the bridge. The default is yes.</p> <p><i>portautoedge</i> is an enhancement to the standard PortAdminEdge (PortFast) mode, which allows for the automatic detection of edge ports.</p> <div style="border: 2px solid orange; padding: 10px;"> <p><span style="color: yellow;">⚠</span> Edge ports and access ports are not the same thing. Edge ports transition directly to the forwarding state and skip the listening and learning stages. Upstream topology change notifications are not generated when an edge port's link changes state. Access ports only forward untagged traffic; however, there is no such restriction on edge ports, which can forward both tagged and untagged traffic.</p> </div> <p>When a BPDU is received on a port configured with PortAutoEdge, the port ceases to be in the edge port state and transitions into a normal STP port.</p> <p>When BPDUs are no longer received on the interface, the port becomes an edge port, and transitions through the discarding and learning states before resuming forwarding.</p>
mstpcctl-portp2p	<pre>net add inter face &lt;inte rface &gt; stp portp 2p yes n o</pre>	<p>Enables or disables the <i>point-to-point detection mode</i> of the interface in the bridge. The default is <i>auto</i>.</p>

Parameter	NCLU Command	Description
mstptcl- portrestrrole	<pre>net add interface &lt;interface&gt; &gt; stp portrestrrole</pre>	Enables or disables the ability of the interface in the bridge to take the <i>root role</i> . The default is <i>no</i> .
mstptcl- portrestrtcn	<pre>net add interface &lt;interface&gt; &gt; stp portrestrtcn</pre>	Enables or disables the ability of the interface in the bridge to propagate <i>received topology change notifications</i> . The default is <i>no</i> .
mstptcl- portnetwork	<pre>net add interface &lt;interface&gt; &gt; stp portnetwork</pre>	Enables or disables the <i>bridge assurance capability</i> for a network interface. The default is <i>no</i> .
mstptcl- bpduguard		Enables or disables the <i>BPDU guard configuration</i> of the interface in the bridge. The default is <i>no</i> .



Parameter	NCLU Command	Description
	<pre>net add interface &lt;intere rface &gt; stp bpdu uard</pre>	See above.
mstpcctl- portbpdufilter	<pre>net add interface &lt;intere rface &gt; stp portb pdufi lter</pre>	Enables or disables the <i>BPDU filter</i> functionality for an interface in the bridge. The default is no.
mstpcctl- treeportcost	<pre>net add interface &lt;intere rface &gt; stp treep ortco st &lt;port _cost &gt;</pre>	Sets the spanning tree <i>port cost</i> to a value from 0 to 255. The default is 0.



## Caveats and Errata

MSTP is not supported currently because Cumulus Linux only supports MSTI 0 (not MSTI 1 through 15). However, interoperability with MSTP networks can be accomplished using PVRSTP or PVSTP.

## Related Information

The source code for `mstpd/mstpc1` was written by [Vitalii Demianets](#) and is hosted at the URL below.

- [Sourceforge - mstpd project](#)
- [Wikipedia - Spanning Tree Protocol](#)
- [brctl\(8\)](#)
- [bridge-utils-interfaces\(5\)](#)
- [ifupdown-addons-interfaces\(5\)](#)
- [mstpc1\(8\)](#)
- [mstpc1-utils-interfaces\(5\)](#)

## Link Layer Discovery Protocol

The `lldpd` daemon implements the IEEE802.1AB (Link Layer Discovery Protocol, or LLDP) standard. LLDP enables you to know which ports are neighbors of a given port. By default, `lldpd` runs as a daemon and is started at system boot. `lldpd` command line arguments are placed in `/etc/default/lldpd`. `lldpd` configuration options are placed in `/etc/lldpd.conf` or under `/etc/lldpd.d/`.

For more details on the command line arguments and config options, see `man lldpd(8)`.

`lldpd` supports CDP (Cisco Discovery Protocol, v1 and v2). `lldpd` logs by default into `/var/log/daemon.log` with an `lldpd` prefix.

`lldpcli` is the CLI tool to query the `lldpd` daemon for neighbors, statistics, and other running configuration information. See `man lldpcli(8)` for details.

## Contents

### This topic describes ...

- Configure LLDP (see page 390)
- Example Lldpcli Commands (see page 391)
- Enable the SNMP Subagent in LLDP (see page 396)
- Caveats and Errata (see page 396)
- Related Information (see page 396)

## Configure LLDP

You configure `lldpd` settings in `/etc/lldpd.conf` or `/etc/lldpd.d/`.

Here is an example persistent configuration:



```
cumulus@switch:~$ sudo cat /etc/lldpd.conf
configure lldp tx-interval 40
configure lldp tx-hold 3
configure system interface pattern *,!eth0,swp*
```

The last line in the example above shows that LLDP is disabled on eth0. You can disable LLDP on a single port by editing the `/etc/default/lldpd` file. This file specifies the default options to present to the `lldpd` service when it starts. The following example uses the `-I` option to disable LLDP on swp43:

```
cumulus@switch:~$ sudo nano /etc/default/lldpd

# Add "-x" to DAEMON_ARGS to start SNMP subagent
# Enable CDP by default
DAEMON_ARGS="-c -I *, !swp43"
```

`lldpd` logs to `/var/log/daemon.log` with the `lldpd` prefix:

```
cumulus@switch:~$ sudo tail -f /var/log/daemon.log | grep lldp
Aug  7 17:26:17 switch lldpd[1712]: unable to get system name
Aug  7 17:26:17 switch lldpd[1712]: unable to get system name
Aug  7 17:26:17 switch lldpccli[1711]: lldpd should resume operations
Aug  7 17:26:32 switch lldpd[1805]: NET-SNMP version 5.4.3 AgentX
subagent connected
```

## Example `lldpcli` Commands

To show all neighbors on all ports/interfaces:

```
cumulus@switch:~$ sudo lldpcli show neighbors
-----
-----
LLDP neighbors:
-----
Interface:    eth0, via: LLDP, RID: 1, Time: 0 day, 17:38:08
  Chassis:
    ChassisID:      mac 08:9e:01:e9:66:5a
    SysName:        PIONEERMS22
    SysDescr:       Cumulus Linux version 2.5.4 running on quanta lb9
    MgmtIP:         192.168.0.22
    Capability:    Bridge, on
    Capability:    Router, on
  Port:
    PortID:        ifname swp47
    PortDescr:     swp47
-----
-----
```

```

Interface:      swp1, via: LLDP, RID: 10, Time: 0 day, 17:08:27
Chassis:
  ChassisID:    mac 00:01:00:00:09:00
  SysName:      MSP-1
  SysDescr:     Cumulus Linux version 3.0.0 running on QEMU
Standard PC (i440FX + PIIX, 1996)
  MgmtIP:       192.0.2.9
  MgmtIP:       fe80::201:ff:fe00:900
  Capability:   Bridge, off
  Capability:   Router, on
Port:
  PortID:       ifname swp1
  PortDescr:    swp1
-----
-----
Interface:      swp2, via: LLDP, RID: 10, Time: 0 day, 17:08:27
Chassis:
  ChassisID:    mac 00:01:00:00:09:00
  SysName:      MSP-1
  SysDescr:     Cumulus Linux version 3.0.0 running on QEMU
Standard PC (i440FX + PIIX, 1996)
  MgmtIP:       192.0.2.9
  MgmtIP:       fe80::201:ff:fe00:900
  Capability:   Bridge, off
  Capability:   Router, on
Port:
  PortID:       ifname swp2
  PortDescr:    swp2
-----
-----
Interface:      swp3, via: LLDP, RID: 11, Time: 0 day, 17:08:27
Chassis:
  ChassisID:    mac 00:01:00:00:0a:00
  SysName:      MSP-2
  SysDescr:     Cumulus Linux version 3.0.0 running on QEMU
Standard PC (i440FX + PIIX, 1996)
  MgmtIP:       192.0.2.10
  MgmtIP:       fe80::201:ff:fe00:a00
  Capability:   Bridge, off
  Capability:   Router, on
Port:
  PortID:       ifname swp1
  PortDescr:    swp1
-----
-----
Interface:      swp4, via: LLDP, RID: 11, Time: 0 day, 17:08:27
Chassis:
  ChassisID:    mac 00:01:00:00:0a:00
  SysName:      MSP-2
  SysDescr:     Cumulus Linux version 3.0.0 running on QEMU
Standard PC (i440FX + PIIX, 1996)
  MgmtIP:       192.0.2.10

```



```
MgmtIP:      fe80::201:ff:fe00:a00
Capability:  Bridge, off
Capability:  Router, on
Port:
  PortID:     ifname swp2
  PortDescr:   swp2
-----
-----
Interface:   swp49s1, via: LLDP, RID: 9, Time: 0 day, 16:55:00
Chassis:
  ChassisID:  mac 00:01:00:00:0c:00
  SysName:    TORC-1-2
  SysDescr:   Cumulus Linux version 3.0.0 running on QEMU
Standard PC (i440FX + PIIIX, 1996)
  MgmtIP:     192.0.2.12
  MgmtIP:     fe80::201:ff:fe00:c00
  Capability: Bridge, on
  Capability: Router, on
Port:
  PortID:     ifname swp6
  PortDescr:   swp6
-----
-----
Interface:   swp49s0, via: LLDP, RID: 9, Time: 0 day, 16:55:00
Chassis:
  ChassisID:  mac 00:01:00:00:0c:00
  SysName:    TORC-1-2
  SysDescr:   Cumulus Linux version 3.0.0 running on QEMU
Standard PC (i440FX + PIIIX, 1996)
  MgmtIP:     192.0.2.12
  MgmtIP:     fe80::201:ff:fe00:c00
  Capability: Bridge, on
  Capability: Router, on
Port:
  PortID:     ifname swp5
  PortDescr:   swp5
-----
```

To show lldpd statistics for all ports:

```
cumulus@switch:~$ sudo lldpccli show statistics
-----
LLDP statistics:
-----
Interface:   eth0
  Transmitted: 9423
  Received:    17634
  Discarded:   0
  Unrecognized: 0
```



```
Ageout:      10
Inserted:    20
Deleted:     10
-----
Interface:   swp1
Transmitted: 9423
Received:    6264
Discarded:   0
Unrecognized: 0
Ageout:      0
Inserted:    2
Deleted:     0
-----
Interface:   swp2
Transmitted: 9423
Received:    6264
Discarded:   0
Unrecognized: 0
Ageout:      0
Inserted:    2
Deleted:     0
-----
Interface:   swp3
Transmitted: 9423
Received:    6265
Discarded:   0
Unrecognized: 0
Ageout:      0
Inserted:    2
Deleted:     0
-----
... and more (output truncated to fit this document)
```

To show lldpd statistics summary for all ports:

```
cumulus@switch:~$ sudo lldpccli show statistics summary
-----
LLDP Global statistics:
-----
Summary of stats:
Transmitted: 648186
Received:    437557
Discarded:   0
Unrecognized: 0
Ageout:      10
Inserted:    38
Deleted:     10
```

To show the lldpd running configuration:



```
cumulus@switch:~$ sudo lldpcli show running-configuration
-----
Global configuration:
-----
Configuration:
    Transmit delay: 30
    Transmit hold: 4
    Receive mode: no
    Pattern for management addresses: (none)
    Interface pattern: (none)
    Interface pattern blacklist: (none)
    Interface pattern for chassis ID: (none)
    Override description with: (none)
    Override platform with: Linux
    Override system name with: (none)
    Advertise version: yes
    Update interface descriptions: no
    Promiscuous mode on managed interfaces: no
    Disable LLDP-MED inventory: yes
    LLDP-MED fast start mechanism: yes
    LLDP-MED fast start interval: 1
    Source MAC for LLDP frames on bond slaves: local
    Portid TLV Subtype for lldp frames: ifname
-----
```

## Runtime Configuration (Advanced)



A runtime configuration does not persist when you reboot the switch — all changes are lost.

To configure active interfaces:

```
cumulus@switch:~$ sudo lldpcli configure system interface pattern "swp
*"
```

To configure inactive interfaces:

```
cumulus@switch:~$ sudo lldpcli configure system interface pattern *,!
eth0,swp*
```



The active interface list always overrides the inactive interface list.

To reset any interface list to none:



```
cumulus@switch:~$ sudo lldpccli configure system interface pattern " "
```

## Enable the SNMP Subagent in LLDP

LLDP does not enable the SNMP subagent by default. You need to edit `/etc/default/lldpd` and enable the `-x` option.

```
cumulus@switch:~$ sudo nano /etc/default/lldpd

# Add "-x" to DAEMON_ARGS to start SNMP subagent

# Enable CDP by default
DAEMON_ARGS="-c"
```

## Caveats and Errata

- Annex E (and hence Annex D) of IEEE802.1AB (lldp) is not supported.

## Related Information

- [GitHub - llpd project](#)
- [Wikipedia - Link Layer Discovery Protocol](#)

## Voice VLAN

In Cumulus Linux, a *voice VLAN* is a VLAN dedicated to voice traffic on a switch port. However, the term can mean different things to different vendors.

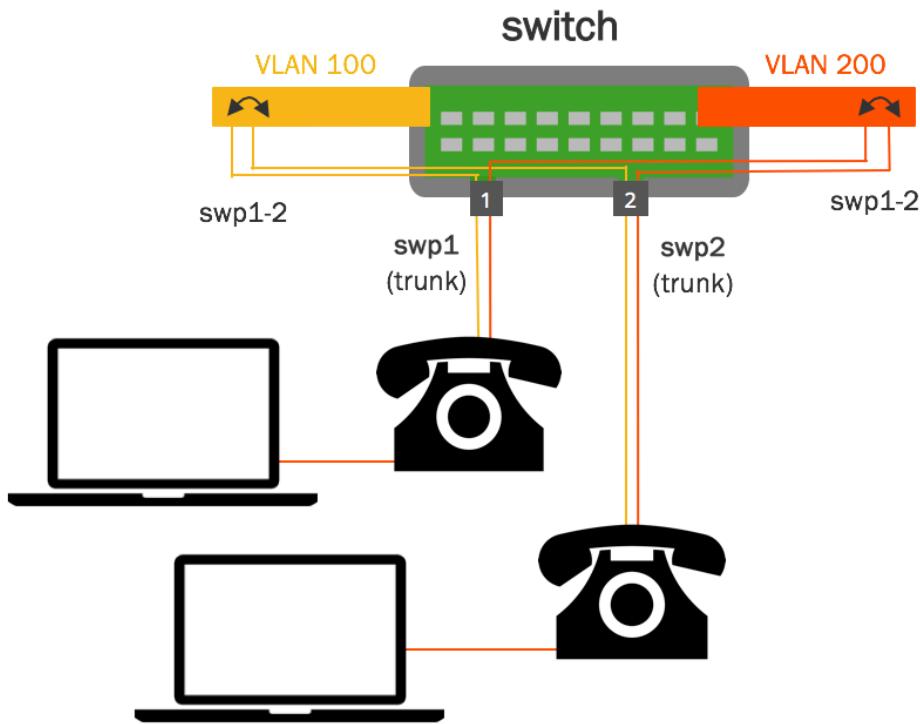
Voice VLAN is part of a trunk port with 2 VLANs that comprises either:

- Native VLAN, which carries both data and voice traffic, or
- Voice VLAN, which carries the voice traffic, and a data or native VLAN, which carries the data traffic in a trunk port.

The voice traffic is an 802.1q-tagged packet with a VLAN ID that has a VLAN ID (which may or may not be 0) and an 802.1p (3-bit layer 2 COS) with a specific value (typically 5 is assigned for voice traffic).

Data traffic is always [untagged \(see page 433\)](#).

## Cumulus Linux Voice VLAN Example



You can configure the topology above using the following [NCLU \(see page 88\)](#) commands. In this configuration:

- swp1 data traffic traverses the bridge's native VLAN and the voice traffic traverses VLAN 200
- swp2 data traffic traverses VLAN 10 and the voice traffic traverses VLAN 100
- swp3 data and voice traffic both traverse the bridge's native VLAN

```
cumulus@switch:~$ net add bridge bridge ports swp1-3
cumulus@switch:~$ net add bridge bridge vids 1-1000
cumulus@switch:~$ net add bridge bridge pvid 1
cumulus@switch:~$ net add interface swp1 bridge voice-vlan 200
cumulus@switch:~$ net add interface swp2 bridge voice-vlan 100 data-
vlan 10
cumulus@switch:~$ net add interface swp3 bridge voice-vlan 300
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands create the following configuration snippet in the /etc/network/interfaces file:

```
auto swp1
iface swp1
    bridge-vids 200
```



```
mstpctl-bpduguard yes
mstpctl-portadmineedge yes

auto swp2
iface swp2
    bridge-pvid 10
    bridge-vids 100
    mstpctl-bpduguard yes
    mstpctl-portadmineedge yes

auto swp3
iface swp3
    bridge-vids 300
    mstpctl-bpduguard yes
    mstpctl-portadmineedge yes

auto bridge
iface bridge
    bridge-ports swp1 swp2 swp3
    bridge-pvid 1
    bridge-vids 1-1000
    bridge-vlan-aware yes
```

## Configure LLDP

Configuring voice VLAN with NCLU does not configure `lldpd` in Cumulus Linux, so LLDP-MED does not provide data and voice VLAN information. You can configure LLDP-MED for each interface in a new file in `/etc/lldp.d`. In the following example, the file is called `/etc/lldpd.d/voice_vlan.conf`:

```
cumulus@switch:~$ sudo nano /etc/lldpd.d/voice_vlan.conf
configure ports swp1 med policy application voice tagged vlan 200
priority voice dscp 46
configure ports swp2 med policy application voice tagged vlan 100
priority voice dscp 46
configure ports swp3 med policy application voice tagged vlan 300
priority voice dscp 46
```

You can also use the `lldpcli` command to configure an LLDP-MED network policy. However, `lldpcli` commands do not persist across reboots of the switch.

## Troubleshooting

The `bridge-vids` can be reviewed with the `net show bridge vlan` command:

```
cumulus@switch:~$ net show bridge vlan
Interface      VLAN Flags
-----  -----  -----

```



```
swp1          1  PVID, Egress Untagged  
              200  
  
swp2          10 PVID, Egress Untagged  
              200  
  
swp3          1  PVID, Egress Untagged  
              300
```

You can get MAC address information using the `net show bridge macs` command:

```
cumulus@switch:~$ net show bridge macs  
  
VLAN      Master      Interface      MAC           TunnelDest  
State     Flags       LastSeen  
-----  -----  
-----  
untagged  bridge      bridge        08:00:27:d5:00:93  
permanent  
untagged  bridge      swp1         08:00:27:6a:ad:da  
permanent  
untagged  bridge      swp2         08:00:27:e3:0c:a7  
permanent  
untagged  bridge      swp3         08:00:27:9e:98:86  
permanent
```

You can capture LLDP information by checking `syslog` or using `tcpdump` on an interface.

### Caveats and Errata

- A static voice VLAN configuration overwrites a switch port's existing configuration.
- Removing the `bridge-vids` or `bridge-pvid` configuration from a voice VLAN does not remove the VLAN from the bridge.

## Bonding - Link Aggregation

Linux bonding provides a method for aggregating multiple network interfaces (*slaves*) into a single logical bonded interface (*bond*). Cumulus Linux supports two bonding modes:

- IEEE 802.3ad link aggregation mode, which allows one or more links to be aggregated together to form a *link aggregation group* (LAG), so that a media access control (MAC) client can treat the link aggregation group as if it were a single link. IEEE 802.3ad link aggregation is the default mode.
- Balance-xor mode, where the bonding of slave interfaces are static and all slave interfaces are active for load balancing and fault tolerance purposes. This is useful for [MLAG](#) (see page 440) deployments.

The benefits of link aggregation include:

- Linear scaling of bandwidth as links are added to LAG
- Load balancing



- Failover protection

Cumulus Linux uses version 1 of the LAG control protocol (LACP).

To temporarily bring up a bond even when there is no LACP partner, use [LACP Bypass \(see page 471\)](#).

## Contents

This topic describes ...

- Hash Distribution (see page 400)
- Create a Bond (see page 400)
  - Configuration Options (see page 401)
  - Enable balance-xor Mode (see page 403)
- Example Configuration: Bonding 4 Slaves (see page 404)
- Caveats and Errata (see page 406)
- Related Information (see page 407)

## Hash Distribution

Egress traffic through a bond is distributed to a slave based on a packet hash calculation, providing load balancing over the slaves; many conversation flows are distributed over all available slaves to load balance the total traffic. Traffic for a single conversation flow always hashes to the same slave.

The hash calculation uses packet header data to choose to which slave to transmit the packet:

- For IP traffic, IP header source and destination fields are used in the calculation.
- For IP + TCP/UDP traffic, source and destination ports are included in the hash calculation.



In a failover event, the hash calculation is adjusted to steer traffic over available slaves.

## Create a Bond

You can create and configure a bond with the Network Command Line Utility ([NCLU \(see page 88\)](#)). Follow the steps below to create a new bond:

1. SSH into the switch.
2. Add a bond using the `net add bond` command, replacing `[bond-name]` with the name of the bond, and `[slaves]` with the list of slaves:

```
cumulus@switch:~$ net add bond [bond-name] bond slaves [slaves]
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

The bond is configured by default in IEEE 802.3ad link aggregation mode. To configure the bond in balance-xor mode, see [bond mode \(see page 401\)](#) below.



The name of the bond must be:

- Compliant with Linux interface naming conventions.
- Unique within the switch.

## Configuration Options

The configuration options and their default values are listed in the table below.



Each bond configuration option, except for `bond slaves`, is set to the recommended value by default in Cumulus Linux. Only configure an option if a different setting is needed. For more information on configuration values, refer to the [Related Information \(see page 407\)](#) section below.

NCLU Configuration Option	Description	Default Value
<code>bond mode</code>	<p>The bonding mode. Cumulus Linux supports IEEE 802.3ad link aggregation mode and balance-xor mode. IEEE 802.3ad link aggregation is the default mode.</p> <p>You can change the bond mode using NCLU. The following example changes bond1 to balance-xor mode.</p> <p><b>Note:</b> Use balance-xor mode only if you cannot use LACP. <a href="#">See below (see page 403)</a> for more information.</p> <pre>cumulus@switch:~\$ net add bond bond1 bond mode balance-xor cumulus@switch:~\$ net pending cumulus@switch:~\$ net commit</pre> <p>The following example changes bond1 to IEEE 802.3ad link aggregation mode:</p> <pre>cumulus@switch:~\$ net add bond bond1 bond mode 802.3ad cumulus@switch:~\$ net pending cumulus@switch:~\$ net commit</pre>	802.3ad
<code>bond slaves</code>	The list of slaves in the bond.	N/A
<code>bond miimon</code>	Defines how often the link state of each slave is inspected for failures.	100
<code>bond downdelay</code>		0

NCLU Configuration Option	Description	Default Value
	Specifies the time, in milliseconds, to wait before disabling a slave after a link failure has been detected. This option is only valid for the miimon link monitor. The downdelay value must be a multiple of the miimon value; if not, it is rounded down to the nearest multiple.	
<code>bond updelay</code>	Specifies the time, in milliseconds, to wait before enabling a slave after a link recovery has been detected. This option is only valid for the miimon link monitor. The updelay value must be a multiple of the miimon value; if not, it is rounded down to the nearest multiple.	0
<code>bond use-carrier</code>	Determines the link state.	1
<code>bond xmit-hash-policy</code>	The hash method used to select the slave for a given packet.  <div style="border: 2px solid red; padding: 5px; width: fit-content;"><span style="color: red;">!</span> Do not change this setting.</div>	layer3+4
<code>bond lacp-bypass-allow</code>	Enables <a href="#">LACP bypass</a> (see page 471).	N/A
<code>bond lacp-rate</code>	Sets the rate to ask the link partner to transmit LACP control packets. You can set the LACP rate to slow using <a href="#">NCLU</a> (see page 88):  <div style="background-color: #f0f0f0; padding: 10px; border-radius: 5px;"><pre>cumulus@switch:~\$ net add bond bond01 bond lacp-rate slow</pre></div>	1
<code>bond min-links</code>	Defines the minimum number of links that must be active before the bond is put into service.  <div style="border: 2px solid teal; padding: 10px; width: fit-content;"><span style="color: teal;">i</span> A value greater than 1 is useful if higher level services need to ensure a minimum aggregate bandwidth level before activating a bond. Keeping <code>bond-min-links</code> set to 1 indicates the bond must have at least one active member. If the number of active members drops below the <code>bond-min-links</code> setting, the bond will appear to upper-level protocols as <code>link-down</code>. When the number of active links returns to greater than or equal to <code>bond-min-links</code>, the bond becomes <code>link-up</code>.</div>	1



## Enable balance-xor Mode

When you enable *balance-xor mode*, the bonding of slave interfaces are static and all slave interfaces are active for load balancing and fault tolerance purposes. Packet transmission on the bond is based on the hash policy specified by `xmit-hash-policy`.

When using balance-xor mode to dual-connect host-facing bonds in an [MLAG \(see page 440\)](#) environment, you **must** configure the `cflag_id` parameter on the MLAG bonds and it must be the same on both MLAG switches. Otherwise, the bonds are treated by the MLAG switch pair as single-connected.



Use balance-xor mode **only** if you cannot use LACP; LACP can detect mismatched link attributes between bond members and can even detect misconnections.

To change the mode of an existing bond to balance-xor, run the `net add bond <bond-name> bond mode balance-xor` command. The following example commands change bond1 to balance-xor mode:

```
cumulus@switch:~$ net add bond bond1 bond mode balance-xor
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

To create a new bond and configure the bond to use balance-xor mode, create the bond, then configure the bond mode. The following example commands create a bond called bond1 and configure bond mode to be balance-xor:

```
cumulus@switch:~$ net add bond bond1 bond slaves swp3,4
cumulus@switch:~$ net add bond bond1 bond mode balance-xor
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands create the following configuration in the `/etc/network/interfaces` file:

```
auto bond1
iface bond1
    bond-mode balance-xor
    bond-slaves swp3 swp4
```

To view the bond, use [NCLU \(see page 88\)](#):

```
cumulus@switch:~$ net show interface bond1
      Name      MAC              Speed      MTU      Mode
      --  -----  -----  -----  -----
UP   bond1   00:02:00:00:00:12  20G       1500     Bond
```

Bond Details

```

Bond Mode:      Balance-XOR
Load Balancing: Layer3+4
Minimum Links:  1
In CLAG:       CLAG Inactive
  
```

	Port	Speed	TX	RX	Err	Link Failures
--	UP	swp3(P)	10G	0	0	0
--	UP	swp4(P)	10G	0	0	0

#### LLDP

```

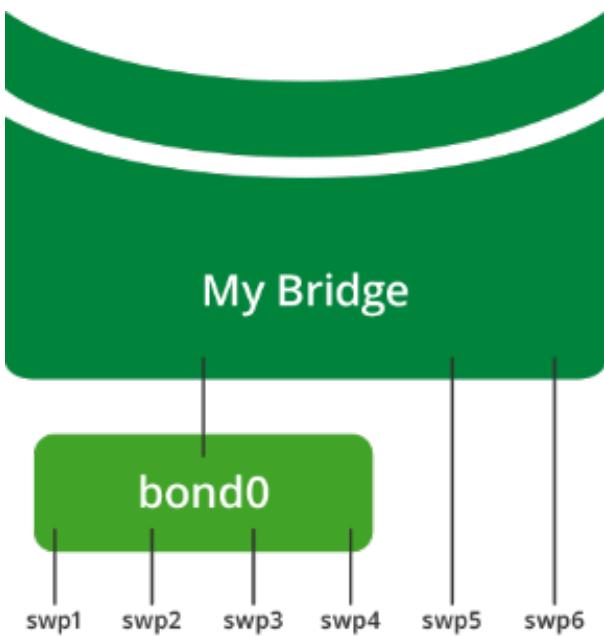
-----  -----
swp3(P)  === swp1(p1c1h1)
swp4(P)  === swp2(p1c1h1)Routing
-----  
```

```

Interface bond1 is up, line protocol is up
Link ups:      3    last: 2017/04/26 21:00:38.26
Link downs:    2    last: 2017/04/26 20:59:56.78
PTM status: disabled
vrf: Default-IP-Routing-Table
index 31 metric 0 mtu 1500
flags: <UP,BROADCAST,RUNNING,MULTICAST>
Type: Ethernet
HWaddr: 00:02:00:00:00:12
inet6 fe80::202:ff:fe00:12/64
Interface Type Other
  
```

## Example Configuration: Bonding 4 Slaves

In the following example, the front panel port interfaces swp1 thru swp4 are slaves in bond0, while swp5 and swp6 are not part of bond0.



## *ⓘ* Example Bond Configuration

The following commands create a bond with four slaves:

```
cumulus@switch:~$ net add bond bond0 address 10.0.0.1/30
cumulus@switch:~$ net add bond bond0 bond slaves swp1-4
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands create this code snippet in the `/etc/network/interfaces` file:

```
auto bond0
iface bond0
    address 10.0.0.1/30
    bond-slaves swp1 swp2 swp3 swp4
```



If the bond is going to become part of a bridge, you do not need to specify an IP address.

When networking is started on the switch, `bond0` is created as `MASTER` and interfaces `swp1` thru `swp4` come up in `SLAVE` mode, as seen in the `ip link show` command:

```
cumulus@switch:~$ ip link show
...
```

```

3: swp1: <BROADCAST,MULTICAST,SLAVE,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast
    master bond0 state UP mode DEFAULT qlen 500
        link/ether 44:38:39:00:03:c1 brd ff:ff:ff:ff:ff:ff
5: swp2: <BROADCAST,MULTICAST,SLAVE,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast
    master bond0 state UP mode DEFAULT qlen 500
        link/ether 44:38:39:00:03:c1 brd ff:ff:ff:ff:ff:ff
6: swp3: <BROADCAST,MULTICAST,SLAVE,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast
    master bond0 state UP mode DEFAULT qlen 500
        link/ether 44:38:39:00:03:c1 brd ff:ff:ff:ff:ff:ff
7: swp4: <BROADCAST,MULTICAST,SLAVE,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast
    master bond0 state UP mode DEFAULT qlen 500
        link/ether 44:38:39:00:03:c1 brd ff:ff:ff:ff:ff:ff
...
55: bond0: <BROADCAST,MULTICAST,MASTER,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP mode DEFAULT
    link/ether 44:38:39:00:03:c1 brd ff:ff:ff:ff:ff:ff

```



All slave interfaces within a bond have the same MAC address as the bond. Typically, the first slave added to the bond donates its MAC address as the bond MAC address, whereas the MAC addresses of the other slaves are set to the bond MAC address.

The bond MAC address is used as the source MAC address for all traffic leaving the bond and provides a single destination MAC address to address traffic to the bond.

## Caveats and Errata

- An interface cannot belong to multiple bonds.
- A bond can have subinterfaces, but subinterfaces cannot have a bond.
- A bond cannot enslave VLAN subinterfaces.
- Set all slave ports within a bond to the same speed/duplex and make sure they match the link partner's slave ports.
- On a [Cumulus RMP](#) switch, if you create a bond with multiple 10G member ports, traffic gets dropped when the bond uses members of the same *unit* listed in the `/var/lib/cumulus/porttab` file. For example, traffic gets dropped if both swp49 and swp52 are in the bond because they both are in the xe0 unit (or if both swp50 and swp51 are in the same bond because they are both in xe1):
   
swp49 xe0 0 0 -1 0
   
swp50 xe1 0 0 -1 0
   
swp51 xe1 1 0 -1 0
   
swp52 xe0 1 0 -1 0
 Single port member bonds, bonds with different units (xe0 or xe1, as above), or layer 3 bonds do not have this issue.



On Cumulus RMP switches, which are built with two Hurricane2 ASICs, you cannot form an LACP bond on links that terminate on different Hurricane2 ASICs.

## Related Information

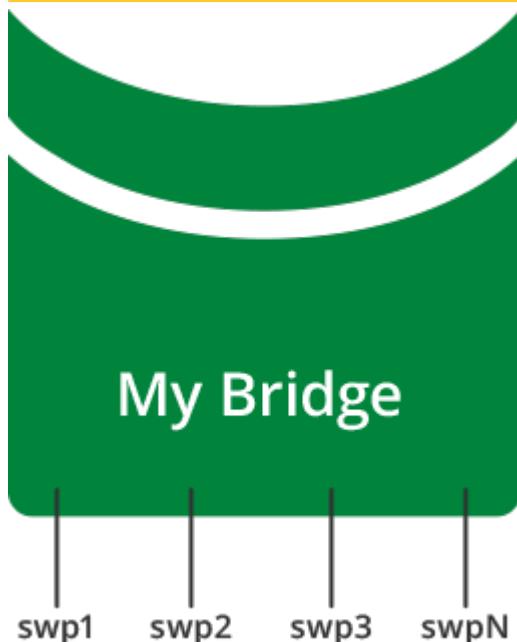
- Linux Foundation - Bonding
- 802.3ad (Accessible writeup)
- Wikipedia - Link aggregation

## Ethernet Bridging - VLANs

Ethernet bridges provide a means for hosts to communicate through layer 2, by connecting all of the physical and logical interfaces in the system into a single layer 2 domain. The bridge is a logical interface with a MAC address and an [MTU \(see page 242\)](#) (maximum transmission unit). The bridge MTU is the minimum MTU among all its members. By default, the [bridge's MAC address](#) is the MAC address of the first port in the `bridge-ports` list. The bridge can also be assigned an IP address, as discussed [below \(see page 409\)](#).



Bridge members can be individual physical interfaces, bonds or logical interfaces that traverse an 802.1Q VLAN trunk.



Cumulus Networks recommends using [VLAN-aware mode \(see page 415\)](#) bridges, rather than *traditional mode* bridges. The bridge driver in Cumulus Linux is capable of VLAN filtering, which allows for configurations that are similar to incumbent network devices. While Cumulus Linux supports Ethernet bridges in traditional mode, Cumulus Networks recommends using VLAN-aware mode.



For a comparison of traditional and VLAN-aware modes, read [this knowledge base article](#).



Cumulus Linux does not put all ports into a bridge by default.



You can configure both VLAN-aware and traditional mode bridges on the same network in Cumulus Linux; however you cannot have more than one VLAN-aware bridge on a given switch.

## Contents

This topic describes ...

- Create a VLAN-aware Bridge (see page 408)
- Create a Traditional Mode Bridge (see page 408)
- Configure Bridge MAC Addresses (see page 408)
- MAC Address Ageing (see page 409)
- Configure an SVI (Switch VLAN Interface) (see page 409)
- IPv6 Link-local Address Generation (see page 412)
- Understanding `bridge fdb` Output (see page 413)
- Caveats and Errata (see page 414)
- Related Information (see page 414)

## Create a VLAN-aware Bridge

To learn about VLAN-aware bridges and how to configure them, read [VLAN-aware Bridge Mode \(see page 415\)](#).

## Create a Traditional Mode Bridge

To create a traditional mode bridge, see [Traditional Bridge Mode \(see page 427\)](#).

## Configure Bridge MAC Addresses

The MAC address for a frame is learned when the frame enters the bridge via an interface. The MAC address is recorded in the bridge table, and the bridge forwards the frame to its intended destination by looking up the destination MAC address. The MAC entry is then maintained for a period of time defined by the `bridge-ageing` configuration option. If the frame is seen with the same source MAC address before the MAC entry age is exceeded, the MAC entry age is refreshed; if the MAC entry age is exceeded, the MAC address is deleted from the bridge table.

The following example output shows a MAC address table for the bridge:

```
cumulus@switch:~$ net show bridge macs
VLAN      Master      Interface      MAC          TunnelDest
State     Flags      LastSeen

```

```
-----  
-----  
untagged bridge      swp1          44:38:39:00:00:  
03                      00:00:15  
untagged bridge      swp1          44:38:39:00:00:04  
permanent           20 days, 01:14:03
```

## MAC Address Ageing

By default, Cumulus Linux stores MAC addresses in the Ethernet switching table for 1800 seconds (30 minutes). You can change this setting using NCLU.

The `bridge-ageing` option is in the [NCLU blacklist \(see page 97\)](#), as it's not frequently used. To configure this setting, you need to remove the `bridge-ageing` keyword from the `ifupdown_blacklist` in `/etc/netd.conf`. [Restart the netd service \(see page 96\)](#) after you edit the file.

Now you can change the setting using NCLU. For example, to change the setting to 600 seconds, run:

```
cumulus@switch:~$ net add bridge bridge ageing 600  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

These commands create the following configuration in the `/etc/network/interfaces` file:

```
cumulus@switch:~$ cat /etc/network/interfaces  
  
...  
  
auto bridge  
iface bridge  
    bridge-ageing 600  
  
...
```

## Configure an SVI (Switch VLAN Interface)

Bridges can be included as part of a routing topology after being assigned an IP address. This enables hosts within the bridge to communicate with other hosts outside of the bridge, via a *switch VLAN interface* (SVI), which provides layer 3 routing. The IP address of the bridge is typically from the same subnet as the bridge's member hosts.



When an interface is added to a bridge, it ceases to function as a router interface, and the IP address on the interface, if any, becomes unreachable.

To configure the SVI, use [NCLU \(see page 88\)](#):

```
cumulus@switch:~$ net add bridge bridge ports swp1-2
cumulus@switch:~$ net add vlan 10 ip address 10.100.100.1/24
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands create the following SVI configuration in the `/etc/network/interfaces` file:

```
auto bridge
iface bridge
    bridge-ports swp1 swp2
    bridge-vids 10
    bridge-vlan-aware yes

auto vlan10
iface vlan10
    address 10.100.100.1/24
    vlan-id 10
    vlan-raw-device bridge
```



Notice the `vlan-raw-device` keyword, which NCLU includes automatically. NCLU uses this keyword to associate the SVI with the VLAN-aware bridge.

Alternately, you can use the `bridge.VLAN-ID` naming convention for the SVI. The following example configuration can be manually created in the `/etc/network/interfaces` file, which functions identically to the above configuration:

```
auto bridge
iface bridge
    bridge-ports swp1 swp2
    bridge-vids 10
    bridge-vlan-aware yes

auto bridge.10
iface bridge.10
    address 10.100.100.1/24
```

When a switch is initially configured, all southbound bridge ports may be down, which means that, by default, the SVI is also down. However, you may want to force the SVI to always be up, to perform connectivity testing, for example. To do this, you essentially need to disable interface state tracking, leaving the SVI in the UP state always, even if all member ports are down. Other implementations describe this feature as *no autostate*.

In Cumulus Linux, you can keep the SVI perpetually UP by creating a dummy interface, and making the dummy interface a member of the bridge. Consider the following configuration, without a dummy interface in the bridge:

```
cumulus@switch:~$ cat /etc/network/interfaces
```



```
...
auto bridge
iface bridge
    bridge-vlan-aware yes
    bridge-ports swp3
    bridge-vids 100
    bridge-pvid 1
```

```
...
```

With this configuration, when swp3 is down, the SVI is also down:

```
cumulus@switch:~$ ip link show swp3
5: swp3: <BROADCAST,MULTICAST> mtu 1500 qdisc pfifo_fast master
bridge state DOWN mode DEFAULT group default qlen 1000
    link/ether 2c:60:0c:66:b1:7f brd ff:ff:ff:ff:ff:ff
cumulus@switch:~$ ip link show bridge
35: bridge: <NO-CARRIER,BROADCAST,MULTICAST,UP> mtu 1500 qdisc
noqueue state DOWN mode DEFAULT group default
    link/ether 2c:60:0c:66:b1:7f brd ff:ff:ff:ff:ff:ff
```

Now add the dummy interface to your network configuration:

1. Create a dummy interface, and add it to the bridge configuration. You do this by editing the /etc/network/interfaces file and adding the dummy interface stanza before the bridge stanza:

```
cumulus@switch:~$ sudo nano /etc/network/interfaces
...
auto dummy
iface dummy
    link-type dummy

auto bridge
iface bridge
...
```

2. Continue editing the interfaces file. Add the dummy interface to the bridge-ports line in the bridge configuration:

```
auto bridge
iface bridge
    bridge-vlan-aware yes
    bridge-ports swp3 dummy
    bridge-vids 100
    bridge-pvid 1
```

3. Save and exit the file, then reload the configuration:

```
cumulus@switch:~$ sudo ifreload -a
```

Now, even when swp3 is down, both the dummy interface and the bridge remain up:

```
cumulus@switch:~$ ip link show swp3
5: swp3: <BROADCAST,MULTICAST> mtu 1500 qdisc pfifo_fast master
bridge state DOWN mode DEFAULT group default qlen 1000
    link/ether 2c:60:0c:66:b1:7f brd ff:ff:ff:ff:ff:ff
cumulus@switch:~$ ip link show dummy
37: dummy: <BROADCAST,NOARP,UP,LOWER_UP> mtu 1500 qdisc noqueue
master bridge state UNKNOWN mode DEFAULT group default
    link/ether 66:dc:92:d4:f3:68 brd ff:ff:ff:ff:ff:ff
cumulus@switch:~$ ip link show bridge
35: bridge: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue
state UP mode DEFAULT group default
    link/ether 2c:60:0c:66:b1:7f brd ff:ff:ff:ff:ff:ff
```

## IPv6 Link-local Address Generation

By default, Cumulus Linux automatically generates IPv6 [link-local addresses](#) on VLAN interfaces. If you want to use a different mechanism to assign link-local addresses, you should disable this feature. You can disable link-local automatic address generation for both regular IPv6 addresses and address-virtual (macvlan) addresses.

To disable automatic address generation for a regular IPv6 address on VLAN 100, run:

```
cumulus@switch:~$ net add vlan 100 ipv6-addrgen off
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands create the following configuration in the `/etc/network/interfaces` file:

```
cumulus@switch:~$ cat /etc/network/interfaces
...
auto vlan100
iface vlan 100
    ipv6-addrgen off
    vlan-id 100
    vlan-raw-device bridge
...
```



To disable automatic address generation for a virtual IPv6 address on VLAN 100, run:

```
cumulus@switch:~$ net add vlan 100 address-virtual-ipv6-addrgen off  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

These commands create the following configuration in the `/etc/network/interfaces` file:

```
cumulus@switch:~$ cat /etc/network/interfaces  
  
...  
  
auto wlan100  
iface wlan 100  
    address-virtual-ipv6-addrgen off  
    vlan-id 100  
    vlan-raw-device bridge  
  
...
```

To re-enable automatic link-local address generation, run:

```
cumulus@switch:~$ net del vlan 100 ipv6-addrgen off  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

or

```
cumulus@switch:~$ net del vlan 100 address-virtual-ipv6-addrgen off  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

This removes the relevant configuration from the `interfaces` file.

## Understanding `bridge fdb` Output

The `bridge fdb` command in Linux interacts with the forwarding database table, which the bridge uses to store MAC addresses it has learned and on which ports it learned those MAC addresses. The `bridge fdb show` command output contains some specific keywords that require further explanation:

- **self**: the Linux kernel FDB entry flag indicating the FDB entry belongs to the FDB on the device referenced by the device.  
For example, this FDB entry belongs to the VXLAN device vx-1000:  
"00:02:00:00:00:08 dev vx-1000 dst 27.0.0.10 self"



- **master:** the Linux kernel FDB entry flag indicating the FDB entry belongs to the FDB on the device's master, and the FDB entry is pointing to a master's port.  
For example, this FDB entry is from the master device named *bridge* and is pointing to the VXLAN bridge port vx-1001:  
`02:02:00:00:00:08 dev vx-1001 vlan 1001 master bridge`
- **offload:** the Linux kernel FDB entry flag indicating the FDB entry is managed (or offloaded) by an external control plane — for example, the BGP control plane for EVPN.

Consider the following output of the `bridge fdb show` command:

```
cumulus@switch:~$ bridge fdb show | grep 02:02:00:00:00:08
02:02:00:00:00:08 dev vx-1001 vlan 1001 offload master bridge
02:02:00:00:00:08 dev vx-1001 dst 27.0.0.10 self offload
```

Some things you should note about the output:

- 02:02:00:00:00:08 is the MAC address learned via BGP EVPN.
- The first FDB entry points to a Linux bridge entry pointing to the VXLAN device *vx-1001*.
- The second FDB entry points to the same entry on the VXLAN device with additional remote destination information.
- The VXLAN FDB augments the bridge FDB with additional remote destination information.
- All FDB entries pointing to a VXLAN port appear as two such entries with the second entry augmenting the remote destination information.

## Caveats and Errata

- A bridge cannot contain multiple subinterfaces of the **same** port. Attempting this configuration results in an error.
- In environments where both VLAN-aware and traditional bridges are in use, if a traditional bridge has a subinterface of a bond that is a normal interface in a VLAN-aware bridge, the bridge is flapped when the traditional bridge's bond subinterface is brought down.
- You cannot enslave a VLAN raw device to a different master interface (that is, you cannot edit the `vlan-raw-device` setting in the `/etc/network/interfaces` file). You need to delete the VLAN and create it again.
- On a Mellanox platform, Cumulus Linux supports up to 2000 VLANs. This includes the internal interfaces, bridge interfaces, logical interfaces, and so forth.
- In Cumulus Linux, MAC learning is enabled by default on traditional or VLAN-aware bridge interfaces. Cumulus Networks recommends you do not disable MAC learning unless you are using EVPN. See [Ethernet Virtual Private Network - EVPN](#).

## Related Information

- [Linux Foundation - VLANs](#)
- [Linux Journal - Linux as an Ethernet Bridge](#)
- [Comparing Traditional Bridge Mode to VLAN-aware Bridge Mode](#)



## VLAN-aware Bridge Mode

The Cumulus Linux bridge driver supports two configuration modes, one that is VLAN-aware, and one that follows a more traditional Linux bridge model.

For [traditional Linux bridges \(see page 427\)](#), the kernel supports VLANs in the form of VLAN subinterfaces. Enabling bridging on multiple VLANs means configuring a bridge for each VLAN and, for each member port on a bridge, creating one or more VLAN subinterfaces out of that port. This mode poses scalability challenges in terms of configuration size as well as boot time and run time state management, when the number of ports times the number of VLANs becomes large.

The VLAN-aware mode in Cumulus Linux implements a configuration model for large-scale L2 environments, with **one single instance** of [Spanning Tree \(see page 372\)](#). Each physical bridge member port is configured with the list of allowed VLANs as well as its port VLAN ID (either PVID or native VLAN — see below). MAC address learning, filtering and forwarding are *VLAN-aware*. This significantly reduces the configuration size, and eliminates the large overhead of managing the port/VLAN instances as subinterfaces, replacing them with lightweight VLAN bitmaps and state updates.



You can configure both VLAN-aware and traditional mode bridges on the same network in Cumulus Linux; however you should not have more than one VLAN-aware bridge on a given switch.

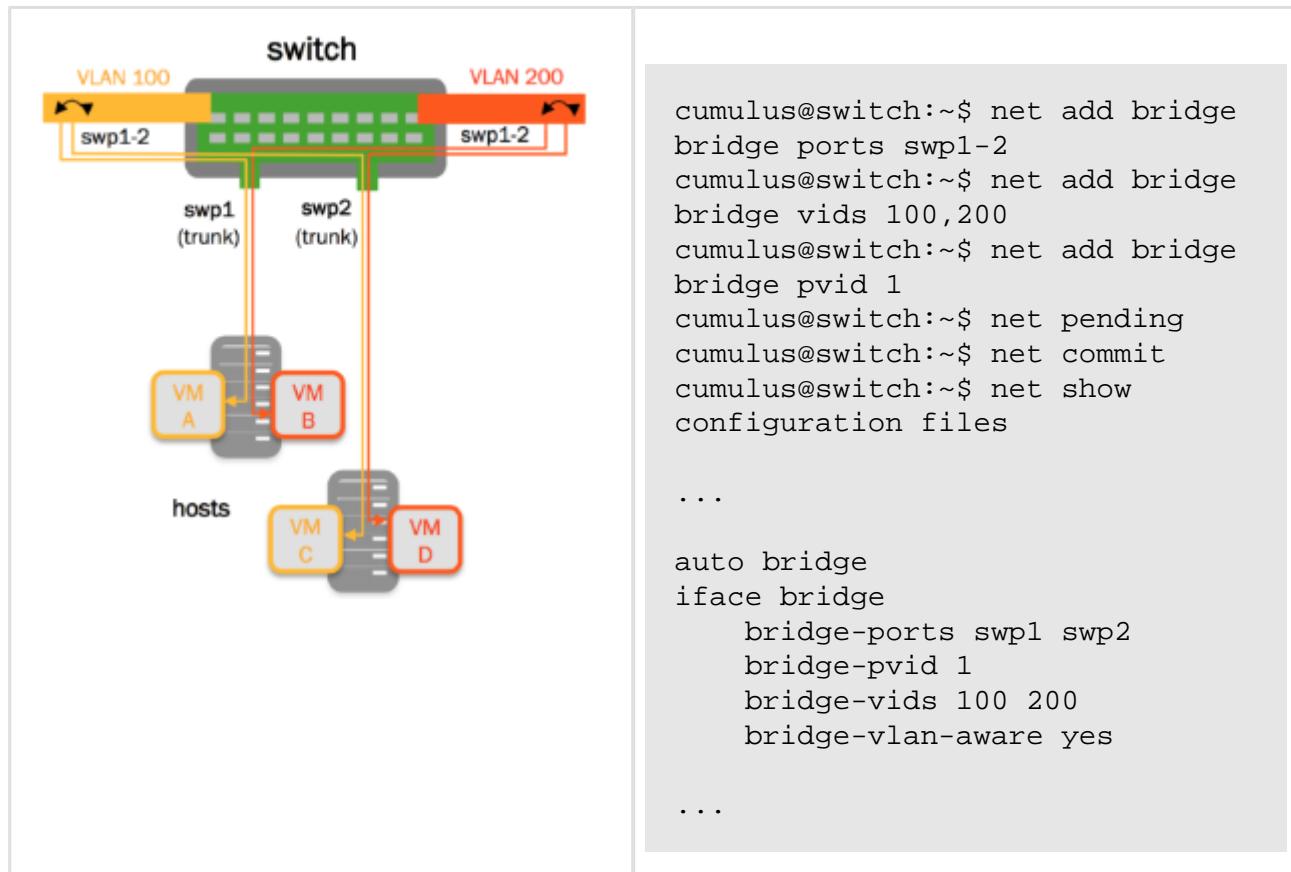
## Contents

### This topic describes ...

- Configure a VLAN-aware Bridge (see page 416)
  - Reserved VLAN Range (see page 417)
- Example Configurations (see page 418)
  - VLAN Filtering/VLAN Pruning (see page 418)
  - Untagged/Access Ports (see page 418)
  - Drop Untagged Frames (see page 419)
  - VLAN Layer 3 Addressing — Switch Virtual Interfaces and Other VLAN Attributes (see page 421)
  - Configure ARP Timers (see page 422)
  - Configure Multiple Ports in a Range (see page 422)
  - Access Ports and Pruned VLANs (see page 422)
  - Large Bond Set Configuration (see page 423)
  - VXLANS with VLAN-aware Bridges (see page 425)
  - Configure a Static MAC Address Entry (see page 426)
- Caveats and Errata (see page 426)
  - Spanning Tree Protocol (STP) (see page 426)
  - IGMP Snooping (see page 426)
  - VLAN Translation (see page 426)
  - Convert Bridges between Supported Modes (see page 426)

## Configure a VLAN-aware Bridge

VLAN-aware bridges can be configured with the Network Command Line Utility ([NCLU \(see page 88\)](#)). The example below shows the NCLU commands required to create a VLAN-aware bridge configured for STP, that contains two switch ports, and includes 3 VLANs — the tagged VLANs 100 and 200 and the untagged (native) VLAN of 1:



The following attributes are useful for configuring VLAN-aware bridges:

- **bridge-vlan-aware**: Is automatically set to yes to indicate that the bridge is in VLAN-aware mode.
- **bridge-pvid**: A PVID is the bridge's *Primary VLAN Identifier*. The PVID defaults to 1; specifying the PVID identifies that VLAN as the native VLAN.
- **bridge-vids**: A VID is the *VLAN Identifier*, which declares the VLANs associated with this bridge.
- **bridge-access**: Declares the physical switch port as an *access port*. Access ports ignore all tagged packets; put all untagged packets into the **bridge-pvid**.
- **bridge-allow-untagged**: When set to *no*, it drops any untagged frames for a given switch port.



If you specify **bridge-vids**, **bridge-access** or **bridge-pvid** at the bridge level, these configurations are inherited by all ports in the bridge. However, specifying any of these settings for a specific port overrides the setting in the bridge.

For a definitive list of bridge attributes, run `ifquery --syntax-help` and look for the entries under **bridge**, **bridgevlan** and **mstpctl**.



The `bridge-pvid 1` is implied by default. You do not have to specify `bridge-pvid` for a bridge or a port; in this case, the VLAN is untagged. And while it does not hurt the configuration, it helps other users for readability.

The following configurations are identical to each other and the configuration above:

```
auto bridge
iface bridge
    bridge-ports
    swp1 swp2
    bridge-vids
    1 100 200
    bridge-vlan-
    aware yes
```

```
auto bridge
iface bridge
    bridge-ports
    swp1 swp2
    bridge-pvid 1
    bridge-vids
    1 100 200
    bridge-vlan-
    aware yes
```

```
auto bridge
iface bridge
    bridge-ports
    swp1 swp2
    bridge-vids
    100 200
    bridge-vlan-
    aware yes
```



Do not try to bridge the management port, `eth0`, with any switch ports (like `swp0`, `swp1` and so forth). For example, if you created a bridge with `eth0` and `swp1`, it will not work properly and may disrupt access to the management interface.

## *Reserved VLAN Range*

For hardware data plane internal operations, the switching silicon requires VLANs for every physical port, Linux bridge, and layer 3 subinterface. Cumulus Linux reserves a range of 1000 VLANs by default; the reserved range is 3000-3999.



You can modify the reserved range if it conflicts with any user-defined VLANs, as long the new range is a contiguous set of VLANs with IDs anywhere between 2 and 4094, and the minimum size of the range is 300 VLANs.

To configure the reserved range:

1. Open `/etc/cumulus/switchd.conf` in a text editor.
2. Uncomment the following line, specify a new range, and save the file:

```
resv_vlan_range
```

3. Restart `switchd` to implement the change:

```
cumulus@switch:~$ sudo systemctl restart switchd.service
```

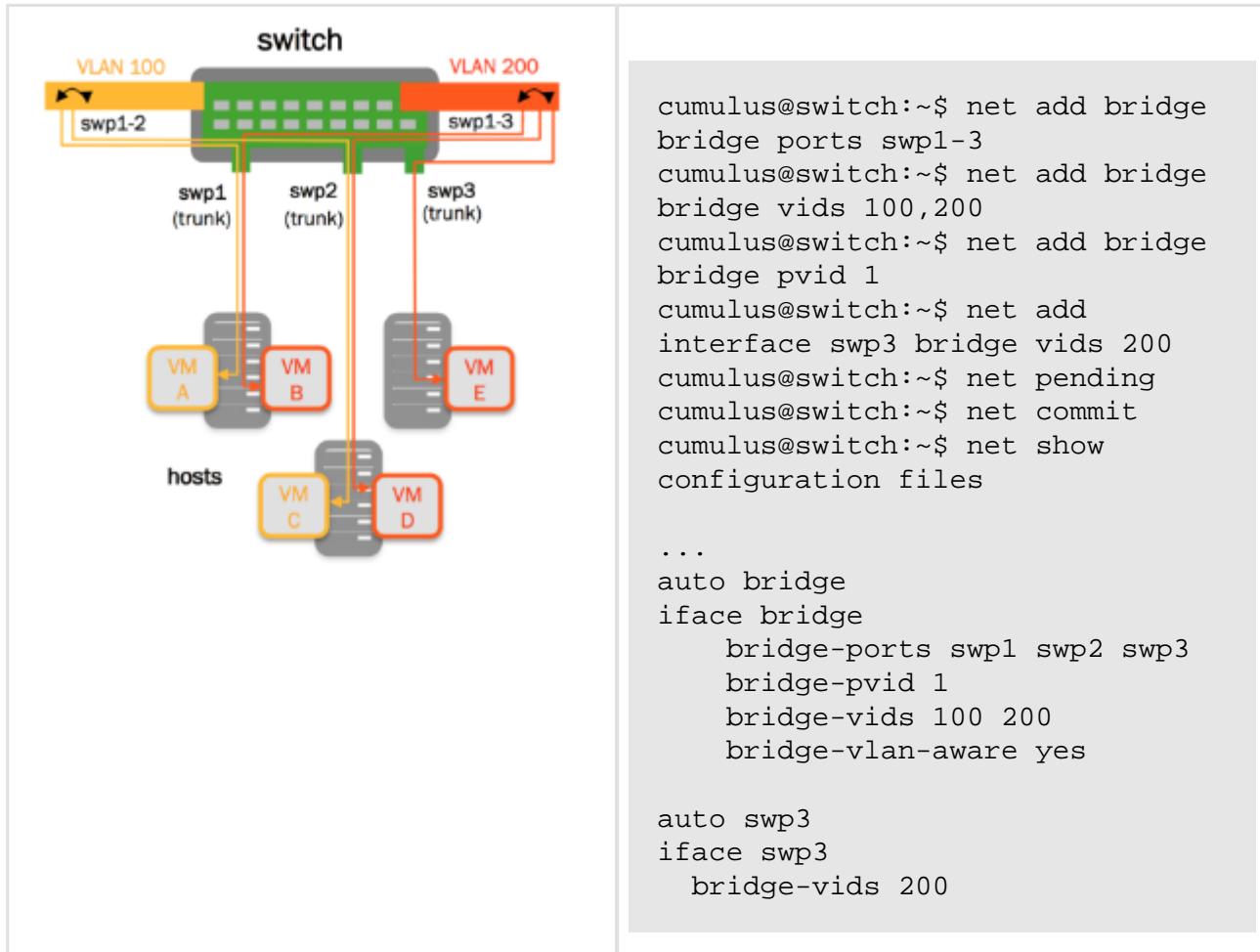


While restarting `switchd`, all running ports will flap, and forwarding will be interrupted.

## Example Configurations

### VLAN Filtering/VLAN Pruning

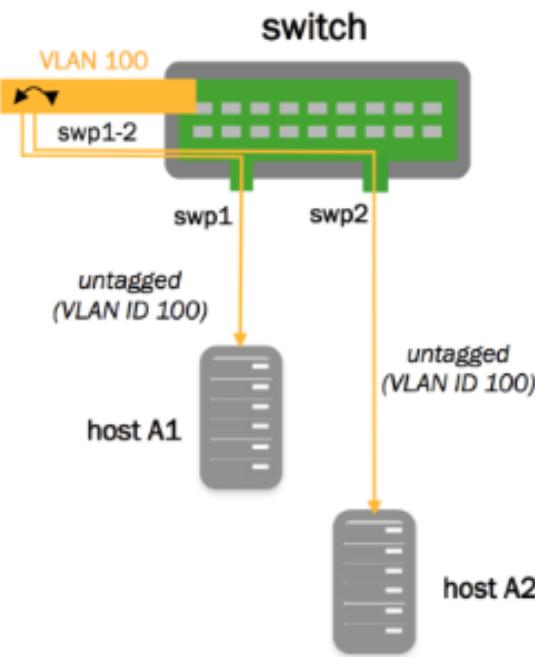
By default, the bridge port inherits the bridge VIDs. A port's configuration can override the bridge VIDs, by using the `bridge-vids` attribute:



### Untagged/Access Ports

Access ports ignore all tagged packets. In the configuration below, `swp1` and `swp2` are configured as access ports, while all untagged traffic goes to VLAN 100, as specified in the example below:

```
cumulus@switch:~$ net add bridge
bridge ports swp1-2
```



```

cumulus@switch:~$ net add bridge
bridge vids 100,200
cumulus@switch:~$ net add bridge
bridge pvid 1
cumulus@switch:~$ net add
interface swp1 bridge access 100
cumulus@switch:~$ net add
interface swp2 bridge access 100
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
cumulus@switch:~$ net show
configuration files

...
auto bridge
iface bridge
    bridge-ports swp1 swp2
    bridge-pvid 1
    bridge-vids 100 200
    bridge-vlan-aware yes

auto swp1
iface swp1
    bridge-access 100

auto swp2
iface swp2
    bridge-access 100
...

```

### *Drop Untagged Frames*

With VLAN-aware bridge mode, you can configure a switch port to drop any untagged frames. To do this, add **bridge-allow-untagged no** to the **switch port** (not to the bridge). This leaves the bridge port without a PVID and drops untagged packets.

Consider the following example bridge:

```

auto bridge
iface bridge
    bridge-ports swp1 swp2
    bridge-pvid 1
    bridge-vids 10 100 200
    bridge-vlan-aware yes

```

Here is the VLAN membership for that configuration:

```
cumulus@switch:~$ net show bridge vlan
```



Interface	VLAN	Flags
swp1	1	PVID, Egress Untagged
	100	
	200	
swp2	1	PVID, Egress Untagged
	10	
	100	
	200	

To configure swp2 to drop untagged frames, add `bridge-allow-untagged no`:

```
cumulus@switch:~$ net add interface swp2 bridge allow-untagged no
```

This command creates the following configuration snippet in the `/etc/network/interfaces` file. Note the `bridge-allow-untagged` configuration is under `sdp2`:

```
cumulus@switch:~$ cat /etc/network/interfaces

...
auto swp1
iface swp1

auto swp2
iface swp2
    bridge-allow-untagged no

auto bridge
iface bridge
    bridge-ports swp1 swp2
    bridge-pvid 1
    bridge-vids 10 100 200
    bridge-vlan-aware yes

...
```

When you check VLAN membership for that port, it shows that there is **no** untagged VLAN.

```
cumulus@switch:~$ net show bridge vlan

Interface      VLAN  Flags
-----  -----  -----
swp1           1     PVID, Egress Untagged
              10
              100
```



```
200  
swp2  
10  
100  
200
```

### VLAN Layer 3 Addressing – Switch Virtual Interfaces and Other VLAN Attributes

When configuring the VLAN attributes for the bridge, specify the attributes for each VLAN interface, each of which is named `vlan<vlanid>`. If you are configuring the SVI for the native VLAN, you must declare the native VLAN and specify its IP address. Specifying the IP address in the bridge stanza itself returns an error.

```
cumulus@switch:~$ net add vlan 100 ip address 192.168.10.1/24  
cumulus@switch:~$ net add vlan 100 ipv6 address 2001:db8::1/32  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

These commands create the following configuration in the `/etc/network/interfaces` file:

```
auto bridge  
iface bridge  
    bridge-ports swp1 swp2  
    bridge-pvid 1  
    bridge-vids 10 100 200  
    bridge-vlan-aware yes  
  
auto vlan100  
iface vlan100  
    address 192.168.10.1/24  
    address 2001:db8::1/32  
    vlan-id 100  
    vlan-raw-device bridge
```



In the above configuration, if your switch is configured for multicast routing, you do not need to specify `bridge-igmp-querier-src`, as there is no need for a static IGMP querier configuration on the switch. Otherwise, the static IGMP querier configuration helps to probe the hosts to refresh their IGMP reports.

You can specify a range of VLANs as well. For example:

```
cumulus@switch:~$ net add vlan 1-200
```



## Configure ARP Timers

Cumulus Linux does not often interact directly with end systems as much as end systems interact with one another. Thus, after a successful [address resolution protocol](#) (ARP) places a neighbor into a reachable state, Cumulus Linux may not interact with the client again for a long enough period of time for the neighbor to move into a stale state. To keep neighbors in the reachable state, Cumulus Linux includes a background process (`/usr/bin/neighmrgd`) that tracks neighbors that move into a stale, delay or probe state, and attempts to refresh their state ahead of any removal from the Linux kernel, and thus before it would be removed from the hardware forwarding.

The ARP refresh timer defaults to 1080 seconds (18 minutes). You can change this setting by following the procedures outlined in this [knowledge base article](#).

## Configure Multiple Ports in a Range

The `bridge-ports` attribute takes a range of numbers. The "swp1-52" in the example below indicates that swp1 through swp52 are part of the bridge, which is a shortcut that saves you from enumerating each port individually:

```
cumulus@switch:~$ net add bridge bridge ports swp1-52
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands create the following configuration in the `/etc/network/interfaces` file:

```
auto bridge
iface bridge
    bridge-ports swp1 swp2 swp3 ... swp51 swp52
    bridge-vids 310 700 707 712 850 910
    bridge-vlan-aware yes
```

## Access Ports and Pruned VLANs

The following example configuration contains an access port and switch port that are *pruned*; they only sends and receive traffic tagged to/from a specific set of VLANs declared by the `bridge-vids` attribute. It also contains other switch ports that send and receive traffic from all the defined VLANs.

```
cumulus@switch:~$ net show configuration files

...
# ports swp3-swp48 are trunk ports which inherit vlans from the
'bridge'
# ie vlans 310,700,707,712,850,910
#
auto bridge
iface bridge
    bridge-ports swp1 swp2 swp3 ... swp51 swp52
```



```
bridge-vids 310 700 707 712 850 910
bridge-vlan-aware yes

auto swp1
iface swp1
    bridge-access 310
    mstpctl-bpduguard yes
    mstpctl-portadminedge yes

# The following is a trunk port that is "pruned".
# native vlan is 1, but only .1q tags of 707, 712, 850 are
# sent and received
#
auto swp2
iface swp2
    mstpctl-bpduguard yes
    mstpctl-portadminedge yes
    bridge-vids 707 712 850

# The following port is the trunk uplink and inherits all vlans
# from 'bridge'; bridge assurance is enabled using 'portnetwork'
attribute
auto swp49
iface swp49
    mstpctl-portnetwork yes
    mstpctl-portpathcost 10

# The following port is the trunk uplink and inherits all vlans
# from 'bridge'; bridge assurance is enabled using 'portnetwork'
attribute
auto swp50
iface swp50
    mstpctl-portnetwork yes
    mstpctl-portpathcost 0

...
```

### Large Bond Set Configuration

The configuration below demonstrates a VLAN-aware bridge with a large set of bonds. The bond configurations are generated from a [Mako](#) template.

```
cumulus@switch:~$ net show configuration files

...
#
# vlan-aware bridge with bonds example
#
# uplink1, peerlink and downlink are bond interfaces.
# 'bridge' is a vlan aware bridge with ports uplink1, peerlink
```



```
# and downlink (swp2-20).
#
# native vlan is by default 1
#
# 'bridge-vids' attribute is used to declare vlans.
# 'bridge-pvid' attribute is used to specify native vlans if other
than 1
# 'bridge-access' attribute is used to declare access port
#
auto lo
iface lo

auto eth0
iface eth0 inet dhcp

# bond interface
auto uplink1
iface uplink1
    bond-slaves swp32
    bridge-vids 2000-2079

# bond interface
auto peerlink
iface peerlink
    bond-slaves swp30 swp31
    bridge-vids 2000-2079 4094

# bond interface
auto downlink
iface downlink
    bond-slaves swp1
    bridge-vids 2000-2079

#
# Declare vlans for all swp ports
# swp2-20 get vlans from 2004 to 2022.
# The below uses mako templates to generate iface sections
# with vlans for swp ports
#
%for port, vlanid in zip(range(2, 20), range(2004, 2022)) :
    auto swp${port}
    iface swp${port}
        bridge-vids ${vlanid}

%endfor

# svi vlan 2000
auto bridge.2000
iface bridge.2000
    address 11.100.1.252/24

# 12 attributes for vlan 2000
```



```
auto bridge.2000
vlan bridge.2000
    bridge-igmp-querier-src 172.16.101.1

#
# vlan-aware bridge
#
auto bridge
iface bridge
    bridge-ports uplink1 peerlink downlink swp1 swp2 swp49 swp50
    bridge-vlan-aware yes

# svi peerlink vlan
auto peerlink.4094
iface peerlink.4094
    address 192.168.10.1/30
    broadcast 192.168.10.3

...
```

## VXLANs with VLAN-aware Bridges

Cumulus Linux supports using VXLANs with VLAN-aware bridge configuration. This provides improved scalability, as multiple VXLANs can be added to a single VLAN-aware bridge. A 1:1 association is used between the VXLAN VNI and the VLAN, using the bridge access VLAN definition on the VXLAN, and the VLAN membership definition on the local bridge member interfaces.

The configuration example below shows the differences between a VXLAN configured for traditional bridge mode and one configured for VLAN-aware mode. The configurations use head end replication (HER), along with the VLAN-aware bridge to map VLANs to VNIs.



See the [VXLAN Scale](#) (see page 655) topic for information about the number of VXLANs you can configure simultaneously.

```
cumulus@switch:~$ net show configuration files

...
auto lo
iface lo inet loopback
    address 10.35.0.10/32

auto bridge
iface bridge
    bridge-ports uplink vni-10000
    bridge-pvid 1
    bridge-vids 1-100
    bridge-vlan-aware yes
auto vni-10000
```



```
iface vni-10000
    alias CUSTOMER X VLAN 10
    bridge-access 10
    vxlan-id 10000
    vxlan-local-tunnelip 10.35.0.10
    vxlan-remoteip 10.35.0.34

...
```

### Configure a Static MAC Address Entry

You can add a static MAC address entry to the layer 2 table for an interface within the VLAN-aware bridge by running a command similar to the following:

```
cumulus@switch:~$ sudo bridge fdb add 12:34:56:12:34:56 dev swp1 vlan 150 master static
cumulus@switch:~$ sudo bridge fdb show
44:38:39:00:00:7c dev swp1 master bridge permanent
12:34:56:12:34:56 dev swp1 vlan 150 master bridge static
44:38:39:00:00:7c dev swp1 self permanent
12:12:12:12:12:12 dev swp1 self permanent
12:34:12:34:12:34 dev swp1 self permanent
12:34:56:12:34:56 dev swp1 self permanent
12:34:12:34:12:34 dev bridge master bridge permanent
44:38:39:00:00:7c dev bridge vlan 500 master bridge permanent
12:12:12:12:12:12 dev bridge master bridge permanent
```

### Caveats and Errata

#### Spanning Tree Protocol (STP)

VLAN-aware mode supports a single instance of STP across all VLANs, as STP is enabled on a per-bridge basis. A common practice when using a single STP instance for all VLANs is to define every VLAN on every switch in the spanning tree instance.

`mstpd` remains the user space protocol daemon.

Cumulus Linux supports Rapid Spanning Tree Protocol (RSTP).

#### IGMP Snooping

IGMP snooping and group membership are supported on a per-VLAN basis, though the IGMP snooping configuration (including enable/disable and mrouter ports) are defined on a per-bridge port basis.

#### VLAN Translation

A bridge in VLAN-aware mode cannot have VLAN translation enabled for it. Only traditional mode bridges can utilize VLAN translation.



## Convert Bridges between Supported Modes

Traditional mode bridges cannot be automatically converted to/from a VLAN-aware bridge. The original configuration must be deleted, and all member switch ports must be brought down, then a new bridge can be created.

## Traditional Bridge Mode

Cumulus Networks recommends you use a [VLAN-aware bridge \(see page 415\)](#) on your switch. You use traditional mode bridges only if you need to run more than one bridge on the switch or if you need to use PVSTP+.

### Contents

#### This topic describes ...

- Create a Traditional Mode Bridge (see page 427)
  - Configure a Traditional Bridge with NCLU (see page 427)
  - Manually Configure a Traditional Mode Bridge (see page 429)
- Trunks in Traditional Bridge Mode (see page 430)
  - Trunk Example (see page 432)
  - VLAN Tagging Examples (see page 432)
  - Configure ARP Timers (see page 432)
- Caveats (see page 433)

### Create a Traditional Mode Bridge

You can configure a traditional mode bridge either using [NCLU \(see page 88\)](#) or manually editing the `/etc/network/interfaces` file.

### Configure a Traditional Bridge with NCLU

NCLU has limited support for configuring bridges in traditional mode.



The traditional bridge must be named something other than *bridge*, as that name is reserved for the single [VLAN-aware bridge \(see page 415\)](#) that you can configure on the switch.

The following example shows how to create a simple traditional mode bridge configuration on the switch, including adding the switch ports that are members of the bridge. You can choose to add one or more of the following elements to the configuration:

- You can add an IP address to provide IP access to the bridge interface.
- You can use glob syntax to specify a range of interfaces.
- You can set two STP attributes on the bridge ports: `portautoedge` and `portrestrole`.



The `portautoedge` attribute defaults to `yes`; to use a setting other than the default, you must set this attribute to `no`.

The `portrestrole` attribute defaults to `no`, but to use a setting other than the default, you must specify this attribute **without** setting an option.

The defaults for these attributes do not appear in the NCLU configuration.

To configure a traditional mode bridge using NCLU, do the following:

```
cumulus@switch:~$ net add bridge my_bridge_A ports swp1-4
cumulus@switch:~$ net add bridge my_bridge_A ip address 10.10.10.10/24
cumulus@switch:~$ net add interface swp1 stp portautoedge no
cumulus@switch:~$ net add interface swp2 stp portrestrole
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands create the following configuration snippet in the `/etc/network/interfaces` file:

```
cumulus@switch:~$ cat /etc/network/interfaces

...
auto swp1
iface swp1
    mstpctl-portautoedge no

auto swp2
iface swp2
    mstpctl-portrestrole yes

auto swp3
iface swp3

auto swp4
iface swp4

...
auto my_bridge_A
iface my_bridge_A
    address 10.10.10.10/24
    bridge-ports swp1 swp2 swp3 swp4
    bridge-vlan-aware no
```

Verify the configuration by running `net show config` commands:

```
cumulus@switch:~$ net show config commands
...
net add bridge my_bridge_A ip address 10.10.10.10/24
net add bridge my_bridge_A ports swp1,swp2,swp3,swp4
...
```

```
net add interface swp1 stp portautoedge no  
net add interface swp2 stp portrestrole  
...
```

## Manually Configure a Traditional Mode Bridge

To create a traditional mode bridge manually, you need to hand edit the `/etc/network/interfaces` file:

1. Open the `/etc/network/interfaces` file in a text editor.
2. Add a new stanza to create the bridge, and save the file. The example below creates a bridge with STP enabled and the MAC address ageing timer configured to a lower value than the default:

```
auto my_bridge  
iface my_bridge  
    bridge-ports bond0 swp5 swp6  
    bridge-ageing 150  
    bridge-stp on
```

Configuration Option	Description	Default Value
bridge-ports	List of logical and physical ports belonging to the logical bridge.	N/A
bridge-ageing	Maximum amount of time before a MAC addresses learned on the bridge expires from the bridge MAC cache.	1800 seconds
bridge-stp	Enables spanning tree protocol on this bridge. The default spanning tree mode is Per VLAN Rapid Spanning Tree Protocol (PVRST).  For more information on spanning-tree configurations see the configuration section: <a href="#">Spanning Tree and Rapid Spanning Tree (see page 372)</a> .	off



The name of the bridge must be:

- Compliant with Linux interface naming conventions.
- Unique within the switch.



Do not try to bridge the management port, eth0, with any switch ports (like swp0, swp1, and so forth). For example, if you created a bridge with eth0 and swp1, it will **not** work.

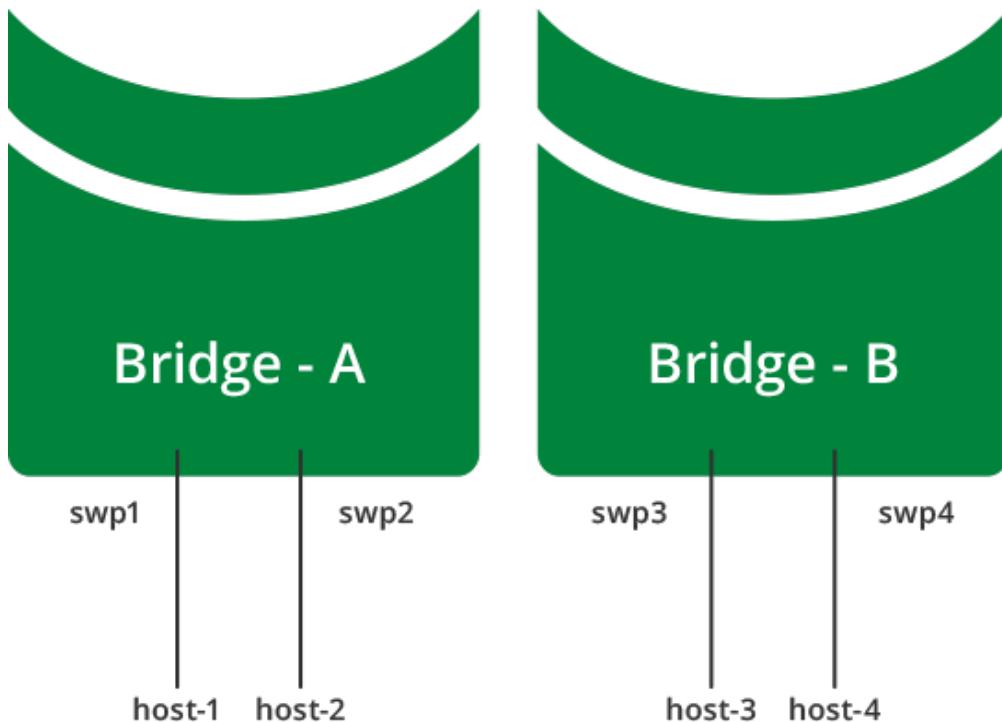
3. Reload the network configuration using the `ifreload` command:

```
cumulus@switch:~$ sudo ifreload -a
```

- i** You can configure multiple bridges, in order to logically divide a switch into multiple layer 2 domains. This allows for hosts to communicate with other hosts in the same domain, while separating them from hosts in other domains.

The diagram below shows a multiple bridge configuration, where host-1 and host-2 are connected to bridge-A, while host-3 and host-4 are connected to bridge-B. This means that:

- host-1 and host-2 can communicate with each other.
- host-3 and host-4 can communicate with each other.
- host-1 and host-2 cannot communicate with host-3 and host-4.



This example configuration looks like this in the /etc/network/interfaces file:

```
auto bridge-A
iface bridge-A
  bridge-ports swp1 swp2
  bridge-stp on

auto bridge-B
iface bridge-B
  bridge-ports swp3 swp4
  bridge-stp on
```



## Trunks in Traditional Bridge Mode

The [IEEE standard](#) for trunking is 802.1Q. The 802.1Q specification adds a 4 byte header within the Ethernet frame that identifies the VLAN of which the frame is a member.

802.1Q also identifies an *untagged* frame as belonging to the *native VLAN* (most network devices default their native VLAN to 1). The concept of native, non-native, tagged or untagged has generated confusion due to mixed terminology and vendor-specific implementations. Some clarification is in order:

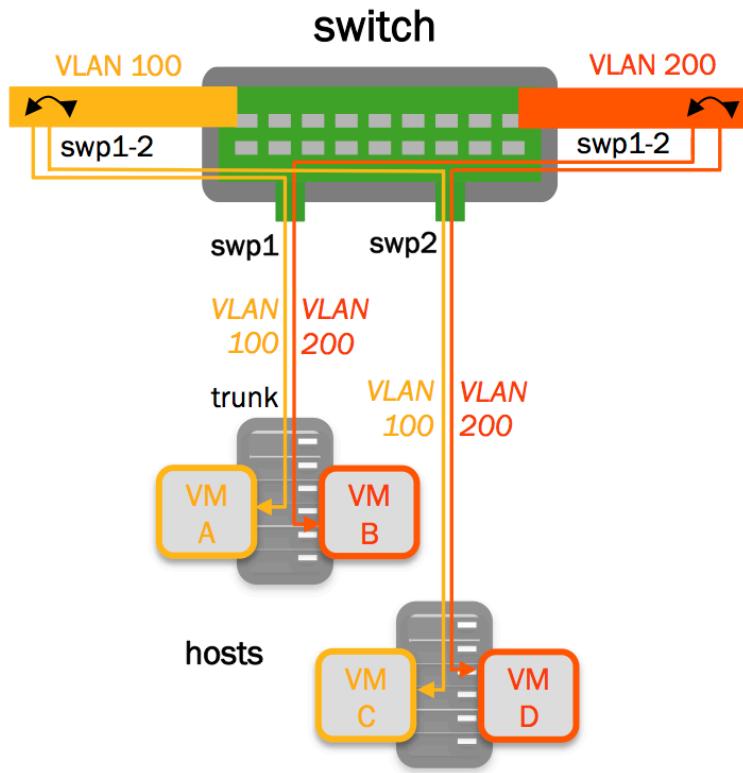
- A *trunk port* is a switch port configured to send and receive 802.1Q tagged frames.
- A switch sending an untagged (bare Ethernet) frame on a trunk port is sending from the native VLAN defined on the trunk port.
- A switch sending a tagged frame on a trunk port is sending to the VLAN identified by the 802.1Q tag.
- A switch receiving an untagged (bare Ethernet) frame on a trunk port places that frame in the native VLAN defined on the trunk port.
- A switch receiving a tagged frame on a trunk port places that frame in the VLAN identified by the 802.1Q tag.

A bridge in traditional mode has no concept of trunks, just tagged or untagged frames. With a trunk of 200 VLANs, there would need to be 199 bridges, each containing a tagged physical interface, and one bridge containing the native untagged VLAN. See the examples below for more information.



The interaction of tagged and un-tagged frames on the same trunk often leads to undesired and unexpected behavior. A switch that uses VLAN 1 for the native VLAN may send frames to a switch that uses VLAN 2 for the native VLAN, thus merging those two VLANs and their spanning tree state.

## Trunk Example



To create the above example, add the following configuration to the `/etc/network/interfaces` file:

```

auto br-VLAN100
iface br-VLAN100
    bridge-ports swp1.100 swp2.100
    bridge-stp on

auto br-VLAN200
iface br-VLAN200
    bridge-ports swp1.200 swp2.200
    bridge-stp on

```

## VLAN Tagging Examples

You can find more examples of VLAN tagging in [the VLAN tagging chapter](#) (see page 433).

## Configure ARP Timers

Cumulus Linux does not often interact directly with end systems as much as end systems interact with one another. Thus, after a successful [address resolution protocol](#) (ARP) places a neighbor into a reachable state, Cumulus Linux may not interact with the client again for a long enough period of time for the neighbor to

move into a stale state. To keep neighbors in the reachable state, Cumulus Linux includes a background process (`/usr/bin/neighmgrd`) that tracks neighbors that move into a stale, delay or probe state, and attempts to refresh their state ahead of any removal from the Linux kernel, and thus before it would be removed from the hardware forwarding.

The ARP refresh timer defaults to 1080 seconds (18 minutes). You can change this setting by following the procedures outlined in this [knowledge base article](#).

### Caveats

On Broadcom switches, when two VLAN subinterfaces are bridged to each other in a traditional mode bridge, `switchd` does not assign an internal resource ID to the subinterface, which is expected for each VLAN subinterface.

To work around this issue, add a VXLAN on the bridge so that it does not require a real tunnel IP address.

## VLAN Tagging

This topic shows two examples of VLAN tagging, one basic and one more advanced. They both demonstrate the streamlined interface configuration from `ifupdown2`.

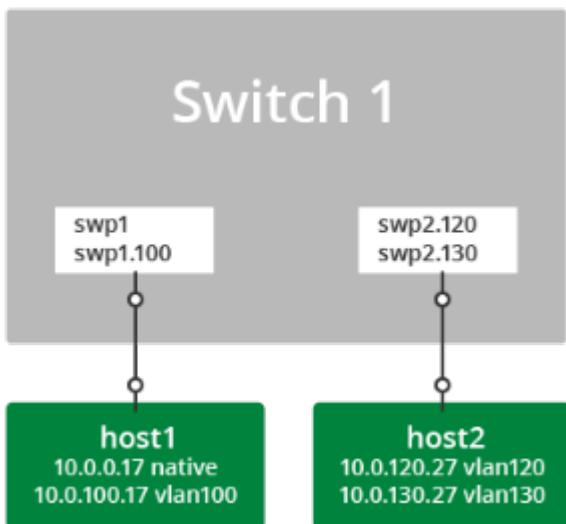
### Contents

#### This topic describes ...

- [VLAN Tagging, a Basic Example \(see page 433\)](#)
- [VLAN Tagging, an Advanced Example \(see page 434\)](#)
- [VLAN Translation \(see page 439\)](#)

### *VLAN Tagging, a Basic Example*

A simple configuration demonstrating VLAN tagging involves two hosts connected to a switch.



- *host1* connects to *swp1* with both untagged frames and with 802.1Q frames tagged for *vlan100*.
- *host2* connects to *swp2* with 802.1Q frames tagged for *vlan120* and *vlan130*.



To configure the above example, edit the `/etc/network/interfaces` file and add a configuration like the following:

```
# Config for host1

auto swp1
iface swp1

auto swp1.100
iface swp1.100

# Config for host2
# swp2 must exist to create the .1Q subinterfaces, but it is not
assigned an address

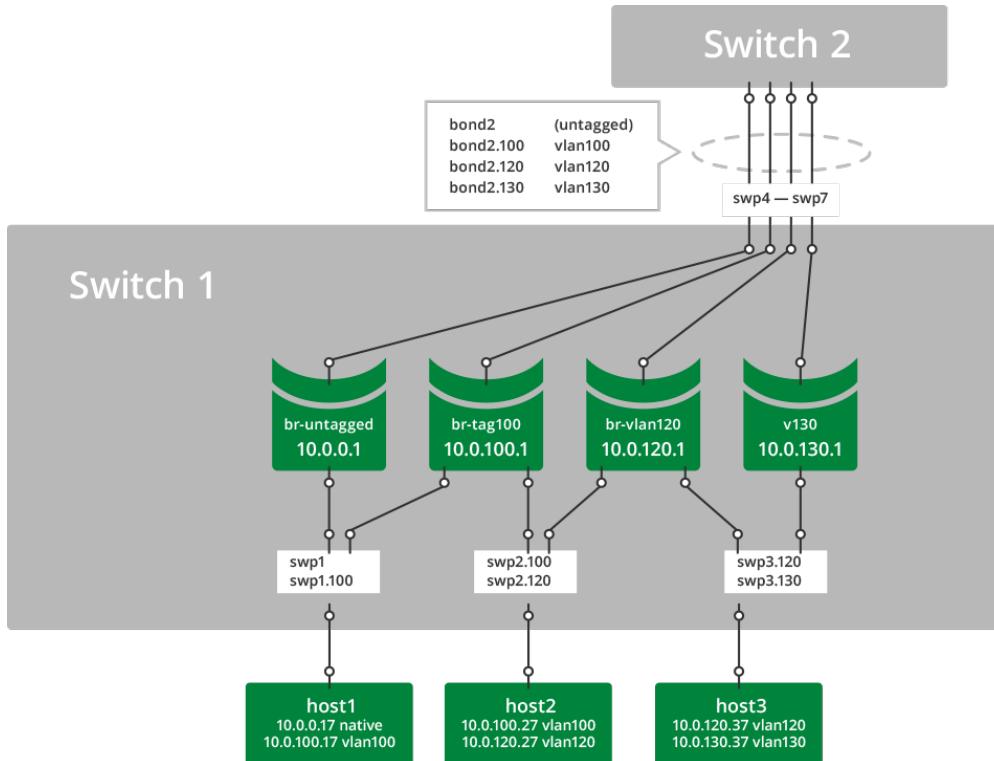
auto swp2
iface swp2

auto swp2.120
iface swp2.120

auto swp2.130
iface swp2.130
```

### *VLAN Tagging, an Advanced Example*

This example of VLAN tagging is more complex, involving three hosts and two switches, with a number of bridges and a bond connecting them all.



- *host1* connects to bridge *br-untagged* with bare Ethernet frames and to bridge *br-tag100* with 802.1q frames tagged for *vlan100*.
- *host2* connects to bridge *br-tag100* with 802.1q frames tagged for *vlan100* and to bridge *br-vlan120* with 802.1q frames tagged for *vlan120*.
- *host3* connects to bridge *br-vlan120* with 802.1q frames tagged for *vlan120* and to bridge *v130* with 802.1q frames tagged for *vlan130*.
- *bond2* carries tagged and untagged frames in this example.

Although not explicitly designated, the bridge member ports function as 802.1Q access ports and trunk ports. In the example above, comparing Cumulus Linux with a traditional Cisco device:

- *swp1* is equivalent to a trunk port with untagged and *vlan100*.
- *swp2* is equivalent to a trunk port with *vlan100* and *vlan120*.
- *swp3* is equivalent to a trunk port with *vlan120* and *vlan130*.
- *bond2* is equivalent to an EtherChannel in trunk mode with untagged, *vlan100*, *vlan120*, and *vlan130*.
- Bridges *br-untagged*, *br-tag100*, *br-vlan120*, and *v130* are equivalent to SVIs (switched virtual interfaces).

To create the above configuration, edit the `/etc/network/interfaces` file and add a configuration like the following:

```
# Config for host1 -----  
-----  
  
# swp1 does not need an iface section unless it has a specific  
# setting,  
# it will be picked up as a dependent of swp1.100.  
# And swp1 must exist in the system to create the .1q subinterfaces..
```





```
auto br-vlan120
iface br-vlan120
    address 10.0.120.1/24
    bridge-ports swp2.120 swp3.120 bond2.120
    bridge-stp on

auto v130
iface v130
    address 10.0.130.1/24
    bridge-ports swp3.130 bond2.130
    bridge-stp on

# -----
```

To verify:

```
cumulus@switch:~$ sudo mstptctl showbridge br-tag100
br-tag100 CIST info
  enabled      yes
  bridge id    8.000.44:38:39:00:32:8B
  designated root 8.000.44:38:39:00:32:8B
  regional root 8.000.44:38:39:00:32:8B
  root port    none
  path cost     0          internal path cost  0
  max age       20         bridge max age    20
  forward delay 15         bridge forward delay 15
  tx hold count 6          max hops        20
  hello time    2          ageing time    300
  force protocol version   rstp
  time since topology change 333040s
  topology change count    1
  topology change           no
  topology change port     swp2.100
  last topology change port None
```

```
cumulus@switch:~$ sudo mstptctl showportdetail br-tag100 | grep -B 2
state
br-tag100:bond2.100 CIST info
  enabled      yes             role
  Designated
    port id    8.003           state
  forwarding
  --
br-tag100:swp1.100 CIST info
  enabled      yes             role
  Designated
```



```
    port id          8.001           state
forwarding
--
br-tag100:swp2.100 CIST info
    enabled        yes            role
Designated
    port id          8.002           state
forwarding
```

```
cumulus@switch:~$ cat /proc/net/vlan/config
VLAN Dev name      | VLAN ID
Name-Type: VLAN_NAME_TYPE_RAW_PLUS_VID_NO_PAD
bond2.100          | 100   | bond2
bond2.120          | 120   | bond2
bond2.130          | 130   | bond2
swp1.100          | 100   | swp1
swp2.100          | 100   | swp2
swp2.120          | 120   | swp2
swp3.120          | 120   | swp3
swp3.130          | 130   | swp3
```

```
cumulus@switch:~$ cat /proc/net/bonding/bond2
Ethernet Channel Bonding Driver: v3.7.1 (April 27, 2011)

Bonding Mode: IEEE 802.3ad Dynamic link aggregation
Transmit Hash Policy: layer3+4 (1)
MII Status: up
MII Polling Interval (ms): 100
Up Delay (ms): 0
Down Delay (ms): 0

802.3ad info
LACP rate: fast
Min links: 0
Aggregator selection policy (ad_select): stable
Active Aggregator Info:
    Aggregator ID: 3
    Number of ports: 4
    Actor Key: 33
    Partner Key: 33
    Partner Mac Address: 44:38:39:00:32:cf

Slave Interface: swp4
MII Status: up
Speed: 10000 Mbps
Duplex: full
Link Failure Count: 0
Permanent HW addr: 44:38:39:00:32:8e
```



```
Aggregator ID: 3
Slave queue ID: 0

Slave Interface: swp5
MII Status: up
Speed: 10000 Mbps
Duplex: full
Link Failure Count: 0
Permanent HW addr: 44:38:39:00:32:8f
Aggregator ID: 3
Slave queue ID: 0

Slave Interface: swp6
MII Status: up
Speed: 10000 Mbps
Duplex: full
Link Failure Count: 0
Permanent HW addr: 44:38:39:00:32:90
Aggregator ID: 3
Slave queue ID: 0

Slave Interface: swp7
MII Status: up
Speed: 10000 Mbps
Duplex: full
Link Failure Count: 0
Permanent HW addr: 44:38:39:00:32:91
Aggregator ID: 3
Slave queue ID: 0
```

- ! A single bridge cannot contain multiple subinterfaces of the **same** port as members. Attempting to apply such a configuration will result in an error:

```
cumulus@switch:~$ sudo brctl addbr another_bridge
cumulus@switch:~$ sudo brctl addif another_bridge swp9 swp9.100
100
bridge cannot contain multiple subinterfaces of the same port:
swp9, swp9.100
```

## VLAN Translation

By default, Cumulus Linux does not allow VLAN subinterfaces associated with different VLAN IDs to be part of the same bridge. Base interfaces are not explicitly associated with any VLAN IDs and are exempt from this restriction.

In some cases, it may be useful to relax this restriction. For example, two servers might be connected to the switch using VLAN trunks, but the VLAN numbering provisioned on the two servers are not consistent. You can choose to just bridge two VLAN subinterfaces of different VLAN IDs from the servers. You do this by enabling the `sysctl net.bridge.bridge-allow-multiple-vlans`. Packets entering a bridge from a member VLAN subinterface will egress another member VLAN subinterface with the VLAN ID translated.



A bridge in [VLAN-aware mode](#) (see page 415) cannot have VLAN translation enabled for it; only bridges configured in [traditional mode](#) (see page 427) can utilize VLAN translation.

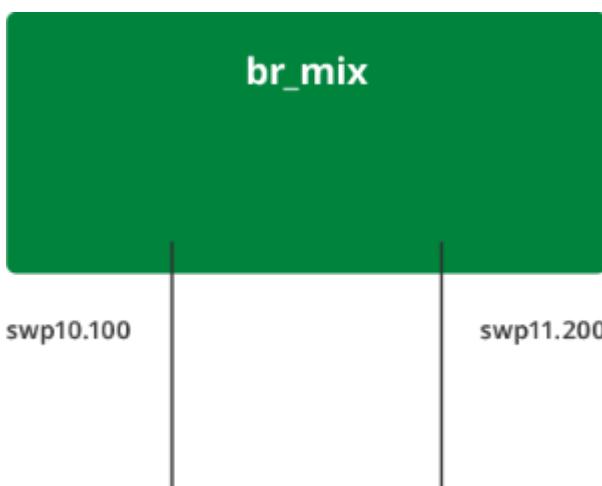
The following example enables the VLAN translation `sysctl`:

```
cumulus@switch:~$ echo net.bridge.bridge-allow-multiple-vlans = 1 |  
sudo tee /etc/sysctl.d/multiple_vlans.conf  
net.bridge.bridge-allow-multiple-vlans = 1  
cumulus@switch:~$ sudo sysctl -p /etc/sysctl.d/multiple_vlans.conf  
net.bridge.bridge-allow-multiple-vlans = 1
```

If the `sysctl` is enabled and you want to disable it, run the above example, setting the `sysctl net.bridge.bridge-allow-multiple-vlans` to 0.

After `sysctl` is enabled, ports with different VLAN IDs can be added to the same bridge. In the following example, packets entering the bridge `br_mix` from `swp10.100` will be bridged to `swp11.200` with the VLAN ID translated from 100 to 200:

```
cumulus@switch:~$ sudo brctl addif br_mix swp10.100 swp11.200  
  
cumulus@switch:~$ sudo brctl show br_mix  
bridge name      bridge id          STP enabled      interfaces  
br_mix           8000.4438390032bd    yes            swp10.100  
                           swp11.200
```



## Multi-Chassis Link Aggregation - MLAG

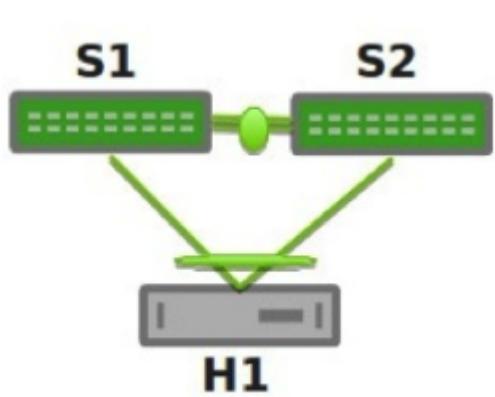
Multi-Chassis Link Aggregation (MLAG) enables a server or switch with a two-port bond, such as a link aggregation group/LAG, EtherChannel, port group or trunk, to connect those ports to different switches and operate as if they are connected to a single, logical switch. This provides greater redundancy and greater system throughput.

### ⓘ MLAG or CLAG?

The Cumulus Linux implementation of MLAG is referred to by other vendors as CLAG, MC-LAG or VPC. You will even see references to CLAG in Cumulus Linux, including the management daemon, named `c1agd`, and other options in the code, such as `c1ag-id`, which exist for historical purposes. The Cumulus Linux implementation is truly a multi-chassis link aggregation protocol, so we call it MLAG.

Dual-connected devices can create LACP bonds that contain links to each physical switch. Therefore, active-active links from the dual-connected devices are supported even though they are connected to two different physical switches.

A basic setup looks like this:



You can see an example of how to set up this configuration by running:

```
cumulus@switch:~$ net example clag basic-clag
```

The two switches, S1 and S2, known as *peer switches*, cooperate so that they appear as a single device to host H1's bond. H1 distributes traffic between the two links to S1 and S2 in any way that you configure on the host. Similarly, traffic inbound to H1 can traverse S1 or S2 and arrive at H1.

## Contents

This topic describes ...

- MLAG Requirements (see page 442)
- LACP and Dual-Connectedness (see page 444)



- Configure MLAG (see page 444)
  - Reserved MAC Address Range (see page 445)
  - Configure the Host or Switch (see page 446)
  - Configure the Interfaces (see page 446)
  - Switch Roles and Priority Setting (see page 448)
- Example MLAG Configuration (see page 448)
- Disable clagd on an Interface (see page 456)
- Check the MLAG Configuration Status (see page 456)
- Configure MLAG with a Traditional Mode Bridge (see page 457)
- Peer Link Interfaces and the protodown State (see page 458)
  - Specify a Backup Link (see page 458)
  - Specify a Backup Link to a VRF (see page 460)
- Monitor Dual-Connected Peers (see page 462)
- Configure Layer 3 Routed Uplinks (see page 462)
- IGMP Snooping with MLAG (see page 464)
- Monitor the Status of the clagd Service (see page 464)
- MLAG Best Practices (see page 465)
  - MTU in an MLAG Configuration (see page 465)
  - Peer Link Sizing (see page 467)
  - Failover Redundancy Scenarios (see page 468)
- STP Interoperability with MLAG (see page 468)
  - Best Practices for STP with MLAG (see page 469)
- Troubleshooting (see page 469)
  - Viewing the MLAG Log File (see page 469)
  - Large Packet Drops on the Peer Link Interface (see page 470)
  - Duplicate LACP Partner MAC Warning (see page 471)
- Caveats and Errata (see page 471)

## MLAG Requirements

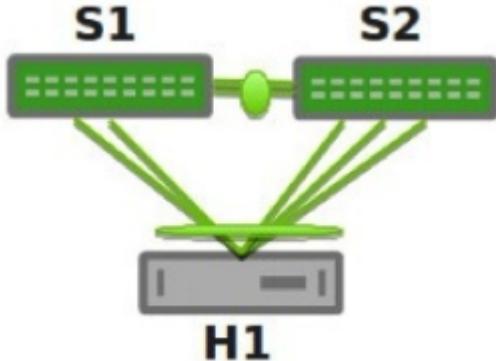
MLAG has these requirements:

- There must be a direct connection between the two peer switches implementing MLAG (S1 and S2). This is typically a bond for increased reliability and bandwidth.
- There must be only two peer switches in one MLAG configuration, but you can have multiple configurations in a network for *switch-to-switch MLAG* (see below).
- The peer switches implementing MLAG must be running Cumulus Linux version 2.5 or later.
- You must specify a unique `clag-id` for every dual-connected bond on each peer switch; the value must be between 1 and 65535 and must be the same on both peer switches in order for the bond to be considered *dual-connected*.
- The dual-connected devices (servers or switches) can use LACP (IEEE 802.3ad/802.1ax) to form the bond (see page 399). In this case, the peer switches must also use LACP.

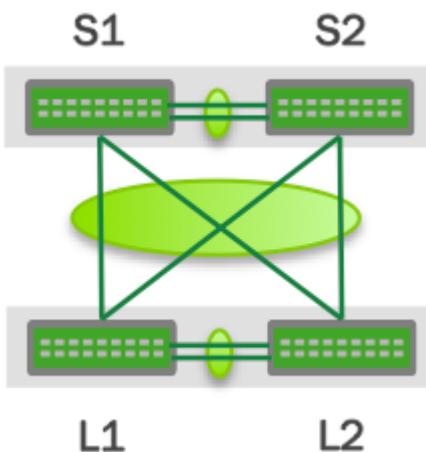


If for some reason you cannot use LACP, you can also use [balance-xor mode \(see page 403\)](#) to dual-connect host-facing bonds in an MLAG environment. If you do, you must still configure the same `c1ag_id` parameter on the MLAG bonds, and it must be the same on both MLAG switches. Otherwise, the MLAG switch pair treats the bonds as if they are single-connected.

More elaborate configurations are also possible. The number of links between the host and the switches can be greater than two, and does not have to be symmetrical:



Additionally, because S1 and S2 appear as a single switch to other bonding devices, you can also connect pairs of MLAG switches to each other in a switch-to-switch MLAG setup:



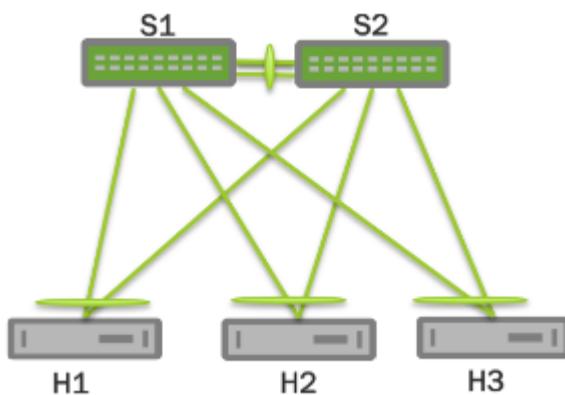
In this case, L1 and L2 are also MLAG peer switches, and present a two-port bond from a single logical system to S1 and S2. S1 and S2 do the same as far as L1 and L2 are concerned. For a switch-to-switch MLAG configuration, each switch pair must have a unique system MAC address. In the above example, switches L1 and L2 each have the same system MAC address configured. Switch pair S1 and S2 each have the same system MAC address configured; however, it is a different system MAC address than the one used by the switch pair L1 and L2.

## LACP and Dual-Connectedness

For MLAG to operate correctly, the peer switches must know which links are *dual-connected* or are connected to the same host or switch. To do this, specify a `c1ag_id` for every dual-connected bond on each peer switch; the `c1ag_id` must be the same for the corresponding bonds on both peer switches. Typically, [Link Aggregation Control Protocol \(LACP\)](#), the IEEE standard protocol for managing bonds, is used for verifying dual-connectedness. LACP runs on the dual-connected device and on each of the peer switches. On the dual-connected device, the only configuration requirement is to create a bond that is managed by LACP.

However, if for some reason you cannot use LACP in your environment, you can configure the bonds in [balance-xor mode \(see page 403\)](#). When using balance-xor mode to dual-connect host-facing bonds in an MLAG environment, you must configure the `c1ag_id` parameter on the MLAG bonds, which must be the same on both MLAG switches. Otherwise, the bonds are treated by the MLAG switch pair as if they are single-connected. In short, dual-connectedness is solely determined by matching `c1ag_id` and any misconnection will **not** be detected.

On each of the peer switches, you must place the links that are connected to the dual-connected host or switch in the bond. This is true even if the links are a single port on each peer switch, where each port is placed into a bond, as shown below:



All of the dual-connected bonds on the peer switches have their system ID set to the MLAG system ID. Therefore, from the point of view of the hosts, each of the links in its bond is connected to the same system, and so the host uses both links.

Each peer switch periodically makes a list of the LACP partner MAC addresses for all of their bonds and sends that list to its peer (using the `c1agd` service; see below). The LACP partner MAC address is the MAC address of the system at the other end of a bond (hosts H1, H2, and H3 in the figure above). When a switch receives this list from its peer, it compares the list to the LACP partner MAC addresses on its switch. If any matches are found and the `c1ag_id` for those bonds match, then that bond is a dual-connected bond. You can also find the LACP partner MAC address by the running `net show bridge macs` command or by examining the `/sys/class/net/<bondname>/bonding/ad_partner_mac sysfs` file for each bond.

## Configure MLAG

To configure MLAG, you need to:

- Create a bond that uses LACP, on the dual-connected devices.
- Configure the interfaces, including bonds, VLANs, bridges and peer links, on each peer switch.



## ⚠️ Keep MLAG Configurations in Sync

MLAG synchronizes the dynamic state between the two peer switches but it does not synchronize the switch configurations. After modifying the configuration of one peer switch, you must make the same changes to the configuration on the other peer switch. This applies to all configuration changes, including:

- Port configuration; for example, VLAN membership, [MTU \(see page 465\)](#), and bonding parameters.
- Bridge configuration; for example, spanning tree parameters or bridge properties.
- Static address entries; for example, static FDB entries and static IGMP entries.
- QoS configuration; for example, ACL entries.

You can verify the configuration of VLAN membership with the `net show clag verify-vlans verbose` command.

[Click to see the output ...](#)

```
cumulus@leaf01:~$ net show clag verify-vlans verbose
Our Bond Interface    VlanId    Peer Bond Interface
-----
server01              1         server01
server01              10        server01
server01              20        server01
server01              30        server01
server01              40        server01
server01              50        server01
uplink                1         uplink
uplink                10        uplink
uplink                20        uplink
uplink                30        uplink
uplink                40        uplink
uplink                50        uplink
uplink                100       uplink
uplink                101       uplink
uplink                102       uplink
uplink                103       uplink
uplink                104       uplink
...
```

### Reserved MAC Address Range

To prevent MAC address conflicts with other interfaces in the same bridged network, Cumulus Networks has [reserved a range of MAC addresses](#) specifically to use with MLAG. This range of MAC addresses is 44:38:39:ff:00:00 to 44:38:39:ff:ff:ff.

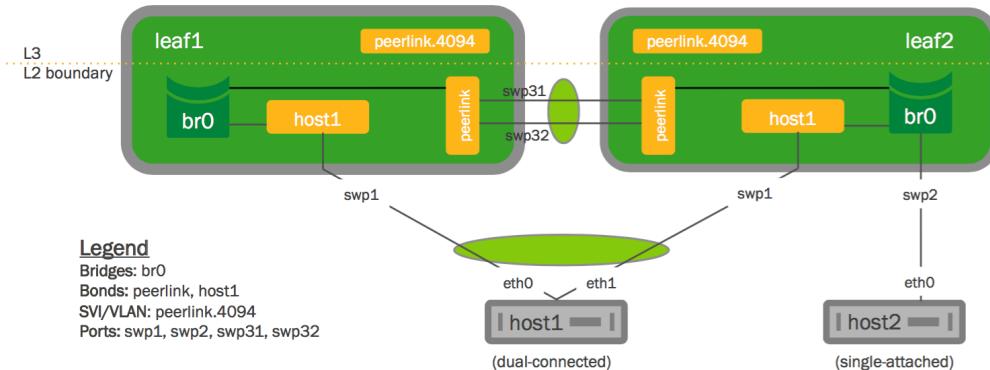
Cumulus Networks recommends you use this range of MAC addresses when configuring MLAG.

## ⚠️ Important

You cannot use the same MAC address for different MLAG pairs. Make sure you specify a different `cldg sys-mac` setting for each MLAG pair in the network.

## Configure the Host or Switch

On your dual-connected device, create a bond that uses LACP. The method you use varies with the type of device you are configuring. The following image is a basic MLAG configuration, showing all the essential elements; a more detailed two-leaf/two-spine configuration is shown [below \(see page 448\)](#).



## Configure the Interfaces

Place every interface that connects to the MLAG pair from a dual-connected device into a [bond \(see page 399\)](#), even if the bond contains only a single link on a single physical switch (even though the MLAG pair contains two or more links). Layer 2 data travels over this bond. In the examples throughout this chapter, `peerlink` is the name of the bond.

Single-attached hosts, also known as *orphan ports*, can be just a member of the bridge.

Additionally, configure the fast mode of LACP on the bond to allow more timely updates of the LACP state. These bonds are then placed in a bridge, which must include the peer link between the switches.

To enable communication between the `cldg` services on the peer switches, do the following:

- Choose an unused VLAN (also known as a *switched virtual interface* or *SVI* here).
- Assign the SVI an unrouteable link-local address to give the peer switches layer 3 connectivity between each other.
- Configure the VLAN as a [VLAN subinterface \(see page 228\)](#) on the peer link bond rather than the VLAN-aware bridge, called `peerlink`. If you're configuring the subinterface with [NCLU \(see page 88\)](#), the VLAN subinterface is named 4094 by default (the subinterface named `peerlink.4094` below). If you are configuring the peer link without NCLU, Cumulus Networks still recommends you use 4094 for the peer link VLAN if possible. This ensures that the VLAN is completely independent of the bridge and spanning tree forwarding decisions.
- Include untagged traffic on the peer link, as this avoids issues with STP.
- Specify a backup interface, which is any layer 3 backup interface for your peer links in case the peer link goes down. While a backup interface is optional, Cumulus Networks recommends you configure one. More information about configuring the [backup link \(see page 458\)](#) and understanding various [redundancy scenarios \(see page 468\)](#) is available below.

For example, if `peerlink` is the inter-chassis bond, and VLAN 4094 is the peer link VLAN, configure `peerlink.4094` as follows:





## Configuring the peerlink Interface

```
cumulus@leaf01:~$ net add bond peerlink bond slaves swp49-50
cumulus@leaf01:~$ net add interface peerlink.4094 ip address
169.254.1.1/30
cumulus@leaf01:~$ net add interface peerlink.4094 clag peer-ip
169.254.1.2
cumulus@leaf01:~$ net add interface peerlink.4094 clag backup-
ip 192.0.2.50
cumulus@leaf01:~$ net add interface peerlink.4094 clag sys-mac
44:38:39:FF:40:94
cumulus@leaf01:~$ net pending
cumulus@leaf01:~$ net commit
```

*Do not add VLAN 4094 to the bridge VLAN list; VLAN 4094 for the peer link subinterface should not also be configured as a bridged VLAN with bridge VIDs under the bridge.*

The above commands save the configuration in the /etc/network/interfaces file.

```
auto peerlink
iface peerlink
    bond-slaves swp49 swp50

auto peerlink.4094
iface peerlink.4094
    address 169.254.1.1/30
    clagd-peer-ip 169.254.1.2
    clagd-backup-ip 192.0.2.50
    clagd-sys-mac 44:38:39:FF:40:94
```

To enable MLAG, *peerlink* must be added to a traditional or VLAN-aware bridge. The commands below add *peerlink* to a VLAN-aware bridge:

```
cumulus@leaf01:~$ net add bridge bridge ports peerlink
cumulus@leaf01:~$ net pending
cumulus@leaf01:~$ net commit
```

This creates the following configuration in the /etc/network/interfaces file:

```
auto bridge
iface bridge
    bridge-ports peerlink
    bridge-vlan-aware yes
```





If you change the MLAG configuration by editing the `interfaces` file, the changes take effect when you bring the peer link interface up with `ifup`. Do **not** use `systemctl restart clagd.service` to apply the new configuration.

## ❗ Don't Use 169.254.0.1

Do not use 169.254.0.1 as the MLAG peer link IP address; Cumulus Linux uses this address exclusively for [BGP unnumbered \(see page 773\)](#) interfaces.

### Switch Roles and Priority Setting

Each MLAG-enabled switch in the pair has a *role*. When the peering relationship is established between the two switches, one switch is put into the *primary* role, and the other into the *secondary* role. When an MLAG-enabled switch is in the secondary role, it does not send STP BPDUs on dual-connected links; it only sends BPDUs on single-connected links. The switch in the primary role sends STP BPDUs on all single- and dual-connected links.

Sends BPDUs Via	Primary	Secondary
Single-connected links	Yes	Yes
Dual-connected links	Yes	No

By default, the role is determined by comparing the MAC addresses of the two sides of the peering link; the switch with the lower MAC address assumes the primary role. You can override this by setting the `clagd-priority` option for the peer link:

```
cumulus@leaf01:~$ net add interface peerlink.4094 clag priority 2048
cumulus@leaf01:~$ net pending
cumulus@leaf01:~$ net commit
```

The switch with the lower priority value is given the primary role; the default value is 32768 and the range is 0 to 65535. Read the `clagd(8)` and `clagct1(8)` man pages for more information.

When the `clagd` service is exited during switch reboot or the service is stopped in the primary switch, the peer switch that is in the secondary role becomes the primary.

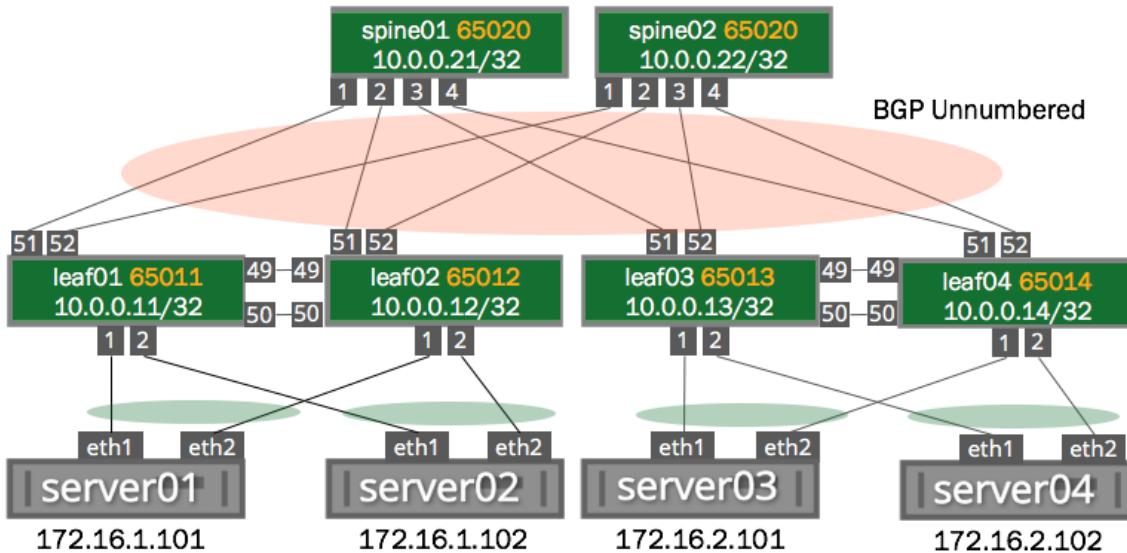
However, if the primary switch goes down without stopping the `clagd` service for any reason, or if the peer link goes down, the secondary switch does **not** change its role. In case the peer switch is determined to be not alive, the switch in the secondary role rolls back the LACP system ID to be the bond interface MAC address instead of the `clagd-sys-mac` and the switch in primary role uses the `clagd-sys-mac` as the LACP system ID on the bonds.

## Example MLAG Configuration

The example configuration below configures two bonds for MLAG, each with a single port, a peer link that is a bond with two member ports, and three VLANs on each port.



You can see a more traditional layer 2 example configuration in NCLU; run `net example clag 12-with-server-vlan-trunks`. For a very basic configuration with just one pair of switches and a single host, run `net example clag 12-with-server-vlan-trunks`.



You configure these interfaces using [NCLU \(see page 88\)](#), so the bridges are in VLAN-aware mode (see [page 415](#)). The bridges use these Cumulus Linux-specific keywords:

- `bridge-vids`, which defines the allowed list of tagged 802.1q VLAN IDs for all bridge member interfaces. You can specify non-contiguous ranges with a space-separated list, like `bridge-vids 100-200 300 400-500`.
- `bridge-pvid`, which defines the untagged VLAN ID for each port. This is commonly referred to as the *native VLAN*.

The bridge configurations below indicate that each bond carries tagged frames on VLANs 10, 20, 30, 40, 50, and 100 to 200 (as specified by `bridge-vids`), but untagged frames on VLAN 1 (as specified by `bridge-pvid`). Also, take note on how you configure the VLAN subinterfaces used for `clagd` communication (`peerlink.4094` in the sample configuration below). Finally, the host configurations for `server01` through `server04` are not shown here. The configurations for each corresponding node are almost identical, except for the IP addresses used for managing the `clagd` service.



## VLAN Precautions

At minimum, this VLAN subinterface should not be in your layer 2 domain, and you should give it a very high VLAN ID (up to 4094). Read more about the [range of VLAN IDs you can use \(see page 417\)](#).

The commands to create the configurations for both spines look like the following. Note that the `clag-id` and `clagd-sys-mac` must be the same for the corresponding bonds on `spine01` and `spine02`:

<code>spine01</code>	<code>spine02</code>
----------------------	----------------------

```
cumulus@spine01:~$ net show
configuration commands
net add interface swp1-4
net add loopback lo ip address
10.0.0.21/32
net add interface eth0 ip
address dhcp
```

These commands create the following configuration in the /etc/network/interfaces file:

```
cumulus@spine01:~$ cat /etc
/network/interfaces
auto lo
iface lo inet loopback
    address 10.0.0.21/32

auto eth0
iface eth0 inet dhcp

# downlinks
auto swp1
iface swp1

auto swp2
iface swp2

auto swp3
iface swp3

auto swp4
iface swp4
```

```
cumulus@spine02:~$ net show
configuration commands
net add interface swp1-4
net add loopback lo ip address
10.0.0.22/32
net add interface eth0 ip
address dhcp
```

These commands create the following configuration in the /etc/network/interfaces file:

```
cumulus@spine02:~$ cat /etc
/network/interfaces
auto lo
iface lo inet loopback
    address 10.0.0.22/32

auto eth0
iface eth0 inet dhcp

# downlinks
auto swp1
iface swp1

auto swp2
iface swp2

auto swp3
iface swp3

auto swp4
iface swp4
```

Here is an example configuration for the switches leaf01 through leaf04. Note that the `clag-id` and `clagd-sys-mac` must be the same for the corresponding bonds on leaf01 and leaf02 as well as leaf03 and leaf04:

### **leaf01**

```
cumulus@leaf01:~$ net show
configuration commands
net add loopback lo ip address
10.0.0.11/32
net add bgp autonomous-system
65011
```

### **leaf02**

```
cumulus@leaf02:~$ net show conf
commands
net add loopback lo ip address
10.0.0.12/32
net add bgp autonomous-system
65012
```



```
net add bgp router-id 10.0.0.11
net add bgp ipv4 unicast
network 10.0.0.11/32
net add routing prefix-list
  ipv4 dc-leaf-in seq 10 permit
    0.0.0.0/0
  net add routing prefix-list
    ipv4 dc-leaf-in seq 20 permit
      10.0.0.0/24 le 32
  net add routing prefix-list
    ipv4 dc-leaf-in seq 30 permit
      172.16.2.0/24
  net add routing prefix-list
    ipv4 dc-leaf-out seq 10 permit
      172.16.1.0/24
  net add bgp neighbor fabric
    peer-group
  net add bgp neighbor fabric
    remote-as external
  net add bgp ipv4 unicast
    neighbor fabric prefix-list dc-
      leaf-in in
  net add bgp ipv4 unicast
    neighbor fabric prefix-list dc-
      leaf-out out
  net add bgp neighbor swp51-52
    interface peer-group fabric
  net add vlan 100 ip address
    172.16.1.1/24
  net add bgp ipv4 unicast
    network 172.16.1.1/24
  net add clag peer sys-mac 44:
    38:39:FF:00:01 interface swp49-
    50 primary backup-ip
    192.168.1.12
  net add clag port bond server1
    interface swp1 clag-id 1
  net add clag port bond server2
    interface swp2 clag-id 2
  net add bond server1-2 bridge
    access 100
  net add bond server1-2 stp
    portadminedge
  net add bond server1-2 stp
    bpduguard
```

These commands create the following configuration in the /etc/network/interfaces file:

```
net add bgp router-id 10.0.0.12
net add bgp ipv4 unicast
network 10.0.0.12/32
net add routing prefix-list
  ipv4 dc-leaf-in seq 10 permit
    0.0.0.0/0
  net add routing prefix-list
    ipv4 dc-leaf-in seq 20 permit
      10.0.0.0/24 le 32
  net add routing prefix-list
    ipv4 dc-leaf-in seq 30 permit
      172.16.2.0/24
  net add routing prefix-list
    ipv4 dc-leaf-out seq 10 permit
      172.16.1.0/24
  net add bgp neighbor fabric
    peer-group
  net add bgp neighbor fabric
    remote-as external
  net add bgp ipv4 unicast
    neighbor fabric prefix-list dc-
      leaf-in in
  net add bgp ipv4 unicast
    neighbor fabric prefix-list dc-
      leaf-out out
  net add bgp neighbor swp51-52
    interface peer-group fabric
  net add vlan 100 ip address
    172.16.1.2/24
  net add bgp ipv4 unicast
    network 172.16.1.2/24
  net add clag peer sys-mac 44:38:
    39:FF:00:01 interface swp49-50
    secondary backup-ip 192.168.1.11
  net add clag port bond server1
    interface swp1 clag-id 1
  net add clag port bond server2
    interface swp2 clag-id 2
  net add bond server1-2 bridge
    access 100
  net add bond server1-2 stp
    portadminedge
  net add bond server1-2 stp
    bpduguard
```

These commands create the following configuration in the /etc/network/interfaces file:

```

cumulus@leaf01:~$ cat /etc
/network/interfaces
auto lo
iface lo inet loopback
    address 10.0.0.11/32

auto eth0
iface eth0 inet dhcp

auto swp1
iface swp1

auto swp2
iface swp2

# peerlink
auto swp49
iface swp49
    post-up ip link set $IFACE
    promisc on      # Only required
    on VX

auto swp50
iface swp50
    post-up ip link set $IFACE
    promisc on      # Only required
    on VX

# uplinks
auto swp51
iface swp51

auto swp52
iface swp52

# bridge to hosts
auto bridge
iface bridge
    bridge-ports peerlink
server1 server2
    bridge-vids 100
    bridge-vlan-aware yes

auto peerlink
iface peerlink
    bond-slaves swp49 swp50

auto peerlink.4094
iface peerlink.4094
    clagd-backup-ip
192.168.1.12

```

```

cumulus@leaf02:~$ cat /etc
/network/interfaces
auto lo
iface lo inet loopback
    address 10.0.0.12/32

auto eth0
iface eth0 inet dhcp

auto swp1
iface swp1

auto swp2
iface swp2

# peerlink
auto swp49
iface swp49
    post-up ip link set $IFACE
    promisc on      # Only required
    on VX

auto swp50
iface swp50
    post-up ip link set $IFACE
    promisc on      # Only required
    on VX

# uplinks
auto swp51
iface swp51

auto swp52
iface swp52

# bridge to hosts
auto bridge
iface bridge
    bridge-ports peerlink
server1 server2
    bridge-vids 100
    bridge-vlan-aware yes

auto peerlink
iface peerlink
    bond-slaves swp49 swp50

auto peerlink.4094
iface peerlink.4094
    clagd-backup-ip 192.168.1.11
    clagd-peer-ip 169.254.1.1

```



```
clagd-peer-ip 169.254.1.2
clagd-priority 1000
clagd-sys-mac 44:38:39:FF:
00:01

auto server1
iface server1
    bond-slaves swp1
    bridge-access 100
    clag-id 1
    mstpcctl-bpduguard yes
    mstpcctl-portadmineedge yes

auto server2
iface server2
    bond-slaves swp2
    bridge-access 100
    clag-id 2
    mstpcctl-bpduguard yes
    mstpcctl-portadmineedge yes

auto vlan100
iface vlan100
    address 172.16.1.1/24
    vlan-id 100
    vlan-raw-device bridge
```

```
clagd-sys-mac 44:38:39:FF:
00:01

auto server1
iface server1
    bond-slaves swp1
    bridge-access 100
    clag-id 1
    mstpcctl-bpduguard yes
    mstpcctl-portadmineedge yes

auto server2
iface server2
    bond-slaves swp2
    bridge-access 100
    clag-id 2
    mstpcctl-bpduguard yes
    mstpcctl-portadmineedge yes

auto vlan100
iface vlan100
    address 172.16.1.2/24
    vlan-id 100
    vlan-raw-device bridge
```

### leaf03

```
cumulus@leaf03:~$ net show
conf commands
net add loopback lo ip address
10.0.0.13/32
net add bgp autonomous-system
65013
net add bgp router-id 10.0.0.13
net add bgp ipv4 unicast
network 10.0.0.13/32
net add routing prefix-list
ipv4 dc-leaf-in seq 10 permit
0.0.0.0/0
net add routing prefix-list
ipv4 dc-leaf-in seq 20 permit
10.0.0.0/24 le 32
net add routing prefix-list
ipv4 dc-leaf-in seq 30 permit
172.16.2.0/24
```

### leaf04

```
cumulus@leaf04:~$ net show
configuration commands
net add loopback lo ip address
10.0.0.14/32
net add bgp autonomous-system
65014
net add bgp router-id 10.0.0.14
net add bgp ipv4 unicast
network 10.0.0.14/32
net add routing prefix-list
ipv4 dc-leaf-in seq 10 permit
0.0.0.0/0
net add routing prefix-list
ipv4 dc-leaf-in seq 20 permit
10.0.0.0/24 le 32
net add routing prefix-list
ipv4 dc-leaf-in seq 30 permit
172.16.2.0/24
```

```

net add routing prefix-list
ipv4 dc-leaf-out seq 10 permit
172.16.1.0/24
net add bgp neighbor fabric
peer-group
net add bgp neighbor fabric
remote-as external
net add bgp ipv4 unicast
neighbor fabric prefix-list dc-
leaf-in in
net add bgp ipv4 unicast
neighbor fabric prefix-list dc-
leaf-out out
net add bgp neighbor swp51-52
interface peer-group fabric
net add vlan 100 ip address
172.16.1.3/24
net add bgp ipv4 unicast
network 172.16.1.3/24
net add clag peer sys-mac 44:
38:39:FF:00:02 interface swp49-
50 primary backup-ip
192.168.1.14
net add clag port bond server3
interface swp1 clag-id 3
net add clag port bond server4
interface swp2 clag-id 4
net add bond server3-4 bridge
access 100
net add bond server3-4 stp
portadminedge
net add bond server3-4 stp
bpdukguard

```

These commands create the following configuration in the /etc/network/interfaces file:

```

cumulus@leaf03:~$ cat /etc
/network/interfaces
auto lo
iface lo inet loopback
    address 10.0.0.13/32

auto eth0
iface eth0 inet dhcp

auto swp1

```

```

net add routing prefix-list
ipv4 dc-leaf-out seq 10 permit
172.16.1.0/24
net add bgp neighbor fabric
peer-group
net add bgp neighbor fabric
remote-as external
net add bgp ipv4 unicast
neighbor fabric prefix-list dc-
leaf-in in
net add bgp ipv4 unicast
neighbor fabric prefix-list dc-
leaf-out out
net add bgp neighbor swp51-52
interface peer-group fabric
net add vlan 100 ip address
172.16.1.4/24
net add bgp ipv4 unicast
network 172.16.1.4/24
net add clag peer sys-mac 44:38:39:FF:00:02 interface swp49-50 secondary backup-ip 192.168.1.13
net add clag port bond server3
interface swp1 clag-id 3
net add clag port bond server4
interface swp2 clag-id 4
net add bond server3-4 bridge
access 100
net add bond server3-4 stp
portadminedge
net add bond server3-4 stp
bpdukguard

```

These commands create the following configuration in the /etc/network/interfaces file:

```

cumulus@leaf04:~$ cat /etc
/network/interfaces
auto lo
iface lo inet loopback
    address 10.0.0.14/32

auto eth0
iface eth0 inet dhcp

auto swp1
iface swp1

```



```
iface swp1

auto swp2
iface swp2

# peerlink
auto swp49
iface swp49
    post-up ip link set $IFACE
    promisc on      # Only required
    on VX

auto swp50
iface swp50
    post-up ip link set $IFACE
    promisc on      # Only required
    on VX

# uplinks
auto swp51
iface swp51

auto swp52
iface swp52

# bridge to hosts
auto bridge
iface bridge
    bridge-ports peerlink
server3 server4
    bridge-vids 100
    bridge-vlan-aware yes

auto peerlink
iface peerlink
    bond-slaves swp49 swp50

auto peerlink.4094
iface peerlink.4094
    clagd-backup-ip 192.168.1.13
    clagd-peer-ip 169.254.1.1
    clagd-sys-mac 44:38:39:FF:
    00:02

auto swp2
iface swp2

# peerlink
auto swp49
iface swp49
    post-up ip link set $IFACE
    promisc on      # Only required
    on VX

auto swp50
iface swp50
    post-up ip link set $IFACE
    promisc on      # Only required
    on VX

# uplinks
auto swp51
iface swp51

auto swp52
iface swp52

# bridge to hosts
auto bridge
iface bridge
    bridge-ports peerlink
server3 server4
    bridge-vids 100
    bridge-vlan-aware yes

auto peerlink
iface peerlink
    bond-slaves swp49 swp50

auto peerlink.4094
iface peerlink.4094
    clagd-backup-ip 192.168.1.13
    clagd-peer-ip 169.254.1.1
    clagd-sys-mac 44:38:39:FF:
    00:02
```

```

clagd-sys-mac 44:38:39:FF:
00:02

auto server3
iface server3
  bond-slaves swp1
  bridge-access 100
  clag-id 3
  mstpcctl-bpduguard yes
  mstpcctl-portadminedge yes

auto server4
iface server4
  bond-slaves swp2
  bridge-access 100
  clag-id 4
  mstpcctl-bpduguard yes
  mstpcctl-portadminedge yes

auto vlan100
iface vlan100
  address 172.16.1.3/24
  vlan-id 100
  vlan-raw-device bridge

```

```

auto server3
iface server3
  bond-slaves swp1
  bridge-access 100
  clag-id 3
  mstpcctl-bpduguard yes
  mstpcctl-portadminedge yes

auto server4
iface server4
  bond-slaves swp2
  bridge-access 100
  clag-id 4
  mstpcctl-bpduguard yes
  mstpcctl-portadminedge yes

auto vlan100
iface vlan100
  address 172.16.1.4/24
  vlan-id 100
  vlan-raw-device bridge

```

## Disable clagd on an Interface

In the configurations above, the `clagd-peer-ip` and `clagd-sys-mac` parameters are mandatory, while the rest are optional. When mandatory `clagd` commands are present under a peer link subinterface, by default `clagd-enable` is set to `yes` and does not need to be specified; to disable `clagd` on the subinterface, set `clagd-enable` to `no`:

```

cumulus@spine01:~$ net add interface peerlink.4094 clag enable no
cumulus@spine01:~$ net pending
cumulus@spine01:~$ net commit

```

Use `clagd-priority` to set the role of the MLAG peer switch to primary or secondary. Each peer switch in an MLAG pair must have the same `clagd-sys-mac` setting. Each `clagd-sys-mac` setting must be unique to each MLAG pair in the network. For more details, refer to `man clagd`.

## Check the MLAG Configuration Status

You can check the status of your MLAG configuration using the `net show clag` command.

```

cumulus@leaf01:~$ net show clag

```



```
The peer is alive
Peer Priority, ID, and Role: 4096 44:38:39:FF:00:01 primary
Our Priority, ID, and Role: 8192 44:38:39:FF:00:02 secondary
    Peer Interface and IP: peerlink.4094 169.254.1.1
        Backup IP: 192.168.1.12 (inactive)
        System MAC: 44:38:39:FF:00:01
```

CLAG Interfaces		
Our Interface	Peer Interface	CLAG Id
Conflicts	Proto-Down Reason	
server1	server1	1
-	-	
server2	server2	2
-	-	

A command line utility called `clagctl` is available for interacting with a running `clagd` service to get status or alter operational behavior. For a detailed explanation of the utility, refer to the `clagctl(8)` man page.

### See the `clagctl` Output ...

The following is a sample output of the MLAG operational status displayed by `clagctl`:

```
The peer is alive
Peer Priority, ID, and Role: 4096 44:38:39:FF:00:01 primary
Our Priority, ID, and Role: 8192 44:38:39:FF:00:02 secondary
    Peer Interface and IP: peerlink.4094 169.254.1.1
        Backup IP: 192.168.1.12 (inactive)
        System MAC: 44:38:39:FF:00:01

CLAG Interfaces
Our Interface      Peer Interface      CLAG Id
Conflicts          Proto-Down Reason
-----            -----
-----            -----
server1           server1           1
-
server2           server2           2
-
```

## Configure MLAG with a Traditional Mode Bridge

You can configure MLAG with a bridge in traditional mode (see page 427) instead of VLAN-aware mode (see page 415).

To configure MLAG with a traditional mode bridge, the peer link and all dual-connected links must be configured as [untagged/native](#) (see page 427) ports on a bridge (note the absence of any VLANs in the `bridge-ports` line and the lack of the `bridge-vlan-aware` parameter below):



```
auto br0
iface br0
    bridge-ports peerlink spine1-2 host1 host2
```

The following example shows you how to allow VLAN 100 across the peer link:

```
auto br0.100
iface br0.100
    bridge-ports peerlink.100 bond1.100
```

For a deeper comparison of traditional versus VLAN-aware bridge modes, read this [knowledge base article](#).

## Peer Link Interfaces and the protodown State

In addition to the standard UP and DOWN administrative states, an interface that is a member of an MLAG bond can also be in a `protodown` state. When MLAG detects a problem that might result in connectivity issues such as traffic black-holing or a network meltdown if the link carrier was left in an UP state, it can put that interface into `protodown` state. Such connectivity issues include:

- When the peer link goes down but the peer switch is up (that is, the backup link is active).
- When the bond is configured with an MLAG ID, but the `clagd` service is not running (whether it was deliberately stopped or simply died).
- When an MLAG-enabled node is booted or rebooted, the MLAG bonds are placed in a `protodown` state until the node establishes a connection to its peer switch, or five minutes have elapsed.

When an interface goes into a `protodown` state, it results in a local OPER DOWN (carrier down) on the interface. As of Cumulus Linux 2.5.5, the `protodown` state can be manipulated with the `ip link set` command. Given its use in preventing network meltdowns, manually manipulating `protodown` is not recommended outside the scope of interaction with the Cumulus Networks support team.

The following `ip link show` command output shows an interface in `protodown` state. Notice that the link carrier is down (NO-CARRIER):

```
cumulus@switch:~$ net show bridge link swp1
3: swp1 state DOWN: <NO-CARRIER,BROADCAST,MULTICAST,MASTER,UP> mtu
9216 master pfifo_fast master host-bond1 state DOWN mode DEFAULT qlen
500 protodown on
    link/ether 44:38:39:00:69:84 brd ff:ff:ff:ff:ff:ff
```

## Specify a Backup Link

You can specify a backup link for your peer links in case the peer link goes down. When this happens, the `clagd` service uses the backup link to check the health of the peer switch. To configure a backup link, add `clagd-backup-ip <ADDRESS>` to the peer link configuration:

### Specifying a Backup Link



```
cumulus@spine01:~$ net add interface peerlink.4094 clag backup-ip 192.0.2.50
cumulus@spine01:~$ net pending
cumulus@spine01:~$ net commit
```



The backup IP address must be different than the peer link IP address (`clagd-peer-ip`). It must be reachable by a route that does not use the peer link and it must be in the same network namespace as the peer link IP address.

Cumulus Networks recommends you use the switch's loopback or management IP address for this purpose. Which one should you choose?

- If your MLAG configuration has **routed uplinks** (a modern approach to the data center fabric network), then configure `clagd` to use the peer switch **loopback** address for the health check. When the peer link is down, the secondary switch must route towards the loopback address using uplinks (towards spine layer). If the primary switch is also suffering a more significant problem (for example, `switchd` is unresponsive /or stopped), then the secondary switch eventually promotes itself to primary and traffic now flows normally.

To ensure IP connectivity between the loopbacks, you must carefully consider what implications this has on the BGP ASN configured:

- The two MLAG member switches must use unique BGP ASNs, **or**,
- If the two MLAG member switches use the same BGP ASN, then you must bypass the BGP loop prevention check on `AS_PATH` attribute.
- If your MLAG configuration has **bridged uplinks** (such as a campus network or a large, flat layer 2 network), then configure `clagd` to use the peer switch **eth0** address for the health check. When the peer link is down, the secondary switch must route towards the `eth0` address using the OOB network (provided you have implemented an OOB network).

You can also specify the backup UDP port. The port defaults to 5342, but you can configure it as an argument in `clagd-args` using `--backupPort <PORT>`.

```
cumulus@spine01:~$ net add interface peerlink.4094 clag args --backupPort 5400
cumulus@spine01:~$ net pending
cumulus@spine01:~$ net commit
```

To see the backup IP address, run the `net show clag` command:

```
cumulus@spine01:~$ net show clag
The peer is alive
    Our Priority, ID, and Role: 32768 44:38:39:00:00:41
primary
    Peer Priority, ID, and Role: 32768 44:38:39:00:00:42
secondary
    Peer Interface and IP: peerlink.4094 169.254.1.1
```

```
Backup IP: 192.168.0.22 (active)
System MAC: 44:38:39:FF:40:90
```

CLAG Interfaces			
Our Interface	Peer Interface	CLAG Id	
Conflicts	Proto-Down Reason		
leaf03-04	leaf03-04	1034	
-	-		
exit01-02	-	2930	
-	-		
leaf01-02	leaf01-02	1012	
-	-		

## Specify a Backup Link to a VRF

You can configure the backup link to a [VRF](#) (see page 847) or [management VRF](#) (see page 877). Include the name of the VRF or management VRF with the `clagd-backup-ip` command. Here is a sample configuration:

### Specifying a Backup Link to a VRF

```
cumulus@spine01:~$ net add interface peerlink.4094 clag backup-
ip 192.168.0.22 vrf mgmt
cumulus@spine01:~$ net pending
cumulus@spine01:~$ net commit
```

⚠ You cannot use the VRF on a peer link subinterface.

Verify the backup link by running the `net show clag backup-ip` command:

```
cumulus@leaf01:~$ net show clag backup-ip
Backup info:
IP: 192.168.0.12; State: active; Role: primary
Peer priority and id: 32768 44:38:39:00:00:12; Peer role:
secondary
```

### Comparing VRF and Management VRF Configurations



The configuration for both a VRF and management VRF is exactly the same. The following example shows a configuration where the backup interface is in a VRF:

```
cumulus@leaf01:~$ net show configuration

...
auto swp52s0
iface swp52s0
    address 192.0.2.1/24
    vrf green

auto green
iface green
    vrf-table auto

auto peer5.4000
iface peer5.4000
    address 192.0.2.15/24
    clagd-peer-ip 192.0.2.16
    clagd-backup-ip 192.0.2.2 vrf green
    clagd-sys-mac 44:38:39:01:01:01
...
```

You can verify the configuration with the `net show clag status verbose` command:

```
cumulus@leaf01:~$ net show clag status verbose
The peer is alive
    Peer Priority, ID, and Role: 32768 00:02:00:00:00:13
primary
    Our Priority, ID, and Role: 32768 c4:54:44:f6:44:5a
secondary
    Peer Interface and IP: peer5.4000 192.0.2.2
    Backup IP: 192.0.2.2 vrf green (active)
    System MAC: 44:38:39:01:01:01
```

CLAG Interfaces	Our Interface	Peer Interface	CLAG Id
Conflicts		Proto-Down Reason	
-	bond4	bond4	4
-		-	
-	bond1	bond1	1
-		-	
-	bond2	bond2	2
-		-	
-	bond3	bond3	3
-		-	

...

## Monitor Dual-Connected Peers

Upon receipt of a valid message from its peer, the switch knows that `c1agd` is alive and executing on that peer. This causes `c1agd` to change the system ID of each bond that is assigned a `c1ag-id` from the default value (the MAC address of the bond) to the system ID assigned to both peer switches. This makes the hosts connected to each switch act as if they are connected to the same system so that they use all ports within their bond. Additionally, `c1agd` determines which bonds are dual-connected and modifies the forwarding and learning behavior to accommodate these dual-connected bonds.

If the peer does not receive any messages for three update intervals, then that peer switch is assumed to no longer be acting as an MLAG peer. In this case, the switch reverts all configuration changes so that it operates as a standard non-MLAG switch. This includes removing all statically assigned MAC addresses, clearing the egress forwarding mask, and allowing addresses to move from any port to the peer port. After a message is again received from the peer, MLAG operation starts again as described earlier. You can configure a custom timeout setting by adding `--peerTimeout <VALUE>` to `c1agd-args`, like this:

```
cumulus@spine01:~$ net add interface peerlink.4094 clag args --
peerTimeout 900
cumulus@spine01:~$ net pending
cumulus@spine01:~$ net commit
```

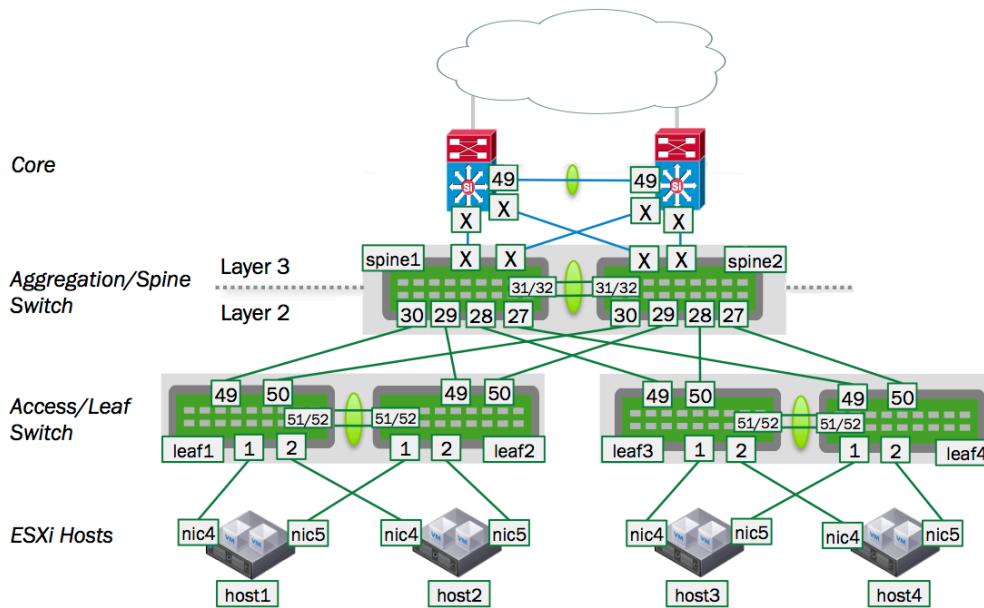
After bonds are identified as dual-connected, `c1agd` sends more information to the peer switch for those bonds. The MAC addresses (and VLANs) that are dynamically learned on those ports are sent along with the LACP partner MAC address for each bond. When a switch receives MAC address information from its peer, it adds MAC address entries on the corresponding ports. As the switch learns and ages out MAC addresses, it informs the peer switch of these changes to its MAC address table so that the peer can keep its table synchronized. Periodically, at 45% of the bridge ageing time, a switch sends its entire MAC address table to the peer, so that peer switch can verify that its MAC address table is properly synchronized.

The switch sends an update frequency value in the messages to its peer, which tells `c1agd` how often the peer will send these messages. You can configure a different frequency by adding `--lacpPoll <SECONDS>` to `c1agd-args`:

```
cumulus@spine01:~$ net add interface peerlink.4094 clag args --
lacpPoll 900
cumulus@spine01:~$ net pending
cumulus@spine01:~$ net commit
```

## Configure Layer 3 Routed Uplinks

In this scenario, the spine switches connect at layer 3, as shown in the image below. Alternatively, the spine switches can be singly connected to each core switch at layer 3 (not shown below).



In this design, the spine switches route traffic between the server hosts in the layer 2 domains and the core. The servers (host1 thru host4) each have a layer 2 connection up to the spine layer where the default gateway for the host subnets resides. However, since the spine switches as gateway devices communicate at layer 3, you need to configure a protocol such as [VRR \(see page 474\)](#) (virtual router redundancy) between the spine switch pair to support active/active forwarding.

Then, to connect the spine switches to the core switches, you need to determine whether the routing is static or dynamic. If it is dynamic, you must choose which protocol — [OSPF \(see page 756\)](#) or [BGP \(see page 773\)](#) — to use. When enabling a routing protocol in an MLAG environment, it is also necessary to manage the uplinks, because by default MLAG is not aware of layer 3 uplink interfaces. In the event of a peer link failure, MLAG does not remove static routes or bring down a BGP or OSPF adjacency unless a separate link state daemon such as `ifplugged` is used.

## ⓘ MLAG and Peer Link Peering

When using MLAG with VRR, Cumulus Networks recommends you set up a routed adjacency across the `peerlink.4094` interface. If a routed connection is not built across the peer link, then during uplink failure on one of the switches in the MLAG pair, egress traffic can be blackholed if it hashes to the leaf whose uplinks are down.

To set up the adjacency, configure a [BGP \(see page 779\)](#) or [OSPF \(see page 767\)](#) unnumbered peering, as appropriate for your network.

For example, if you are using BGP, use a configuration like this:

```
cumulus@switch:~$ net add bgp neighbor peerlink.4094 interface
remote-as internal
cumulus@switch:~$ net commit
```

If you are using OSPF, use a configuration like this:

```
cumulus@switch:~$ net add interface peerlink.4094 ospf area
0.0.0.1
```

```
cumulus@switch:~$ net commit
```

If you are using [EVPN \(see page 501\)](#) and MLAG, you need to enable the EVPN address family across the peerlink.4094 interface as well:

```
cumulus@switch:~$ net add bgp neighbor peerlink.4094 interface
remote-as internal
cumulus@switch:~$ net add bgp 12vpn evpn neighbor peerlink.
4094 activate
cumulus@switch:~$ net commit
```



Be aware of an existing issue when you use NCLU to create an iBGP peering, it creates an eBGP peering instead. For more information, see [release note 1222](#).

## IGMP Snooping with MLAG

[IGMP snooping \(see page 485\)](#) processes IGMP reports received on a bridge port in a bridge to identify hosts that are configured to receive multicast traffic destined to that group. An IGMP query message received on a port is used to identify the port that is connected to a router and configured to receive multicast traffic.

IGMP snooping is enabled by default on the bridge. IGMP snooping multicast database entries and router port entries are synced to the peer MLAG switch. If there is no multicast router in the VLAN, you can configure the IGMP querier on the switch to generate IGMP query messages. For more information, read the [IGMP and MLD Snooping \(see page 485\)](#) chapter.

## Monitor the Status of the clagd Service

Due to the critical nature of the `clagd` service, `systemd` continuously monitors the status of `clagd`. `systemd` monitors the `clagd` service through the use of notify messages every 30 seconds. If the `clagd` service dies or becomes unresponsive for any reason and `systemd` receives no messages after 60 seconds, `systemd` restarts `clagd`. `systemd` logs these failures in `/var/log/syslog`, and, on the first failure, generates a `cl-support` file as well.

This monitoring is automatically configured and enabled as long as `clagd` is enabled (that is, `clagd-peer-ip` and `clagd-sys-mac` are configured for an interface) and the `clagd` service is running. When `clagd` is explicitly stopped, for example with the `systemctl stop clagd.service` command, monitoring of `clagd` is also stopped.

### ⌚ Checking clagd Status

You can check the status of `clagd` monitoring by using the `cl-service-summary` command:

```
cumulus@switch:~$ sudo cl-service-summary summary
The systemctl daemon 5.4 uptime: 15m
```



```
...
Service clagd           enabled    active
...

```

Or the `systemctl status` command:

```
cumulus@switch:~$ sudo systemctl status clagd.service
clagd.service - Cumulus Linux Multi-Chassis LACP Bonding
Daemon
   Loaded: loaded (/lib/systemd/system/clagd.service; enabled)
   Active: active (running) since Mon 2016-10-03 20:31:50 UTC;
4 days ago
     Docs: man:clagd(8)
   Main PID: 1235 (clagd)
     CGroup: /system.slice/clagd.service
             1235 /usr/bin/python /usr/sbin/clagd --daemon
169.254.255.2 peerlink.4094 44:38:39:FF:40:90 --prior...
             1307 /sbin/bridge monitor fdb

Feb 01 23:19:30 leaf01 clagd[1717]: Cleanup is executing.
Feb 01 23:19:31 leaf01 clagd[1717]: Cleanup is finished
Feb 01 23:19:31 leaf01 clagd[1717]: Beginning execution of
clagd version 1.3.0
Feb 01 23:19:31 leaf01 clagd[1717]: Invoked with: /usr/sbin
/clagd --daemon 169.254.255.2 peerlink.4094 44:38:39:FF:40:94
--pri...168.0.12
Feb 01 23:19:31 leaf01 clagd[1717]: Role is now secondary
Feb 01 23:19:31 leaf01 clagd[1717]: Initial config loaded
Feb 01 23:19:31 leaf01 systemd[1]: Started Cumulus Linux Multi-
Chassis LACP Bonding Daemon.
Feb 01 23:24:31 leaf01 clagd[1717]: HealthCheck: reload
timeout.
Feb 01 23:24:31 leaf01 clagd[1717]: Role is now primary;
Reload timeout
Hint: Some lines were ellipsized, use -l to show in full.
```

## MLAG Best Practices

For MLAG to function properly, you must configure the dual-connected host interfaces identically on the pair of peering switches. See the note above in the [Configuring MLAG \(see page 444\)](#) section.

### *MTU in an MLAG Configuration*

The best way to configure [MTU \(see page 239\)](#) in MLAG is to set the MTU at the system level, as per the documentation for [setting a policy for a global system MTU \(see page 243\)](#).

Otherwise, traffic is determined by the bridge MTU. Bridge MTU in turn is determined by the lowest MTU setting of an interface that is a member of the bridge. If you want to set an MTU other than the default of 1500 bytes, you must configure the MTU on each physical interface and bond interface that are members of the MLAG bridges in the entire bridged domain.

### For example ...

For example, if an MTU of 9216 is desired through the MLAG domain in the example shown above, on all four leaf switches, configure `mtu 9216` for each of the following bond interfaces, as they are members of the bridge named `bridge`: `peerlink`, `uplink`, `server01`.

## ➊ Configuring MTU

```
cumulus@leaf01:~$ net add bond peerlink mtu 9216
cumulus@leaf01:~$ net add bond uplink mtu 9216
cumulus@leaf01:~$ net add bond server01 mtu 9216
cumulus@leaf01:~$ net pending
cumulus@leaf01:~$ net commit
```

The above commands produce the following configuration in the `/etc/network/interfaces` file:

```
auto bridge
iface bridge
    bridge-ports peerlink uplink server01
auto peerlink
iface peerlink
    mtu 9216
auto server01
iface server01
    mtu 9216
auto uplink
iface uplink
    mtu 9216
```

Likewise, to ensure the MTU 9216 path is respected through the spine switches above, also change the MTU setting for bridge `bridge` by configuring `mtu 9216` for each of the following members of bridge `bridge` on both spine01 and spine02: `leaf01-02`, `leaf03-04`, `exit01-02`, `peerlink`.

```
cumulus@spine01:~$ net add bond leaf01-02 mtu 9216
cumulus@spine01:~$ net add bond leaf03-04 mtu 9216
cumulus@spine01:~$ net add bond exit01-02 mtu 9216
cumulus@spine01:~$ net add bond peerlink mtu 9216
cumulus@spine01:~$ net pending
cumulus@spine01:~$ net commit
```

The above commands produce the following configuration in the `/etc/network/interfaces` file:



```
auto bridge
iface bridge
    bridge-ports leaf01-02 leaf03-04 exit01-02 peerlink
auto exit01-02
iface exit01-02
    mtu 9216
auto leaf01-02
iface leaf01-02
    mtu 9216
auto leaf03-04
iface leaf03-04
    mtu 9216
auto peerlink
iface peerlink
    mtu 9216
```

## Peer Link Sizing

The peer link carries very little traffic when compared to the bandwidth consumed by dataplane traffic. In a typical MLAG configuration, most every connection between the two switches in the MLAG pair is dual-connected, so the only traffic going across the peer link is traffic from the `clagd` process and some LLDP or LACP traffic; the traffic received on the peer link is not forwarded out of the dual-connected bonds.

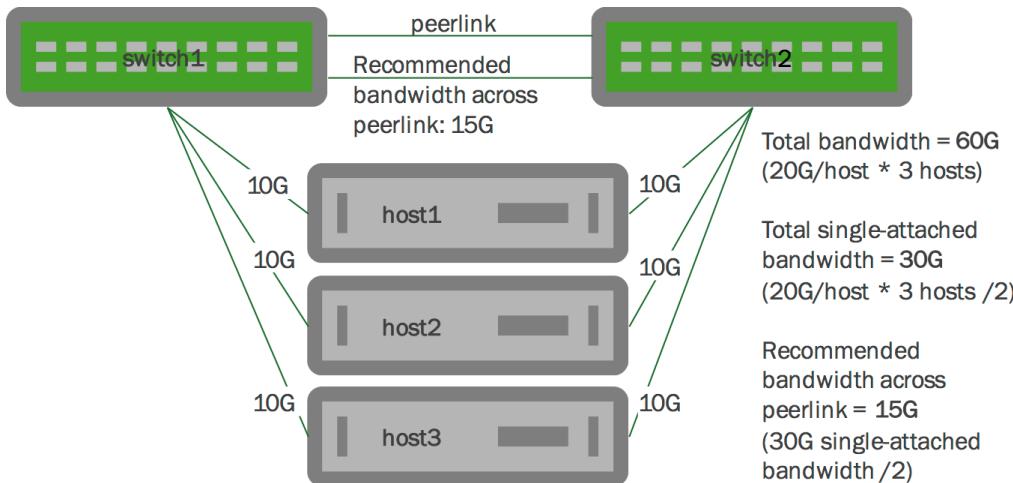
However, there are some instances where a host is connected to only one switch in the MLAG pair; for example:

- You have a hardware limitation on the host where there is only one PCIE slot, and therefore, one NIC on the system, so the host is only single-connected across that interface.
- The host does not support 802.3ad and you cannot create a bond on it.
- You are accounting for a link failure, where the host may become single connected until the failure is rectified.

In general, you need to determine how much bandwidth is traveling across the single-connected interfaces, and allocate half of that bandwidth to the peer link. We recommend half of the single-connected bandwidth because, on average, one half of the traffic destined to the single-connected host arrives on the switch directly connected to the single-connected host and the other half arrives on the switch that is not directly connected to the single-connected host. When this happens, only the traffic that arrives on the switch that is not directly connected to the single-connected host needs to traverse the peer link, which is how you calculate 50% of the traffic.

In addition, you might want to add extra links to the peer link bond to handle link failures in the peer link bond itself.

In the illustration below, each host has two 10G links, with each 10G link going to each switch in the MLAG pair. Each host has 20G of dual-connected bandwidth, so all three hosts have a total of 60G of dual-connected bandwidth. We recommend you allocate at least 15G of bandwidth to each peer link bond, which represents half of the single-connected bandwidth.



Scaling this example out to a full rack, when planning for link failures, you need only allocate enough bandwidth to meet your site's strategy for handling failure scenarios. Imagine a full rack with 40 servers and two switches. You might plan for four to six servers to lose connectivity to a single switch and become single connected before you respond to the event. So expanding upon our previous example, if you have 40 hosts each with 20G of bandwidth dual-connected to the MLAG pair, you might allocate 20G to 30G of bandwidth to the peer link — which accounts for half of the single-connected bandwidth for four to six hosts.

### *Failover Redundancy Scenarios*

To get a better understanding of how STP and LACP behave in response to various failover redundancy scenarios, read [this knowledge base article](#).

## STP Interoperability with MLAG

Cumulus Networks recommends that you always enable STP in your layer 2 network.

With MLAG, Cumulus Networks recommends you enable BPDU guard on the host-facing bond interfaces. For more information about BPDU guard, see [BPDU Guard and Bridge Assurance \(see page 379\)](#).

### ⌚ Debugging STP with MLAG

Running `net show <interface> spanning-tree` displays MLAG information that can be useful when debugging:

```
cumulus@switch:~$ net show bridge spanning-tree
bridge:peerlink CIST info
    enabled          yes
    role             Designated
    port id         8.002
    state           forwarding
    .....
    bpdufilter port no
    clag ISL        yes
    UP              yes
                                         clag ISL Oper
```



```
clag role      primary
mac 00:00:00:00:00:00
clag remote portID F.FFF
mac      44:38:39:FF:40:90
clag dual conn
clag system
```

## Best Practices for STP with MLAG

- The STP global configuration must be the same on both peer switches.
- The STP configuration for dual-connected ports should be the same on both peer switches.
- The STP priority must be the same on both peer switches. You set the priority with this command:

```
cumulus@switch:~$ net add bridge stp treeprio PRIORITY_VALUE
cumulus@switch:~$ net commit
```

- Use [NCLU \(see page 88\)](#) (net) commands for all spanning tree configurations, including bridge priority, path cost and so forth. Do not use brctl commands for spanning tree, except for brctl stp on/off, as changes are not reflected to mstpd and can create conflicts.

## Troubleshooting

### Viewing the MLAG Log File

By default, when clagd is running, it logs its status to the /var/log/clagd.log file and syslog. Example log file output is below:

```
cumulus@spine01:~$ sudo tail /var/log/clagd.log
2016-10-03T20:31:50.471400+00:00 spine01 clagd[1235]: Initial config
loaded
2016-10-03T20:31:52.479769+00:00 spine01 clagd[1235]: The peer switch
is active.
2016-10-03T20:31:52.496490+00:00 spine01 clagd[1235]: Initial data
sync to peer done.
2016-10-03T20:31:52.540186+00:00 spine01 clagd[1235]: Role is now
primary; elected
2016-10-03T20:31:54.250572+00:00 spine01 clagd[1235]: HealthCheck:
role via backup is primary
2016-10-03T20:31:54.252642+00:00 spine01 clagd[1235]: HealthCheck:
backup active
2016-10-03T20:31:54.537967+00:00 spine01 clagd[1235]: Initial data
sync from peer done.
2016-10-03T20:31:54.538435+00:00 spine01 clagd[1235]: Initial
handshake done.
2016-10-03T20:31:58.527464+00:00 spine01 clagd[1235]: leaf03-04 is
now dual connected.
```



```
2016-10-03T22:47:35.255317+00:00 spine01 clagd[1235]: leaf01-02 is
now dual connected.
```

## Large Packet Drops on the Peer Link Interface

A large volume of packet drops across one of the peer link interfaces can be expected. These drops serve to prevent looping of BUM (broadcast, unknown unicast, multicast) packets. When a packet is received across the peer link, if the destination lookup results in an egress interface that is a dual-connected bond, the switch does not forward the packet to prevent loops. This results in a drop being recorded on the peer link.

You can detect this issue by running the `net show counters` or `ethtool -S <interface>` command.

Using [NCLU](#) (see page 88), the number of dropped packets is displayed in the RX\_DRP column when you run `net show counters`:

```
cumulus@switch:~$ net show counters

Kernel Interface table
Iface           MTU     Met      RX_OK      RX_ERR      RX_DRP
RX_OVR    TX_OK    TX_ERR    TX_DRP    TX_OVR   Flg
-----  -----  -----  -----  -----  -----
peerlink       1500        0  19226721        0  2952460
0      55115330        0       364        0  BMmRU
peerlink.4094   1500        0        0        0        0
0      5379243         0        0        0  BMRU
swp51          1500        0  6587220        0  2129676
0      38957769        0       202        0  BMsRU
swp52          1500        0  12639501        0  822784
0      16157561        0       162        0  BMsRU
```

When you run `ethtool -S` on a peer link interface, the drops are indicated by the `HwIfInDiscards` counter:

```
cumulus@switch:~$ sudo ethtool -S swp51
NIC statistics:
HwIfInOctets: 669507330
HwIfInUcastPkts: 658871
HwIfInBcastPkts: 2231559
HwIfInMcastPkts: 3696790
HwIfOutOctets: 2752224343
HwIfOutUcastPkts: 1001632
HwIfOutMcastPkts: 3743199
HwIfOutBcastPkts: 34212938
HwIfInDiscards: 2129675
```



## Duplicate LACP Partner MAC Warning

When you run `clagctl`, you may see output like this:

```
bond01 bond01 52 duplicate lacp - partner mac
```

This occurs when you have multiple LACP bonds between the same two LACP endpoints — for example, an MLAG switch pair is one endpoint and an ESXi host is another. These bonds have duplicate LACP identifiers, which are MAC addresses. This same warning could be triggered when you have a cabling or configuration error.

## Caveats and Errata

- If both the backup and peer connectivity are lost within a 30-second window, the switch in the secondary role misinterprets the event sequence, believing the peer switch is down, so it takes over as the primary.
- MLAG is disabled on the chassis, including the [Facebook Backpack](#) and EdgeCore OMP-800.

## LACP Bypass

On Cumulus Linux, *LACP Bypass* is a feature that allows a [bond](#) (see page 399) configured in 802.3ad mode to become active and forward traffic even when there is no LACP partner. A typical use case for this feature is to enable a host, without the capability to run LACP, to PXE boot while connected to a switch on a bond configured in 802.3ad mode. Once the pre-boot process finishes and the host is capable of running LACP, the normal 802.3ad link aggregation operation takes over.

## Contents

### This topic describes ...

- [LACP Bypass All-active Mode \(see page 471\)](#)
- [Configure LACP Bypass \(see page 472\)](#)

## LACP Bypass All-active Mode

When a bond has multiple slave interfaces, each bond slave interface operates as an active link while the bond is in bypass mode. This is known as *all-active mode*. This is useful during PXE boot of a server with multiple NICs, when the user cannot determine beforehand which port needs to be active.

Keep in the mind the following caveats with all-active mode:

- All-active mode is not supported on bonds that are not specified as bridge ports on the switch.
- Spanning tree protocol (STP) does not run on the individual bond slave interfaces when the LACP bond is in all-active mode. Therefore, only use all-active mode on host-facing LACP bonds. Cumulus Networks highly recommends you configure [STP BPDU guard \(see page 379\)](#) along with all-active mode.



The following features are not supported:



- priority mode
- bond-lacp-bypass-period
- bond-lacp-bypass-priority
- bond-lacp-bypass-all-active



In an [MLAG deployment \(see page 440\)](#) where bond slaves of a host are connected to two switches and the bond is in all-active mode, all the slaves of bond are active on both the primary and secondary MLAG nodes.

## Configure LACP Bypass

To enable LACP bypass on the host-facing bond, set `bond-lacp-bypass-allow` to yes.

### Example VLAN-aware Bridge Mode Configuration

The following commands create a VLAN-aware bridge with LACP bypass enabled:

```
cumulus@switch:~$ net add bond bond1 bond slaves swp51s2,swp51s3
cumulus@switch:~$ net add bond bond1 clag id 1
cumulus@switch:~$ net add bond bond1 bond lacp-bypass-allow
cumulus@switch:~$ net add bond bond1 stp bpduguard
cumulus@switch:~$ net add bridge bridge ports bond1,bond2,bond3,
bond4,peer5
cumulus@switch:~$ net add bridge bridge vids 100-105
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands create the following stanzas in `/etc/network/interfaces`:

```
auto bond1
iface bond1
    bond-lacp-bypass-allow yes
    bond-slaves swp51s2 swp51s3
    clag-id 1
    mstpcctl-bpduguard yes

...
auto bridge
iface bridge
    bridge-ports bond1 bond2 bond3 bond4 peer5
    bridge-vids 100-105
    bridge-vlan-aware yes
```



You can check the status of the configuration by running `net show interface <bond>` on the bond and its slave interfaces:

```
cumulus@switch:~$ net show interface bond1

  Name      MAC              Speed     MTU     Mode
--- -----
UP  bond1   44:38:39:00:00:5b  1G        1500   Bond/Trunk
```

#### Bond Details

```
Bond Mode:          LACP
Load Balancing:    Layer3+4
Minimum Links:     1
In CLAG:           CLAG Active
LACP Sys Priority:
LACP Rate:         Fast Timeout
LACP Bypass:       LACP Bypass Not Supported
```

Port	Speed	TX	RX	Err	Link Failures
UP swp51s2(P)	1G	0	0	0	0
UP swp51s3(P)	1G	0	0	0	0

#### All VLANs on L2 Port

```
-----  
100-105
```

#### Untagged

```
-----  
1
```

#### Vlans in disabled State

```
-----  
100-105
```

#### LLDP

```
-----  
swp51s2(P) === swp1(spine01)  
swp51s3(P) === swp1(spine02)
```

Use the `cat` command to verify that LACP bypass is enabled on a bond and its slave interfaces:



```
cumulus@switch:~$ cat /sys/class/net/bond1/bonding/lacp_bypass
on 1
cumulus@switch:~$ cat /sys/class/net/bond1/bonding/slaves
swp51 swp52
cumulus@switch:~$ cat /sys/class/net/swp52/bonding_slave/ad_rx_bypass
1
cumulus@switch:~$ cat /sys/class/net/swp51/bonding_slave/ad_rx_bypass
1
```

The following configuration shows LACP bypass enabled for multiple active interfaces (all-active mode) with a bridge in [traditional bridge mode \(see page 427\)](#):

```
auto bond1
iface bond1
    bond-slaves swp3 swp4
    bond-lacp-bypass-allow 1

auto br0
iface br0
    bridge-ports bond1 bond2 bond3 bond4 peer5
    mstpcctl-bpduguard bond1=yes
```

## Virtual Router Redundancy - VRR and VRRP

Cumulus Linux provides the option of using Virtual Router Redundancy (VRR) or Virtual Router Redundancy Protocol (VRRP).

**VRR** enables hosts to communicate with any redundant router without reconfiguration, running dynamic router protocols, or running router redundancy protocols. This means that redundant routers respond to Address Resolution Protocol (ARP) requests from hosts. Routers are configured to respond in an identical manner, but if one fails, the other redundant routers continue to respond, leaving the hosts with the impression that nothing has changed. VRR is typically used in an MLAG configuration.

**VRRP** allows a single virtual default gateway to be shared between two or more network devices in an active /standby configuration. The physical VRRP router that forwards packets at any given time is called the master. If this VRRP router fails, another VRRP standby router automatically takes over as master. VRRP is used in a non-MLAG configuration.



- VRRP is supported in Cumulus Linux 3.7.4 and later.
- You cannot configure both VRR and VRRP on the same switch.

## Contents

### This topic describes ...

- VRR (see page 475)
  - Configure VRR (see page 476)
  - Example VRR Configuration with MLAG (see page 477)

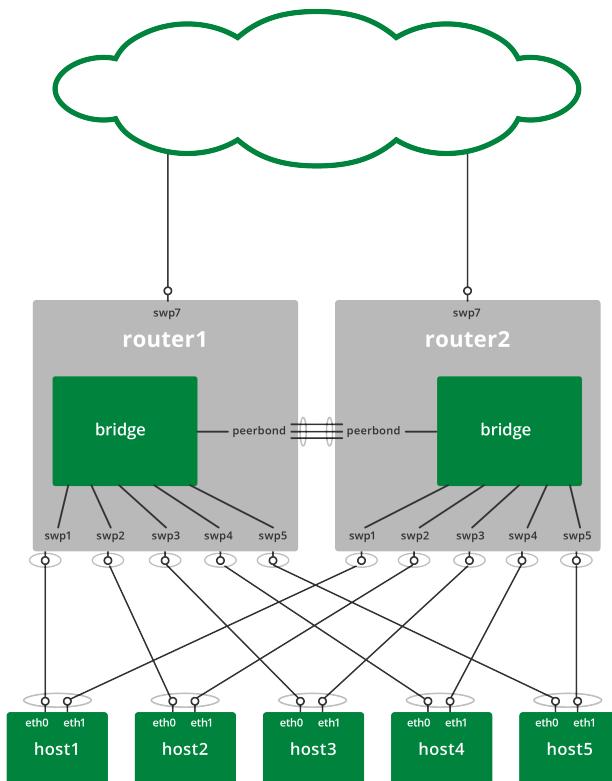
- VRRP (see page 481)
  - Configure VRRP (see page 482)
  - Show VRRP Configuration (see page 484)

## VRR

The diagram below illustrates a basic VRR-enabled network configuration. The network includes several hosts and two routers running Cumulus Linux configured with [Multi-chassis Link Aggregation \(see page 440\)](#) (MLAG).



Cumulus Linux only supports VRR on switched virtual interfaces (SVIs). VRR is not supported on physical interfaces or virtual subinterfaces.



A production implementation will have many more server hosts and network connections than are shown here. However, this basic configuration provides a complete description of the important aspects of the VRR setup.

As the bridges in each of the redundant routers are connected, they will each receive and reply to ARP requests for the virtual router IP address.



**Multiple ARP Replies**

Each ARP request made by a host will receive replies from each router; these replies will be identical, and so the host receiving the replies will either ignore replies after the first, or accept them and overwrite the previous identical reply, rather than being confused over which response is correct.

## **i Reserved MAC Address Range**

A range of MAC addresses is reserved for use with VRR, in order to prevent MAC address conflicts with other interfaces in the same bridged network. The reserved range is `00:00:5E:00:01:00` to `00:00:5E:00:01:ff`.

**!** Cumulus Networks recommends using MAC addresses from the reserved range when configuring VRR.

**!** The reserved MAC address range for VRR is the same as for the Virtual Router Redundancy Protocol (VRRP), as they serve similar purposes.

### *Configure VRR*

#### *Configure the Routers*

The routers implement the layer 2 network interconnecting the hosts and the redundant routers. To configure the routers, add a bridge with the following interfaces to each router:

- One bond interface or switch port interface to each host.

**!** For networks using MLAG, use bond interfaces. Otherwise, use switch port interfaces.

- One or more interfaces to each peer router.

**!** Multiple inter-peer links are typically bonded interfaces that accommodate higher bandwidth between the routers and offer link redundancy.

**!** The VLAN interface must have unique IP addresses for both the physical (the `address` option below) and virtual (the `address-virtual` option below) interfaces, as the unique address is used when the switch initiates an ARP request.

## **Example VRR Configuration**



The example NCLU commands below create a VLAN-aware bridge interface for a VRR-enabled network:

## NCLU Commands

```
cumulus@switch:~$ net add bridge
cumulus@switch:~$ net add vlan 500 ip address 192.0.2.252/24
cumulus@switch:~$ net add vlan 500 ip address-virtual 00:00:5e:00:01:01 192.0.2.254/24
cumulus@switch:~$ net add vlan 500 ipv6 address 2001:db8::1/32
cumulus@switch:~$ net add vlan 500 ipv6 address-virtual 00:00:5e:00:01:01 2001:db8::f/32
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

The NCLU commands above produce the following /etc/network/interfaces snippet:

## /etc/network/interfaces Snippet

```
auto bridge
iface bridge
    bridge-vids 500
    bridge-vlan-aware yes

auto vlan500
iface vlan500
    address 192.0.2.252/24
    address 2001:db8::1/32
    address-virtual 00:00:5e:00:01:01 2001:db8::f/32 192.0.2.254/2
4
    vlan-id 500
    vlan-raw-device bridge
```

## Configure the Hosts

Each host should have two network interfaces. The routers configure the interfaces as bonds running LACP; the hosts should also configure its two interfaces using teaming, port aggregation, port group, or EtherChannel running LACP. Configure the hosts, either statically or via DHCP, with a gateway address that is the IP address of the virtual router; this default gateway address never changes.

Configure the links between the hosts and the routers in *active-active* mode for First Hop Redundancy Protocol.

## Example VRR Configuration with MLAG

To create an [MLAG](#) (see page 440) configuration that incorporates VRR, use a configuration like the following:



## leaf01 Configuration

```
cumulus@leaf01:~$ net add
interface eth0 ip address
192.168.0.21/24
cumulus@leaf01:~$ net add bond
server01 bond slaves swp1
cumulus@leaf01:~$ net add bond
server01 clag id 1
cumulus@leaf01:~$ net add bond
server01 mtu 9216
cumulus@leaf01:~$ net add bond
server01 alias LACP
etherchannel to uplink on
server01
cumulus@leaf01:~$ net add bond
peerlink bond slaves swp49-50
cumulus@leaf01:~$ net add
interface peerlink.4094
peerlink.4094
cumulus@leaf01:~$ net add
interface peerlink.4094 ip
address 169.254.255.1/30
cumulus@leaf01:~$ net add
interface peerlink.4094 clag
peer-ip 169.254.255.2
cumulus@leaf01:~$ net add
interface peerlink.4094 clag
backup-ip 192.168.0.22
cumulus@leaf01:~$ net add
interface peerlink.4094 clag
sys-mac 44:38:39:FF:40:90
cumulus@leaf01:~$ net add
bridge bridge ports server01,
peerlink
cumulus@leaf01:~$ net add
bridge stp treeprio 4096
cumulus@leaf01:~$ net add vlan
100 ip address 10.0.1.2/24
cumulus@leaf01:~$ net add vlan
100 ip address-virtual 44:38:
39:FF:00:01 10.0.1.1/24
cumulus@leaf01:~$ net add vlan
200 ip address 10.0.2.2/24
cumulus@leaf01:~$ net add vlan
200 ip address-virtual 44:38:
39:FF:00:02 10.0.2.1/24
cumulus@leaf01:~$ net add vlan
300 ip address 10.0.3.2/24
```

## leaf02 Configuration

```
cumulus@leaf02:~$ net add
interface eth0 ip address
192.168.0.22/24
cumulus@leaf02:~$ net add bond
server01 bond slaves swp1
cumulus@leaf02:~$ net add bond
server01 clag id 1
cumulus@leaf02:~$ net add bond
server01 mtu 9216
cumulus@leaf02:~$ net add bond
server01 alias LACP
etherchannel to uplink on
server01
cumulus@leaf02:~$ net add bond
peerlink bond slaves swp49-50
cumulus@leaf02:~$ net add
interface peerlink.4094
peerlink.4094
cumulus@leaf02:~$ net add
interface peerlink.4094 ip
address 169.254.255.2/30
cumulus@leaf02:~$ net add
interface peerlink.4094 clag
peer-ip 169.254.255.1
cumulus@leaf02:~$ net add
interface peerlink.4094 clag
backup-ip 192.168.0.21
cumulus@leaf02:~$ net add
interface peerlink.4094 clag
sys-mac 44:38:39:FF:40:90
cumulus@leaf02:~$ net add
bridge bridge ports server01,
peerlink
cumulus@leaf02:~$ net add
bridge stp treeprio 4096
cumulus@leaf02:~$ net add vlan
100 ip address 10.0.1.3/24
cumulus@leaf02:~$ net add vlan
100 ip address-virtual 44:38:
39:FF:00:01 10.0.1.1/24
cumulus@leaf02:~$ net add vlan
200 ip address 10.0.2.3/24
cumulus@leaf02:~$ net add vlan
200 ip address-virtual 44:38:
39:FF:00:02 10.0.2.1/24
cumulus@leaf02:~$ net add vlan
300 ip address 10.0.3.3/24
```



```
cumulus@leaf01:~$ net add vlan  
300 ip address-virtual 44:38:  
39:FF:00:03 10.0.3.1/24  
cumulus@leaf01:~$ net add vlan  
400 ip address 10.0.4.2/24  
cumulus@leaf01:~$ net add vlan  
400 ip address-virtual 44:38:  
39:FF:00:04 10.0.4.1/24  
cumulus@leaf01:~$ net pending  
cumulus@leaf01:~$ net commit
```

These commands create the following configuration in /etc/network/interfaces:

```
auto eth0  
iface eth0  
    address 192.168.0.21/24  
  
auto bridge  
iface bridge  
    bridge-ports server01  
    peerlink  
    bridge-vids 100 200 300 400  
    bridge-vlan-aware yes  
    mstpcctl-treepriority 4096  
  
auto server01  
iface server01  
    alias LACP etherchannel to  
    uplink on server01  
    bond-slaves swp1  
    clag-id 1  
    mtu 9216  
  
auto peerlink  
iface peerlink  
    bond-slaves swp49 swp50  
  
auto peerlink.4094  
iface peerlink.4094  
    address 169.254.255.1/30  
    clagd-backup-ip  
    192.168.0.22  
    clagd-peer-ip 169.254.255.2  
    clagd-sys-mac 44:38:39:FF:  
    40:90  
  
auto vlan100  
iface vlan100  
    address 10.0.1.2/24
```

```
cumulus@leaf02:~$ net add vlan  
300 ip address-virtual 44:38:  
39:FF:00:03 10.0.3.1/24  
cumulus@leaf02:~$ net add vlan  
400 ip address 10.0.4.3/24  
cumulus@leaf02:~$ net add vlan  
400 ip address-virtual 44:38:  
39:FF:00:04 10.0.4.1/24  
cumulus@leaf02:~$ net pending  
cumulus@leaf02:~$ net commit
```

These commands create the following configuration in /etc/network/interfaces:

```
auto eth0  
iface eth0  
    address 192.168.0.22/24  
  
auto bridge  
iface bridge  
    bridge-ports server01  
    peerlink  
    bridge-vids 100 200 300 400  
    bridge-vlan-aware yes  
    mstpcctl-treepriority 4096  
  
auto server01  
iface server01  
    alias LACP etherchannel to  
    uplink on server01  
    bond-slaves swp1  
    clag-id 1  
    mtu 9216  
  
auto peerlink  
iface peerlink  
    bond-slaves swp49 swp50  
  
auto peerlink.4094  
iface peerlink.4094  
    address 169.254.255.2/30  
    clagd-backup-ip  
    192.168.0.21  
    clagd-peer-ip 169.254.255.1  
    clagd-sys-mac 44:38:39:FF:  
    40:90  
  
auto vlan100  
iface vlan100  
    address 10.0.1.3/24
```

```

address-virtual 44:38:39:
FF:00:01 10.0.1.1/24
  vlan-id 100
  vlan-raw-device bridge

auto vlan200
iface vlan200
  address 10.0.2.2/24
  address-virtual 44:38:39:
FF:00:02 10.0.2.1/24
  vlan-id 200
  vlan-raw-device bridge

auto vlan300
iface vlan300
  address 10.0.3.2/24
  address-virtual 44:38:39:
FF:00:03 10.0.3.1/24
  vlan-id 300
  vlan-raw-device bridge

auto vlan400
iface vlan400
  address 10.0.4.2/24
  address-virtual 44:38:39:
FF:00:04 10.0.4.1/24
  vlan-id 400
  vlan-raw-device bridge

```

```

address-virtual 44:38:39:
FF:00:01 10.0.1.1/24
  vlan-id 100
  vlan-raw-device bridge

auto vlan200
iface vlan200
  address 10.0.2.3/24
  address-virtual 44:38:39:
FF:00:02 10.0.2.1/24
  vlan-id 200
  vlan-raw-device bridge

auto vlan300
iface vlan300
  address 10.0.3.3/24
  address-virtual 44:38:39:
FF:00:03 10.0.3.1/24
  vlan-id 300
  vlan-raw-device bridge

auto vlan400
iface vlan400
  address 10.0.4.3/24
  address-virtual 44:38:39:
FF:00:04 10.0.4.1/24
  vlan-id 400
  vlan-raw-device bridge

```

## server01 Configuration

Create a configuration like the following on an Ubuntu host:

```

auto eth0
iface eth0 inet dhcp

auto eth1
iface eth1 inet manual
  bond-master uplink

auto eth2
iface eth2 inet manual
  bond-master uplink

auto uplink
iface uplink inet static
  bond-slaves eth1 eth2
  bond-mode 802.3ad

```

## server02 Configuration

Create a configuration like the following on an Ubuntu host:

```

auto eth0
iface eth0 inet dhcp

auto eth1
iface eth1 inet manual
  bond-master uplink

auto eth2
iface eth2 inet manual
  bond-master uplink

auto uplink
iface uplink inet static
  bond-slaves eth1 eth2
  bond-mode 802.3ad

```



```
bond-miimon 100
bond-lacp-rate 1
bond-min-links 1
bond-xmit-hash-policy
layer3+4
    address 172.16.1.101
    netmask 255.255.255.0
    post-up ip route add
    172.16.0.0/16 via 172.16.1.1
    post-up ip route add
    10.0.0.0/8 via 172.16.1.1

auto uplink:200
iface uplink:200 inet static
    address 10.0.2.101

auto uplink:300
iface uplink:300 inet static
    address 10.0.3.101

auto uplink:400
iface uplink:400 inet static
    address 10.0.4.101

# modprobe bonding
```

```
bond-miimon 100
bond-lacp-rate 1
bond-min-links 1
bond-xmit-hash-policy
layer3+4
    address 172.16.1.101
    netmask 255.255.255.0
    post-up ip route add
    172.16.0.0/16 via 172.16.1.1
    post-up ip route add
    10.0.0.0/8 via 172.16.1.1

auto uplink:200
iface uplink:200 inet static
    address 10.0.2.101

auto uplink:300
iface uplink:300 inet static
    address 10.0.3.101

auto uplink:400
iface uplink:400 inet static
    address 10.0.4.101

# modprobe bonding
```

## VRP

VRP allows for a single virtual default gateway to be shared among two or more network devices in an active/standby configuration. The VRP router that forwards packets at any given time is called the master. If this VRP router fails, another VRP standby router automatically takes over as master. The master sends VRP advertisements to other VRP routers in the same virtual router group, which include the priority and state of the master. VRP router priority determines the role that each virtual router plays and who becomes the new master if the master fails.

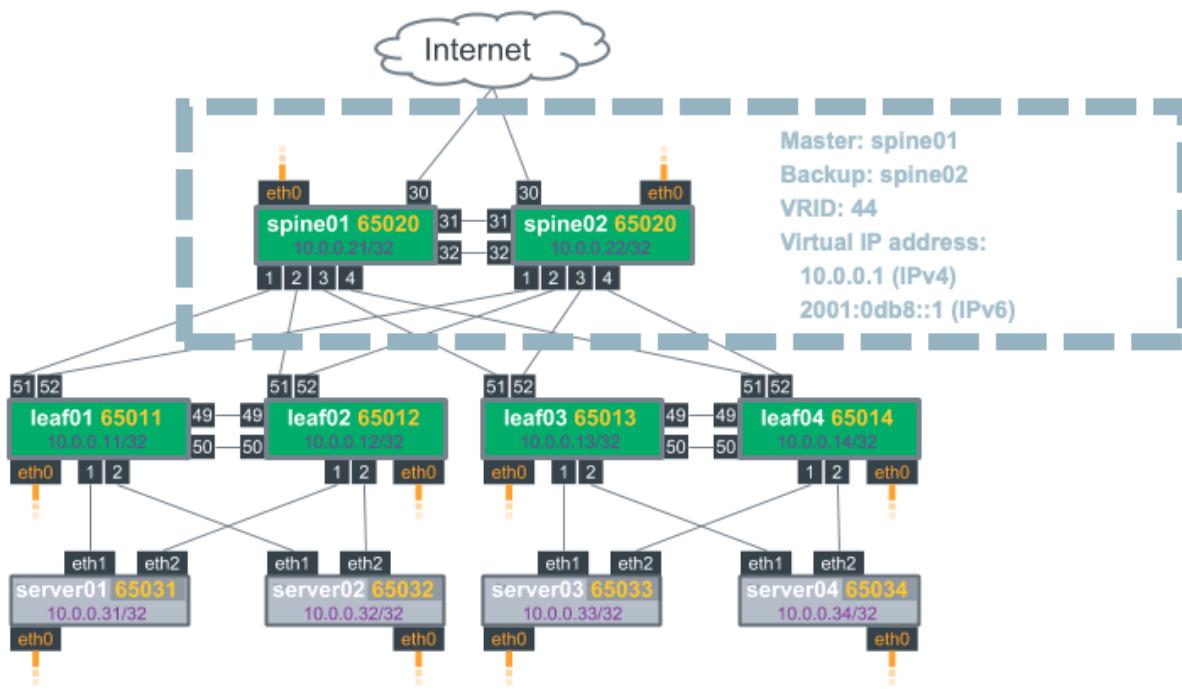
All virtual routers use 00:00:5E:00:01:XX for IPv4 gateways or 00:00:5E:00:02:XX for IPv6 gateways as their MAC address. The last byte of the address is the Virtual Router IDentifier (VRID), which is different for each virtual router in the network. This MAC address is used by only one physical router at a time, which replies with this address when ARP requests or neighbor solicitation packets are sent for the IP addresses of the virtual router.



- VRP is supported in Cumulus Linux 3.7.4.
- Cumulus Linux supports both VRPv2 and VRPv3. The default protocol version is VRPv3.
- 255 virtual routers are supported per switch.
- VRP is not supported currently in an MLAG environment or with EVPN.
- VRP is supported on physical interfaces and sub-interfaces.

[RFC 5798](#) describes VRRP in detail.

The following example illustrates a basic VRRP configuration.



## Configure VRRP

To configure VRRP, you need to specify the following information on each switch:

- **A virtual router ID (VRID) that identifies the group of VRRP routers.** You must specify the same ID across all virtual routers in the group.
- **One or more virtual IP addresses that are assigned to the virtual router group.** These are IP addresses that do not directly connect to a specific interface. Inbound packets sent to a virtual IP address are redirected to a physical network interface.

You can also set these optional parameters. If you do not set these parameters, the defaults are used:

Optional Parameter	Default Value	Description
priority	100	The priority level of the virtual router within the virtual router group, which determines the role that each virtual router plays and what happens if the master fails. Virtual routers have a priority between 1 and 254; the router with the highest priority becomes the master.
advertisement interval	1000 milliseconds	The advertisement interval is the interval between successive advertisements by the master in a virtual router group. You can specify a value between 10 and 40950.
preempt	enabled	



Optional Parameter	Default Value	Description
		Preempt mode lets the router take over as master for a virtual router group if it has a higher priority than the current master. Preempt mode is enabled by default. To disable preempt mode, you need to edit the <code>/etc/frr/frr.conf</code> file and add the line <code>vrrp &lt;VRID&gt; preempt no</code> to the interface stanza, then restart FRR service.

The NCLU commands write VRRP configuration to the `/etc/network/interfaces` file and the `/etc/frr/frr.conf` file.

The following example commands configure two switches (spine01 and spine02) that form one virtual router group (VRID 44) with IPv4 address 10.0.0.1/24 and IPv6 address 2001:0db8::1/64. *spine01* is the master; it has a priority of 254. *spine02* is the backup VRRP router.

### spine01

```
cumulus@spine01:~$ net add interface swp1 vrrp 44 10.0.0.1/24
cumulus@spine01:~$ net add interface swp1 vrrp 44 2001:0db8::1/64
cumulus@spine01:~$ net add interface swp1 vrrp 44 priority 254
cumulus@spine01:~$ net add interface swp1 vrrp 44 advertisement-
interval 5000
cumulus@spine01:~$ net pending
cumulus@spine01:~$ net commit
```

### spine02

```
cumulus@spine02:~$ net add interface swp1 vrrp 44 10.0.0.1/24
cumulus@spine02:~$ net add interface swp1 vrrp 44 2001:0db8::1/64
cumulus@spine02:~$ net pending
cumulus@spine02:~$ net commit
```

The NCLU commands save the configuration in the `/etc/frr/frr.conf` file. For example:

```
cumulus@spine01:~$ sudo cat /etc/frr/frr.conf
...
interface swp1
vrrp 44
vrrp 44 advertisement-interval 5000
vrrp 44 priority 254
vrrp 44 ip 10.0.0.1
vrrp 44 ipv6 2001:0db8::1
...
```



### Show VRRP Configuration

To show virtual router information on a switch, run the `net show vrrp <VRID>` command. For example:

## IGMP and MLD Snooping

IGMP (Internet Group Management Protocol) and MLD (Multicast Listener Discovery) snooping are implemented in the bridge driver in the Cumulus Linux kernel and are enabled by default. IGMP snooping processes IGMP v1/v2/v3 reports received on a bridge port in a bridge to identify the hosts which would like to receive multicast traffic destined to that group.

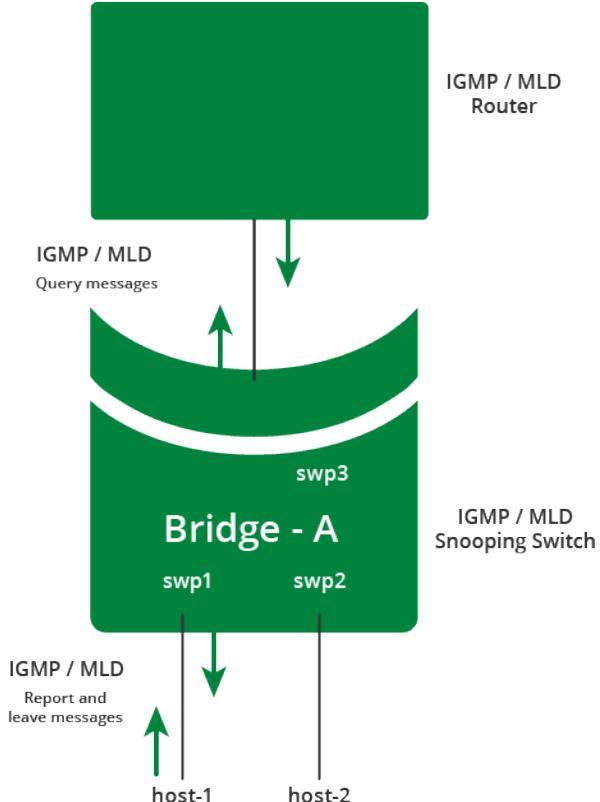


In Cumulus Linux 3.7.4 and later, IGMP and MLD snooping is supported over VXLAN bridges on Broadcom switches; however, this feature is *not* enabled by default. To enable IGMP and MLD over VXLAN, see [Configure IGMP/MLD Snooping over VXLAN \(see page 486\)](#).

When an IGMPv2 leave message is received, a group specific query is sent to identify if there are any other hosts interested in that group, before the group is deleted.

An IGMP query message received on a port is used to identify the port that is connected to a router and is interested in receiving multicast traffic.

MLD snooping processes MLD v1/v2 reports, queries and v1 done messages for IPv6 groups. If IGMP or MLD snooping is disabled, multicast traffic gets flooded to all the bridge ports in the bridge. Similarly, in the absence of receivers in a VLAN, multicast traffic would be flooded to all ports in the VLAN. The multicast group IP address is mapped to a multicast MAC address and a forwarding entry is created with a list of ports interested in receiving multicast traffic destined to that group.



## Contents

This topic describes ...



- Configure IGMP/MLD Snooping over VXLAN (see page 486)
- Configure IGMP/MLD Querier (see page 486)
- Disable IGMP and MLD Snooping (see page 487)
- Troubleshooting (see page 488)
- Related Information (see page 489)

## Configure IGMP/MLD Snooping over VXLAN

Cumulus Linux 3.7.4 and later supports IGMP/MLD snooping over VXLAN bridges on Broadcom switches, where VXLAN ports are set as router ports.

To enable IGMP/MLD snooping over VXLAN, run the `net add bridge <bridge> mcsnoop yes` command:

```
cumulus@switch:~$ net add bridge mybridge mcsnoop yes
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

Cumulus Networks recommends that you also configure IGMP/MLD querier. See [Configure IGMP/MLD Querier \(see page 486\)](#), below.

To disable IGMP/MLD snooping over VXLAN, run the `net add bridge <bridge> mcsnoop no` command.

## Configure IGMP/MLD Querier

If no multicast router is sending queries to configure IGMP/MLD querier on the switch, you can add a configuration similar to the following in `/etc/network/interfaces`. To enable IGMP and MLD snooping for a bridge, set `bridge-mcquerier` to 1 in the bridge stanza. By default, the source IP address of IGMP queries is 0.0.0.0. To set the source IP address of the queries to be the bridge IP address, configure `bridge-mcqifaddr 1`.

For an explanation of the relevant parameters, see the `ifupdown-addons-interfaces` man page.

For a [VLAN-aware bridge \(see page 415\)](#), use a configuration like the following:

```
auto bridge.100
vlan bridge.100
    bridge-igmp-querier-src 123.1.1.1

auto bridge
iface bridge
    bridge-ports swp1 swp2 swp3
    bridge-vlan-aware yes
    bridge-vids 100 200
    bridge-pvid 1
    bridge-mcquerier 1
```

For a VLAN-aware bridge, like `bridge` in the above example, to enable querier functionality for VLAN 100 in the bridge, set `bridge-mcquerier` to `1` in the bridge stanza and set `bridge-igmp-querier-src` to `123.1.1.1` in the `bridge.100` stanza.

You can specify a range of VLANs as well. For example:

```
auto bridge.[1-200]
vlan bridge.[1-200]
  bridge-igmp-querier-src 123.1.1.1
```

For a bridge in [traditional mode \(see page 407\)](#), use a configuration like the following:

```
auto br0
iface br0
  address 192.0.2.10/24
  bridge-ports swp1 swp2 swp3
  bridge-vlan-aware no
  bridge-mcquerier 1
  bridge-mcqifaddr 1
```

## Disable IGMP and MLD Snooping

To disable IGMP and MLD snooping, set the `bridge-mcsnoop` value to `0`.

### ⓘ Example Disable IGMP MLD Snooping Configuration

The example NCLU commands below create a VLAN-aware bridge interface for a VRR-enabled network:

```
cumulus@switch:~$ net add bridge bridge mcsnoop no
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

The commands above add the `bridge-mcsnoop` line to the following example bridge in `/etc/network/interfaces`:

```
auto bridge
iface bridge
  bridge-mcquerier 1
  bridge-mcsnoop 0
  bridge-ports swp1 swp2 swp3
  bridge-pvid 1
  bridge-vids 100 200
  bridge-vlan-aware yes
```



## Troubleshooting

To show the IGMP/MLD snooping bridge state, run `brctl showstp <bridge>`:

```
cumulus@switch:~$ sudo brctl showstp bridge
bridge
bridge id          8000.7072cf8c272c
designated root    8000.7072cf8c272c
root port          0
cost               0
max age            20.00
age                20.00
hello time         2.00
time               2.00
forward delay      15.00
delay              15.00
ageing time        300.00
hello timer        0.00
timer              0.00
topology change timer 0.00
timer              263.70
hash elasticity    4096
max                4096
mc last member count 2
count              2
mc router          1
snooping           1
mc last member timer 1.00
timer              260.00
mc querier timer   255.00
interval           125.00
mc response interval 10.00
interval           31.25
mc querier          0
ifaddr             0
flags

swp1 (1)
port id            8001
forwarding
designated root    8000.7072cf8c272c
cost               2
designated bridge  8000.7072cf8c272c
timer              0.00
designated port    8001
timer              0.00
designated cost    0
timer              0.00
```

```

mc router          1           mc fast
leave             0
flags

swp2 (2)
port id          8002        state
forwarding
designated root  8000.7072cf8c272c path
cost              2
designated bridge 8000.7072cf8c272c message age
timer            0.00
designated port   8002        forward delay
timer            0.00
designated cost    0           hold
timer            0.00
mc router          1           mc fast
leave             0
flags

swp3 (3)
port id          8003        state
forwarding
designated root  8000.7072cf8c272c path
cost              2
designated bridge 8000.7072cf8c272c message age
timer            0.00
designated port   8003        forward delay
timer            8.98
designated cost    0           hold
timer            0.00
mc router          1           mc fast
leave             0
flags

```

To show the groups and bridge port state, use the `bridge mdb show` command. To show router ports and group information use the `bridge -d -s mdb show` command:

```

cumulus@switch:~$ sudo bridge -d -s mdb show
dev bridge port swp2 grp 234.10.10.10 temp 241.67
dev bridge port swp1 grp 238.39.20.86 permanent 0.00
dev bridge port swp1 grp 234.1.1.1 temp 235.43
dev bridge port swp2 grp ff1a::9 permanent 0.00
router ports on bridge: swp3

```

## Related Information

- [tools.ietf.org/html/rfc4541](http://tools.ietf.org/html/rfc4541)
- [en.wikipedia.org/wiki/IGMP\\_snooping](http://en.wikipedia.org/wiki/IGMP_snooping)
- [tools.ietf.org/rfc/rfc2236.txt](http://tools.ietf.org/rfc/rfc2236.txt)



- [tools.ietf.org/html/rfc3376](https://tools.ietf.org/html/rfc3376)
- [tools.ietf.org/search/rfc2710](https://tools.ietf.org/search/rfc2710)
- [tools.ietf.org/html/rfc3810](https://tools.ietf.org/html/rfc3810)



# Network Virtualization

Cumulus Linux supports these forms of [network virtualization](#):

VXLAN (Virtual Extensible LAN) is a standard overlay protocol that abstracts logical virtual networks from the physical network underneath. You can deploy simple and scalable layer 3 Clos architectures while extending layer 2 segments over that layer 3 network.

VXLAN uses a VLAN-like encapsulation technique to encapsulate MAC-based layer 2 Ethernet frames within layer 3 UDP packets. Each virtual network is a VXLAN logical layer 2 segment. VXLAN scales to 16 million segments – a 24-bit VXLAN network identifier (VNI ID) in the VXLAN header – for multi-tenancy.

Hosts on a given virtual network are joined together through an overlay protocol that initiates and terminates tunnels at the edge of the multi-tenant network, typically the hypervisor vSwitch or top of rack. These edge points are the VXLAN tunnel end points (VTEP).

Cumulus Linux can initiate and terminate VTEPs in hardware and supports wire-rate VXLAN. VXLAN provides an efficient hashing scheme across the IP fabric during the encapsulation process; the source UDP port is unique, with the hash based on layer 2 through layer 4 information from the original frame. The UDP destination port is the standard port 4789.

Cumulus Linux includes the native Linux VXLAN kernel support and integrates with controller-based overlay solutions like [VMware NSX](#) (see page 699) and [Midokura MidoNet](#) (see page 670).

VXLAN is supported only on switches in the [Cumulus Linux HCL](#) using the Broadcom Tomahawk, Trident II, Trident II+ and Trident3 chipsets, as well as the Mellanox Spectrum chipset.



VXLAN encapsulation over layer 3 subinterfaces (for example, swp3.111) is not supported. Only configure VXLAN uplinks as layer 3 interfaces without any subinterfaces (for example, swp3).

The VXLAN tunnel endpoints cannot share a common subnet; there must be at least one layer 3 hop between the VXLAN source and destination.

## Caveats and Errata

### Cut-through Mode and Store and Forward Switching

On switches using Broadcom Tomahawk, Trident II, Trident II+, and Trident3 ASICs, Cumulus Linux supports store and forward switching for VXLANs but does **not** support [cut-through mode](#) (see page 285).

On switches using Mellanox Spectrum ASICs, Cumulus Linux supports cut-through mode for VXLANs but does **not** support store and forward switching.

### MTU Size for Virtual Network Interfaces

The maximum transmission unit (MTU) size for a virtual network interface should be 50 bytes smaller than the MTU for the physical interfaces on the switch. For more information on setting MTU, read [Layer 1 and Switch Port Attributes](#) (see page 244).



## VLANs and VXLANs Cannot Share the Same ID

The layer 3 VNI and layer 2 VNI cannot share the same number space; that is, you cannot have `vlan10` and `vxlan10`, for example. Otherwise, the layer 2 VNI does not get created.

## Useful Links

- [VXLAN - RFC 7348](#)
- [ovsdb-server](#)

## Static VXLAN Tunnels

In VXLAN-based networks, there are a range of complexities and challenges in determining the destination *virtual tunnel endpoints* (VTEPs) for any given VXLAN. At scale, various solutions, including [Lightweight Network Virtualization \(see page 602\)](#) (LNv), controller-based options like [Midokura MidoNet \(see page 670\)](#) or [VMware NSX \(see page 699\)](#) and even new standards like [EVPN \(see page 501\)](#) are attempts to address these complexities, however do retain their own complexities.

Enter *static VXLAN tunnels*, which simply serve to connect two VTEPs in a given environment. Static VXLAN tunnels are the simplest deployment mechanism for small scale environments and are interoperable with other vendors that adhere to VXLAN standards. Because you are simply mapping which VTEPs are in a particular VNI, you can avoid the tedious process of defining connections to every VLAN on every other VTEP on every other rack.

## Contents

### This topic describes ...

- Requirements (see page 492)
- Example Configuration (see page 493)
- Configure Static VXLAN Tunnels (see page 493)
- Verify the Configuration (see page 497)
- Caveats and Errata (see page 498)

## Requirements

Cumulus Networks supports static VXLAN tunnels only on switches in the [Cumulus Linux HCL](#) using the Broadcom Tomahawk, Trident II+ and Trident II ASICs, as well as the Mellanox Spectrum ASIC.

For a basic VXLAN configuration, make sure that:

- The VXLAN has a network identifier (VNI); do not use 0 or 16777215 as the VNI ID, which are reserved values under Cumulus Linux.
- The VXLAN link and local interfaces are added to bridge to create the association between port, VLAN, and VXLAN instance.
- Each traditional bridge on the switch has only one VXLAN interface. Cumulus Linux does not support more than one VXLAN ID per traditional bridge.



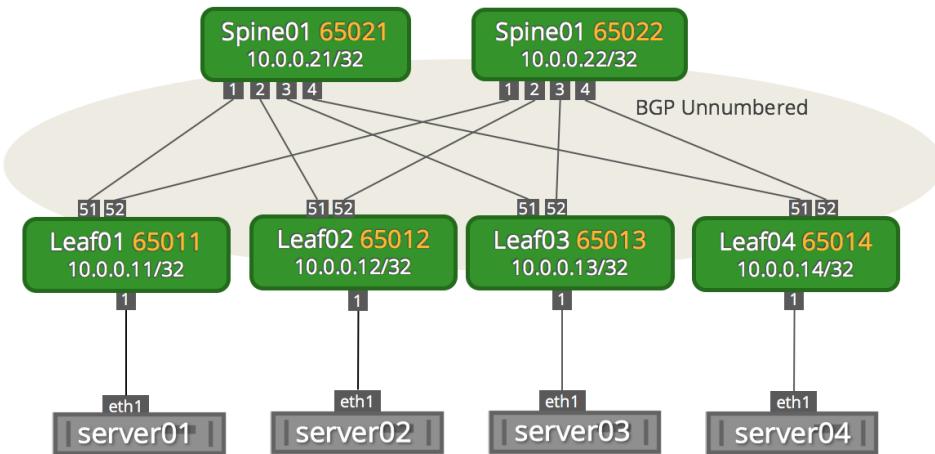
When deploying VXLAN with a VLAN-aware bridge, there is no restriction on using a single VNI. This limitation is only present when using the traditional bridge configuration.

- The VXLAN registration daemon (`vxrd`) is not running. Static VXLAN tunnels do not interoperate with LNV or EVPN. If `vxrd` is running, stop it with the following command:

```
cumulus@switch:~ sudo systemctl stop vxrd.service
```

## Example Configuration

The following topology is used in this chapter. Each IP address corresponds to the loopback address of the switch.



## Configure Static VXLAN Tunnels

To configure static VXLAN tunnels, do the following for each leaf:

- Specify an IP address for the loopback
- Create a VXLAN interface using the loopback address for the local tunnel IP address
- Create the tunnels by configuring the remote IP address to each other leaf switch's loopback address

To configure leaf01, run the following commands:

```
cumulus@leaf01:~$ net add loopback lo ip address 10.0.0.11/32
cumulus@leaf01:~$ net add vxlan vni-10 vxlan id 10
cumulus@leaf01:~$ net add vxlan vni-10 vxlan local-tunnelip 10.0.0.11
cumulus@leaf01:~$ net add vxlan vni-10 vxlan remoteip 10.0.0.12
cumulus@leaf01:~$ net add vxlan vni-10 vxlan remoteip 10.0.0.13
cumulus@leaf01:~$ net add vxlan vni-10 vxlan remoteip 10.0.0.14
cumulus@leaf01:~$ net add vxlan vni-10 bridge access 10
cumulus@leaf01:~$ net pending
cumulus@leaf01:~$ net commit
```



These commands create the following configuration in the `/etc/network/interfaces` file:

```
# The loopback network interface
auto lo
iface lo inet loopback
    address 10.0.0.11/32

# The primary network interface
auto eth0
iface eth0 inet dhcp

auto swp1
iface swp1

auto swp2
iface swp2

auto bridge
iface bridge
    bridge-ports vni-10
    bridge-vids 10
    bridge-vlan-aware yes

auto vni-10
iface vni-10
    bridge-access 10
    mstpcctl-bpduguard yes
    mstpcctl-portbpdufilter yes
    vxlan-id 10
    vxlan-local-tunnelip 10.0.0.11
    vxlan-remoteip 10.0.0.12
    vxlan-remoteip 10.0.0.13
    vxlan-remoteip 10.0.0.14
```

Repeat these steps for leaf02, leaf03, and leaf04:

Node	NCLU Commands	/etc/network/interfaces Configuration
leaf02	<pre>cumulus@leaf02:~\$ net add loopback lo ip address 10.0.0.12/32 cumulus@leaf02:~\$ net add vxlan vni-10 vxlan id 10 cumulus@leaf02:~\$ net add vxlan vni-10 vxlan local-tunnelip 10.0.0.12 cumulus@leaf02:~\$ net add vxlan vni-10 vxlan remoteip 10.0.0.11</pre>	<pre># The loopback network interface auto lo iface lo inet loopback     address 10.0.0.12/32</pre>



Node	NCLU Commands	/etc/network/interfaces Configuration
	<pre>cumulus@leaf02:~\$ net add vxlan vni-10 vxlan remoteip 10.0.0.13 cumulus@leaf02:~\$ net add vxlan vni-10 vxlan remoteip 10.0.0.14 cumulus@leaf02:~\$ net add vxlan vni-10 bridge access 10 cumulus@leaf02:~\$ net pending cumulus@leaf02:~\$ net commit</pre>	<pre># The primary network interface auto eth0 iface eth0 inet dhcp  auto swp1 iface swp1  auto swp2 iface swp2  auto bridge iface bridge     bridge-ports vni-10     bridge-vids 10     bridge-vlan- aware yes  auto vni-10 iface vni-10     bridge-access 10     mstptl- bpduguard yes     mstptl- portbpdufilter yes     vxlan-id 10     vxlan-local- tunnelip 10.0.0.12     vxlan- remoteip 10.0.0.11     vxlan- remoteip 10.0.0.13     vxlan- remoteip 10.0.0.14</pre>
leaf03	<pre>cumulus@leaf03:~\$ net add loopback lo ip address 10.0.0.13/32 cumulus@leaf03:~\$ net add vxlan vni-10 vxlan id 10 cumulus@leaf03:~\$ net add vxlan vni-10 vxlan local-tunnelip 10.0.0.13</pre>	<pre># The loopback network interface auto lo iface lo inet loopback     address 10.0.0.13/32</pre>

Node	NCLU Commands	/etc/network/interfaces Configuration
	<pre> cumulus@leaf03:~\$ net add vxlan vni-10 vxlan remoteip 10.0.0.11 cumulus@leaf03:~\$ net add vxlan vni-10 vxlan remoteip 10.0.0.12 cumulus@leaf03:~\$ net add vxlan vni-10 vxlan remoteip 10.0.0.14 cumulus@leaf03:~\$ net add vxlan vni-10 bridge access 10 cumulus@leaf03:~\$ net pending cumulus@leaf03:~\$ net commit </pre>	<pre> # The primary network interface auto eth0 iface eth0 inet dhcp  auto swp1 iface swp1  auto swp2 iface swp2  auto bridge iface bridge     bridge-ports vni-10     bridge-vids 10     bridge-vlan- aware yes  auto vni-10 iface vni-10     bridge-access 10     mstpctl- bpduguard yes     mstpctl- portbpdufilter yes     vxlan-id 10     vxlan-local- tunnelip 10.0.0.13     vxlan- remoteip 10.0.0.11     vxlan- remoteip 10.0.0.12     vxlan- remoteip 10.0.0.14 </pre>
leaf04	<pre> cumulus@leaf04:~\$ net add loopback lo ip address 10.0.0.14/32 cumulus@leaf04:~\$ net add vxlan vni-10 vxlan id 10 cumulus@leaf04:~\$ net add vxlan vni-10 vxlan local-tunnelip 10.0.0.14 </pre>	<pre> # The loopback network interface auto lo iface lo inet loopback </pre>



Node	NCLU Commands	/etc/network/interfaces Configuration
	<pre>cumulus@leaf04:~\$ net add vxlan vni-10 vxlan remoteip 10.0.0.11 cumulus@leaf04:~\$ net add vxlan vni-10 vxlan remoteip 10.0.0.12 cumulus@leaf04:~\$ net add vxlan vni-10 vxlan remoteip 10.0.0.13 cumulus@leaf04:~\$ net add vxlan vni-10 bridge access 10 cumulus@leaf04:~\$ net pending cumulus@leaf04:~\$ net commit</pre>	<pre>address 10.0.0.14/32  # The primary network interface auto eth0 iface eth0 inet dhcp  auto swp1 iface swp1  auto swp2 iface swp2  auto bridge iface bridge     bridge-ports vni-10     bridge-vids 10     bridge-vlan- aware yes  auto vni-10 iface vni-10     bridge-access 10     mstpc1- bpduguard yes     mstpc1- portbpdufilter yes     vxlan-id 10     vxlan-local- tunnelip 10.0.0.14     vxlan- remoteip 10.0.0.11     vxlan- remoteip 10.0.0.12     vxlan- remoteip 10.0.0.13</pre>

## Verify the Configuration

After you configure all the leaf switches, check for replication entries:

```
cumulus@leaf01:~$ sudo bridge fdb show | grep 00:00:00:00:00:00
00:00:00:00:00:00 dev vni-10 dst 10.0.0.14 self permanent
00:00:00:00:00:00 dev vni-10 dst 10.0.0.12 self permanent
00:00:00:00:00:00 dev vni-10 dst 10.0.0.13 self permanent
```

## Caveats and Errata

Cumulus Linux does not support different `bridge-learning` settings for different VNIs of VXLAN tunnels between 2 VTEPs. For example, the following configuration in the `/etc/network/interfaces` file is *not* supported.

```
...
auto vni300
iface vni300
vxlan-id 300
vxlan-local-tunnelip 10.252.255.58
vxlan-remoteip 10.250.255.161
mtu 9000

auto vni258
iface vni258
vxlan-id 258
vxlan-local-tunnelip 10.252.255.58
vxlan-remoteip 10.250.255.161
bridge-access 258
bridge-learning off
mtu 9000
```

## Static MAC Bindings with VXLAN

Cumulus Linux includes native Linux VXLAN kernel support.

### Contents

This topic describes ...

- Requirements (see page 498)
- Example VXLAN Configuration (see page 499)
- Configure the Static MAC Bindings VXLAN (see page 499)
- Troubleshooting (see page 500)

### Requirements

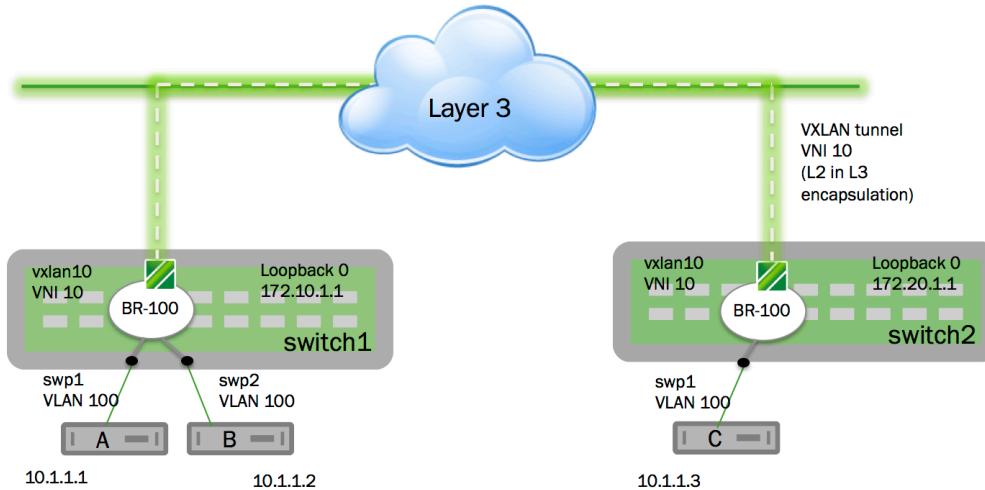
A VXLAN configuration requires a Broadcom switch with the Tomahawk, Trident II+, or Trident II ASIC running Cumulus Linux 2.0 or later, or a Mellanox switch with the Spectrum ASIC running Cumulus Linux 3.2.0 or later.

For a basic VXLAN configuration, make sure that:

- The VXLAN has a network identifier (VNI); do not use 0 or 16777215 as the VNI ID, which are reserved values under Cumulus Linux.
- The VXLAN link and local interfaces are added to the bridge to create the association between port, VLAN, and VXLAN instance.

## Example VXLAN Configuration

Consider the following example:



Preconfiguring remote MAC addresses does not scale. A better solution is to use the Cumulus Networks [Lightweight Network Virtualization](#) feature, or a controller-based option like [Midokura MidoNet](#) and [OpenStack](#) or [VMware NSX](#).

## Configure the Static MAC Bindings VXLAN

To configure the example illustrated above, first create the following configuration on switch1:

```
cumulus@switch1:~$ net add loopback lo ip address 172.10.1.1
cumulus@switch1:~$ net add loopback lo vxrd-src-ip 172.10.1.1
cumulus@switch1:~$ net add bridge bridge ports swp1-2
cumulus@switch1:~$ net add bridge post-up bridge fdb add 0:00:10:00:
00:0C dev vtep1000 dst 172.20.1.1 vni 1000
cumulus@switch1:~$ net add vxlan vtep1000 vxlan id 1000
cumulus@switch1:~$ net add vxlan vtep1000 vxlan local-tunnelip
172.10.1.1
cumulus@switch1:~$ net add vxlan vtep1000 bridge access 10
cumulus@switch1:~$ net pending
cumulus@switch1:~$ net commit
```

These commands create the following configuration in the /etc/network/interfaces file:

```
auto vtep1000
```



```
iface vtep1000
    vxlan-id 1000
    vxlan-local-tunnelip 172.10.1.1

auto bridge
iface bridge
    bridge-ports swp1 swp2 vtep1000
    bridge-vids 10
    bridge-vlan-aware yes
    post-up bridge fdb add 0:00:10:00:00:0C dev vtep1000 dst 172.20.1.
1 vni 1000
```

Then create the following configuration on switch2:

```
cumulus@switch2:~$ net add loopback lo ip address 172.20.1.1
cumulus@switch2:~$ net add loopback lo vxrd-src-ip 172.20.1.1
cumulus@switch1:~$ net add bridge bridge ports swp1-2
cumulus@switch2:~$ net add bridge post-up bridge fdb add 00:00:10:00:
00:0A dev vtep1000 dst 172.10.1.1 vni 1000
cumulus@switch2:~$ net add bridge post-up bridge fdb add 00:00:10:00:
00:0B dev vtep1000 dst 172.10.1.1 vni 1000
cumulus@switch2:~$ net add vxlan vtep1000 vxlan id 1000
cumulus@switch2:~$ net add vxlan vtep1000 vxlan local-tunnelip
172.10.1.1
cumulus@switch2:~$ net add vxlan vtep1000 bridge access 10
cumulus@switch2:~$ net pending
cumulus@switch2:~$ net commit
```

These commands create the following configuration in the /etc/network/interfaces file:

```
auto vtep1000
iface vtep1000
    vxlan-id 1000
    vxlan-local-tunnelip 172.20.1.1

auto bridge
iface bridge
    bridge-ports swp1 swp2 vtep1000
    bridge-vlan-aware yes
    post-up bridge fdb add 00:00:10:00:00:0A dev vtep1000 dst 172.10.1
.1 vni 1000
    post-up bridge fdb add 00:00:10:00:00:0B dev vtep1000 dst 172.10.1
.1 vni 1000
```

## Troubleshooting

Use the following commands to troubleshoot issues on the switch:



- `brctl show` verifies the VXLAN configuration in a bridge:

```
cumulus@switch:~$ brctl show
bridge name      bridge id          STP enabled    interfaces
bridge          8000.2a179a8cc471    yes           swp1
                           swp2
                           vni-10
                           vni-2000
```

- `bridge fdb show` displays the list of MAC addresses in an FDB:

```
cumulus@switch1:~$ bridge fdb show
44:38:39:00:00:18 dev swp1 master bridge permanent
44:38:39:00:00:1c dev swp2 master bridge permanent
2a:17:9a:8c:c4:71 dev vni-2000 master bridge permanent
9a:e8:ef:a1:9d:6f dev vni-10 master bridge permanent
00:00:10:00:00:0c dev vni-10 dst 172.20.1.1 self permanent
```

- `ip -d link show` displays information about the VXLAN link:

```
cumulus@switch1:~$ ip -d link show vni-10
15: vni-10: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue
        master bridge state UNKNOWN mode DEFAULT group default
          link/ether 9a:e8:ef:a1:9d:6f brd ff:ff:ff:ff:ff:ff
          promiscuity 1
          vxlan id 10 remote 10.2.1.3 local 10.2.1.1 srcport 0 0
          dstport 4789 ageing 1800
          bridge_slave state forwarding priority 8 cost 100 hairpin
          off guard off root_block off fastleave off learning on flood on
          port_id 0x8004 port_no 0x4 designated_port 32772 designated_cost
          0 designated_bridge 8000.2a:17:9a:8c:c4:71 designated_root 8000.2
          a:17:9a:8c:c4:71 hold_timer 0.00 message_age_timer 0.00
          forward_delay_timer 0.00 topology_change_ack 0 config_pending
          0 proxy_arp off proxy_arp_wifi off mcast_router 1
          mcast_fast_leave off mcast_flood on addrgenmode eui64
```

## Ethernet Virtual Private Network - EVPN

VXLAN is the de facto technology for implementing network virtualization in the data center, enabling layer 2 segments to be extended over an IP core (the underlay). The initial definition of VXLAN ([RFC 7348](#)) did not include any control plane and relied on a flood-and-learn approach for MAC address learning. An alternate deployment model was to use a controller or a technology such as [Lightweight Network Virtualization \(LVN\)](#) in Cumulus Linux.



- You cannot use EVPN and LNV at the same time.

- When using EVPN, you *must* disable data plane MAC learning on all VXLAN interfaces. This is described in [Basic EVPN Configuration \(see page 504\)](#), below.

Ethernet Virtual Private Network (EVPN) is a standards-based control plane for VXLAN defined in [RFC 7432](#) and [draft-ietf-bess-evpn-overlay](#) that allows for building and deploying VXLANs at scale. It relies on multi-protocol BGP (MP-BGP) for exchanging information and is based on BGP-MPLS IP VPNs ([RFC 4364](#)). It has provisions to enable not only bridging between end systems in the same layer 2 segment but also routing between different segments (subnets). There is also inherent support for multi-tenancy. EVPN is often referred to as the means of implementing *controller-less VXLAN*.

Cumulus Linux fully supports EVPN as the control plane for VXLAN, including for both intra-subnet bridging and inter-subnet routing. Key features include:

- VNI membership exchange between VTEPs using EVPN type-3 (Inclusive multicast Ethernet tag) routes.
- Exchange of host MAC and IP addresses using EVPN type-2 (MAC/IP advertisement) routes.
- Support for host/VM mobility (MAC and IP moves) through exchange of the MAC Mobility Extended community.
- Support for dual-attached hosts via [VXLAN active-active mode \(see page 633\)](#). MAC synchronization between the peer switches is done using [MLAG \(see page 440\)](#).
- Support for ARP/ND suppression, which provides VTEPs with the ability to suppress ARP flooding over VXLAN tunnels.
- Support for exchange of static (sticky) MAC addresses through EVPN.
- Support for distributed symmetric routing between different subnets.
- Support for distributed asymmetric routing between different subnets.
- Support for centralized routing.
- Support for prefix-based routing using EVPN type-5 routes (EVPN IP prefix route)
- Support for layer 3 multi-tenancy.
- Support for IPv6 tenant routing.
- Symmetric routing, asymmetric routing and prefix-based routing are supported for both IPv4 and IPv6 hosts and prefixes.
- ECMP (equal cost multipath) support for overlay networks on RIOT-capable Broadcom switches (Trident 3, Maverick, Trident 2+) in addition to Tomahawk and Mellanox Spectrum-A1 switches. No configuration is needed, ECMP occurs in the overlay when there are multiple next hops.

EVPN address-family is supported with both eBGP and iBGP peering. If the underlay routing is provisioned using eBGP, the same eBGP session can also be used to carry EVPN routes. For example, in a typical 2-tier Clos network topology where the leaf switches are the VTEPs, if eBGP sessions are in use between the leaf and spine switches for the underlay routing, the same sessions can be used to exchange EVPN routes; the spine switches merely act as "route forwarders" and do not install any forwarding state as they are not VTEPs. When EVPN routes are exchanged over iBGP peering, OSPF can be used as the IGP or the next hops can also be resolved using iBGP.

You can provision and manage EVPN using [NCLU \(see page 88\)](#).



For Cumulus Linux 3.4 and later releases, the routing control plane (including EVPN) is installed as part of the [FRRouting](#) (FRR) package. For more information about FRR, refer to the [FRR Overview \(see page 731\)](#).



For information about VXLAN routing, including platform and hardware limitations, see [VXLAN Routing](#) (see page 651).

## Contents

This topic describes ...

- Basic EVPN Configuration (see page 504)
  - Enable EVPN between BGP Neighbors (see page 504)
  - Advertise All VNIs (see page 505)
  - Auto-derivation of RDs and RTs (see page 506)
  - User-defined RDs and RTs (see page 506)
  - Enable EVPN in an iBGP Environment with an OSPF Underlay (see page 507)
  - Disable Data Plane MAC Learning over VXLAN Tunnels (see page 508)
  - BUM Traffic and Head End Replication (see page 510)
- ARP and ND Suppression (see page 510)
  - UFT Profiles Other than the Default (see page 512)
  - Support for EVPN Neighbor Discovery (ND) Extended Community (see page 512)
- EVPN and VXLAN Active-active Mode (see page 513)
- Inter-subnet Routing (see page 514)
  - Centralized Routing (see page 514)
  - Asymmetric Routing (see page 515)
  - Symmetric Routing (see page 515)
- Prefix-based Routing — EVPN Type-5 Routes (see page 519)
  - Configure the Switch to Install EVPN Type-5 Routes (see page 520)
  - Announce EVPN Type-5 Routes (see page 520)
  - EVPN Type-5 Routing with Asymmetric Routing (see page 520)
  - Control Which RIB Routes Are Injected into EVPN (see page 521)
  - Originate Default EVPN Type-5 Routes (see page 521)
- EVPN Enhancements (see page 521)
  - Static (Sticky) MAC Addresses (see page 521)
  - Filter EVPN Routes Based on Type (see page 522)
  - Advertise SVI IP Addresses (see page 523)
  - Extended Mobility (see page 524)
  - Duplicate Address Detection (see page 525)
- EVPN Operational Commands (see page 530)
  - General Linux Commands Related to EVPN (see page 530)
  - General BGP Operational Commands Relevant to EVPN (see page 531)
  - Display EVPN address-family Peers (see page 535)
  - Display VNIs in EVPN (see page 535)
  - Examine Local and Remote MAC Addresses for a VNI in EVPN (see page 536)

- Examine Local and Remote Neighbors for a VNI in EVPN (see page 537)
- Examine Remote Router MACs in EVPN (see page 537)
- Examine Gateway Next Hops in EVPN (see page 538)
- Display the VRF Routing Table in FRR (see page 538)
- Display the Global BGP EVPN Routing Table (see page 539)
- Display a Specific EVPN Route (see page 540)
- Display the per-VNI EVPN Routing Table (see page 542)
- Display the per-VRF BGP Routing Table (see page 542)
- Examine MAC Moves (see page 543)
- Examine Sticky MAC Addresses (see page 544)
- Troubleshooting (see page 544)
- Caveats (see page 545)
- Example Configurations (see page 547)
  - Basic Clos (4x2) for Bridging (see page 547)
  - Clos Configuration with MLAG and Centralized Routing (see page 558)
  - Clos Configuration with MLAG and EVPN Asymmetric Routing (see page 571)
  - Basic Clos Configuration with EVPN Symmetric Routing (see page 584)

## Basic EVPN Configuration

The following steps represent the fundamental configuration to use EVPN as the control plane for VXLAN. These steps are in addition to configuring VXLAN interfaces, attaching them to a bridge, and mapping VLANs to VNIs.

1. Enable EVPN route exchange (that is, address-family layer 2 VPN/EVPN) between BGP peers.
2. Enable EVPN on the system to advertise VNIs and host reachability information (MAC addresses learned on associated VLANs) to BGP peers.
3. Disable MAC learning on VXLAN interfaces as EVPN is responsible for installing remote MACs.

Additional configuration is necessary to enable ARP/ND suppression, provision inter-subnet routing, and so on. The configuration depends on the deployment scenario. You can also configure various other BGP parameters.

### Enable EVPN between BGP Neighbors

You enable EVPN between [BGP \(see page 773\)](#) neighbors by adding the address family `evpn` to the existing neighbor address-family activation command.

For a non-VTEP device that is merely participating in EVPN route exchange, such as a spine switch (the network deployment uses hop-by-hop eBGP or the switch is acting as an iBGP route reflector), activating the interface for the EVPN address family is the fundamental configuration needed in [FRRouting \(see page 731\)](#). Additional configuration options for specific scenarios are described later on in this chapter.

The other BGP neighbor address-family-specific configurations supported for EVPN are `allowas-in` and `route-reflector-client`.

To configure an EVPN route exchange with a BGP peer, you must activate the peer or peer-group within the EVPN address-family:



```
cumulus@switch:~$ net add bgp autonomous-system 65000
cumulus@switch:~$ net add bgp neighbor swp1 interface remote-as
external
cumulus@switch:~$ net add bgp 12vpn evpn neighbor swp1 activate
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```



Adjust the `remote-as` above to be appropriate for your environment.



The command syntax `bgp evpn` is also permitted for backwards compatibility with prior versions of Cumulus Linux, but the syntax `bgp 12vpn evpn` is recommended to standardize the BGP address-family configuration to the AFI/SAFI format.

The above commands create the following configuration snippet in the `/etc/frr/frr.conf` file.

```
router bgp 65000
neighbor swp1 interface remote-as external
address-family 12vpn evpn
    neighbor swp1 activate
```

The above configuration does not result in BGP knowing about the local VNIs defined on the system and advertising them to peers. This requires additional configuration, [as described below \(see page 505\)](#).

### Advertise All VNIs

A single configuration variable enables the BGP control plane for all VNIs configured on the switch. Set the variable `advertise-all-vni` to provision all locally configured VNIs to be advertised by the BGP control plane. FRR is not aware of any local VNIs and MACs and hosts (neighbors) associated with those VNIs until `advertise-all-vni` is configured.

To build upon the previous example, run the following commands to advertise all VNIs:

```
cumulus@switch:~$ net add bgp autonomous-system 65000
cumulus@switch:~$ net add bgp neighbor swp1 interface remote-as
external
cumulus@switch:~$ net add bgp 12vpn evpn neighbor swp1 activate
cumulus@switch:~$ net add bgp 12vpn evpn advertise-all-vni
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```



Adjust the `remote-as` above to be appropriate for your environment.



The above commands create the following configuration snippet in the `/etc/frr/frr.conf` file.

```
router bgp 65000
neighbor swp1 interface remote-as external
address-family l2vpn evpn
neighbor swp1 activate
advertise-all-vni
```



This configuration is only needed on leaf switches that are VTEPs. EVPN routes received from a BGP peer are accepted, even without this explicit EVPN configuration. These routes are maintained in the global EVPN routing table. However, they only become effective (that is, imported into the per-VNI routing table and appropriate entries installed in the kernel) when the VNI corresponding to the received route is locally known.

### *Auto-derivation of RDs and RTs*

When a local VNI is learned by FRR and there is no explicit configuration for that VNI in FRR, the route distinguisher (RD) and import and export route targets (RTs) for this VNI are automatically derived — the RD uses "RouterId:VNI-Index" and the import and export RTs use "AS:VNI". The RD and RTs are used in the EVPN route exchange. The RD disambiguates EVPN routes in different VNIs (as they may have the same MAC and/or IP address) while the RTs describe the VPN membership for the route. The "VNI-Index" used for the RD is a unique, internally generated number for a VNI. It solely has local significance; on remote switches, its only role is for route disambiguation. This number is used instead of the VNI value itself because this number has to be less than or equal to 65535. In the RT, the AS part is always encoded as a 2-byte value to allow room for a large VNI. If the router has a 4-byte AS, only the lower 2 bytes are used. This ensures a unique RT for different VNIs while having the same RT for the same VNI across routers in the same AS.

For eBGP EVPN peering, the peers are in a different AS so using an automatic RT of "AS:VNI" does not work for route import. Therefore, the import RT is treated as "\*:VNI" to determine which received routes are applicable to a particular VNI. This only applies when the import RT is auto-derived and not configured.

### *User-defined RDs and RTs*

EVPN also supports manual configuration of RDs and RTs, if you don't want them derived automatically. To manually define RDs and RTs, use the `vni` option within NCLU to configure the switch:

```
cumulus@switch:~$ net add bgp 12vpn evpn vni 10200 rd 172.16.100.1:20
cumulus@switch:~$ net add bgp 12vpn evpn vni 10200 route-target
import 65100:20
cumulus@switch:~$ net add bgp 12vpn evpn advertise-all-vni
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands create the following configuration snippet in the `/etc/frr/frr.conf` file.

```
address-family l2vpn evpn
advertise-all-vni
vni 10200
rd 172.16.100.1:20
route-target import 65100:20
```



These commands are per VNI and must be specified under `address-family l2vpn evpn` in BGP.



If you delete the RD or RT later, it reverts back to its corresponding default value.

You can configure multiple RT values for import or export for a VNI. In addition, you can configure both the import and export route targets with a single command by using `route-target both`:

```
cumulus@switch:~$ net add bgp evpn vni 10400 route-target import 100:400
cumulus@switch:~$ net add bgp evpn vni 10400 route-target import 100:500
cumulus@switch:~$ net add bgp evpn vni 10500 route-target both 65000:500
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

The above commands create the following configuration snippet in the `/etc/frr/frr.conf` file:

```
address-family l2vpn evpn
vni 10400
  route-target import 100:400
  route-target import 100:500
vni 10500
  route-target import 65000:500
  route-target export 65000:500
```

### *Enable EVPN in an iBGP Environment with an OSPF Underlay*

EVPN can be deployed with an [OSPF \(see page 756\)](#) or static route underlay if needed. This is a more complex configuration than using eBGP. In this case, iBGP advertises EVPN routes directly between VTEPs, and the spines are unaware of EVPN or BGP.

The leaf switches peer with each other in a full mesh within the EVPN address family without using route reflectors. The leafs generally peer to their loopback addresses, which are advertised in OSPF. The receiving VTEP imports routes into a specific VNI with a matching route target community.

```
cumulus@switch:~$ net add bgp autonomous-system 65020
```

```

cumulus@switch:~$ net add bgp evpn neighbor 10.1.1.2 remote-as
internal
cumulus@switch:~$ net add bgp evpn neighbor 10.1.1.3 remote-as
internal
cumulus@switch:~$ net add bgp evpn neighbor 10.1.1.4 remote-as
internal
cumulus@switch:~$ net add bgp evpn neighbor 10.1.1.2 activate
cumulus@switch:~$ net add bgp evpn neighbor 10.1.1.3 activate
cumulus@switch:~$ net add bgp evpn neighbor 10.1.1.4 activate
cumulus@switch:~$ net add bgp evpn advertise-all-vni
cumulus@switch:~$ net add ospf router-id 10.1.1.1
cumulus@switch:~$ net add loopback lo ospf area 0.0.0.0
cumulus@switch:~$ net add ospf passive-interface lo
cumulus@switch:~$ net add interface swp50 ospf area 0.0.0.0
cumulus@switch:~$ net add interface swp51 ospf area 0.0.0.0
cumulus@switch:~$ net add interface swp50 ospf network point-to-point
cumulus@switch:~$ net add interface swp51 ospf network point-to-point
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit

```

These commands create the following configuration snippet in the `/etc/frr/frr.conf` file.

```

interface lo
  ip ospf area 0.0.0.0
!
interface swp50
  ip ospf area 0.0.0.0
  ip ospf network point-to-point

interface swp51
  ip ospf area 0.0.0.0
  ip ospf network point-to-point
!
router bgp 65020
  neighbor 10.1.1.2 remote-as internal
  neighbor 10.1.1.3 remote-as internal
  neighbor 10.1.1.4 remote-as internal
!
  address-family l2vpn evpn
    neighbor 10.1.1.2 activate
    neighbor 10.1.1.3 activate
    neighbor 10.1.1.4 activate
    advertise-all-vni
  exit-address-family
!
Router ospf
  Ospf router-id 10.1.1.1
  Passive-interface lo

```

## Disable Data Plane MAC Learning over VXLAN Tunnels

When EVPN is provisioned, you must disable data plane MAC learning for VXLAN interfaces because the purpose of EVPN is to exchange MACs between VTEPs in the control plane. In the `/etc/network/interfaces` file, configure the `bridge-learning` value to `off`:

```
cumulus@switch:~$ net add vxlan vni200 vxlan id 10200
cumulus@switch:~$ net add vxlan vni200 vxlan local-tunnelip 10.0.0.1
cumulus@switch:~$ net add vxlan vni200 bridge access 200
cumulus@switch:~$ net add vxlan vni200 bridge learning off
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands create the following code snippet in the `/etc/network/interfaces` file:

```
auto vni200
iface vni200
    bridge-access 200
    bridge-learning off
    vxlan-id 10200
    vxlan-local-tunnelip 10.0.0.1
```



For a bridge in [traditional mode](#) (see page 427), you must edit the bridge configuration in the `/etc/network/interfaces` file using a text editor:

```
auto bridge1
iface bridge1
    bridge-ports swp3.100 swp4.100 vni100
    bridge-learning vni100=off
```



For a traditional-mode bridge on Broadcom switches, the `bridge learning` setting is per physical port; you *cannot* control MAC learning behavior based on subinterface. For example, you cannot set `bridge learning off` on some subinterfaces and `on` for other subinterfaces of the same physical interface.



Cumulus Linux does not support different `bridge-learning` settings for different VNIs of VXLAN tunnels between 2 VTEPs.

## BUM Traffic and Head End Replication

With EVPN, the only method of generating BUM traffic in hardware is *head end replication*. Head end replication is enabled by default in Cumulus Linux.

Broadcom switches with Tomahawk, Trident3, Trident II+, and Trident II ASICs and Mellanox switches with Spectrum ASICs are capable of head end replication. The most scalable solution available with EVPN is to have each VTEP (top of rack switch) generate all of its own BUM traffic instead of relying on an external service node.

Cumulus Linux supports up to 128 VTEPs with head end replication.

## ARP and ND Suppression

ARP suppression in an EVPN context refers to the ability of a VTEP to suppress ARP flooding over VXLAN tunnels as much as possible. Instead, a local proxy handles ARP requests received from locally attached hosts for remote hosts. ARP suppression is the implementation for IPv4; ND suppression is the implementation for IPv6.



Cumulus Networks recommends that you *enable* ARP and ND suppression in all EVPN bridging and symmetric routing deployments to reduce flooding of ARP/ND packets over VXLAN tunnels.



On switches with the Mellanox Spectrum chipset, ND suppression only functions with the Spectrum A1 chip.

ARP and ND suppression are not enabled by default. You configure ARP/ND suppression on a VXLAN interface. You also need to create an SVI for the neighbor entry.



When ARP and ND suppression are enabled, you need to configure layer 3 interfaces even if the switch is configured only for layer 2 (that is, you are not using VXLAN routing). To avoid unnecessary layer 3 information from being installed, Cumulus Networks recommends you configure the `ip forward off` or `ip6 forward off` options as appropriate on the VLANs. See the example configuration below.

To configure ARP or ND suppression, use [NCLU \(see page 88\)](#). Here is an example configuration using two VXLANs (10100 and 10200) and two VLANs (100 and 200).

```
cumulus@switch:~$ net add bridge bridge ports vni100,vni200
cumulus@switch:~$ net add bridge bridge vids 100,200
cumulus@switch:~$ net add vxlan vni100 vxlan id 10100
cumulus@switch:~$ net add vxlan vni200 vxlan id 10200
cumulus@switch:~$ net add vxlan vni100 bridge learning off
cumulus@switch:~$ net add vxlan vni200 bridge learning off
cumulus@switch:~$ net add vxlan vni100 bridge access 100
cumulus@switch:~$ net add vxlan vni100 bridge arp-nd-suppress on
cumulus@switch:~$ net add vxlan vni200 bridge arp-nd-suppress on
cumulus@switch:~$ net add vxlan vni200 bridge access 200
```



```
cumulus@switch:~$ net add vxlan vni100 vxlan local-tunnelip 10.0.0.1
cumulus@switch:~$ net add vxlan vni200 vxlan local-tunnelip 10.0.0.1
cumulus@switch:~$ net add vlan 100 ip forward off
cumulus@switch:~$ net add vlan 100 ipv6 forward off
cumulus@switch:~$ net add vlan 200 ip forward off
cumulus@switch:~$ net add vlan 200 ipv6 forward off
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands create the following configuration in the /etc/network/interfaces file:

```
auto bridge
iface bridge
    bridge-ports vni100 vni200
    bridge-stp on
    bridge-vids 100 200
    bridge-vlan-aware yes

auto vlan100
iface vlan100
    ip6-forward off
    ip-forward off
    vlan-id 100
    vlan-raw-device bridge

auto vlan200
iface vlan200
    ip6-forward off
    ip-forward off
    vlan-id 200
    vlan-raw-device bridge

auto vni100
iface vni100
    bridge-access 100
    bridge-arp-nd-suppress on
    bridge-learning off
    vxlan-id 10100
    vxlan-local-tunnelip 10.0.0.1

auto vni200
iface vni200
    bridge-learning off
    bridge-access 200
    bridge-arp-nd-suppress on
    vxlan-id 10200
    vxlan-local-tunnelip 10.0.0.1
```



For a bridge in [traditional mode \(see page 427\)](#), you must edit the bridge configuration in the `/etc/network/interfaces` file using a text editor:

```
auto bridge1
iface bridge1
    bridge-ports swp3.100 swp4.100 vni100
    bridge-learning vni100=off
    bridge-arp-nd-suppress vni100=on
    ip6-forward off
    ip-forward off
```

### *UFT Profiles Other than the Default*

When deploying EVPN and VXLAN using a hardware profile other than the default UFT profile, ensure that the Linux kernel ARP sysctl settings `gc_thresh2` and `gc_thresh3` are both set to a value larger than the number of neighbor (ARP/ND) entries anticipated in the deployment.

To configure these settings, edit the `/etc/sysctl.d/neigh.conf` file. If your network has more hosts than the values used in the example below, change the sysctl entries accordingly.

```
cumulus@switch:~$ sudo nano /etc/sysctl.d/neigh.conf
...
net.ipv4.neigh.default.gc_thresh3=14336
net.ipv6.neigh.default.gc_thresh3=16384
net.ipv4.neigh.default.gc_thresh2=7168
net.ipv6.neigh.default.gc_thresh2=8192
...
```

After you save your settings, reboot the switch to apply the new configuration.

### *Support for EVPN Neighbor Discovery (ND) Extended Community*

In an EVPN VXLAN deployment with ARP and ND suppression where the VTEPs are only configured for layer 2, EVPN needs to carry additional information for the attached devices so proxy ND can provide the correct information to attached hosts. Without this information, hosts might not be able to configure their default routers or might lose their existing default router information.

Cumulus Linux supports the EVPN Neighbor Discovery (ND) Extended Community with a type field value of 0x06, a sub-type field value of 0x08 (ND Extended Community), and a router flag; this enables the switch to determine if a particular IPv6-MAC pair belongs to a host or a router.

### *Router Flag*

The router flag (R-bit) is used in following scenarios:

- In a centralized VXLAN routing configuration with a gateway router.
- In a layer 2 switch deployment with ARP/ND suppression.

When the MAC/IP (type-2) route contains the IPv6-MAC pair and the R-bit is set, the route belongs to a router. If the R-bit is set to zero, the route belongs to a host. If the router is in a local LAN segment, the switch implementing the proxy ND function learns of this information by snooping on neighbor advertisement messages for the associated IPv6 address. This information is then exchanged with other EVPN peers by using the ND extended community in BGP updates.

To show the EVPN arp-cache that gets populated by the neighbor table and see if the IPv6-MAC entry belongs to a router, run this command:

```
cumulus@switch:mgmt-vrf:~$ net show evpn arp-cache vni 101 ip fe80::  
202:ff:fe00:11  
IP: fe80::202:ff:fe00:11  
Type: remote  
State: active  
MAC: 00:02:00:00:00:11  
Remote VTEP: 10.0.0.134  
Flags: Router  
Local Seq: 0 Remote Seq: 0
```

To show the BGP routing table entry for the IPv6-MAC EVPN route with the ND extended community, run this command:

```
cumulus@switch:mgmt-vrf:~$ net show bgp l2vpn evpn route vni 101 mac  
00:02:00:00:00:11 ip fe80::202:ff:fe00:11  
BGP routing table entry for [2]:[0]:[0]:[48]:[00:02:00:00:00:11]:  
[128]:[fe80::202:ff:fe00:11]  
Paths: (1 available, best #1)  
    Not advertised to any peer  
    Route [2]:[0]:[0]:[48]:[00:02:00:00:00:11]:[128]:[fe80::202:ff:fe00:  
11] VNI 101  
        Imported from 1.1.1.2:2:[2]:[0]:[0]:[48]:[00:02:00:00:00:11]:[128]:  
[fe80::202:ff:fe00:11]  
        65002  
        10.0.0.134 from leaf2(swp53s0) (10.0.0.134)  
            Origin IGP, valid, external, bestpath-from-AS 65002, best  
            Extended Community: RT:65002:101 ET:8 ND:Router Flag  
            AddPath ID: RX 0, TX 18  
            Last update: Thu Aug 30 14:12:09 2018
```

## EVPN and VXLAN Active-active Mode

No additional EVPN-specific configuration is needed for [VXLAN active-active mode \(see page 633\)](#). Both switches in the [MLAG \(see page 440\)](#) pair establish EVPN peering with other EVPN speakers (for example, with spine switches, if using hop-by-hop eBGP) and inform about their locally known VNIs and MACs. When MLAG is active, both switches announce this information with the shared anycast IP address.

The active-active configuration, make sure that:

- The `clagd-vxlan-anycast-ip` parameter is under the [loopback stanza \(see page \)](#) on both peers.

- The anycast address is advertised to the routed fabric from both peers.
- The [VNIs \(see page 638\)](#) are configured identically on both peers. However, `vxlan-local-tunnelip` must be sourced from unique loopback stanza IP address of the switch.
- The [peerlink \(see page 638\)](#) must belong to the bridge.

MLAG synchronizes information between the two switches in the MLAG pair; EVPN does not synchronize.

For information about active-active VTEPs and anycast IP behavior, and for failure scenarios, read the [VXLAN Active-Active Mode \(see page 633\)](#) chapter.

## Inter-subnet Routing

There are multiple models in EVPN for routing between different subnets (VLANs), also known as inter-VLAN routing. These models arise due to the following considerations:

- Does every VTEP act as a layer 3 gateway and do routing, or only specific VTEPs do routing?
- Is routing done only at the ingress of the VXLAN tunnel or is it done at both the ingress and the egress of the VXLAN tunnel?

These models are:

- **Centralized routing:** Specific VTEPs act as designated layer 3 gateways and perform routing between subnets; other VTEPs just perform bridging.
- **Distributed asymmetric routing:** Every VTEP participates in routing, but all routing is done at the ingress VTEP; the egress VTEP only performs bridging.
- **Distributed symmetric routing:** Every VTEP participates in routing and routing is done at both the ingress VTEP and the egress VTEP.

Distributed routing — asymmetric or symmetric — is commonly deployed with the VTEPs configured with an *anycast IP/MAC address* for each subnet. That is, each VTEP that has a particular subnet is configured with the same IP/MAC for that subnet. Such a model facilitates easy host/VM mobility as there is no need to change the host/VM configuration when it moves from one VTEP to another.

EVPN in Cumulus Linux supports all of the routing models listed above. The models are described further in the following sections.

All routing happens in the context of a tenant VRF ([virtual routing and forwarding \(see page 847\)](#)). A VRF instance is provisioned for each tenant, and the subnets of the tenant are associated with that VRF (the corresponding SVI is attached to the VRF). Inter-subnet routing for each tenant occurs within the context of that tenant's VRF and is separate from the routing for other tenants.



When configuring [VXLAN routing \(see page 651\)](#), Cumulus Networks recommends enabling ARP suppression on all VXLAN interfaces. Otherwise, when a locally attached host ARPs for the gateway, it will receive multiple responses, one from each anycast gateway.

### Centralized Routing

In centralized routing, a specific VTEP is configured to act as the default gateway for all the hosts in a particular subnet throughout the EVPN fabric. It is common to provision a pair of VTEPs in active-active mode as the default gateway, using an anycast IP/MAC address for each subnet. All subnets need to be configured on such gateway VTEP(s). When a host in one subnet wants to communicate with a host in another subnet, it addresses the packets to the gateway VTEP. The ingress VTEP (to which the source host

is attached) bridges the packets to the gateway VTEP over the corresponding VXLAN tunnel. The gateway VTEP performs the routing to the destination host and post-routing, the packet gets bridged to the egress VTEP (to which the destination host is attached). The egress VTEP then bridges the packet on to the destination host.

### *Advertising the Default Gateway*

To enable centralized routing, you must configure the gateway VTEPs to advertise their IP/MAC address. Use the `advertise-default-gw` command, as shown below.

```
cumulus@leaf01:~$ net add bgp autonomous-system 65000
cumulus@leaf01:~$ net add bgp l2vpn evpn advertise-default-gw
cumulus@leaf01:~$ net pending
cumulus@leaf01:~$ net commit
```

These commands create the following configuration snippet in the `/etc/frr/frr.conf` file.

```
router bgp 65000
  address-family l2vpn evpn
    advertise-default-gw
  exit-address-family
```



- You can deploy centralized routing at the VNI level. Therefore, you can configure the `advertise-default-gw` command per VNI so that centralized routing is used for some VNIs while distributed routing (described below) is used for other VNIs. This type of configuration is not recommended unless the deployment requires it.
- When centralized routing is in use, even if the source host and destination host are attached to the same VTEP, the packets travel to the gateway VTEP to get routed and then come back.

### *Asymmetric Routing*

In distributed asymmetric routing, each VTEP acts as a layer 3 gateway, performing routing for its attached hosts. The routing is called asymmetric because only the ingress VTEP performs routing, the egress VTEP only performs the bridging. Asymmetric routing is easy to deploy as it can be achieved with only host routing and does not involve any interconnecting VNIs. However, each VTEP must be provisioned with all VLANs/VNIs — the subnets between which communication can take place; this is required even if there are no locally-attached hosts for a particular VLAN.



- The only additional configuration required to implement asymmetric routing beyond the standard configuration for a layer 2 VTEP described earlier is to ensure that each VTEP has all VLANs (and corresponding VNIs) provisioned on it and the SVI for each such VLAN is configured with an anycast IP/MAC address.

## Symmetric Routing

In distributed symmetric routing, each VTEP acts as a layer 3 gateway, performing routing for its attached hosts. This is the same as in asymmetric routing. The difference is that with symmetric routing, both the ingress VTEP and egress VTEP route the packets. Therefore, it can be compared to the traditional routing behavior of routing to a next hop router. In the VXLAN encapsulated packet, the inner destination MAC address is set to the router MAC address of the egress VTEP as an indication that the egress VTEP is the next hop and also needs to perform routing. All routing happens in the context of a tenant (VRF). For a packet received by the ingress VTEP from a locally attached host, the SVI interface corresponding to the VLAN determines the VRF. For a packet received by the egress VTEP over the VXLAN tunnel, the VNI in the packet has to specify the VRF. For symmetric routing, this is a VNI corresponding to the tenant and is different from either the source VNI or the destination VNI. This VNI is referred to as the layer 3 VNI or interconnecting VNI; it has to be provisioned by the operator and is exchanged through the EVPN control plane. In order to make the distinction clear, the regular VNI, which is used to map a VLAN, is referred to as the layer 2 VNI.

### L3-VNI

- There is a one-to-one mapping between a layer 3 VNI and a tenant (VRF).
- The VRF to layer 3 VNI mapping has to be consistent across all VTEPs. The layer 3 VNI has to be provisioned by the operator.
- Layer 3 VNI and layer 2 VNI cannot share the same number space; that is, you cannot have vlan10 and vxlan10 for example. Otherwise, the layer 2 VNI does not get created.
- In an MLAG configuration, the SVI used for the layer 3 VNI cannot be part of the bridge. This ensures that traffic tagged with that VLAN ID is not forwarded on the peer link or other trunks.

In an EVPN symmetric routing configuration, when a type-2 (MAC/IP) route is announced, in addition to containing two VNIs (the layer 2 VNI and the layer 3 VNI), the route also contains separate RTs for layer 2 and layer 3. The layer 3 RT associates the route with the tenant VRF. By default, this is auto-derived in a similar way to the layer 2 RT, using the layer 3 VNI instead of the layer 2 VNI; however you can also explicitly configure it.

For EVPN symmetric routing, additional configuration is required:

1. Configure a per-tenant VXLAN interface that specifies the layer 3 VNI for the tenant. This VXLAN interface is part of the bridge and router MAC addresses of remote VTEPs is installed over this interface.
2. Configure an SVI (layer 3 interface) corresponding to the per-tenant VXLAN interface. This is attached to the tenant's VRF. Remote host routes for symmetric routing are installed over this SVI.
3. Specify the mapping of VRF to layer 3 VNI. This configuration is for the BGP control plane.

### VXLAN Interface Corresponding to the Layer 3 VNI

```
cumulus@leaf01:~$ net add vxlan vni104001 vxlan id 104001
cumulus@leaf01:~$ net add vxlan vni104001 bridge access 4001
cumulus@leaf01:~$ net add vxlan vni104001 vxlan local-tunnelip
10.0.0.11
cumulus@leaf01:~$ net add vxlan vni104001 bridge learning off
cumulus@leaf01:~$ net add vxlan vni104001 bridge arp-nd-suppress on
```



```
cumulus@leaf01:~$ net add bridge bridge ports vni104001
cumulus@leaf01:~$ net pending
cumulus@leaf01:~$ net commit
```

The above commands create the following snippet in the `/etc/network/interfaces` file:

```
auto vni104001
iface vni104001
    bridge-access 4001
    bridge-arp-nd-suppress on
    bridge-learning off
    vxlan-id 104001
    vxlan-local-tunnelip 10.0.0.11

auto bridge
iface bridge
    bridge-ports vni104001
    bridge-vlan-aware yes
```

### SVI for the Layer 3 VNI

```
cumulus@leaf01:~$ net add vlan 4001 vrf turtle
cumulus@leaf01:~$ net pending
cumulus@leaf01:~$ net commit
```

These commands create the following snippet in the `/etc/network/interfaces` file:

```
auto vlan4001
iface vlan4001
    vlan-id 4001
    vlan-raw-device bridge
    vrf turtle
```



When two VTEPs are operating in VXLAN active-active mode and performing symmetric routing, you need to configure the router MAC corresponding to each layer 3 VNI to ensure both VTEPs use the same MAC address. Specify the `hwaddress` (MAC address) for the SVI corresponding to the layer 3 VNI. Use the same address on both switches in the MLAG pair. Cumulus Networks recommends you use the MLAG system MAC address.

```
cumulus@leaf01:~$ net add vlan 4001 hwaddress 44:39:39:FF:40:94
```

This command creates the following snippet in the `/etc/network/interfaces` file:



```
auto vlan4001
iface vlan4001
    hwaddress 44:39:39:FF:40:94
    vlan-id 4001
    vlan-raw-device bridge
    vrf turtle
```

### VRF to Layer 3 VNI Mapping

```
cumulus@leaf01:~$ net add vrf turtle vni 104001
cumulus@leaf01:~$ net pending
cumulus@leaf01:~$ net commit
```

These commands create the following configuration snippet in the `/etc/frr/frr.conf` file.

```
vrf turtle
  vni 104001
!
```

### Configure RD and RTs for the Tenant VRF

If you do not want the RD and RTs (layer 3 RTs) for the tenant VRF to be derived automatically, you can configure them manually by specifying them under the `l2vpn evpn` address family for that specific VRF. For example:

```
cumulus@switch:~$ net add bgp vrf tenant1 l2vpn evpn rd 172.16.100.1:20
cumulus@switch:~$ net add bgp vrf tenant1 l2vpn evpn route-target import 65100:20
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands create the following configuration snippet in the `/etc/frr/frr.conf` file:

```
router bgp <as> vrf tenant1
  address-family l2vpn evpn
    rd 172.16.100.1:20
    route-target import 65100:20
```





The tenant VRF RD and RTs are different from the RD and RTs for the layer 2 VNI, which are described in [Auto-derivation of RDs and RTs \(see page 506\)](#) and [User-defined RDs and RTs \(see page 506\)](#), above.

### *Advertise the Locally-attached Subnets*

Symmetric routing presents a problem in the presence of silent hosts. If the ingress VTEP does not have the destination subnet and the host route is not advertised for the destination host, the ingress VTEP cannot route the packet to its destination. This problem can be overcome by having VTEPs announce the subnet prefixes corresponding to their connected subnets in addition to announcing host routes. These routes will be announced as EVPN prefix (type-5) routes.

To advertise locally attached subnets, you must:

1. Enable advertisement of EVPN prefix (type-5) routes. Refer to [Prefix-based Routing — EVPN Type-5 Routes \(see page 519\)](#), below.
2. Ensure that the routes corresponding to the connected subnets are known in the BGP VRF routing table by injecting them using the `network` command or redistributing them using the `redistribute connected` command.



This configuration is recommended only if the deployment is known to have silent hosts. It is also recommended that you enable on only one VTEP per subnet, or two for redundancy.



An earlier version of this chapter referred to the `advertise-subnet` command. That command is deprecated and should not be used.

## **Prefix-based Routing — EVPN Type-5 Routes**

EVPN in Cumulus Linux supports prefix-based routing using EVPN type-5 (prefix) routes. Type-5 routes (or prefix routes) are primarily used to route to destinations outside of the data center fabric.

EVPN prefix routes carry the layer 3 VNI and router MAC address and follow the symmetric routing model for routing to the destination prefix.



When connecting to a WAN edge router to reach destinations outside the data center, it is highly recommended that specific border/exit leaf switches be deployed to originate the type-5 routes.



On switches with the Mellanox Spectrum chipset, centralized routing, symmetric routing and prefix-based routing only function with the Spectrum A1 chip.



If you are using a Broadcom Trident II+ switch as a border/exit leaf, see [caveats \(see page 545\)](#), below for a necessary workaround; the workaround only applies to Trident II+ switches, not Tomahawk or Spectrum.



## Configure the Switch to Install EVPN Type-5 Routes

For a switch to be able to install EVPN type-5 routes into the routing table, it must be configured with the layer 3 VNI related information. This configuration is the same as for symmetric routing. You need to:

1. Configure a per-tenant VXLAN interface that specifies the layer 3 VNI for the tenant. This VXLAN interface is part of the bridge; router MAC addresses of remote VTEPs are installed over this interface.
2. Configure an SVI (layer 3 interface) corresponding to the per-tenant VXLAN interface. This is attached to the tenant's VRF. The remote prefix routes are installed over this SVI.
3. Specify the mapping of the VRF to layer 3 VNI. This configuration is for the BGP control plane.

## Announce EVPN Type-5 Routes

The following configuration is needed in the tenant VRF to announce IP prefixes in BGP's RIB as EVPN type-5 routes.

```
cumulus@bl1:~$ net add bgp vrf vrf1 l2vpn evpn advertise ipv4 unicast
cumulus@bl1:~$ net pending
cumulus@bl1:~$ net commit
```

These commands create the following snippet in the `/etc/frr/frr.conf` file:

```
router bgp 65005 vrf vrf1
  address-family l2vpn evpn
    advertise ipv4 unicast
  exit-address-family
end
```

## EVPN Type-5 Routing with Asymmetric Routing

Asymmetric routing is an ideal choice when all VLANs (subnets) are configured on all leaf switches. It simplifies the routing configuration and eliminates the potential need for advertising subnet routes to handle silent hosts. However, most deployments need access to external networks to reach the Internet or global destinations, or to do subnet-based routing between pods or data centers; this requires EVPN type-5 routes.

Cumulus Linux supports EVPN type-5 routes for prefix-based routing in asymmetric configurations within the pod or data center by providing an option to use the layer 3 VNI only for type-5 routes; type-2 routes (host routes) only use the layer 2 VNI.

The following example commands show how to use the layer 3 VNI for type-5 routes only:

```
cumulus@leaf01:~$ net add vrf turtle vni 104001 prefix-routes-only
cumulus@leaf01:~$ net pending
cumulus@leaf01:~$ net commit
```



These commands create the following snippet in the `/etc/frr/frr.conf` file:

```
vrf turtle
  vni 104001 prefix-routes-only
```

### *Control Which RIB Routes Are Injected into EVPN*

By default, when announcing IP prefixes in the BGP RIB as EVPN type-5 routes, all routes in the BGP RIB are picked for advertisement as EVPN type-5 routes. You can use a route map to allow selective advertisement of routes from the BGP RIB as EVPN type-5 routes.

The following command adds a route map filter to IPv4 EVPN type-5 route advertisement:

```
cumulus@switch:~$ net add bgp vrf turtle 12vpn evpn advertise ipv4
unicast route-map map1
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

### *Originate Default EVPN Type-5 Routes*

Cumulus Linux supports originating EVPN default type-5 routes. The default type-5 route is originated from a border (exit) leaf and advertised to all the other leafs within the pod. Any leaf within the pod follows the default route towards the border leaf for all external traffic (towards the Internet or a different pod).

To originate a default type-5 route in EVPN, you need to execute FRouting commands. The following shows an example:

```
switch(config)# router bgp 650030 vrf vrf1
switch(config-router)# address-family 12vpn evpn
switch(config-router-af)# default-originate ipv4
switch(config-router-af)# default-originate ipv6
switch(config-router-af)# exit
switch(config-router)# exit
switch(config)# exit
switch# write memory
```

## **EVPN Enhancements**

### *Static (Sticky) MAC Addresses*

MAC addresses that are intended to be pinned to a particular VTEP can be provisioned on the VTEP as a static bridge FDB entry. EVPN picks up these MAC addresses and advertises them to peers as remote static MACs. You configure static bridge FDB entries for sticky MACs under the bridge configuration using NCLU:

```
cumulus@switch:~$ net add bridge post-up bridge fdb add 00:11:22:33:  
44:55 dev swp1 vlan 101 master static  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

These commands create the following configuration in the `/etc/network/interfaces` file:

```
auto bridge  
iface bridge  
    bridge-ports swp1 vni10101  
    bridge-vids 101  
    bridge-vlan-aware yes  
    post-up bridge fdb add 00:11:22:33:44:55 dev swp1 vlan 101 master  
static
```



For a bridge in [traditional mode \(see page 427\)](#), you must edit the bridge configuration in the `/etc/network/interfaces` file using a text editor:

```
auto br101  
iface br101  
    bridge-ports swp1.101 vni10101  
    bridge-learning vni10101=off  
    post-up bridge fdb add 00:11:22:33:44:55 dev swp1.101  
master static
```

## *Filter EVPN Routes Based on Type*

In many situations, it is desirable to only exchange EVPN routes of a particular type. For example, a common deployment scenario for large data centers is to sub-divide the data center into multiple pods with full host mobility within a pod but only do prefix-based routing across pods. This can be achieved by only exchanging EVPN type-5 routes across pods.

To filter EVPN routes based on the route-type and allow only certain types of EVPN routes to be advertised in the fabric, use these commands:

```
net add routing route-map <route_map_name> (deny|permit) <1-65535>  
match evpn default-route  
net add routing route-map <route_map_name> (deny|permit) <1-65535>  
match evpn route-type (macip|prefix|multicast)
```

The following example command configures EVPN to advertise type-5 routes only:



```
cumulus@switch:~$ net add routing route-map map1 permit 1 match evpn  
route-type prefix  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

## Advertise SVI IP Addresses

In a typical EVPN deployment, you *reuse* SVI IP addresses on VTEPs across multiple racks. However, if you use *unique* SVI IP addresses across multiple racks and you want the local SVI IP address to be reachable via remote VTEPs, you can enable the `advertise-svi-ip` option. This option advertises the SVI IP/MAC address as a type-2 route and eliminates the need for any flooding over VXLAN to reach the SVI IP from a remote VTEP/rack.

### ⚠ Notes

- The `advertise-svi-ip` option is available in Cumulus Linux 3.7.4 and later.
- When you enable the `advertise-svi-ip` option, the anycast IP/MAC address pair is not advertised. Be sure **not** to enable both the `advertise-svi-ip` option and the `advertise-default-gw` option at the same time. (The `advertise-default-gw` option configures the gateway VTEPs to advertise their IP/MAC address. See [Advertising the Default Gateway \(see page 514\)](#)).

To advertise *all* SVI IP/MAC addresses on the switch, run these commands:

```
cumulus@switch:~$ net add bgp evpn advertise-svi-ip  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

These commands save the configuration in the `/etc/frr/frr.conf` file. For example:

```
cumulus@switch:~$ sudo cat /etc/frr/frr.conf  
...  
address-family l2vpn evpn  
  advertise-svi-ip  
exit-address-family  
...
```

To advertise a *specific* SVI IP/MAC address, run these commands:

```
cumulus@switch:~$ net add bgp evpn vni 10 advertise-svi-ip  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

These commands save the configuration in the `/etc/frr/frr.conf` file. For example:

```
cumulus@switch:~$ sudo cat /etc/frr/frr.conf
...
address-family l2vpn evpn
  vni 10
  advertise-svi-ip
exit-address-family
...
```

## *Extended Mobility*

Cumulus Linux support for host and virtual machine mobility in an EVPN deployment has been enhanced to handle scenarios where the IP to MAC binding for a host or virtual machine changes across the move. This is referred to as *extended mobility*. The simple mobility scenario where a host or virtual machine with a binding of **IP1, MAC1** moves from one rack to another has been supported in previous releases of Cumulus Linux. The EVPN enhancements support additional scenarios where a host or virtual machine with a binding of **IP1, MAC1** moves and takes on a new binding of **IP2, MAC1** or **IP1, MAC2**. The EVPN protocol mechanism to handle extended mobility continues to use the MAC mobility extended community and is the same as the standard mobility procedures. Extended mobility defines how the sequence number in this attribute is computed when binding changes occur.

Extended mobility not only supports virtual machine *moves*, but also a scenario where one virtual machine shuts down and another is provisioned on a different rack that uses the IP address or the MAC address of the previous virtual machine. For example, in an EVPN deployment with OpenStack, where virtual machines for a tenant are provisioned and shut down very dynamically, a new virtual machine can use the same IP address as an earlier virtual machine but with a different MAC address.

The support for extended mobility is enabled by default and does not require any additional configuration.

You can examine the sequence numbers associated with a host or virtual machine MAC address and IP address with NCLU commands. For example:

```
cumulus@switch:~$ net show evpn mac vni 10100 mac 00:02:00:00:00:42
MAC: 00:02:00:00:00:42
  Remote VTEP: 10.0.0.2
  Local Seq: 0 Remote Seq: 3
  Neighbors:
    10.1.1.74 Active
```

```
cumulus@switch:~$ net show evpn arp vni 10100 ip 10.1.1.74
IP: 10.1.1.74
  Type: local
  State: active
  MAC: 44:39:39:ff:00:24
  Local Seq: 2 Remote Seq: 3
```



## Duplicate Address Detection

Cumulus Linux 3.7.2 and later is able to detect duplicate MAC and IPv4/IPv6 addresses on hosts or virtual machines in a VXLAN-EVPN configuration. The Cumulus Linux switch (VTEP) considers a host MAC or IP address to be duplicate if the address moves across the network more than a certain number of times within a certain number of seconds (five moves within 180 seconds by default). In addition to legitimate host or VM mobility scenarios, address movement can occur when IP addresses are misconfigured on hosts or when packet looping occurs in the network due to faulty configuration or behavior.

Duplicate address detection is enabled by default and triggers when:

- Two hosts have the same MAC address (the host IP addresses might be the same or different)
- Two hosts have the same IP address but different MAC addresses

By default, when a duplicate address is detected, Cumulus Linux flags the address as a duplicate and generates an error in syslog so that you can troubleshoot the reason and address the fault, then clear the duplicate address flag. No functional action is taken on the address.



If a MAC address is flagged as a duplicate, all IP addresses associated with that MAC are flagged as duplicates.



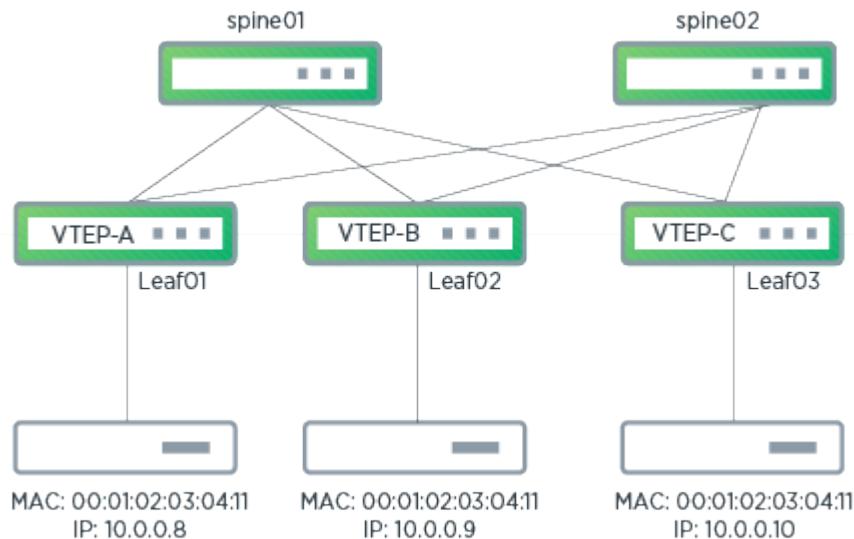
## MLAG Deployments

In an MLAG configuration, duplicate address detection runs independently on each switch in the MLAG pair. Based on the sequence in which local learn and/or route withdrawal from the remote VTEP occurs, an IP address might be flagged as duplicate only on one of the switches in the MLAG pair. In rare cases, neither switch might flag the IP address as a duplicate.

## When Does Duplicate Address Detection Trigger?

The VTEP that sees an address move from remote to local begins the detection process by starting a timer. Each VTEP runs duplicate address detection independently. Detection always starts with the first mobility event from *remote* to *local*. If the address is initially remote, the detection count can start with the very first move for the address. If the address is initially local, the detection count starts only with the second or higher move for the address. If an address is undergoing a mobility event between remote VTEPs, duplicate detection is not started.

The following illustration shows VTEP-A, VTEP-B, and VTEP-C in an EVPN configuration. Duplicate address detection triggers on VTEP-A when there is a duplicate MAC address for two hosts attached to VTEP-A and VTEP-B. However, duplicate detection does *not* trigger on VTEP-A when mobility events occur between two remote VTEPs (VTEP-B and VTEP-C).



### Configure Duplicate Address Detection

To change the threshold for MAC and IP address moves, run the `net add bgp 12vpn evpn dup-addr-detection max-moves <number-of-events> time <duration>` command. You can specify `max-moves` to be between 2 and 1000 and `time` to be between 2 and 1800 seconds.

The following example command sets the maximum number of address moves allowed to 10 and the duplicate address detection time interval to 1200 seconds.

```
cumulus@switch:~$ net add bgp 12vpn evpn dup-addr-detection max-moves 10 time 1200
```

To disable duplicate address detection, see [Disable Duplicate Address Detection \(see page 528\)](#) below.

### Example syslog Messages

The following example shows the syslog message that is generated when Cumulus Linux detects a MAC address as a duplicate during a local update:

```
2018/11/06 18:55:29.463327 ZEBRA: [EC 4043309149] VNI 1001: MAC 00:01:02:03:04:11 detected as duplicate during local update, last VTEP 172.16.0.16
```

The following example shows the syslog message that is generated when Cumulus Linux detects an IP address as a duplicate during a remote update:

```
2018/11/09 22:47:15.071381 ZEBRA: [EC 4043309151] VNI 1002: MAC aa:22:aa:aa:aa:aa IP 10.0.0.9 detected as duplicate during remote update, from VTEP 172.16.0.16
```



## Freeze a Detected Duplicate Address

Cumulus Linux 3.7.3 and later provides a *freeze* option that takes action on a detected duplicate address. You can freeze the address *permanently* (until you intervene) or for a *defined amount of time*, after which it is cleared automatically.

When you enable the *freeze* option and a duplicate address is detected:

- If the MAC or IP address is learned from a remote VTEP at the time it is frozen, the forwarding information in the kernel and hardware is not updated, leaving it in the prior state. Any future remote updates are processed but they are not reflected in the kernel entry. If the remote VTEP sends a MAC-IP route withdrawal, the local VTEP removes the frozen remote entry. Then, if the local VTEP has a locally-learned entry already present in its kernel, FRR will originate a corresponding MAC-IP route and advertise it to all remote VTEPs.
- If the MAC or IP address is locally learned on this VTEP at the time it is frozen, the address is not advertised to remote VTEPs. Future local updates are processed but are not advertised to remote VTEPs. If FRR receives a local entry delete event, the frozen entry is removed from the FRR database. Any remote updates (from other VTEPs) change the state of the entry to remote but the entry is not installed in the kernel (until cleared).

**To recover from a freeze**, shut down the faulty host or VM or fix any other misconfiguration in the network. If the address is frozen *permanently*, issue the [clear command \(see page 528\)](#) on the VTEP where the address is marked as duplicate. If the address is frozen for a defined period of time, it is cleared automatically after the timer expires (you can clear the duplicate address before the timer expires with the [clear command \(see page 528\)](#)).



If you issue the [clear command \(see page 528\)](#) or the timer expires before you address the fault, duplicate address detection might occur repeatedly.

After you clear a frozen address, if it is present behind a remote VTEP, the kernel and hardware forwarding tables are updated. If the address is locally learned on this VTEP, the address is advertised to remote VTEPs. All VTEPs get the correct address as soon as the host communicates. Silent hosts are learned only after the faulty entries age out, or you intervene and clear the faulty MAC and ARP table entries.

### Configure the Freeze Option

To enable Cumulus Linux to *freeze* detected duplicate addresses, run the `net add bgp 12vpn evpn dup-addr-detection freeze <duration>|permanent` command. The duration can be any number of seconds between 30 and 3600.

The following example command freezes duplicate addresses for a period of 1000 seconds, after which it is cleared automatically :

```
cumulus@switch:~$ net add bgp 12vpn evpn dup-addr-detection freeze  
1000
```



### Best Practice

Cumulus Networks recommends you set the freeze timer to be three times the duplicate address detection window. For example, if the duplicate address detection window is set to the default of 180 seconds, set the freeze timer to 540 seconds.

The following example command freezes duplicate addresses permanently (until you issue the [clear command \(see page 528\)](#)):

```
cumulus@switch:~$ net add bgp 12vpn evpn dup-addr-detection freeze  
permanent
```

### *Clear Duplicate Addresses*

To clear a duplicate MAC or IP address (and unfreeze a frozen address), run the `net clear evpn dup-addr vni <vni_id> ip <mac/ip address>` command. The following example command clears IP address 10.0.0.9 for VNI 101.

```
cumulus@switch:~$ net clear evpn dup-addr vni 101 ip 10.0.0.9
```

To clear duplicate addresses for all VNIs, run the following command:

```
cumulus@switch:~$ net clear evpn dup-addr vni all
```



In an MLAG configuration, you need to run the [clear command \(see page 528\)](#) on both the MLAG primary and secondary switch.



When you clear a duplicate MAC address, all its associated IP addresses are also cleared. However, you cannot clear an associated IP address if its MAC address is still in a duplicate state.

### *Disable Duplicate Address Detection*

By default, duplicate address detection is enabled and a syslog error is generated when a duplicate address is detected. To disable duplicate address detection, run the following command.

```
cumulus@switch:~$ net del bgp 12vpn evpn dup-addr-detection
```

When you disable duplicate address detection, Cumulus Linux clears the configuration and all existing duplicate addresses.

### *Show Detected Duplicate Address Information*

During the duplicate address detection process, you can see the start time and current detection count with the `net show evpn mac vni <vni_id> mac <mac_addr>` command. The following command example shows that detection started for MAC address 00:01:02:03:04:11 for VNI 1001 on Tuesday, Nov 6 at 18:55:05 and the number of moves detected is 1.



```
cumulus@switch:~$ net show evpn mac vni 1001 mac 00:01:02:03:04:11
MAC: 00:01:02:03:04:11
  Intf: hostbond3(15) VLAN: 1001
  Local Seq: 1 Remote Seq: 0
  Duplicate detection started at Tue Nov  6 18:55:05 2018, detection
  count 1
  Neighbors:
    10.0.1.26 Active
```

After the duplicate MAC address is cleared, the `net show evpn mac vni <vni_id> mac <mac_addr>` command shows:

```
MAC: 00:01:02:03:04:11
  Remote VTEP: 172.16.0.16
  Local Seq: 13 Remote Seq: 14
  Duplicate, detected at Tue Nov  6 18:55:29 2018
  Neighbors:
    10.0.1.26 Active
```

To display information for a duplicate IP address, run the `net show evpn arp-cache vni <vni_id> ip <ip_addr>` command. The following command example shows information for IP address 10.0.0.9 for VNI 1001.

```
cumulus@switch:~$ net show evpn arp-cache vni 1001 ip 10.0.0.9
IP: 10.0.0.9
  Type: remote
  State: inactive
  MAC: 00:01:02:03:04:11
  Remote VTEP: 10.0.0.34
  Local Seq: 0 Remote Seq: 14
  Duplicate, detected at Tue Nov  6 18:55:29 2018
```

To show a list of MAC addresses detected as duplicate for a specific VNI or for all VNIs, run the `net show evpn mac vni <vni_id|all> duplicate` command. The following example command shows a list of duplicate MAC addresses for VNI 1001:

```
cumulus@switch:~$ net show evpn mac vni 1001 duplicate
Number of MACs (local and remote) known for this VNI: 16
  MAC          Type      Intf/Remote VTEP      VLAN
  aa:bb:cc:dd:ee:ff  local    hostbond3            1001
```

To show a list of IP addresses detected as duplicate for a specific VNI or for all VNIs, run the `net show evpn arp-cache vni <vni_id|all> duplicate` command. The following example command shows a list of duplicate IP addresses for VNI 1001:

```
cumulus@switch:~$ net show evpn arp-cache vni 1001 duplicate
```

Number of ARPs (local and remote) known for this VNI: 20				
IP	Type	State	MAC	Remote
<b>VTEP</b>				
10.0.0.8	local	active	aa:11:aa:aa:aa:aa	
10.0.0.9	local	active	aa:11:aa:aa:aa:aa	
10.10.0.12	remote	active	aa:22:aa:aa:aa:aa	172.16.0.16

To show configured duplicate address detection parameters, run the `net show evpn` command:

```
cumulus@switch:~$ net show evpn
L2 VNIs: 4
L3 VNIs: 2
Advertise gateway mac-ip: No
Duplicate address detection: Enable
  Detection max-moves 7, time 300
  Detection freeze permanent
```

## EVPN Operational Commands

### General Linux Commands Related to EVPN

You can use various `iproute2` commands to examine links, VLAN mappings and the bridge MAC forwarding database known to the Linux kernel. You can also use these commands to examine the neighbor cache and the routing table (for the underlay or for a specific tenant VRF). Some of the key commands are:

- `ip [-d] link show`
- `bridge link show`
- `bridge vlan show`
- `bridge [-s] fdb show`
- `ip neighbor show`
- `ip route show [table <vrf-name>]`

A sample output of `ip -d link show type vxlan` is shown below for one VXLAN interface. Some relevant parameters are the VNI value, the state, the local IP address for the VXLAN tunnel, the UDP port number (4789) and the bridge that the interface is part of (`bridge` in the example below). The output also shows that MAC learning is disabled (`off`) on the VXLAN interface.

```
cumulus@leaf01:~$ ip -d link show type vxlan
9: vni100: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue
  master bridge state UNKNOWN mode DEFAULT group default
    link/ether 72:bc:b4:a3:eb:1e brd ff:ff:ff:ff:ff:ff promiscuity 1
    vxlan id 10100 local 10.0.0.1 srcport 0 0 dstport 4789 nolearning
      ageing 300
    bridge_slave state forwarding priority 8 cost 100 hairpin off
      guard off root_block off fastleave off learning off flood on port_id
      0x8001 port_no 0x1 designated_port 32769 designated_cost 0
```



```
designated_bridge 8000.0:1:0:0:0:11:0 designated_root 8000.0:1:0:0:0:11:0
hold_timer      0.00 message_age_timer     0.00 forward_delay_timer
0.00 topology_change_ack 0 config_pending 0 proxy_arp off
proxy_arp_wifi off mcast_router 1 mcast_fast_leave off mcast_flood on
neigh_suppress on group_fwd_mask 0x0 group_fwd_mask_str 0x0
group_fwd_maskhi 0x0 group_fwd_maskhi_str 0x0 addrgenmode eui64
...
cumulus@leaf01:~$
```

A sample output of `bridge fdb show` is depicted below. Some interesting information from this output includes:

- swp3 and swp4 are access ports with VLAN ID 100. This is mapped to VXLAN interface vni100.
- 00:02:00:00:00:01 is a local host MAC learned on swp3.
- The remote VTEPs which participate in VLAN ID 100 are 10.0.0.3, 10.0.0.4 and 10.0.0.2. This is evident from the FDB entries with a MAC address of 00:00:00:00:00:00. These entries are used for BUM traffic replication.
- 00:02:00:00:00:06 is a remote host MAC reachable over the VXLAN tunnel to 10.0.0.2.

```
cumulus@leaf01:~$ bridge fdb show
00:02:00:00:00:13 dev swp3 master bridge permanent
00:02:00:00:00:01 dev swp3 vlan 100 master bridge
00:02:00:00:00:02 dev swp4 vlan 100 master bridge
72:bc:b4:a3:eb:1e dev vni100 master bridge permanent
00:02:00:00:00:06 dev vni100 vlan 100 offload master bridge
00:00:00:00:00:00 dev vni100 dst 10.0.0.3 self permanent
00:00:00:00:00:00 dev vni100 dst 10.0.0.4 self permanent
00:00:00:00:00:00 dev vni100 dst 10.0.0.2 self permanent
00:02:00:00:00:06 dev vni100 dst 10.0.0.2 self offload
...
```

A sample output of `ip neigh show` is shown below. Some interesting information from this output includes:

- 172.16.120.11 is a locally-attached host on VLAN 100. It is shown twice because of the configuration of the anycast IP/MAC on the switch.
- 172.16.120.42 is a remote host on VLAN 100 and 172.16.130.23 is a remote host on VLAN 200. The MAC address of these hosts can be examined using the `bridge fdb show` command described earlier to determine the VTEPs behind which these hosts are located.

```
cumulus@leaf01:~$ ip neigh show
172.16.120.11 dev vlan100-v0 lladdr 00:02:00:00:00:01 STALE
172.16.120.42 dev vlan100 lladdr 00:02:00:00:00:0e offload REACHABLE
172.16.130.23 dev vlan200 lladdr 00:02:00:00:00:07 offload REACHABLE
172.16.120.11 dev vlan100 lladdr 00:02:00:00:00:01 REACHABLE
...
```

## *General BGP Operational Commands Relevant to EVPN*

The following commands are not unique to EVPN but help troubleshoot connectivity and route propagation. If BGP is used for the underlay routing, you can view a summary of the layer 3 fabric connectivity by running the `net show bgp summary` command:

```
cumulus@leaf01:~$ net show bgp summary
show bgp ipv4 unicast summary
=====
BGP router identifier 10.0.0.1, local AS number 65001 vrf-id 0
BGP table version 9
RIB entries 11, using 1496 bytes of memory
Peers 2, using 42 KiB of memory
Peer groups 1, using 72 bytes of memory

Neighbor          V        AS MsgRcvd MsgSent   TblVer  InQ OutQ Up
/Down State/PfxRcd
s1(swp49s0)      4       65100    43      49        0      0     0 02:04:
00              4
s2(swp49s1)      4       65100    43      49        0      0     0 02:03:
59              4
Total number of neighbors 2

show bgp ipv6 unicast summary
=====
No IPv6 neighbor is configured

show bgp evpn summary
=====
BGP router identifier 10.0.0.1, local AS number 65001 vrf-id 0
BGP table version 0
RIB entries 15, using 2040 bytes of memory
Peers 2, using 42 KiB of memory
Peer groups 1, using 72 bytes of memory

Neighbor          V        AS MsgRcvd MsgSent   TblVer  InQ OutQ Up
/Down State/PfxRcd
s1(swp49s0)      4       65100    43      49        0      0     0 02:04:
00              30
s2(swp49s1)      4       65100    43      49        0      0     0 02:03:
59              30
Total number of neighbors 2
```

You can examine the underlay routing, which determines how remote VTEPs are reached. Run the `net show route` command. Here is some sample output from a leaf switch:

```
cumulus@leaf01:~$ net show route
show ip route
=====
```



```
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, D - SHARP,
       F - PBR,
       > - selected route, * - FIB route

C>* 10.0.0.11/32 is directly connected, lo, 19:48:21
B>* 10.0.0.12/32 [20/0] via fe80::4638:39ff:fe00:54, swp51, 19:48:03
   *                               via fe80::4638:39ff:fe00:25, swp52, 19:48:03
B>* 10.0.0.13/32 [20/0] via fe80::4638:39ff:fe00:54, swp51, 19:48:03
   *                               via fe80::4638:39ff:fe00:25, swp52, 19:48:03
B>* 10.0.0.14/32 [20/0] via fe80::4638:39ff:fe00:54, swp51, 19:48:03
   *                               via fe80::4638:39ff:fe00:25, swp52, 19:48:03
B>* 10.0.0.21/32 [20/0] via fe80::4638:39ff:fe00:54, swp51, 19:48:04
B>* 10.0.0.22/32 [20/0] via fe80::4638:39ff:fe00:25, swp52, 19:48:03
B>* 10.0.0.41/32 [20/0] via fe80::4638:39ff:fe00:54, swp51, 19:48:03
   *                               via fe80::4638:39ff:fe00:25, swp52, 19:48:03
B>* 10.0.0.42/32 [20/0] via fe80::4638:39ff:fe00:54, swp51, 19:48:03
   *                               via fe80::4638:39ff:fe00:25, swp52, 19:48:03
C>* 10.0.0.112/32 is directly connected, lo, 19:48:21
B>* 10.0.0.134/32 [20/0] via fe80::4638:39ff:fe00:54, swp51, 19:48:03
   *                               via fe80::4638:39ff:fe00:25, swp52, 19:48:03
C>* 169.254.1.0/30 is directly connected, peerlink.4094, 19:48:21

show ipv6 route
=====
Codes: K - kernel route, C - connected, S - static, R - RIPng,
       O - OSPFv3, I - IS-IS, B - BGP, N - NHRP, T - Table,
       v - VNC, V - VNC-Direct, A - Babel, D - SHARP, F - PBR,
       > - selected route, * - FIB route
C * fe80::/64 is directly connected, bridge, 19:48:21
C * fe80::/64 is directly connected, peerlink.4094, 19:48:21
C * fe80::/64 is directly connected, swp52, 19:48:21
C>* fe80::/64 is directly connected, swp51, 19:48:21
```

cumulus@leaf01:~\$

You can view the MAC forwarding database on the switch by running the `net show bridge macs` command:

```
cumulus@leaf01:~$ net show bridge macs
VLAN      Master      Interface      MAC                                TunnelDest
State     Flags        LastSeen
-----  -----  -----
-----  -----  -----
100       br0         br0          00:00:5e:00:01:01
permanent
100       br0         br0          00:01:00:00:11:00
permanent
```

```

100      br0      swp3          00:02:00:00:00:
01                  00:00:26
100      br0      swp4          00:02:00:00:00:
02                  00:00:16
100      br0      vni100        00:02:00:00:00:
0a                  offload       1 day, 03:38:20
100      br0      vni100        00:02:00:00:00:
0d                  offload       1 day, 03:38:20
100      br0      vni100        00:02:00:00:00:
0e                  offload       1 day, 03:38:20
100      br0      vni100        00:02:00:00:00:
05                  offload       1 day, 03:38:19
100      br0      vni100        00:02:00:00:00:
06                  offload       1 day, 03:38:19
100      br0      vni100        00:02:00:00:00:
09                  offload       1 day, 03:38:20
200      br0      br0           00:00:5e:00:01:01
permanent          1 day, 03:38:42
200      br0      br0           00:01:00:00:11:00
permanent          1 day, 03:38:43
200      br0      swp5          00:02:00:00:00:
03                  00:00:26
200      br0      swp6          00:02:00:00:00:
04                  00:00:26
200      br0      vni200        00:02:00:00:00:
0b                  offload       1 day, 03:38:20
200      br0      vni200        00:02:00:00:00:
0c                  offload       1 day, 03:38:20
200      br0      vni200        00:02:00:00:00:
0f                  offload       1 day, 03:38:20
200      br0      vni200        00:02:00:00:00:
07                  offload       1 day, 03:38:19
200      br0      vni200        00:02:00:00:00:
08                  offload       1 day, 03:38:19
200      br0      vni200        00:02:00:00:00:
10                  offload       1 day, 03:38:20
4001     br0      br0           00:01:00:00:11:00
permanent          1 day, 03:38:42
4001     br0      vni4001        00:01:00:00:12:
00                  offload       1 day, 03:38:19
4001     br0      vni4001        00:01:00:00:13:
00                  offload       1 day, 03:38:20
4001     br0      vni4001        00:01:00:00:14:
00                  offload       1 day, 03:38:20
untagged          br0           00:00:5e:00:01:01
permanent self    never
untagged          vlan100        00:00:5e:00:01:01
permanent self    never
untagged          vlan200        00:00:5e:00:01:01
permanent self    never
...

```



## Display EVPN address-family Peers

You can see the BGP peers participating in the layer 2 VPN/EVPN address-family and their states using the `net show bgp l2vpn evpn summary` command. The following sample output from a leaf switch shows eBGP peering with two spine switches for exchanging EVPN routes; both peering sessions are in the *established* state.

```
cumulus@leaf01:~$ net show bgp l2vpn evpn summary
BGP router identifier 10.0.0.1, local AS number 65001 vrf-id 0
BGP table version 0
RIB entries 15, using 2280 bytes of memory
Peers 2, using 39 KiB of memory
Peer groups 1, using 64 bytes of memory
Neighbor          V      AS MsgRcvd MsgSent   TblVer  InQ OutQ Up
/Down State/PfxRcd
s1(swp1)        4      65100    103     107       0      0      0
1d02h08m          30
s2(swp2)        4      65100    103     107       0      0      0
1d02h08m          30
Total number of neighbors 2
cumulus@leaf01:~$
```

## Display VNIs in EVPN

Run the `show bgp l2vpn evpn vni` command to display the configured VNIs on a network device participating in BGP EVPN. This command is only relevant on a VTEP. If symmetric routing is configured, this command displays the special layer 3 VNIs that are configured per tenant VRF.

The following example from a leaf switch shows two layer 2 VNIs — 10100 and 10200 — as well as a layer 3 VNI — 104001. For layer 2 VNIs, the number of associated MAC and neighbor entries are shown. The VXLAN interface and VRF corresponding to each VNI are also shown.

```
cumulus@leaf01:~$ net show evpn vni
VNI          Type VxLAN IF           # MACs  # ARPs  # Remote
VTEPs  Tenant VRF
10200    L2   vni200            8      12      3
vrf1
10100    L2   vni100            8      12      3
vrf1
104001   L3   vni4001           3      3      n/a
vrf1
cumulus@leaf01:~$
```

You can examine the EVPN information for a specific VNI in detail. The following output shows details for the layer 2 VNI 10100 as well as for the layer 3 VNI 104001. For the layer 2 VNI, the remote VTEPs which have that VNI are shown. For the layer 3 VNI, the router MAC and associated layer 2 VNIs are shown. The state of the layer 3 VNI depends on the state of its associated VRF as well as the states of its underlying VXLAN interface and SVI.



```
cumulus@leaf01:~$ net show evpn vni 10100
VNI: 10100
Type: L2
Tenant VRF: vrf1
VxLAN interface: vni100
VxLAN ifIndex: 9
Local VTEP IP: 10.0.0.1
Remote VTEPs for this VNI:
  10.0.0.2
  10.0.0.4
  10.0.0.3
Number of MACs (local and remote) known for this VNI: 8
Number of ARPs (IPv4 and IPv6, local and remote) known for this VNI:
12
Advertise-gw-macip: No
cumulus@leaf01:~$
cumulus@leaf01:~$ net show evpn vni 104001
VNI: 104001
Type: L3
Tenant VRF: vrf1
Local Vtep Ip: 10.0.0.1
Vxlan-Intf: vni4001
SVI-If: vlan4001
State: Up
Router MAC: 00:01:00:00:11:00
L2 VNIs: 10100 10200
cumulus@leaf01:~$
```

### Examine Local and Remote MAC Addresses for a VNI in EVPN

Run `net show evpn mac vni <vni>` to examine all local and remote MAC addresses for a VNI. This command is only relevant for a layer 2 VNI:

```
cumulus@leaf01:~$ net show evpn mac vni 10100
Number of MACs (local and remote) known for this VNI: 8
MAC          Type    Intf/Remote VTEP      VLAN
00:02:00:00:00:0e remote 10.0.0.4
00:02:00:00:00:06 remote 10.0.0.2
00:02:00:00:00:05 remote 10.0.0.2
00:02:00:00:00:02 local   swp4           100
00:00:5e:00:01:01 local   vlan100-v0       100
00:02:00:00:00:09 remote 10.0.0.3
00:01:00:00:11:00 local   vlan100           100
00:02:00:00:00:01 local   swp3           100
00:02:00:00:00:0a remote 10.0.0.3
00:02:00:00:00:0d remote 10.0.0.4
cumulus@leaf01:~$
```



Run the `net show evpn mac vni all` command to examine MAC addresses for all VNIs.

You can examine the details for a specific MAC address or query all remote MAC addresses behind a specific VTEP:

```
cumulus@leaf01:~$ net show evpn mac vni 10100 mac 00:02:00:00:00:02
MAC: 00:02:00:00:00:02
  Intf: swp4(6) VLAN: 100
  Local Seq: 0 Remote Seq: 0
  Neighbors:
    172.16.120.12 Active
cumulus@leaf01:~$ net show evpn mac vni 10100 mac 00:02:00:00:00:05
MAC: 00:02:00:00:00:05
  Remote VTEP: 10.0.0.2
  Neighbors:
    172.16.120.21
cumulus@leaf01:~$ net show evpn mac vni 10100 vtep 10.0.0.3
VNI 10100
  MAC          Type   Intf/Remote VTEP      VLAN
  00:02:00:00:00:09  remote 10.0.0.3
  00:02:00:00:00:0a  remote 10.0.0.3
cumulus@leaf01:~$
```

### Examine Local and Remote Neighbors for a VNI in EVPN

Run the `net show evpn arp-cache vni <vni>` command to examine all local and remote neighbors (ARP entries) for a VNI. This command is only relevant for a layer 2 VNI and the output shows both IPv4 and IPv6 neighbor entries:

```
cumulus@leaf01:~$ net show evpn arp-cache vni 10100
Number of ARPs (local and remote) known for this VNI: 12
  IP          Type   MAC           Remote VTEP
  172.16.120.11  local  00:02:00:00:00:01
  172.16.120.12  local  00:02:00:00:00:02
  172.16.120.22  remote 00:02:00:00:00:06 10.0.0.2
  fe80::201:ff:fe00:1100  local  00:01:00:00:11:00
  172.16.120.1    local  00:01:00:00:11:00
  172.16.120.31  remote 00:02:00:00:00:09 10.0.0.3
  fe80::200:5eff:fe00:101 local  00:00:5e:00:01:01
  ...
```

Run the `net show evpn arp-cache vni all` command to examine neighbor entries for all VNIs.

### Examine Remote Router MACs in EVPN

When symmetric routing is deployed, run the `net show evpn rmac vni <vni>` command to examine the router MACs corresponding to all remote VTEPs. This command is only relevant for a layer 3 VNI:

```
cumulus@leaf01:~$ net show evpn rmac vni 104001
Number of Remote RMACs known for this VNI: 3
MAC           Remote VTEP
00:01:00:00:14:00 10.0.0.4
00:01:00:00:12:00 10.0.0.2
00:01:00:00:13:00 10.0.0.3
cumulus@leaf01:~$
```

Run the `net show evpn rmac vni all` command to examine router MACs for all layer 3 VNIs.

### *Examine Gateway Next Hops in EVPN*

When symmetric routing is deployed, you can run the `net show evpn next-hops vni <vnid>` command to examine the gateway next hops. This command is only relevant for a layer 3 VNI. In general, the gateway next hop IP addresses correspond to the remote VTEP IP addresses. Remote host and prefix routes are installed using these next hops:

```
cumulus@leaf01:~$ net show evpn next-hops vni 104001
Number of NH Neighbors known for this VNI: 3
IP           RMAC
10.0.0.3     00:01:00:00:13:00
10.0.0.4     00:01:00:00:14:00
10.0.0.2     00:01:00:00:12:00
cumulus@leaf01:~$
```

Run the `net show evpn next-hops vni all` command to examine gateway next hops for all layer 3 VNIs.

You can query a specific next hop; the output displays the remote host and prefix routes through this next hop:

```
cumulus@leaf01:~$ net show evpn next-hops vni 104001 ip 10.0.0.4
Ip: 10.0.0.4
  RMAC: 00:01:00:00:14:00
  Refcount: 4
  Prefixes:
    172.16.120.41/32
    172.16.120.42/32
    172.16.130.43/32
    172.16.130.44/32
cumulus@leaf01:~$
```

### *Display the VRF Routing Table in FRR*

Run the `net show route vrf <vrf-name>` command to examine the VRF routing table. This command is not specific to EVPN. In the context of EVPN, this command is relevant when symmetric routing is deployed and can be used to verify that remote host and prefix routes are installed in the VRF routing table and point to the appropriate gateway next hop.



```
cumulus@leaf01:~$ net show route vrf vrf1
show ip route vrf vrf1
=====
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, P - PIM, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel,
       > - selected route, * - FIB route

VRF vrf1:
K * 0.0.0.0/0 [255/8192] unreachable (ICMP unreachable), 1d02h42m
C * 172.16.120.0/24 is directly connected, vlan100-v0, 1d02h42m
C>* 172.16.120.0/24 is directly connected, vlan100, 1d02h42m
B>* 172.16.120.21/32 [20/0] via 10.0.0.2, vlan4001 onlink, 1d02h41m
B>* 172.16.120.22/32 [20/0] via 10.0.0.2, vlan4001 onlink, 1d02h41m
B>* 172.16.120.31/32 [20/0] via 10.0.0.3, vlan4001 onlink, 1d02h41m
B>* 172.16.120.32/32 [20/0] via 10.0.0.3, vlan4001 onlink, 1d02h41m
B>* 172.16.120.41/32 [20/0] via 10.0.0.4, vlan4001 onlink, 1d02h41m
...
...
```

In the output above, the next hops for these routes are specified by EVPN to be *onlink*, or reachable over the specified SVI. This is necessary because this interface is not required to have an IP address. Even if the interface is configured with an IP address, the next hop is not on the same subnet as it is usually the IP address of the remote VTEP (part of the underlay IP network).

### Display the Global BGP EVPN Routing Table

Run the `net show bgp 12vpn evpn route` command to display all EVPN routes, both local and remote. The routes displayed here are based on RD as they are across VNIs and VRFs:

```
cumulus@leaf01:~$ net show bgp 12vpn evpn route
BGP table version is 0, local router ID is 10.0.0.1
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal
Origin codes: i - IGP, e - EGP, ? - incomplete
EVPN type-2 prefix: [2]:[ESI]:[EthTag]:[MAClen]:[MAC]
EVPN type-3 prefix: [3]:[EthTag]:[IPlen]:[OrigIP]
      Network          Next Hop          Metric LocPrf Weight Path
Route Distinguisher: 10.0.0.1:1
*> [2]:[0]:[0]:[48]:[00:02:00:00:00:01]
              10.0.0.1                  32768 i
*> [2]:[0]:[0]:[48]:[00:02:00:00:00:01]:[32]:[172.16.120.11]
              10.0.0.1                  32768 i
*> [2]:[0]:[0]:[48]:[00:02:00:00:00:01]:[128]:[2001:172:16:120::11]
              10.0.0.1                  32768 i
*> [2]:[0]:[0]:[48]:[00:02:00:00:00:02]
              10.0.0.1                  32768 i
*> [2]:[0]:[0]:[48]:[00:02:00:00:00:02]:[32]:[172.16.120.12]
              10.0.0.1                  32768 i
*> [3]:[0]:[32]:[10.0.0.1]
              10.0.0.1                  32768 i
```

```

Route Distinguisher: 10.0.0.1:2
*> [2]:[0]:[0]:[48]:[00:02:00:00:00:01]
    10.0.0.1                      32768 i
*> [2]:[0]:[0]:[48]:[00:02:00:00:00:01]:[32]:[172.16.130.11]
    10.0.0.1                      32768 i
*> [2]:[0]:[0]:[48]:[00:02:00:00:00:02]
    10.0.0.1                      32768 i
*> [2]:[0]:[0]:[48]:[00:02:00:00:00:02]:[32]:[172.16.130.12]
    10.0.0.1                      32768 i
*> [3]:[0]:[32]:[10.0.0.1]
    10.0.0.1                      32768 i
...

```

You can filter the routing table based on EVPN route type. The available options are shown below:

```

cumulus@leaf01:~$ net show bgp 12vpn evpn route type
  macip      : MAC-IP (Type-2) route
  multicast   : Multicast
  prefix      : An IPv4 or IPv6 prefix
cumulus@leaf01:~$
```

### *Display a Specific EVPN Route*

To drill down on a specific route for more information, run the `net show bgp 12vpn evpn route rd <rd-value>` command. This command displays all EVPN routes with that RD and with the path attribute details for each path. Additional filtering is possible based on route type or by specifying the MAC and/or IP address. The following example shows a specific MAC/IP route. The output shows that this remote host is behind VTEP 10.0.0.4 and is reachable through two paths; one through either spine switch. This example is from a symmetric routing deployment, so the route shows both the layer 2 VNI (10200) and the layer 3 VNI (104001) as well as the EVPN route target attributes corresponding to each and the associated router MAC address.

```

cumulus@leaf01:~$ net show bgp 12vpn evpn route rd 10.0.0.4:3 mac 00:
02:00:00:00:10 ip 172.16.130.44
BGP routing table entry for 10.0.0.4:3:[2]:[0]:[0]:[48]:[00:02:00:00:
00:10]:[32]:[172.16.130.44]
Paths: (2 available, best #2)
  Advertised to non peer-group peers:
    s1(swp1) s2(swp2)
  Route [2]:[0]:[0]:[48]:[00:02:00:00:00:10]:[32]:[172.16.130.44] VNI
  10200/104001
  65100 65004
    10.0.0.4 from s2(swp2) (172.16.110.2)
      Origin IGP, localpref 100, valid, external
      Extended Community: RT:65004:10200 RT:65004:104001 ET:8 Rmac:00:
  01:00:00:14:00
      AddPath ID: RX 0, TX 97
      Last update: Sun Dec 17 20:57:24 2017

```



```
Route [2]:[0]:[0]:[48]:[00:02:00:00:00:10]:[32]:[172.16.130.44] VNI  
10200/104001  
65100 65004  
    10.0.0.4 from s1(swp1) (172.16.110.1)  
        Origin IGP, localpref 100, valid, external, bestpath-from-AS  
65100, best  
        Extended Community: RT:65004:10200 RT:65004:104001 ET:8 Rmac:00:  
01:00:00:14:00  
            AddPath ID: RX 0, TX 71  
            Last update: Sun Dec 17 20:57:23 2017  
  
Displayed 2 paths for requested prefix  
cumulus@leaf01:~$
```



- Only global VNIs are supported. Even though VNI values are exchanged in the type-2 and type-5 routes, the received values are not used when installing the routes into the forwarding plane; the local configuration is used. You must ensure that the VLAN to VNI mappings and the layer 3 VNI assignment for a tenant VRF are uniform throughout the network.
- If the remote host is dual attached, the next hop for the EVPN route is the anycast IP address of the remote [MLAG](#) (see page 440) pair, when MLAG is active.

The following example shows a prefix (type-5) route. Such a route has only the layer 3 VNI and the route target corresponding to this VNI. This route is learned through two paths, one through each spine switch.

```
cumulus@leaf01:~$ net show bgp 12vpn evpn route rd 172.16.100.2:3  
type prefix  
EVPN type-2 prefix: [2]:[ESI]:[EthTag]:[MAClen]:[MAC]  
EVPN type-3 prefix: [3]:[EthTag]:[IPlen]:[OrigIP]  
EVPN type-5 prefix: [5]:[EthTag]:[IPlen]:[IP]  
BGP routing table entry for 172.16.100.2:3:[5]:[0]:[30]:[172.16.100.0]  
Paths: (2 available, best #2)  
    Advertised to non peer-group peers:  
        s1(swp1) s2(swp2)  
Route [5]:[0]:[30]:[172.16.100.0] VNI 104001  
65100 65050  
    10.0.0.5 from s2(swp2) (172.16.110.2)  
        Origin incomplete, localpref 100, valid, external  
        Extended Community: RT:65050:104001 ET:8 Rmac:00:01:00:00:01:00  
        AddPath ID: RX 0, TX 112  
        Last update: Tue Dec 19 00:12:18 2017  
Route [5]:[0]:[30]:[172.16.100.0] VNI 104001  
65100 65050  
    10.0.0.5 from s1(swp1) (172.16.110.1)  
        Origin incomplete, localpref 100, valid, external, bestpath-  
from-AS 65100, best  
        Extended Community: RT:65050:104001 ET:8 Rmac:00:01:00:00:01:00  
        AddPath ID: RX 0, TX 71
```

Last update: Tue Dec 19 00:12:17 2017

```
Displayed 1 prefixes (2 paths) with this RD (of requested type)
cumulus@leaf01:~$
```

### *Display the per-VNI EVPN Routing Table*

Received EVPN routes are maintained in the global EVPN routing table (described above), even if there are no appropriate local VNIs to **import** them into. For example, a spine switch maintains the global EVPN routing table even though there are no VNIs present on it. When local VNIs are present, received EVPN routes are imported into the per-VNI routing tables based on the route target attributes. You can examine the per-VNI routing table with the `net show bgp 12vpn evpn route vni <vnid>` command:

```
cumulus@leaf01:~$ net show bgp 12vpn evpn route vni 10110
BGP table version is 8, local router ID is 10.0.0.1
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal
Origin codes: i - IGP, e - EGP, ? - incomplete
EVPN type-2 prefix: [2]:[ESI]:[EthTag]:[MAClen]:[MAC]:[IPlen]:[IP]
EVPN type-3 prefix: [3]:[EthTag]:[IPlen]:[OrigIP]
      Network          Next Hop            Metric LocPrf Weight Path
*> [2]:[0]:[48]:[00:02:00:00:00:07]
                  10.0.0.1                32768  i
*> [2]:[0]:[48]:[00:02:00:00:00:07]:[32]:[172.16.120.11]
                  10.0.0.1                32768  i
*> [2]:[0]:[48]:[00:02:00:00:00:07]:[128]:[fe80::202:ff:fe00:7]
                  10.0.0.1                32768  i
*> [2]:[0]:[48]:[00:02:00:00:00:08]
                  10.0.0.1                32768  i
*> [2]:[0]:[48]:[00:02:00:00:00:08]:[32]:[172.16.120.12]
                  10.0.0.1                32768  i
*> [2]:[0]:[48]:[00:02:00:00:00:08]:[128]:[fe80::202:ff:fe00:8]
                  10.0.0.1                32768  i
*> [3]:[0]:[32]:[10.0.0.1]
                  10.0.0.1                32768  i
Displayed 7 prefixes (7 paths)
cumulus@leaf01:~$
```

To display the VNI routing table for all VNIs, run the `net show bgp 12vpn evpn route vni all` command.

### *Display the per-VRF BGP Routing Table*

When symmetric routing is deployed, received type-2 and type-5 routes are imported into the VRF routing table (against the corresponding address-family: IPv4 unicast or IPv6 unicast) based on a match on the route target attributes. You can examine BGP's VRF routing table using the `net show bgp vrf <vrf-name> ipv4 unicast` command or the `net show bgp vrf <vrf-name> ipv6 unicast` command.



```
cumulus@leaf01:~$ net show bgp vrf vrf1 ipv4 unicast
BGP table version is 8, local router ID is 172.16.120.250
Status codes: s suppressed, d damped, h history, * valid, > best, =
multipath,
                i internal, r RIB-failure, S Stale, R Removed
Origin codes: i - IGP, e - EGP, ? - incomplete
      Network          Next Hop            Metric LocPrf Weight Path
* 172.16.120.21/32    10.0.0.2                    0 65100
65002 i
*>                      10.0.0.2                    0 65100
65002 i
* 172.16.120.22/32    10.0.0.2                    0 65100
65002 i
*>                      10.0.0.2                    0 65100
65002 i
* 172.16.120.31/32    10.0.0.3                    0 65100
65003 i
*>                      10.0.0.3                    0 65100
65003 i
* 172.16.120.32/32    10.0.0.3                    0 65100
65003 i
*>                      10.0.0.3                    0 65100
65003 i
* 172.16.120.41/32    10.0.0.4                    0 65100
65004 i
*>                      10.0.0.4                    0 65100
65004 i
* 172.16.120.42/32    10.0.0.4                    0 65100
65004 i
*>                      10.0.0.4                    0 65100
65004 i
* 172.16.100.0/24     10.0.0.5                    0 65100
65050 ?
*>                      10.0.0.5                    0 65100
65050 ?
* 172.16.100.0/24     10.0.0.6                    0 65100
65050 ?
*>                      10.0.0.6                    0 65100
65050 ?
Displayed 8 routes and 16 total paths
cumulus@leaf01:~$
```

## Examine MAC Moves

The first time a MAC moves from behind one VTEP to behind another, BGP associates a MAC Mobility (MM) extended community attribute of sequence number 1, with the type-2 route for that MAC. From there, each time this MAC moves to a new VTEP, the MM sequence number increments by 1. You can examine the MM sequence number associated with a MAC's type-2 route with the `net show bgp 12vpn evpn route vni <vni> mac <mac>` command. The sample output below shows the type-2 route for a MAC that has moved three times:



```
cumulus@switch:~$ net show bgp 12vpn evpn route vni 10109 mac 00:02:  
22:22:22:02  
BGP routing table entry for [2]:[0]:[0]:[48]:[00:02:22:22:22:02]  
Paths: (1 available, best #1)  
Not advertised to any peer  
Route [2]:[0]:[0]:[48]:[00:02:22:22:22:02] VNI 10109  
Local  
6.0.0.184 from 0.0.0.0 (6.0.0.184)  
Origin IGP, localpref 100, weight 32768, valid, sourced, local,  
bestpath-from-AS Local, best  
Extended Community: RT:650184:10109 ET:8 MM:3  
AddPath ID: RX 0, TX 10350121  
Last update: Tue Feb 14 18:40:37 2017  
  
Displayed 1 paths for requested prefix
```

### Examine Sticky MAC Addresses

You can identify static or *sticky* MACs in EVPN by the presence of `MM:0`, `sticky MAC` in the Extended Community line of the output from `net show bgp 12vpn evpn route vni <vni> mac <mac>`:

```
cumulus@switch:~$ net show bgp 12vpn evpn route vni 10101 mac 00:02:  
00:00:00:01  
BGP routing table entry for [2]:[0]:[0]:[48]:[00:02:00:00:00:01]  
Paths: (1 available, best #1)  
Not advertised to any peer  
Route [2]:[0]:[0]:[48]:[00:02:00:00:00:01] VNI 10101  
Local  
172.16.130.18 from 0.0.0.0 (172.16.130.18)  
Origin IGP, localpref 100, weight 32768, valid, sourced, local,  
bestpath-from-AS Local, best  
Extended Community: ET:8 RT:60176:10101 MM:0, sticky MAC  
AddPath ID: RX 0, TX 46  
Last update: Tue Apr 11 21:44:02 2017  
  
Displayed 1 paths for requested prefix
```

## Troubleshooting

To troubleshoot EVPN, enable FRR debug logs. The relevant debug options are as follows:

- `debug zebra vxlan` traces VNI addition and deletion (local and remote) as well as MAC and neighbor addition and deletion (local and remote).
- `debug zebra kernel` traces actual netlink messages exchanged with the kernel, which includes everything, not just EVPN.
- `debug bgp updates` traces BGP update exchanges, including all updates. Output is extended to show EVPN specific information.



- `debug bgp zebra` traces interactions between BGP and zebra for EVPN (and other) routes.

## Caveats

The following caveats apply to EVPN in this version of Cumulus Linux:

- When EVPN is enabled on a switch (VTEP), all locally defined VNIs on that switch and other information (such as MAC addresses) pertaining to them are advertised to EVPN peers. There is no provision to only announce certain VNIs.
- In a [VXLAN active-active \(see page 633\)](#) configuration, ARPs are sometimes *not* suppressed even if ARP suppression is enabled. This is because the neighbor entries are not synchronized between the two switches operating in active-active mode by a control plane. This has no impact on forwarding.
- You must configure the overlay (tenants) in a specific VRF(s) and separate from the underlay, which resides in the default VRF. A layer 3 VNI mapping for the default VRF is not supported.
- On the Broadcom Trident II+, Trident 3, and Maverick-based switch, when a lookup is done after VXLAN decapsulation on the external-facing switch (exit/border leaf), the switch does not rewrite the MAC addresses or TTL; for through traffic, packets are dropped by the next hop instead of correctly routing from a VXLAN overlay network into a non-VXLAN external network (such as the Internet). This applies to all forms of VXLAN routing (centralized, asymmetric and symmetric) and affects all traffic from VXLAN overlay hosts that need to be routed after VXLAN decapsulation on an exit /border leaf, including traffic destined to external networks (through traffic) and traffic destined to the exit leaf SVI address.

To work around this issue, modify the external-facing interface for each VLAN sub-interface on the exit leaf by creating a temporary VNI and associating it with the existing VLAN ID.

For example, if the expected interface configuration is:

```
auto swp3.2001
iface swp3.2001
    vrf vrf1
    address 10.0.0.2/24
# where swp3 is the external facing port and swp3.2001 is the
VLAN sub-interface

auto bridge
iface bridge
    bridge-vlan-aware yes
    bridge ports vx-4001
    bridge-vids 4001

auto vx-4001
iface vx-4001
    vxlan-id 4001
    <... usual vxlan config ...>
    bridge-access 4001
# where vniid 4001 represents the L3 VNI

auto vlan4001
iface vlan4001
    vlan-id 4001
    vlan-raw-device bridge
```



```
vrf vrf1
```

Modify the configuration as follows:

```
auto swp3
iface swp3
    bridge-access 2001
# associate the port (swp3) with bridge 2001

auto bridge
iface bridge
    bridge-vlan-aware yes
    bridge ports swp3 vx-4001 vx-16000000
    bridge-vids 2001
# where vx-4001 is the existing VNI and vx-16000000 is a new
temporary VNI
# this is now bridging the port (swp3), the VNI (vx-4001),
# and the new temporary VNI (vx-16000000)
# the bridge VLAN ID is now 2001

auto vlan2001
iface vlan2001
    vlan-id 2001
    vrf vrf1
    address 10.0.0.2/24
    vlan-raw-device bridge
# create a VLAN 2001 with the associated VRF and IP address

auto vx-16000000
iface vx-16000000
    vxlan-id 16000000
    bridge-access 2001
    <... usual vxlan config ...>
# associate the temporary VNI (vx-16000000) with bridge 2001

auto vx-4001
iface vx-4001
    vxlan-id 4001
    <... usual vxlan config ...>
    bridge-access 4001
# where vnid 4001 represents the L3 VNI

auto vlan4001
iface vlan4001
    vlan-id 4001
    vlan-raw-device bridge
    vrf vrf1
```

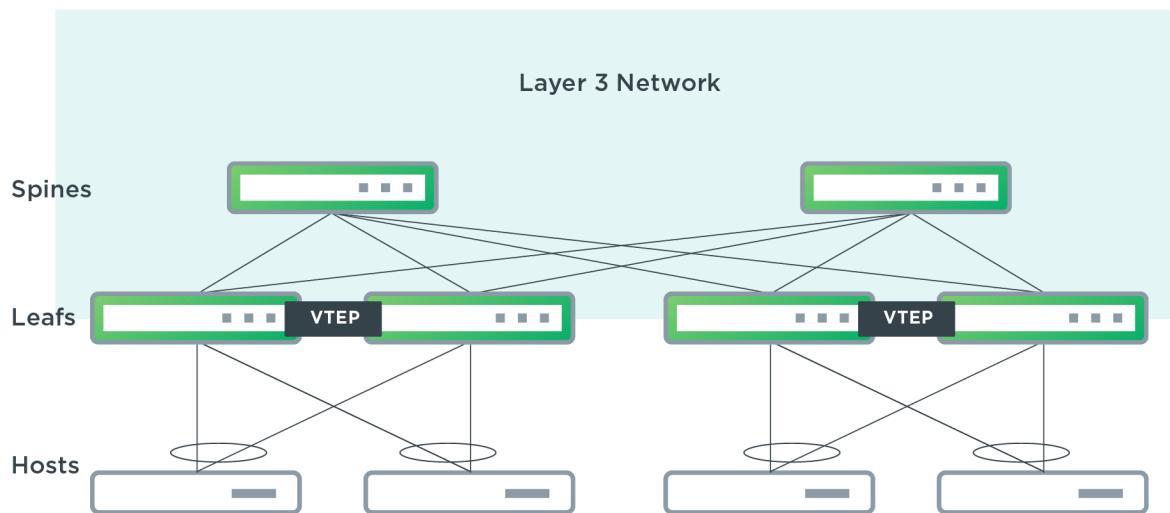
If an MLAG pair is used instead of a single exit/border leaf, add the same temporary VNIs on both switches of the MLAG pair.

## Example Configurations

- Basic Clos (4x2) for bridging
- Clos with MLAG and centralized routing
- Clos with MLAG and asymmetric routing
- Basic Clos with symmetric routing and exit leafs

### *Basic Clos (4x2) for Bridging*

The following example configuration shows a basic Clos topology for bridging.



*leaf01 and leaf02 Configurations*
**leaf01 /etc/network/interfaces**

```
cumulus@leaf01:~$ cat /etc
/network/interfaces
# This file describes the
network interfaces available
on your system
# and how to activate them.
For more information, see
interfaces(5)
# The primary network interface
auto eth0
iface eth0 inet dhcp
# Include any platform-
specific interface
configuration
#source /etc/network
/interfaces.d/*.if
auto lo
iface lo
    address 10.0.0.7/32
    alias BGP un-numbered Use
for Vxlan Src Tunnel
    clagd-vxlan-anycast-ip
172.16.100.7
auto uplink-1
iface uplink-1
    bond-slaves swp1 swp2
    mtu 920
auto uplink-2
iface uplink-2
    bond-slaves swp3 swp4
    mtu 9202
auto peerlink-3
iface peerlink-3
    bond-slaves swp5 swp6
    mtu 9202
auto peerlink-3.4094
iface peerlink-3.4094
    address 169.254.0.9/30
    mtu 9202
    clagd-priority 4096
    clagd-sys-mac 44:38:39:ff:
ff:01
    clagd-peer-ip 169.254.0.10
```

**leaf02 /etc/network/interfaces**

```
cumulus@leaf02:~$ cat /etc
/network/interfaces
# This file describes the
network interfaces available
on your system
# and how to activate them.
For more information, see
interfaces(5)
# The primary network interface
auto eth0
iface eth0 inet dhcp
# Include any platform-
specific interface
configuration
#source /etc/network
/interfaces.d/*.if
auto lo
iface lo
    address 10.0.0.8/32
    alias BGP un-numbered Use
for Vxlan Src Tunnel
    clagd-vxlan-anycast-ip
172.16.100.7
auto uplink-1
iface uplink-1
    bond-slaves swp1 swp2
    mtu 9202
auto uplink-2
iface uplink-2
    bond-slaves swp3 swp4
    mtu 9202
auto peerlink-3
iface peerlink-3
    bond-slaves swp5 swp6
    mtu 9202
auto peerlink-3.4094
iface peerlink-3.4094
    address 169.254.0.10/30
    mtu 9202
    clagd-priority 8192
    clagd-sys-mac 44:38:39:ff:
ff:01
    clagd-peer-ip 169.254.0.9
```



```
# post-up sysctl -w net.
ipv4.conf.peerlink-3/4094.
accept_local=1
    clagd-backup-ip 10.0.0.8
auto hostbond4
iface hostbond4
    bond-slaves swp7
    mtu 9152
    clag-id 1
    bridge-pvid 1000
auto hostbond5
iface hostbond5
    bond-slaves swp8
    mtu 9152
    clag-id 2
    bridge-pvid 1001
auto vx-101000
iface vx-101000
    vxlan-id 101000
    bridge-access 1000
    vxlan-local-tunnelip
10.0.0.7
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpcctl-portbpdufilter yes
    mstpcctl-bpduguard yes
    mtu 9152
auto vx-101001
iface vx-101001
    vxlan-id 101001
    bridge-access 1001
    vxlan-local-tunnelip
10.0.0.7
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpcctl-portbpdufilter yes
    mstpcctl-bpduguard yes
    mtu 9152
auto VxLanA-1
iface VxLanA-1
    bridge-vlan-aware yes
    bridge-ports vx-101000 vx-
101001 peerlink-3 hostbond4
hostbond5
    bridge-stp on
    bridge-vids 1000-1001
    bridge-pvid 1
auto vlan1
iface vlan1
    vlan-id 1
    vlan-raw-device VxLanA-1
```

```
# post-up sysctl -w net.
ipv4.conf.peerlink-3/4094.
accept_local=1
    clagd-backup-ip 10.0.0.7
auto hostbond4
iface hostbond4
    bond-slaves swp7
    mtu 9152
    clag-id 1
    bridge-pvid 1000
auto hostbond5
iface hostbond5
    bond-slaves swp8
    mtu 9152
    clag-id 2
    bridge-pvid 1001
auto vx-101000
iface vx-101000
    vxlan-id 101000
    bridge-access 1000
    vxlan-local-tunnelip
10.0.0.8
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpcctl-portbpdufilter yes
    mstpcctl-bpduguard yes
    mtu 9152
auto vx-101001
iface vx-101001
    vxlan-id 101001
    bridge-access 1001
    vxlan-local-tunnelip
10.0.0.8
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpcctl-portbpdufilter yes
    mstpcctl-bpduguard yes
    mtu 9152
auto VxLanA-1
iface VxLanA-1
    bridge-vlan-aware yes
    bridge-ports vx-101000 vx-
101001 peerlink-3 hostbond4
hostbond5
    bridge-stp on
    bridge-vids 1000-1001
    bridge-pvid 1
auto vlan1
iface vlan1
    vlan-id 1
    vlan-raw-device VxLanA-1
```

```

ip-forward off
auto vlan1000
iface vlan1000
    vlan-id 1000
    vlan-raw-device VxLanA-1
    ip-forward off
auto vlan1001
iface vlan1001
    vlan-id 1001
    vlan-raw-device VxLanA-1
    ip-forward off

```

```

ip-forward off
auto vlan1000
iface vlan1000
    vlan-id 1000
    vlan-raw-device VxLanA-1
    ip-forward off
auto vlan1001
iface vlan1001
    vlan-id 1001
    vlan-raw-device VxLanA-1
    ip-forward off

```

#### **leaf01 /etc/frr/frr.conf**

```

cumulus@leaf01:~$ cat /etc/frr
/frr.conf
log file /var/log/frr/bgpd.log
!
log timestamp precision 6
!
interface peerlink-3.4094
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
interface uplink-1
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
interface uplink-2
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
router bgp 65542
    bgp router-id 10.0.0.7
    coalesce-time 1000
    bgp bestpath as-path
multipath-relax
    neighbor peerlink-3.4094
interface v6only remote-as
external
    neighbor uplink-1 interface
v6only remote-as external
    neighbor uplink-2 interface
v6only remote-as external
!
address-family ipv4 unicast
    redistribute connected
exit-address-family

```

#### **leaf02 /etc/frr/frr.conf**

```

cumulus@leaf02:~$ cat /etc/frr
/frr.conf
log file /var/log/frr/bgpd.log
!
log timestamp precision 6
!
interface peerlink-3.4094
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
interface uplink-1
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
interface uplink-2
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
router bgp 65543
    bgp router-id 10.0.0.8
    coalesce-time 1000
    bgp bestpath as-path
multipath-relax
    neighbor peerlink-3.4094
interface v6only remote-as
external
    neighbor uplink-1 interface
v6only remote-as external
    neighbor uplink-2 interface
v6only remote-as external
!
address-family ipv4 unicast
    redistribute connected
exit-address-family

```

```
!
address-family ipv6 unicast
 redistribute connected
 neighbor peerlink-3.4094
activate
 neighbor uplink-1 activate
 neighbor uplink-2 activate
exit-address-family
!
address-family l2vpn evpn
 neighbor uplink-1 activate
 neighbor uplink-2 activate
 advertise-all-vni
exit-address-family
!
line vty
 exec-timeout 0 0
!
```

```
!
address-family ipv6 unicast
 redistribute connected
 neighbor peerlink-3.4094
activate
 neighbor uplink-1 activate
 neighbor uplink-2 activate
exit-address-family
!
address-family l2vpn evpn
 neighbor uplink-1 activate
 neighbor uplink-2 activate
 advertise-all-vni
exit-address-family
!
line vty
 exec-timeout 0 0
!
```

*leaf03 and leaf04 Configurations*
**leaf03 /etc/network/interfaces**

```
cumulus@leaf03:~$ cat /etc
/network/interfaces
# This file describes the
network interfaces available
on your system
# and how to activate them.
For more information, see
interfaces(5)
# The primary network interface
auto eth0
iface eth0 inet dhcp
# Include any platform-
specific interface
configuration
#source /etc/network
/interfaces.d/*.if
auto lo
iface lo
    address 10.0.0.9/32
    alias BGP un-numbered Use
for Vxlan Src Tunnel
    clagd-vxlan-anycast-ip
172.16.100.9
auto uplink-1
iface uplink-1
    bond-slaves swp1 swp2
    mtu 9202
auto uplink-2
iface uplink-2
    bond-slaves swp3 swp4
    mtu 9202
auto peerlink-3
iface peerlink-3
    bond-slaves swp5 swp6
    mtu 9202
auto peerlink-3.4094
iface peerlink-3.4094
    address 169.254.0.9/30
    mtu 9202
    alias clag and vxlan
communication primary path
    clagd-priority 4096
    clagd-sys-mac 44:38:39:ff:
ff:02
```

**leaf04 /etc/network/interfaces**

```
cumulus@leaf04:~$ cat /etc
/network/interfaces
# This file describes the
network interfaces available
on your system
# and how to activate them.
For more information, see
interfaces(5)
# The primary network interface
auto eth0
iface eth0 inet dhcp
# Include any platform-
specific interface
configuration
#source /etc/network
/interfaces.d/*.if
auto lo
iface lo
    address 10.0.0.10/32
    alias BGP un-numbered Use
for Vxlan Src Tunnel
    clagd-vxlan-anycast-ip
172.16.100.9
auto uplink-1
iface uplink-1
    bond-slaves swp1 swp2
    mtu 9202
auto uplink-2
iface uplink-2
    bond-slaves swp3 swp4
    mtu 9202
auto peerlink-3
iface peerlink-3
    bond-slaves swp5 swp6
    mtu 9202
auto peerlink-3.4094
iface peerlink-3.4094
    address 169.254.0.10/30
    mtu 9202
    alias clag and vxlan
communication primary path
    clagd-priority 8192
    clagd-sys-mac 44:38:39:ff:
ff:02
```



```
    clagd-peer-ip 169.254.0.10
        # post-up sysctl -w net.
    ipv4.conf.peerlink-3/4094.
    accept_local=1
        clagd-backup-ip 10.0.0.10
    auto hostbond4
    iface hostbond4
        bond-slaves swp7
        mtu 9152
        clag-id 1
        bridge-pvid 1000
    auto hostbond5
    iface hostbond5
        bond-slaves swp8
        mtu 9152
        clag-id 2
        bridge-pvid 1001
    auto vx-101000
    iface vx-101000
        vxlan-id 101000
        bridge-access 1000
        vxlan-local-tunnelip
10.0.0.9
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpcctl-portbpdufilter yes
    mstpcctl-bpduguard yes
    mtu 9152
    auto vx-101001
    iface vx-101001
        vxlan-id 101001
        bridge-access 1001
        vxlan-local-tunnelip
10.0.0.9
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpcctl-portbpdufilter yes
    mstpcctl-bpduguard yes
    mtu 9152
    auto VxLanA-1
    iface VxLanA-1
        bridge-vlan-aware yes
        bridge-ports vx-101000 vx-101001 peerlink-3 hostbond4
    hostbond5
        bridge-stp on
        bridge-vids 1000-1001
        bridge-pvid 1
    auto vlan1
    iface vlan1
        vlan-id 1
```

```
    clagd-peer-ip 169.254.0.9
        # post-up sysctl -w net.
    ipv4.conf.peerlink-3/4094.
    accept_local=1
        clagd-backup-ip 10.0.0.9
    auto hostbond4
    iface hostbond4
        bond-slaves swp7
        mtu 9152
        clag-id 1
        bridge-pvid 1000
    auto hostbond5
    iface hostbond5
        bond-slaves swp8
        mtu 9152
        clag-id 2
        bridge-pvid 1001
    auto vx-101000
    iface vx-101000
        vxlan-id 101000
        bridge-access 1000
        vxlan-local-tunnelip
10.0.0.10
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpcctl-portbpdufilter yes
    mstpcctl-bpduguard yes
    mtu 9152
    auto vx-101001
    iface vx-101001
        vxlan-id 101001
        bridge-access 1001
        vxlan-local-tunnelip
10.0.0.10
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpcctl-portbpdufilter yes
    mstpcctl-bpduguard yes
    mtu 9152
    auto VxLanA-1
    iface VxLanA-1
        bridge-vlan-aware yes
        bridge-ports vx-101000 vx-101001 peerlink-3 hostbond4
    hostbond5
        bridge-stp on
        bridge-vids 1000-1001
        bridge-pvid 1
    auto vlan1
    iface vlan1
        vlan-id 1
```

```
vlan-raw-device VxLanA-1
  ip-forward off
auto vlan1000
iface vlan1000
  vlan-id 1000
  vlan-raw-device VxLanA-1
  ip-forward off
auto vlan1001
iface vlan1001
  vlan-id 1001
  vlan-raw-device VxLanA-1
  ip-forward off
```

```
vlan-raw-device VxLanA-1
  ip-forward off
auto vlan1000
iface vlan1000
  vlan-id 1000
  vlan-raw-device VxLanA-1
  ip-forward off
auto vlan1001
iface vlan1001
  vlan-id 1001
  vlan-raw-device VxLanA-1
  ip-forward off
```

**leaf03 /etc/frr/frr.conf**

```
cumulus@leaf03:~$ cat /etc/frr
/frr.conf
log file /var/log/frr/bgpd.log
!
log timestamp precision 6
!
interface peerlink-3.4094
  ipv6 nd ra-interval 10
  no ipv6 nd suppress-ra
!
interface uplink-1
  ipv6 nd ra-interval 10
  no ipv6 nd suppress-ra
!
interface uplink-2
  ipv6 nd ra-interval 10
  no ipv6 nd suppress-ra
!
router bgp 65544
  bgp router-id 10.0.0.9
  coalesce-time 1000
  bgp bestpath as-path
  multipath-relax
    neighbor peerlink-3.4094
  interface v6only remote-as
  external
    neighbor uplink-1 interface
    v6only remote-as external
    neighbor uplink-2 interface
    v6only remote-as external
  !
  address-family ipv4 unicast
  redistribute connected
```

**leaf04 /etc/frr/frr.conf**

```
cumulus@leaf04:~$ cat /etc/frr
/frr.conf
log file /var/log/frr/bgpd.log
!
log timestamp precision 6
!
interface peerlink-3.4094
  ipv6 nd ra-interval 10
  no ipv6 nd suppress-ra
!
interface uplink-1
  ipv6 nd ra-interval 10
  no ipv6 nd suppress-ra
!
interface uplink-2
  ipv6 nd ra-interval 10
  no ipv6 nd suppress-ra
!
router bgp 65545
  bgp router-id 10.0.0.10
  coalesce-time 1000
  bgp bestpath as-path
  multipath-relax
    neighbor peerlink-3.4094
  interface v6only remote-as
  external
    neighbor uplink-1 interface
    v6only remote-as external
    neighbor uplink-2 interface
    v6only remote-as external
  !
  address-family ipv4 unicast
  redistribute connected
```

```
exit-address-family
!
address-family ipv6 unicast
  redistribute connected
    neighbor peerlink-3.4094
  activate
    neighbor uplink-1 activate
    neighbor uplink-2 activate
  exit-address-family
!
address-family l2vpn evpn
  neighbor uplink-1 activate
  neighbor uplink-2 activate
  advertise-all-vni
  exit-address-family
!
line vty
  exec-timeout 0 0
!
```

```
exit-address-family
!
address-family ipv6 unicast
  redistribute connected
    neighbor peerlink-3.4094
  activate
    neighbor uplink-1 activate
    neighbor uplink-2 activate
  exit-address-family
!
address-family l2vpn evpn
  neighbor uplink-1 activate
  neighbor uplink-2 activate
  advertise-all-vni
  exit-address-family
!
line vty
  exec-timeout 0 0
!
```

*spine01 and spine02 Configurations*
**spine01 /etc/network/interfaces**

```
cumulus@spine01:~$ cat /etc
/network/interfaces
# This file describes the
network interfaces available
on your system
# and how to activate them.
For more information, see
interfaces(5)
# The primary network interface
auto eth0
iface eth0 inet dhcp
# Include any platform-
specific interface
configuration
#source /etc/network
/interfaces.d/*.if
auto lo
iface lo
    address 10.0.0.5/32
    alias BGP un-numbered Use
for Vxlan Src Tunnel
auto downlink-1
iface downlink-1
    bond-slaves swp1 swp2
    mtu 9202
auto downlink-2
iface downlink-2
    bond-slaves swp3 swp4
    mtu 9202
auto downlink-3
iface downlink-3
    bond-slaves swp5 swp6
    mtu 9202
auto downlink-4
iface downlink-4
    bond-slaves swp7 swp8
    mtu 9202
```

**spine02 /etc/network/interfaces**

```
cumulus@spine02:~$ cat /etc
/network/interfaces
# This file describes the
network interfaces available
on your system
# and how to activate them.
For more information, see
interfaces(5)
# The primary network interface
auto eth0
iface eth0 inet dhcp
# Include any platform-
specific interface
configuration
#source /etc/network
/interfaces.d/*.if
auto lo
iface lo
    address 10.0.0.6/32
    alias BGP un-numbered Use
for Vxlan Src Tunnel
auto downlink-1
iface downlink-1
    bond-slaves swp1 swp2
    mtu 9202
auto downlink-2
iface downlink-2
    bond-slaves swp3 swp4
    mtu 9202
auto downlink-3
iface downlink-3
    bond-slaves swp5 swp6
    mtu 9202
auto downlink-4
iface downlink-4
    bond-slaves swp7 swp8
    mtu 9202
```

**spine01 /etc/frr/frr.conf**

```
cumulus@spine01:~$ cat /etc/frr
/frr.conf
```

**spine02 /etc/frr/frr.conf**

```
cumulus@spine02:~$ cat /etc/frr
/frr.conf
```



```
log file /var/log/frr/bgpd.log
!
log timestamp precision 6
!
interface downlink-1
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
interface downlink-2
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
interface downlink-3
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
interface downlink-4
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
router bgp 64435
    bgp router-id 10.0.0.5
    coalesce-time 1000
    bgp bestpath as-path
    multipath-relax
        neighbor downlink-1 interface
        v6only remote-as external
        neighbor downlink-2 interface
        v6only remote-as external
        neighbor downlink-3 interface
        v6only remote-as external
        neighbor downlink-4 interface
        v6only remote-as external
    !
    address-family ipv4 unicast
        redistribute connected
        neighbor downlink-1 allowas-
        in origin
        neighbor downlink-2 allowas-
        in origin
        neighbor downlink-3 allowas-
        in origin
        neighbor downlink-4 allowas-
        in origin
    exit-address-family
    !
    address-family ipv6 unicast
        redistribute connected
        neighbor downlink-1 activate
        neighbor downlink-2 activate
        neighbor downlink-3 activate
```

```
log file /var/log/frr/bgpd.log
!
log timestamp precision 6
!
interface downlink-1
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
interface downlink-2
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
interface downlink-3
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
interface downlink-4
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
router bgp 64435
    bgp router-id 10.0.0.6
    coalesce-time 1000
    bgp bestpath as-path
    multipath-relax
        neighbor downlink-1 interface
        v6only remote-as external
        neighbor downlink-2 interface
        v6only remote-as external
        neighbor downlink-3 interface
        v6only remote-as external
        neighbor downlink-4 interface
        v6only remote-as external
    !
    address-family ipv4 unicast
        redistribute connected
        neighbor downlink-1 allowas-
        in origin
        neighbor downlink-2 allowas-
        in origin
        neighbor downlink-3 allowas-
        in origin
        neighbor downlink-4 allowas-
        in origin
    exit-address-family
    !
    address-family ipv6 unicast
        redistribute connected
        neighbor downlink-1 activate
        neighbor downlink-2 activate
        neighbor downlink-3 activate
```

```

neighbor downlink-4 activate
exit-address-family
!
address-family l2vpn evpn
neighbor downlink-1 activate
neighbor downlink-2 activate
neighbor downlink-3 activate
neighbor downlink-4 activate
exit-address-family
!
line vty
exec-timeout 0 0
!

```

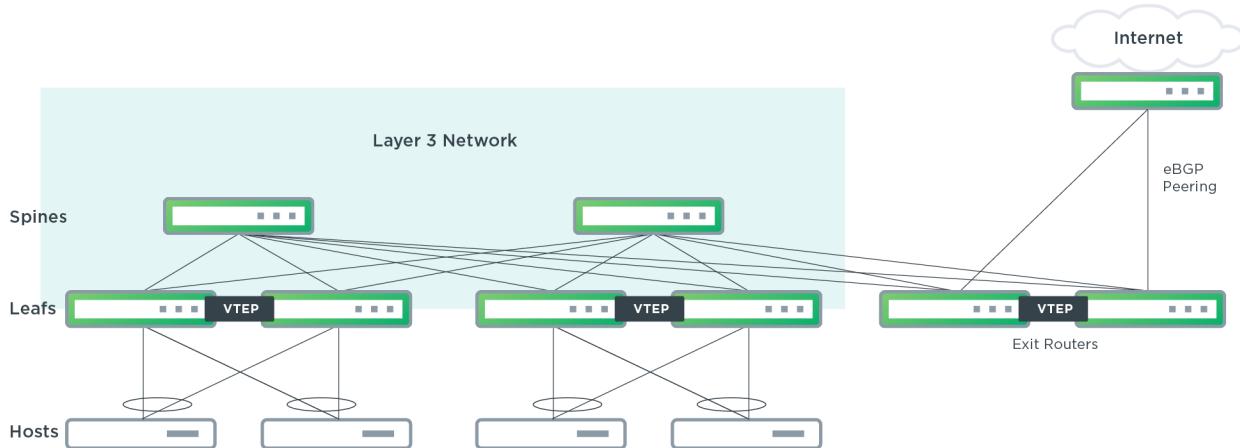
```

neighbor downlink-4 activate
exit-address-family
!
address-family l2vpn evpn
neighbor downlink-1 activate
neighbor downlink-2 activate
neighbor downlink-3 activate
neighbor downlink-4 activate
exit-address-family
!
line vty
exec-timeout 0 0
!

```

### *Clos Configuration with MLAG and Centralized Routing*

The following example configuration shows a basic Clos topology with centralized routing. MLAG is configured between leaf switches.





## *leaf01 and leaf02 Configurations*

### **leaf01 /etc/network/interfaces**

```
cumulus@leaf01:~$ cat /etc  
/network/interfaces  
# This file describes the  
network interfaces available  
on your system  
# and how to activate them.  
For more information, see  
interfaces(5)  
# The primary network interface  
auto eth0  
iface eth0 inet dhcp  
# Include any platform-  
specific interface  
configuration  
#source /etc/network  
/interfaces.d/*.if  
auto lo  
iface lo  
    address 10.0.0.7/32  
    alias BGP un-numbered Use  
for Vxlan Src Tunnel  
    clagd-vxlan-anycast-ip  
172.16.100.7  
auto uplink-1  
iface uplink-1  
    bond-slaves swp1 swp2  
    mtu 9202  
auto uplink-2  
iface uplink-2  
    bond-slaves swp3 swp4  
    mtu 9202  
auto peerlink-3  
iface peerlink-3  
    bond-slaves swp5 swp6  
    mtu 9202  
auto peerlink-3.4094  
iface peerlink-3.4094  
    address 169.254.0.9/30  
    mtu 9202  
    alias clag and vxlan  
communication primary path  
    clagd-priority 4096  
    clagd-sys-mac 44:38:39:ff:  
ff:01
```

### **leaf02 /etc/network/interfaces**

```
cumulus@leaf02:~$ cat /etc  
/network/interfaces  
# This file describes the  
network interfaces available  
on your system  
# and how to activate them.  
For more information, see  
interfaces(5)  
# The primary network interface  
auto eth0  
iface eth0 inet dhcp  
# Include any platform-  
specific interface  
configuration  
#source /etc/network  
/interfaces.d/*.if  
auto lo  
iface lo  
    address 10.0.0.8/32  
    alias BGP un-numbered Use  
for Vxlan Src Tunnel  
    clagd-vxlan-anycast-ip  
172.16.100.7  
auto uplink-1  
iface uplink-1  
    bond-slaves swp1 swp2  
    mtu 9202  
auto uplink-2  
iface uplink-2  
    bond-slaves swp3 swp4  
    mtu 9202  
auto peerlink-3  
iface peerlink-3  
    bond-slaves swp5 swp6  
    mtu 9202  
auto peerlink-3.4094  
iface peerlink-3.4094  
    address 169.254.0.10/30  
    mtu 9202  
    alias clag and vxlan  
communication primary path  
    clagd-priority 8192  
    clagd-sys-mac 44:38:39:ff:  
ff:01
```

```

clagd-peer-ip 169.254.0.10
clagd-backup-ip 10.0.0.8
auto hostbond4
iface hostbond4
    bond-slaves swp7
    mtu 9152
    clag-id 1
    bridge-pvid 1000
auto hostbond5
iface hostbond5
    bond-slaves swp8
    mtu 9152
    clag-id 2
    bridge-pvid 1001
auto vx-101000
iface vx-101000
    vxlan-id 101000
    bridge-access 1000
    vxlan-local-tunnelip
10.0.0.7
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpcl-portbpdufilter yes
    mstpcl-bpduguard yes
    mtu 9152
auto vx-101001
iface vx-101001
    vxlan-id 101001
    bridge-access 1001
    vxlan-local-tunnelip
10.0.0.7
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpcl-portbpdufilter yes
    mstpcl-bpduguard yes
    mtu 9152
auto vx-101002
iface vx-101002
    vxlan-id 101002
    bridge-access 1002
    vxlan-local-tunnelip
10.0.0.7
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpcl-portbpdufilter yes
    mstpcl-bpduguard yes
    mtu 9152
auto vx-101003
iface vx-101003
    vxlan-id 101003
    bridge-access 1003

```

```

clagd-peer-ip 169.254.0.9
clagd-backup-ip 10.0.0.7
auto hostbond4
iface hostbond4
    bond-slaves swp7
    mtu 9152
    clag-id 1
    bridge-pvid 1000
auto hostbond5
iface hostbond5
    bond-slaves swp8
    mtu 9152
    clag-id 2
    bridge-pvid 1001
auto vx-101000
iface vx-101000
    vxlan-id 101000
    bridge-access 1000
    vxlan-local-tunnelip
10.0.0.8
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpcl-portbpdufilter yes
    mstpcl-bpduguard yes
    mtu 9152
auto vx-101001
iface vx-101001
    vxlan-id 101001
    bridge-access 1001
    vxlan-local-tunnelip
10.0.0.8
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpcl-portbpdufilter yes
    mstpcl-bpduguard yes
    mtu 9152
auto vx-101002
iface vx-101002
    vxlan-id 101002
    bridge-access 1002
    vxlan-local-tunnelip
10.0.0.8
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpcl-portbpdufilter yes
    mstpcl-bpduguard yes
    mtu 9152
auto vx-101003
iface vx-101003
    vxlan-id 101003
    bridge-access 1003

```



```
vxlan-local-tunnelip
10.0.0.7
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpcctl-portbpdufilter yes
    mstpcctl-bpduguard yes
    mtu 9152
auto bridge
iface bridge
    bridge-vlan-aware yes
    bridge-ports vx-101000 vx-
101001 vx-101002 vx-101003
peerlink-3 hostbond4 hostbond5
    bridge-stp on
    bridge-vids 1000-1003
    bridge-pvid 1
auto vrf1
iface vrf1
    vrf-table auto
auto vlan1000
iface vlan1000
    address 45.0.0.2/24
    address 2001:feel::2/64
    vlan-id 1000
    vlan-raw-device bridge
    address-virtual 00:00:5e:
00:01:01 45.0.0.1/24 2001:
feel::1/64
    vrf vrf1
auto vlan1001
iface vlan1001
    address 45.0.1.2/24
    address 2001:feel:0:1::2/64
    vlan-id 1001
    vlan-raw-device bridge
    address-virtual 00:00:5e:
00:01:01 45.0.1.1/24 2001:feel:
0:1::1/64
    vrf vrf1
auto vrf2
iface vrf2
    vrf-table auto
auto vlan1002
iface vlan1002
    address 45.0.2.2/24
    address 2001:feel:0:2::2/64
    vlan-id 1002
    vlan-raw-device bridge
    address-virtual 00:00:5e:
00:01:01 45.0.2.1/24 2001:feel:
0:2::1/64
```

```
vxlan-local-tunnelip
10.0.0.8
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpcctl-portbpdufilter yes
    mstpcctl-bpduguard yes
    mtu 9152
auto bridge
iface bridge
    bridge-vlan-aware yes
    bridge-ports vx-101000 vx-
101001 vx-101002 vx-101003
peerlink-3 hostbond4 hostbond5
    bridge-stp on
    bridge-vids 1000-1003
    bridge-pvid 1
auto vrf1
iface vrf1
    vrf-table auto
auto vlan1000
iface vlan1000
    address 45.0.0.3/24
    address 2001:feel::3/64
    vlan-id 1000
    vlan-raw-device bridge
    address-virtual 00:00:5e:
00:01:01 45.0.0.1/24 2001:
feel::1/64
    vrf vrf1
auto vlan1001
iface vlan1001
    address 45.0.1.3/24
    address 2001:feel:0:1::3/64
    vlan-id 1001
    vlan-raw-device bridge
    address-virtual 00:00:5e:
00:01:01 45.0.1.1/24 2001:feel:
0:1::1/64
    vrf vrf1
auto vrf2
iface vrf2
    vrf-table auto
auto vlan1002
iface vlan1002
    address 45.0.2.3/24
    address 2001:feel:0:2::3/64
    vlan-id 1002
    vlan-raw-device bridge
    address-virtual 00:00:5e:
00:01:01 45.0.2.1/24 2001:feel:
0:2::1/64
```

```

vrf vrf2
auto vlan1003
iface vlan1003
    address 45.0.3.2/24
    address 2001:feel:0:3::2/64
    vlan-id 1003
    vlan-raw-device bridge
    address-virtual 00:00:5e:
00:01:01 45.0.3.1/24 2001:feel:
0:3::1/64
vrf vrf2

```

```

vrf vrf2
auto vlan1003
iface vlan1003
    address 45.0.3.3/24
    address 2001:feel:0:3::3/64
    vlan-id 1003
    vlan-raw-device bridge
    address-virtual 00:00:5e:
00:01:01 45.0.3.1/24 2001:feel:
0:3::1/64
vrf vrf2

```

#### **leaf01 /etc/frr/frr.conf**

```

cumulus@leaf01:~$ cat /etc/frr
/frr.conf
log file /var/log/frr/bgpd.log
!
log timestamp precision 6
!
interface peerlink-3.4094
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
interface uplink-1
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
interface uplink-2
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
router bgp 65542
    bgp router-id 10.0.0.7
    coalesce-time 1000
    bgp bestpath as-path
multipath-relax
    neighbor peerlink-3.4094
interface v6only remote-as
external
    neighbor uplink-1 interface
v6only remote-as external
    neighbor uplink-2 interface
v6only remote-as external
!
address-family ipv4 unicast
    redistribute connected
exit-address-family

```

#### **leaf02 /etc/frr/frr.conf**

```

cumulus@leaf02:~$ cat /etc/frr
/frr.conf
log file /var/log/frr/bgpd.log
!
log timestamp precision 6
!
interface peerlink-3.4094
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
interface uplink-1
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
interface uplink-2
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
router bgp 65543
    bgp router-id 10.0.0.8
    coalesce-time 1000
    bgp bestpath as-path
multipath-relax
    neighbor peerlink-3.4094
interface v6only remote-as
external
    neighbor uplink-1 interface
v6only remote-as external
    neighbor uplink-2 interface
v6only remote-as external
!
address-family ipv4 unicast
    redistribute connected
exit-address-family

```

```
!
address-family ipv6 unicast
 redistribute connected
 neighbor peerlink-3.4094
activate
 neighbor uplink-1 activate
 neighbor uplink-2 activate
exit-address-family
!
address-family l2vpn evpn
 neighbor uplink-1 activate
 neighbor uplink-2 activate
 advertise-default-gw
 advertise-all-vni
exit-address-family
!
line vty
 exec-timeout 0 0
!
```

```
!
address-family ipv6 unicast
 redistribute connected
 neighbor peerlink-3.4094
activate
 neighbor uplink-1 activate
 neighbor uplink-2 activate
exit-address-family
!
address-family l2vpn evpn
 neighbor uplink-1 activate
 neighbor uplink-2 activate
 advertise-default-gw
 advertise-all-vni
exit-address-family
!
line vty
 exec-timeout 0 0
!
```

*leaf03 and leaf04 Configurations*
**leaf03 /etc/network/interfaces**

```
cumulus@leaf03:~$ cat /etc
/network/interfaces
# This file describes the
network interfaces available
on your system
# and how to activate them.
For more information, see
interfaces(5)
# The primary network interface
auto eth0
iface eth0 inet dhcp
# Include any platform-
specific interface
configuration
#source /etc/network
/interfaces.d/*.if
auto lo
iface lo
    address 10.0.0.9/32
    alias BGP un-numbered Use
for Vxlan Src Tunnel
    clagd-vxlan-anycast-ip
172.16.100.9
auto uplink-1
iface uplink-1
    bond-slaves swp1 swp2
    mtu 9202
auto uplink-2
iface uplink-2
    bond-slaves swp3 swp4
    mtu 9202
auto peerlink-3
iface peerlink-3
    bond-slaves swp5 swp6
    mtu 9202
auto peerlink-3.4094
iface peerlink-3.4094
    address 169.254.0.9/30
    mtu 9202
    alias clag and vxlan
communication primary path
    clagd-priority 4096
    clagd-sys-mac 44:38:39:ff:
ff:02
```

**leaf04 /etc/network/interfaces**

```
cumulus@leaf04:~$ cat /etc
/network/interfaces
# This file describes the
network interfaces available
on your system
# and how to activate them.
For more information, see
interfaces(5)
# The primary network interface
auto eth0
iface eth0 inet dhcp
# Include any platform-
specific interface
configuration
#source /etc/network
/interfaces.d/*.if
auto lo
iface lo
    address 10.0.0.10/32
    alias BGP un-numbered Use
for Vxlan Src Tunnel
    clagd-vxlan-anycast-ip
172.16.100.9
auto uplink-1
iface uplink-1
    bond-slaves swp1 swp2
    mtu 9202
auto uplink-2
iface uplink-2
    bond-slaves swp3 swp4
    mtu 9202
auto peerlink-3
iface peerlink-3
    bond-slaves swp5 swp6
    mtu 9202
auto peerlink-3.4094
iface peerlink-3.4094
    address 169.254.0.10/30
    mtu 9202
    alias clag and vxlan
communication primary path
    clagd-priority 8192
    clagd-sys-mac 44:38:39:ff:
ff:02
```



```
clagd-peer-ip 169.254.0.10
clagd-backup-ip 10.0.0.10
auto hostbond4
iface hostbond4
    bond-slaves swp7
    mtu 9152
    clag-id 1
    bridge-pvid 1000
auto hostbond5
iface hostbond5
    bond-slaves swp8
    mtu 9152
    clag-id 2
    bridge-pvid 1001
auto vx-101000
iface vx-101000
    vxlan-id 101000
    bridge-access 1000
    vxlan-local-tunnelip
10.0.0.9
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpctl-portbpdufilter yes
    mstpctl-bpduguard yes
    mtu 9152
auto vx-101001
iface vx-101001
    vxlan-id 101001
    bridge-access 1001
    vxlan-local-tunnelip
10.0.0.9
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpctl-portbpdufilter yes
    mstpctl-bpduguard yes
    mtu 9152
auto vx-101002
iface vx-101002
    vxlan-id 101002
    bridge-access 1002
    vxlan-local-tunnelip
10.0.0.9
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpctl-portbpdufilter yes
    mstpctl-bpduguard yes
    mtu 9152
auto vx-101003
iface vx-101003
    vxlan-id 101003
    bridge-access 1003
```

```
clagd-peer-ip 169.254.0.9
clagd-backup-ip 10.0.0.9
auto hostbond4
iface hostbond4
    bond-slaves swp7
    mtu 9152
    clag-id 1
    bridge-pvid 1000
auto hostbond5
iface hostbond5
    bond-slaves swp8
    mtu 9152
    clag-id 2
    bridge-pvid 1001
auto vx-101000
iface vx-101000
    vxlan-id 101000
    bridge-access 1000
    vxlan-local-tunnelip
10.0.0.10
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpctl-portbpdufilter yes
    mstpctl-bpduguard yes
    mtu 9152
auto vx-101001
iface vx-101001
    vxlan-id 101001
    bridge-access 1001
    vxlan-local-tunnelip
10.0.0.10
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpctl-portbpdufilter yes
    mstpctl-bpduguard yes
    mtu 9152
auto vx-101002
iface vx-101002
    vxlan-id 101002
    bridge-access 1002
    vxlan-local-tunnelip
10.0.0.10
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpctl-portbpdufilter yes
    mstpctl-bpduguard yes
    mtu 9152
auto vx-101003
iface vx-101003
    vxlan-id 101003
    bridge-access 1003
```

```

vxlan-local-tunnelip
10.0.0.9
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpcl-portbpdufilter yes
    mstpcl-bpduguard yes
    mtu 9152
auto bridge
iface bridge
    bridge-vlan-aware yes
    bridge-ports vx-101000 vx-
101001 vx-101002 vx-101003
peerlink-3 hostbond4 hostbond5
    bridge-stp on
    bridge-vids 1000-1003
    bridge-pvid 1
auto vrf1
iface vrf1
    vrf-table auto
auto vlan1000
iface vlan1000
    vlan-id 1000
    vlan-raw-device bridge
    ip-forward off
auto vlan1001
iface vlan1001
    vlan-id 1001
    vlan-raw-device bridge
    ip-forward off
auto vrf2
iface vrf2
    vrf-table auto
auto vlan1002
iface vlan1002
    vlan-id 1002
    vlan-raw-device bridge
    ip-forward off
auto vlan1003
iface vlan1003
    vlan-id 1003
    vlan-raw-device bridge
    ip-forward off

```

```

vxlan-local-tunnelip
10.0.0.10
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpcl-portbpdufilter yes
    mstpcl-bpduguard yes
    mtu 9152
auto bridge
iface bridge
    bridge-vlan-aware yes
    bridge-ports vx-101000 vx-
101001 vx-101002 vx-101003
peerlink-3 hostbond4 hostbond5
    bridge-stp on
    bridge-vids 1000-1003
    bridge-pvid 1
auto vrf1
iface vrf1
    vrf-table auto
auto vlan1000
iface vlan1000
    vlan-id 1000
    vlan-raw-device bridge
    ip-forward off
auto vlan1001
iface vlan1001
    vlan-id 1001
    vlan-raw-device bridge
    ip-forward off
auto vrf2
iface vrf2
    vrf-table auto
auto vlan1002
iface vlan1002
    vlan-id 1002
    vlan-raw-device bridge
    ip-forward off
auto vlan1003
iface vlan1003
    vlan-id 1003
    vlan-raw-device bridge
    ip-forward off

```

#### **leaf03 /etc/frr/frr.conf**

```

cumulus@leaf03:~$ cat /etc/frr
/frr.conf
log file /var/log/frr/bgpd.log

```

#### **leaf04 /etc/frr/frr.conf**

```

cumulus@leaf04:~$ cat /etc/frr
/frr.conf
log file /var/log/frr/bgpd.log

```



```
!
log timestamp precision 6
!
interface peerlink-3.4094
  ipv6 nd ra-interval 10
  no ipv6 nd suppress-ra
!
interface uplink-1
  ipv6 nd ra-interval 10
  no ipv6 nd suppress-ra
!
interface uplink-2
  ipv6 nd ra-interval 10
  no ipv6 nd suppress-ra
!
router bgp 65544
  bgp router-id 10.0.0.9
  coalesce-time 1000
  bgp bestpath as-path
  multipath-relax
    neighbor peerlink-3.4094
  interface v6only remote-as
    external
      neighbor uplink-1 interface
      v6only remote-as external
      neighbor uplink-2 interface
      v6only remote-as external
    !
    address-family ipv4 unicast
      redistribute connected
    exit-address-family
    !
    address-family ipv6 unicast
      redistribute connected
      neighbor peerlink-3.4094
    activate
      neighbor uplink-1 activate
      neighbor uplink-2 activate
    exit-address-family
    !
    address-family l2vpn evpn
      neighbor uplink-1 activate
      neighbor uplink-2 activate
      advertise-all-vni
    exit-address-family
    !
    line vty
      exec-timeout 0 0
!
```

```
!
log timestamp precision 6
!
interface peerlink-3.4094
  ipv6 nd ra-interval 10
  no ipv6 nd suppress-ra
!
interface uplink-1
  ipv6 nd ra-interval 10
  no ipv6 nd suppress-ra
!
interface uplink-2
  ipv6 nd ra-interval 10
  no ipv6 nd suppress-ra
!
router bgp 65545
  bgp router-id 10.0.0.10
  coalesce-time 1000
  bgp bestpath as-path
  multipath-relax
    neighbor peerlink-3.4094
  interface v6only remote-as
    external
      neighbor uplink-1 interface
      v6only remote-as external
      neighbor uplink-2 interface
      v6only remote-as external
    !
    address-family ipv4 unicast
      redistribute connected
    exit-address-family
    !
    address-family ipv6 unicast
      redistribute connected
      neighbor peerlink-3.4094
    activate
      neighbor uplink-1 activate
      neighbor uplink-2 activate
    exit-address-family
    !
    address-family l2vpn evpn
      neighbor uplink-1 activate
      neighbor uplink-2 activate
      advertise-all-vni
    exit-address-family
    !
    line vty
      exec-timeout 0 0
!
```



*spine01 and spine02 Configurations***spine01 /etc/network/interfaces**

```
cumulus@spine01:~$ cat /etc  
/network/interfaces  
# This file describes the  
network interfaces available  
on your system  
# and how to activate them.  
For more information, see  
interfaces(5)  
# The primary network interface  
auto eth0  
iface eth0 inet dhcp  
# Include any platform-  
specific interface  
configuration  
#source /etc/network  
/interfaces.d/*.if  
auto lo  
iface lo  
    address 10.0.0.5/32  
    alias BGP un-numbered Use  
for Vxlan Src Tunnel  
auto downlink-1  
iface downlink-1  
    bond-slaves swp1 swp2  
    mtu 9202  
auto downlink-2  
iface downlink-2  
    bond-slaves swp3 swp4  
    mtu 9202  
auto downlink-3  
iface downlink-3  
    bond-slaves swp5 swp6  
    mtu 9202  
auto downlink-4  
iface downlink-4  
    bond-slaves swp7 swp8  
    mtu 9202
```

**spine02 /etc/network/interfaces**

```
cumulus@spine02:~$ cat /etc  
/network/interfaces  
# This file describes the  
network interfaces available  
on your system  
# and how to activate them.  
For more information, see  
interfaces(5)  
# The primary network interface  
auto eth0  
iface eth0 inet dhcp  
# Include any platform-  
specific interface  
configuration  
#source /etc/network  
/interfaces.d/*.if  
auto lo  
iface lo  
    address 10.0.0.6/32  
    alias BGP un-numbered Use  
for Vxlan Src Tunnel  
auto downlink-1  
iface downlink-1  
    bond-slaves swp1 swp2  
    mtu 9202  
auto downlink-2  
iface downlink-2  
    bond-slaves swp3 swp4  
    mtu 9202  
auto downlink-3  
iface downlink-3  
    bond-slaves swp5 swp6  
    mtu 9202  
auto downlink-4  
iface downlink-4  
    bond-slaves swp7 swp8  
    mtu 9202
```

**spine01 /etc/frr/frr.conf**

```
cumulus@spine01:~$ cat /etc/frr  
/frr.conf
```

**spine02 /etc/frr/frr.conf**

```
cumulus@spine02:~$ cat /etc/frr  
/frr.conf
```

```

log file /var/log/frr/bgpd.log
!
log timestamp precision 6
!
interface downlink-1
  ipv6 nd ra-interval 10
  no ipv6 nd suppress-ra
!
interface downlink-2
  ipv6 nd ra-interval 10
  no ipv6 nd suppress-ra
!
interface downlink-3
  ipv6 nd ra-interval 10
  no ipv6 nd suppress-ra
!
interface downlink-4
  ipv6 nd ra-interval 10
  no ipv6 nd suppress-ra
!
router bgp 64435
  bgp router-id 10.0.0.5
  coalesce-time 1000
  bgp bestpath as-path
  multipath-relax
    neighbor downlink-1 interface
    v6only remote-as external
    neighbor downlink-2 interface
    v6only remote-as external
    neighbor downlink-3 interface
    v6only remote-as external
    neighbor downlink-4 interface
    v6only remote-as external
  !
  address-family ipv4 unicast
    redistribute connected
    neighbor downlink-1 allowas-
    in origin
    neighbor downlink-2 allowas-
    in origin
    neighbor downlink-3 allowas-
    in origin
    neighbor downlink-4 allowas-
    in origin
  exit-address-family
  !
  address-family ipv6 unicast
    redistribute connected
    neighbor downlink-1 activate
    neighbor downlink-2 activate
    neighbor downlink-3 activate
  
```

```

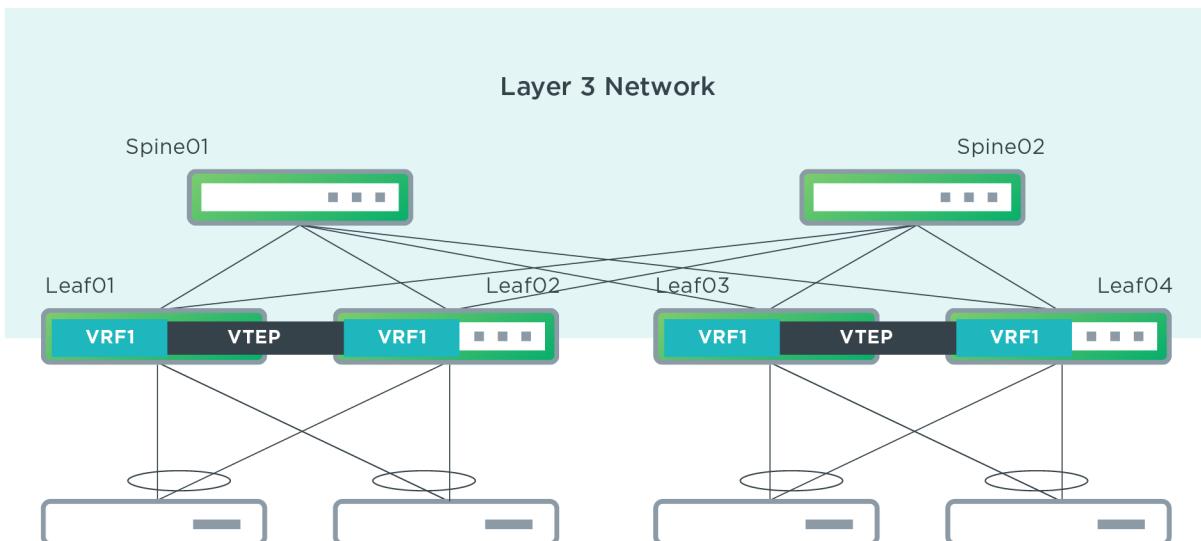
log file /var/log/frr/bgpd.log
!
log timestamp precision 6
!
interface downlink-1
  ipv6 nd ra-interval 10
  no ipv6 nd suppress-ra
!
interface downlink-2
  ipv6 nd ra-interval 10
  no ipv6 nd suppress-ra
!
interface downlink-3
  ipv6 nd ra-interval 10
  no ipv6 nd suppress-ra
!
interface downlink-4
  ipv6 nd ra-interval 10
  no ipv6 nd suppress-ra
!
router bgp 64435
  bgp router-id 10.0.0.6
  coalesce-time 1000
  bgp bestpath as-path
  multipath-relax
    neighbor downlink-1 interface
    v6only remote-as external
    neighbor downlink-2 interface
    v6only remote-as external
    neighbor downlink-3 interface
    v6only remote-as external
    neighbor downlink-4 interface
    v6only remote-as external
  !
  address-family ipv4 unicast
    redistribute connected
    neighbor downlink-1 allowas-
    in origin
    neighbor downlink-2 allowas-
    in origin
    neighbor downlink-3 allowas-
    in origin
    neighbor downlink-4 allowas-
    in origin
  exit-address-family
  !
  address-family ipv6 unicast
    redistribute connected
    neighbor downlink-1 activate
    neighbor downlink-2 activate
    neighbor downlink-3 activate
  
```

```
neighbor downlink-4 activate
exit-address-family
!
address-family l2vpn evpn
neighbor downlink-1 activate
neighbor downlink-2 activate
neighbor downlink-3 activate
neighbor downlink-4 activate
exit-address-family
!
line vty
exec-timeout 0 0
!
```

```
neighbor downlink-4 activate
exit-address-family
!
address-family l2vpn evpn
neighbor downlink-1 activate
neighbor downlink-2 activate
neighbor downlink-3 activate
neighbor downlink-4 activate
exit-address-family
!
line vty
exec-timeout 0 0
!
```

### Clos Configuration with MLAG and EVPN Asymmetric Routing

The following example configuration is a basic Clos topology with EVPN asymmetric routing. MLAG is configured between leaf switches.



*leaf01 and leaf02 Configurations*
**leaf01 /etc/network/interfaces**

```
cumulus@leaf01:~$ cat /etc
/network/interfaces
# This file describes the
network interfaces available
on your system
# and how to activate them.
For more information, see
interfaces(5)
# The primary network interface
auto eth0
iface eth0 inet dhcp
# Include any platform-
specific interface
configuration
#source /etc/network
/interfaces.d/*.if
auto lo
iface lo
    address 10.0.0.7/32
    alias BGP un-numbered Use
for Vxlan Src Tunnel
    clagd-vxlan-anycast-ip
172.16.100.7
auto uplink-1
iface uplink-1
    bond-slaves swp1 swp2
    mtu 9202
auto uplink-2
iface uplink-2
    bond-slaves swp3 swp4
    mtu 9202
auto peerlink-3
iface peerlink-3
    bond-slaves swp5 swp6
    mtu 9202
auto peerlink-3.4094
iface peerlink-3.4094
    address 169.254.0.9/30
    mtu 9202
    alias clag and vxlan
communication primary path
    clagd-priority 4096
    clagd-sys-mac 44:38:39:ff:
ff:01
```

**leaf02 /etc/network/interfaces**

```
cumulus@leaf02:~$ cat /etc
/network/interfaces
# This file describes the
network interfaces available
on your system
# and how to activate them.
For more information, see
interfaces(5)
# The primary network interface
auto eth0
iface eth0 inet dhcp
# Include any platform-
specific interface
configuration
#source /etc/network
/interfaces.d/*.if
auto lo
iface lo
    address 10.0.0.8/32
    alias BGP un-numbered Use
for Vxlan Src Tunnel
    clagd-vxlan-anycast-ip
172.16.100.7
auto uplink-1
iface uplink-1
    bond-slaves swp1 swp2
    mtu 9202
auto uplink-2
iface uplink-2
    bond-slaves swp3 swp4
    mtu 9202
auto peerlink-3
iface peerlink-3
    bond-slaves swp5 swp6
    mtu 9202
auto peerlink-3.4094
iface peerlink-3.4094
    address 169.254.0.10/30
    mtu 9202
    alias clag and vxlan
communication primary path
    clagd-priority 8192
    clagd-sys-mac 44:38:39:ff:
ff:01
```



```
clagd-peer-ip 169.254.0.10
clagd-backup-ip 10.0.0.8
auto hostbond4
iface hostbond4
    bond-slaves swp7
    mtu 9152
    clag-id 1
    bridge-pvid 1000
auto hostbond5
iface hostbond5
    bond-slaves swp8
    mtu 9152
    clag-id 2
    bridge-pvid 1001
auto vx-101000
iface vx-101000
    vxlan-id 101000
    bridge-access 1000
    vxlan-local-tunnelip
10.0.0.7
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpcctl-portbpdufilter yes
    mstpcctl-bpduguard yes
    mtu 9152
auto vx-101001
iface vx-101001
    vxlan-id 101001
    bridge-access 1001
    vxlan-local-tunnelip
10.0.0.7
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpcctl-portbpdufilter yes
    mstpcctl-bpduguard yes
    mtu 9152
auto vx-101002
iface vx-101002
    vxlan-id 101002
    bridge-access 1002
    vxlan-local-tunnelip
10.0.0.7
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpcctl-portbpdufilter yes
    mstpcctl-bpduguard yes
    mtu 9152
auto vx-101003
iface vx-101003
    vxlan-id 101003
    bridge-access 1003
```

```
clagd-peer-ip 169.254.0.9
clagd-backup-ip 10.0.0.7
auto hostbond4
iface hostbond4
    bond-slaves swp7
    mtu 9152
    clag-id 1
    bridge-pvid 1000
auto hostbond5
iface hostbond5
    bond-slaves swp8
    mtu 9152
    clag-id 2
    bridge-pvid 1001
auto vx-101000
iface vx-101000
    vxlan-id 101000
    bridge-access 1000
    vxlan-local-tunnelip
10.0.0.8
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpcctl-portbpdufilter yes
    mstpcctl-bpduguard yes
    mtu 9152
auto vx-101001
iface vx-101001
    vxlan-id 101001
    bridge-access 1001
    vxlan-local-tunnelip
10.0.0.8
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpcctl-portbpdufilter yes
    mstpcctl-bpduguard yes
    mtu 9152
auto vx-101002
iface vx-101002
    vxlan-id 101002
    bridge-access 1002
    vxlan-local-tunnelip
10.0.0.8
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpcctl-portbpdufilter yes
    mstpcctl-bpduguard yes
    mtu 9152
auto vx-101003
iface vx-101003
    vxlan-id 101003
    bridge-access 1003
```

```

vxlan-local-tunnelip
10.0.0.7
  bridge-learning off
  bridge-arp-nd-suppress on
  mstptctl-portbpdufilter yes
  mstptctl-bpduguard yes
  mtu 9152
auto bridge
iface bridge
  bridge-vlan-aware yes
  bridge-ports vx-101000 vx-
101001 vx-101002 vx-101003
peerlink-3 hostbond4 hostbond5
  bridge-stp on
  bridge-vids 1000-1003
  bridge-pvid 1
auto vrf1
iface vrf1
  vrf-table auto
auto vlan1000
iface vlan1000
  address 45.0.0.2/24
  address 2001:feel::2/64
  vlan-id 1000
  vlan-raw-device bridge
  address-virtual 00:00:5e:
00:01:01 45.0.0.1/24 2001:
feel::1/64
  vrf vrf1
auto vlan1001
iface vlan1001
  address 45.0.1.2/24
  address 2001:feel:0:1::2/64
  vlan-id 1001
  vlan-raw-device bridge
  address-virtual 00:00:5e:
00:01:01 45.0.1.1/24 2001:feel:
0:1::1/64
  vrf vrf1
auto vrf2
iface vrf2
  vrf-table auto
auto vlan1002
iface vlan1002
  address 45.0.2.2/24
  address 2001:feel:0:2::2/64
  vlan-id 1002
  vlan-raw-device bridge
  address-virtual 00:00:5e:
00:01:01 45.0.2.1/24 2001:feel:
0:2::1/64

```

```

vxlan-local-tunnelip
10.0.0.8
  bridge-learning off
  bridge-arp-nd-suppress on
  mstptctl-portbpdufilter yes
  mstptctl-bpduguard yes
  mtu 9152
auto bridge
iface bridge
  bridge-vlan-aware yes
  bridge-ports vx-101000 vx-
101001 vx-101002 vx-101003
peerlink-3 hostbond4 hostbond5
  bridge-stp on
  bridge-vids 1000-1003
  bridge-pvid 1
auto vrf1
iface vrf1
  vrf-table auto
auto vlan1000
iface vlan1000
  address 45.0.0.3/24
  address 2001:feel::3/64
  vlan-id 1000
  vlan-raw-device bridge
  address-virtual 00:00:5e:
00:01:01 45.0.0.1/24 2001:
feel::1/64
  vrf vrf1
auto vlan1001
iface vlan1001
  address 45.0.1.3/24
  address 2001:feel:0:1::3/64
  vlan-id 1001
  vlan-raw-device bridge
  address-virtual 00:00:5e:
00:01:01 45.0.1.1/24 2001:feel:
0:1::1/64
  vrf vrf1
auto vrf2
iface vrf2
  vrf-table auto
auto vlan1002
iface vlan1002
  address 45.0.2.3/24
  address 2001:feel:0:2::3/64
  vlan-id 1002
  vlan-raw-device bridge
  address-virtual 00:00:5e:
00:01:01 45.0.2.1/24 2001:feel:
0:2::1/64

```



```
vrf vrf2
auto vlan1003
iface vlan1003
    address 45.0.3.2/24
    address 2001:feel:0:3::2/64
    vlan-id 1003
    vlan-raw-device bridge
    address-virtual 00:00:5e:
00:01:01 45.0.3.1/24 2001:feel:
0:3::1/64
vrf vrf2
```

```
vrf vrf2
auto vlan1003
iface vlan1003
    address 45.0.3.3/24
    address 2001:feel:0:3::3/64
    vlan-id 1003
    vlan-raw-device bridge
    address-virtual 00:00:5e:
00:01:01 45.0.3.1/24 2001:feel:
0:3::1/64
vrf vrf2
```

### leaf01 /etc/frr/frr.conf

```
cumulus@leaf01:~$ cat /etc/frr
/frr.conf
log file /var/log/frr/bgpd.log
!
log timestamp precision 6
!
interface peerlink-3.4094
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
interface uplink-1
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
interface uplink-2
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
router bgp 65542
    bgp router-id 10.0.0.7
    coalesce-time 1000
    bgp bestpath as-path
    multipath-relax
    neighbor peerlink-3.4094
interface v6only remote-as
external
    neighbor uplink-1 interface
v6only remote-as external
    neighbor uplink-2 interface
v6only remote-as external
!
address-family ipv4 unicast
    redistribute connected
exit-address-family
```

### leaf02 /etc/frr/frr.conf

```
cumulus@leaf02:~$ cat /etc/frr
/frr.conf
log file /var/log/frr/bgpd.log
!
log timestamp precision 6
!
interface peerlink-3.4094
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
interface uplink-1
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
interface uplink-2
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
router bgp 65543
    bgp router-id 10.0.0.8
    coalesce-time 1000
    bgp bestpath as-path
    multipath-relax
    neighbor peerlink-3.4094
interface v6only remote-as
external
    neighbor uplink-1 interface
v6only remote-as external
    neighbor uplink-2 interface
v6only remote-as external
!
address-family ipv4 unicast
    redistribute connected
exit-address-family
```

```
!
address-family ipv6 unicast
  redistribute connected
  neighbor peerlink-3.4094
  activate
    neighbor uplink-1 activate
    neighbor uplink-2 activate
  exit-address-family
!
address-family l2vpn evpn
  neighbor uplink-1 activate
  neighbor uplink-2 activate
  advertise-all-vni
  exit-address-family
!
line vty
  exec-timeout 0 0
!
```

```
!
address-family ipv6 unicast
  redistribute connected
  neighbor peerlink-3.4094
  activate
    neighbor uplink-1 activate
    neighbor uplink-2 activate
  exit-address-family
!
address-family l2vpn evpn
  neighbor uplink-1 activate
  neighbor uplink-2 activate
  advertise-all-vni
  exit-address-family
!
line vty
  exec-timeout 0 0
!
```



## *leaf03 and leaf04 Configurations*

### **leaf03 /etc/network/interfaces**

```
cumulus@leaf03:~$ cat /etc  
/network/interfaces  
# This file describes the  
network interfaces available  
on your system  
# and how to activate them.  
For more information, see  
interfaces(5)  
# The primary network interface  
auto eth0  
iface eth0 inet dhcp  
# Include any platform-  
specific interface  
configuration  
#source /etc/network  
/interfaces.d/*.if  
auto lo  
iface lo  
    address 10.0.0.9/32  
    alias BGP un-numbered Use  
for Vxlan Src Tunnel  
    clagd-vxlan-anycast-ip  
36.0.0.9  
auto uplink-1  
iface uplink-1  
    bond-slaves swp1 swp2  
    mtu 9202  
auto uplink-2  
iface uplink-2  
    bond-slaves swp3 swp4  
    mtu 9202  
auto peerlink-3  
iface peerlink-3  
    bond-slaves swp5 swp6  
    mtu 9202  
auto peerlink-3.4094  
iface peerlink-3.4094  
    address 169.254.0.9/30  
    mtu 9202  
    alias clag and vxlan  
communication primary path  
    clagd-priority 4096  
    clagd-sys-mac 44:38:39:ff:  
ff:02
```

### **leaf04 /etc/network/interfaces**

```
cumulus@leaf04:~$ cat /etc  
/network/interfaces  
# This file describes the  
network interfaces available  
on your system  
# and how to activate them.  
For more information, see  
interfaces(5)  
# The primary network interface  
auto eth0  
iface eth0 inet dhcp  
# Include any platform-  
specific interface  
configuration  
#source /etc/network  
/interfaces.d/*.if  
auto lo  
iface lo  
    address 10.0.0.10/32  
    alias BGP un-numbered Use  
for Vxlan Src Tunnel  
    clagd-vxlan-anycast-ip  
36.0.0.9  
auto uplink-1  
iface uplink-1  
    bond-slaves swp1 swp2  
    mtu 9202  
auto uplink-2  
iface uplink-2  
    bond-slaves swp3 swp4  
    mtu 9202  
auto peerlink-3  
iface peerlink-3  
    bond-slaves swp5 swp6  
    mtu 9202  
auto peerlink-3.4094  
iface peerlink-3.4094  
    address 169.254.0.10/30  
    mtu 9202  
    alias clag and vxlan  
communication primary path  
    clagd-priority 8192  
    clagd-sys-mac 44:38:39:ff:  
ff:02
```

```

    clagd-peer-ip 169.254.0.10
    clagd-backup-ip 10.0.0.10
auto hostbond4
iface hostbond4
    bond-slaves swp7
    mtu 9152
    clag-id 1
    bridge-pvid 1000
auto hostbond5
iface hostbond5
    bond-slaves swp8
    mtu 9152
    clag-id 2
    bridge-pvid 1001
auto vx-101000
iface vx-101000
    vxlan-id 101000
    bridge-access 1000
    vxlan-local-tunnelip
10.0.0.9
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpcl-portbpdufilter yes
    mstpcl-bpduguard yes
    mtu 9152
auto vx-101001
iface vx-101001
    vxlan-id 101001
    bridge-access 1001
    vxlan-local-tunnelip
10.0.0.9
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpcl-portbpdufilter yes
    mstpcl-bpduguard yes
    mtu 9152
auto vx-101002
iface vx-101002
    vxlan-id 101002
    bridge-access 1002
    vxlan-local-tunnelip
10.0.0.9
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpcl-portbpdufilter yes
    mstpcl-bpduguard yes
    mtu 9152
auto vx-101003
iface vx-101003
    vxlan-id 101003
    bridge-access 1003

```

```

    clagd-peer-ip 169.254.0.9
    clagd-backup-ip 10.0.0.9
auto hostbond4
iface hostbond4
    bond-slaves swp7
    mtu 9152
    clag-id 1
    bridge-pvid 1000
auto hostbond5
iface hostbond5
    bond-slaves swp8
    mtu 9152
    clag-id 2
    bridge-pvid 1001
auto vx-101000
iface vx-101000
    vxlan-id 101000
    bridge-access 1000
    vxlan-local-tunnelip
10.0.0.10
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpcl-portbpdufilter yes
    mstpcl-bpduguard yes
    mtu 9152
auto vx-101001
iface vx-101001
    vxlan-id 101001
    bridge-access 1001
    vxlan-local-tunnelip
10.0.0.10
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpcl-portbpdufilter yes
    mstpcl-bpduguard yes
    mtu 9152
auto vx-101002
iface vx-101002
    vxlan-id 101002
    bridge-access 1002
    vxlan-local-tunnelip
10.0.0.10
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpcl-portbpdufilter yes
    mstpcl-bpduguard yes
    mtu 9152
auto vx-101003
iface vx-101003
    vxlan-id 101003
    bridge-access 1003

```



```
vxlan-local-tunnelip
10.0.0.9
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpcctl-portbpdufilter yes
    mstpcctl-bpduguard yes
    mtu 9152
auto bridge
iface bridge
    bridge-vlan-aware yes
    bridge-ports vx-101000 vx-
101001 vx-101002 vx-101003
peerlink-3 hostbond4 hostbond5
    bridge-stp on
    bridge-vids 1000-1003
    bridge-pvid 1
auto vrf1
iface vrf1
    vrf-table auto
auto vlan1000
iface vlan1000
    address 45.0.0.2/24
    address 2001:feel::2/64
    vlan-id 1000
    vlan-raw-device bridge
    address-virtual 00:00:5e:
00:01:01 45.0.0.1/24 2001:
feel::1/64
    vrf vrf1
auto vlan1001
iface vlan1001
    address 45.0.1.2/24
    address 2001:feel:0:1::2/64
    vlan-id 1001
    vlan-raw-device bridge
    address-virtual 00:00:5e:
00:01:01 45.0.1.1/24 2001:feel:
0:1::1/64
    vrf vrf1
auto vrf2
iface vrf2
    vrf-table auto
auto vlan1002
iface vlan1002
    address 45.0.2.2/24
    address 2001:feel:0:2::2/64
    vlan-id 1002
    vlan-raw-device bridge
    address-virtual 00:00:5e:
00:01:01 45.0.2.1/24 2001:feel:
0:2::1/64
```

```
vxlan-local-tunnelip
10.0.0.10
    bridge-learning off
    bridge-arp-nd-suppress on
    mstpcctl-portbpdufilter yes
    mstpcctl-bpduguard yes
    mtu 9152
auto bridge
iface bridge
    bridge-vlan-aware yes
    bridge-ports vx-101000 vx-
101001 vx-101002 vx-101003
peerlink-3 hostbond4 hostbond5
    bridge-stp on
    bridge-vids 1000-1003
    bridge-pvid 1
auto vrf1
iface vrf1
    vrf-table auto
auto vlan1000
iface vlan1000
    address 45.0.0.3/24
    address 2001:feel::3/64
    vlan-id 1000
    vlan-raw-device bridge
    address-virtual 00:00:5e:
00:01:01 45.0.0.1/24 2001:
feel::1/64
    vrf vrf1
auto vlan1001
iface vlan1001
    address 45.0.1.3/24
    address 2001:feel:0:1::3/64
    vlan-id 1001
    vlan-raw-device bridge
    address-virtual 00:00:5e:
00:01:01 45.0.1.1/24 2001:feel:
0:1::1/64
    vrf vrf1
auto vrf2
iface vrf2
    vrf-table auto
auto vlan1002
iface vlan1002
    address 45.0.2.3/24
    address 2001:feel:0:2::3/64
    vlan-id 1002
    vlan-raw-device bridge
    address-virtual 00:00:5e:
00:01:01 45.0.2.1/24 2001:feel:
0:2::1/64
```

```

vrf vrf2
auto vlan1003
iface vlan1003
    address 45.0.3.2/24
    address 2001:feel:0:3::2/64
    vlan-id 1003
    vlan-raw-device bridge
    address-virtual 00:00:5e:
00:01:01 45.0.3.1/24 2001:feel:
0:3::1/64
vrf vrf2

```

```

vrf vrf2
auto vlan1003
iface vlan1003
    address 45.0.3.3/24
    address 2001:feel:0:3::3/64
    vlan-id 1003
    vlan-raw-device bridge
    address-virtual 00:00:5e:
00:01:01 45.0.3.1/24 2001:feel:
0:3::1/64
vrf vrf2

```

#### **leaf03 /etc/frr/frr.conf**

```

cumulus@leaf03:~$ cat /etc/frr
/frr.conf
log file /var/log/frr/bgpd.log
!
log timestamp precision 6
!
interface peerlink-3.4094
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
interface uplink-1
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
interface uplink-2
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
router bgp 65544
    bgp router-id 10.0.0.9
    coalesce-time 1000
    bgp bestpath as-path
multipath-relax
    neighbor peerlink-3.4094
interface v6only remote-as
external
    neighbor uplink-1 interface
v6only remote-as external
    neighbor uplink-2 interface
v6only remote-as external
!
address-family ipv4 unicast
    redistribute connected
exit-address-family

```

#### **leaf04 /etc/frr/frr.conf**

```

cumulus@leaf04:~$ cat /etc/frr
/frr.conf
log file /var/log/frr/bgpd.log
!
log timestamp precision 6
!
interface peerlink-3.4094
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
interface uplink-1
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
interface uplink-2
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
router bgp 65545
    bgp router-id 10.0.0.10
    coalesce-time 1000
    bgp bestpath as-path
multipath-relax
    neighbor peerlink-3.4094
interface v6only remote-as
external
    neighbor uplink-1 interface
v6only remote-as external
    neighbor uplink-2 interface
v6only remote-as external
!
address-family ipv4 unicast
    redistribute connected
exit-address-family

```

```
!
address-family ipv6 unicast
 redistribute connected
 neighbor peerlink-3.4094
activate
 neighbor uplink-1 activate
 neighbor uplink-2 activate
exit-address-family
!
address-family l2vpn evpn
 neighbor uplink-1 activate
 neighbor uplink-2 activate
 advertise-all-vni
exit-address-family
!
line vty
 exec-timeout 0 0
!
```

```
!
address-family ipv6 unicast
 redistribute connected
 neighbor peerlink-3.4094
activate
 neighbor uplink-1 activate
 neighbor uplink-2 activate
exit-address-family
!
address-family l2vpn evpn
 neighbor uplink-1 activate
 neighbor uplink-2 activate
 advertise-all-vni
exit-address-family
!
line vty
 exec-timeout 0 0
!
```

*spine01 and spine02 Configurations*
**spine01 /etc/network/interfaces**

```
cumulus@spine01:~$ cat /etc
/network/interfaces
# This file describes the
network interfaces available
on your system
# and how to activate them.
For more information, see
interfaces(5)
# The primary network interface
auto eth0
iface eth0 inet dhcp
# Include any platform-
specific interface
configuration
#source /etc/network
/interfaces.d/*.if
auto lo
iface lo
    address 10.0.0.5/32
    alias BGP un-numbered Use
for Vxlan Src Tunnel
auto downlink-1
iface downlink-1
    bond-slaves swp1 swp2
    mtu 9202
auto downlink-2
iface downlink-2
    bond-slaves swp3 swp4
    mtu 9202
auto downlink-3
iface downlink-3
    bond-slaves swp5 swp6
    mtu 9202
auto downlink-4
iface downlink-4
    bond-slaves swp7 swp8
    mtu 9202
```

**spine02 /etc/network/interfaces**

```
cumulus@spine02:~$ cat /etc
/network/interfaces
# This file describes the
network interfaces available
on your system
# and how to activate them.
For more information, see
interfaces(5)
# The primary network interface
auto eth0
iface eth0 inet dhcp
# Include any platform-
specific interface
configuration
#source /etc/network
/interfaces.d/*.if
auto lo
iface lo
    address 10.0.0.6/32
    alias BGP un-numbered Use
for Vxlan Src Tunnel
auto downlink-1
iface downlink-1
    bond-slaves swp1 swp2
    mtu 9202
auto downlink-2
iface downlink-2
    bond-slaves swp3 swp4
    mtu 9202
auto downlink-3
iface downlink-3
    bond-slaves swp5 swp6
    mtu 9202
auto downlink-4
iface downlink-4
    bond-slaves swp7 swp8
    mtu 9202
```

**spine01 /etc/frr/frr.conf**

```
cumulus@spine01:~$ cat /etc/frr
/frr.conf
```

**spine02 /etc/frr/frr.conf**

```
cumulus@spine02:~$ cat /etc/frr
/frr.conf
```



```
log file /var/log/frr/bgpd.log
!
log timestamp precision 6
!
interface downlink-1
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
interface downlink-2
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
interface downlink-3
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
interface downlink-4
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
router bgp 64435
    bgp router-id 10.0.0.5
    coalesce-time 1000
    bgp bestpath as-path
    multipath-relax
        neighbor downlink-1 interface
        v6only remote-as external
        neighbor downlink-2 interface
        v6only remote-as external
        neighbor downlink-3 interface
        v6only remote-as external
        neighbor downlink-4 interface
        v6only remote-as external
    !
    address-family ipv4 unicast
        redistribute connected
        neighbor downlink-1 allowas-
        in origin
        neighbor downlink-2 allowas-
        in origin
        neighbor downlink-3 allowas-
        in origin
        neighbor downlink-4 allowas-
        in origin
    exit-address-family
    !
    address-family ipv6 unicast
        redistribute connected
        neighbor downlink-1 activate
        neighbor downlink-2 activate
        neighbor downlink-3 activate
```

```
log file /var/log/frr/bgpd.log
!
log timestamp precision 6
!
interface downlink-1
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
interface downlink-2
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
interface downlink-3
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
interface downlink-4
    ipv6 nd ra-interval 10
    no ipv6 nd suppress-ra
!
router bgp 64435
    bgp router-id 10.0.0.6
    coalesce-time 1000
    bgp bestpath as-path
    multipath-relax
        neighbor downlink-1 interface
        v6only remote-as external
        neighbor downlink-2 interface
        v6only remote-as external
        neighbor downlink-3 interface
        v6only remote-as external
        neighbor downlink-4 interface
        v6only remote-as external
    !
    address-family ipv4 unicast
        redistribute connected
        neighbor downlink-1 allowas-
        in origin
        neighbor downlink-2 allowas-
        in origin
        neighbor downlink-3 allowas-
        in origin
        neighbor downlink-4 allowas-
        in origin
    exit-address-family
    !
    address-family ipv6 unicast
        redistribute connected
        neighbor downlink-1 activate
        neighbor downlink-2 activate
        neighbor downlink-3 activate
```

```

neighbor downlink-4 activate
exit-address-family
!
address-family l2vpn evpn
neighbor downlink-1 activate
neighbor downlink-2 activate
neighbor downlink-3 activate
neighbor downlink-4 activate
exit-address-family
!
line vty
exec-timeout 0 0
!

```

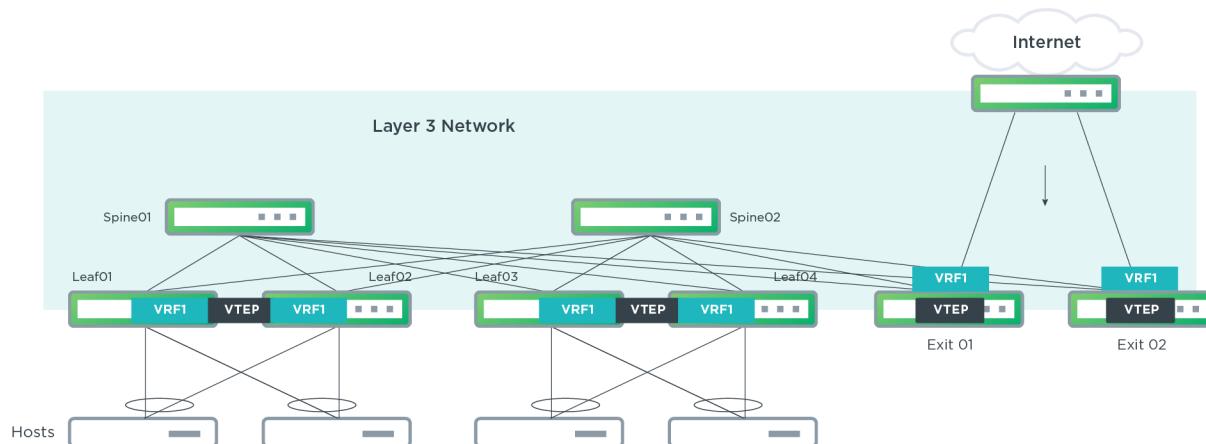
```

neighbor downlink-4 activate
exit-address-family
!
address-family l2vpn evpn
neighbor downlink-1 activate
neighbor downlink-2 activate
neighbor downlink-3 activate
neighbor downlink-4 activate
exit-address-family
!
line vty
exec-timeout 0 0
!

```

### *Basic Clos Configuration with EVPN Symmetric Routing*

The following example configuration is a basic Clos topology with EVPN symmetric routing with external prefix (type-5) routing via dual, non-MLAG exit leafs connected to an edge router. Here is the topology diagram:





## *leaf01 and leaf02 Configurations*

### **leaf01 /etc/network/interfaces**

```
cumulus@leaf01:~$ cat /etc  
/network/interfaces  
# This file describes the  
network interfaces available  
on your system  
# and how to activate them.  
For more information, see  
interfaces(5).  
# The loopback network  
interface  
auto lo  
iface lo inet loopback  
auto eth0  
iface eth0  
    address 192.168.0.15/24  
    gateway 192.168.0.2  
auto lo:1  
iface lo:1  
    address 10.0.0.1/32  
    #pre-up sysctl -w net.ipv4.  
neigh.default.gc_thresh1=0  
    #pre-up sysctl -w net.ipv4.  
route.gc_timeout=60  
    #pre-up sysctl -w net.ipv4.  
neigh.default.  
base_reachable_time_ms=240000  
# L2 interfaces - ports, vxlan  
and bridge  
auto swp1  
iface swp1  
auto swp2  
iface swp2  
auto swp3  
iface swp3  
    bridge-access 110  
auto swp4  
iface swp4  
    bridge-access 110  
auto swp5  
iface swp5  
    bridge-access 210  
auto swp6  
iface swp6  
    bridge-access 210
```

### **leaf02 /etc/network/interfaces**

```
cumulus@leaf02:~$ cat /etc  
/network/interfaces  
# This file describes the  
network interfaces available  
on your system  
# and how to activate them.  
For more information, see  
interfaces(5).  
# The loopback network  
interface  
auto lo  
iface lo inet loopback  
auto eth0  
iface eth0  
    address 192.168.0.15/24  
    gateway 192.168.0.2  
auto lo:1  
iface lo:1  
    address 10.0.0.2/32  
    #pre-up sysctl -w net.ipv4.  
neigh.default.gc_thresh1=0  
    #pre-up sysctl -w net.ipv4.  
route.gc_timeout=60  
    #pre-up sysctl -w net.ipv4.  
neigh.default.  
base_reachable_time_ms=240000  
# L2 interfaces - ports, vxlan  
and bridge  
auto swp1  
iface swp1  
auto swp2  
iface swp2  
auto swp3  
iface swp3  
    bridge-access 120  
auto swp4  
iface swp4  
    bridge-access 120  
auto swp5  
iface swp5  
    bridge-access 220  
auto swp6  
iface swp6  
    bridge-access 220
```

```

auto vni110
iface vni110
  vxlan-id 10110
  vxlan-local-tunnelip
10.0.0.1
  bridge-learning off
  bridge-access 110
  bridge-arp-nd-suppress on
auto vni210
iface vni210
  vxlan-id 10210
  vxlan-local-tunnelip
10.0.0.1
  bridge-learning off
  bridge-access 210
  bridge-arp-nd-suppress on
auto vni4001
iface vni4001
  vxlan-id 104001
  vxlan-local-tunnelip
10.0.0.1
  bridge-learning off
  bridge-access 4001
auto vni4002
iface vni4002
  vxlan-id 104002
  vxlan-local-tunnelip
10.0.0.1
  bridge-learning off
  bridge-access 4002
auto bridge
iface bridge
  bridge-vlan-aware yes
  bridge-ports swp3 swp4
swp5 swp6 vni110 vni210
vni4001 vni4002
  bridge-stp on
  bridge-vids 110 210
# Tenants (VRFs)
auto vrf1
iface vrf1
  vrf-table auto
auto vrf2
iface vrf2
  vrf-table auto
# Tenant SVIs - anycast GW
auto vlan110
iface vlan110
  address 172.16.120.1/24
  vlan-id 110
  vlan-raw-device bridge

```

```

auto vni120
iface vni120
  vxlan-id 10120
  vxlan-local-tunnelip
10.0.0.2
  bridge-learning off
  bridge-access 120
  bridge-arp-nd-suppress on
auto vni220
iface vni220
  vxlan-id 10220
  vxlan-local-tunnelip
10.0.0.2
  bridge-learning off
  bridge-access 220
  bridge-arp-nd-suppress on
auto vni4001
iface vni4001
  vxlan-id 104001
  vxlan-local-tunnelip
10.0.0.2
  bridge-learning off
  bridge-access 4001
auto vni4002
iface vni4002
  vxlan-id 104002
  vxlan-local-tunnelip
10.0.0.2
  bridge-learning off
  bridge-access 4002
auto bridge
iface bridge
  bridge-vlan-aware yes
  bridge-ports swp3 swp4
swp5 swp6 vni120 vni220
vni4001 vni4002
  bridge-stp on
  bridge-vids 120 220
# Tenants (VRFs)
auto vrf1
iface vrf1
  vrf-table auto
auto vrf2
iface vrf2
  vrf-table auto
# Tenant SVIs - anycast GW
auto vlan120
iface vlan120
  address 172.16.120.2/24
  vlan-id 120
  vlan-raw-device bridge

```



```
address-virtual 00:00:5e:  
00:01:01 172.16.120.250/24  
    vrf vrf1  
auto vlan210  
iface vlan210  
    address 172.16.130.1/24  
    vlan-id 210  
    vlan-raw-device bridge  
    address-virtual 00:00:5e:  
00:01:01 172.16.130.250/24  
    vrf vrf2  
# L3 VLAN interface per tenant  
(for L3 VNI)  
auto vlan4001  
iface vlan4001  
    vlan-id 4001  
    vlan-raw-device bridge  
    vrf vrf1  
auto vlan4002  
iface vlan4002  
    vlan-id 4002  
    vlan-raw-device bridge  
    vrf vrf2
```

```
address-virtual 00:00:5e:  
00:01:01 172.16.120.250/24  
    vrf vrf1  
auto vlan220  
iface vlan220  
    address 172.16.130.2/24  
    vlan-id 220  
    vlan-raw-device bridge  
    address-virtual 00:00:5e:  
00:01:01 172.16.130.250/24  
    vrf vrf2  
# L3 VLAN interface per tenant  
(for L3 VNI)  
auto vlan4001  
iface vlan4001  
    vlan-id 4001  
    vlan-raw-device bridge  
    vrf vrf1  
auto vlan4002  
iface vlan4002  
    vlan-id 4002  
    vlan-raw-device bridge  
    vrf vrf2
```

#### leaf01 /etc/frr/frr.conf

```
cumulus@leaf01:~$ cat /etc/frr/  
frr.conf  
log file /var/log/frr/frr.log  
log timestamp precision 6  
!  
password CumulusLinux!  
enable password CumulusLinux!  
!  
vrf vrf1  
    vni 104001  
vrf vrf2  
    vni 104002  
!  
interface swp1  
    no ipv6 nd suppress-ra  
    ipv6 nd ra-interval 10  
!  
interface swp2  
    no ipv6 nd suppress-ra  
    ipv6 nd ra-interval 10  
!  
router bgp 65001
```

#### leaf02 /etc/frr/frr.conf

```
cumulus@leaf02:~$ cat /etc/frr/  
frr.conf  
log file /var/log/frr/frr.log  
log timestamp precision 6  
!  
password CumulusLinux!  
enable password CumulusLinux!  
!  
vrf vrf1  
    vni 104001  
vrf vrf2  
    vni 104002  
!  
interface swp1  
    no ipv6 nd suppress-ra  
    ipv6 nd ra-interval 10  
!  
interface swp2  
    no ipv6 nd suppress-ra  
    ipv6 nd ra-interval 10  
!  
router bgp 65002
```

```

bgp router-id 10.0.0.1
neighbor SPINE peer-group
neighbor SPINE remote-as
external
neighbor SPINE timers 10 30
neighbor swp1 interface peer-
group SPINE
neighbor swp2 interface peer-
group SPINE
!
address-family ipv4 unicast
  network 10.0.0.1/32
exit-address-family
!
address-family l2vpn evpn
  neighbor SPINE activate
  advertise-all-vni
exit-address-family
!
line vty
  exec-timeout 0 0
!
```

```

bgp router-id 10.0.0.2
neighbor SPINE peer-group
neighbor SPINE remote-as
external
neighbor SPINE timers 10 30
neighbor swp1 interface peer-
group SPINE
neighbor swp2 interface peer-
group SPINE
!
address-family ipv4 unicast
  network 10.0.0.2/32
exit-address-family
!
address-family l2vpn evpn
  neighbor SPINE activate
  advertise-all-vni
exit-address-family
!
line vty
  exec-timeout 0 0
!
```

*leaf03 and leaf04 Configurations***leaf03 /etc/network/interfaces**

```
cumulus@leaf03:~$ cat /etc  
/network/interfaces  
# This file describes the  
network interfaces available  
on your system  
# and how to activate them.  
For more information, see  
interfaces(5).  
# The loopback network  
interface  
auto lo  
iface lo inet loopback  
auto eth0  
iface eth0  
    address 192.168.0.15/24  
    gateway 192.168.0.2  
auto lo:1  
iface lo:1  
    address 10.0.0.3/32  
    #pre-up sysctl -w net.ipv4.  
neigh.default.gc_thresh1=0  
    #pre-up sysctl -w net.ipv4.  
route.gc_timeout=60  
    #pre-up sysctl -w net.ipv4.  
neigh.default.  
base_reachable_time_ms=240000  
# L2 interfaces - ports, vxlan  
and bridge  
auto swp1  
iface swp1  
auto swp2  
iface swp2  
auto swp3  
iface swp3  
    bridge-access 130  
auto swp4  
iface swp4  
    bridge-access 130  
auto swp5  
iface swp5  
    bridge-access 230  
auto swp6  
iface swp6  
    bridge-access 230
```

**leaf04 /etc/network/interfaces**

```
cumulus@leaf04:~$ cat /etc  
/network/interfaces  
# This file describes the  
network interfaces available  
on your system  
# and how to activate them.  
For more information, see  
interfaces(5).  
# The loopback network  
interface  
auto lo  
iface lo inet loopback  
auto eth0  
iface eth0  
    address 192.168.0.15/24  
    gateway 192.168.0.2  
auto lo:1  
iface lo:1  
    address 10.0.0.4/32  
    #pre-up sysctl -w net.ipv4.  
neigh.default.gc_thresh1=0  
    #pre-up sysctl -w net.ipv4.  
route.gc_timeout=60  
    #pre-up sysctl -w net.ipv4.  
neigh.default.  
base_reachable_time_ms=240000  
# L2 interfaces - ports, vxlan  
and bridge  
auto swp1  
iface swp1  
auto swp2  
iface swp2  
auto swp3  
iface swp3  
    bridge-access 140  
auto swp4  
iface swp4  
    bridge-access 140  
auto swp5  
iface swp5  
    bridge-access 240  
auto swp6  
iface swp6  
    bridge-access 240
```

```

auto vni130
iface vni130
  vxlan-id 10130
  vxlan-local-tunnelip
10.0.0.3
  bridge-learning off
  bridge-access 130
  bridge-arp-nd-suppress on
auto vni230
iface vni230
  vxlan-id 10230
  vxlan-local-tunnelip
10.0.0.3
  bridge-learning off
  bridge-access 230
  bridge-arp-nd-suppress on
auto vni4001
iface vni4001
  vxlan-id 104001
  vxlan-local-tunnelip
10.0.0.3
  bridge-learning off
  bridge-access 4001
auto vni4002
iface vni4002
  vxlan-id 104002
  vxlan-local-tunnelip
10.0.0.3
  bridge-learning off
  bridge-access 4002
auto bridge
iface bridge
  bridge-vlan-aware yes
  bridge-ports swp3 swp4
swp5 swp6 vni130 vni230
vni4001 vni4002
  bridge-stp on
  bridge-vids 130 230
# Tenants (VRFs)
auto vrf1
iface vrf1
  vrf-table auto
auto vrf2
iface vrf2
  vrf-table auto
# Tenant SVIs - anycast GW
auto vlan130
iface vlan130
  address 172.16.120.3/24
  vlan-id 130
  vlan-raw-device bridge

```

```

auto vni140
iface vni140
  vxlan-id 10140
  vxlan-local-tunnelip
10.0.0.4
  bridge-learning off
  bridge-access 140
  bridge-arp-nd-suppress on
auto vni240
iface vni240
  vxlan-id 10240
  vxlan-local-tunnelip
10.0.0.4
  bridge-learning off
  bridge-access 240
  bridge-arp-nd-suppress on
auto vni4001
iface vni4001
  vxlan-id 104001
  vxlan-local-tunnelip
10.0.0.4
  bridge-learning off
  bridge-access 4001
auto vni4002
iface vni4002
  vxlan-id 104002
  vxlan-local-tunnelip
10.0.0.4
  bridge-learning off
  bridge-access 4002
auto bridge
iface bridge
  bridge-vlan-aware yes
  bridge-ports swp3 swp4
swp5 swp6 vni140 vni240
vni4001 vni4002
  bridge-stp on
  bridge-vids 140 240
# Tenants (VRFs)
auto vrf1
iface vrf1
  vrf-table auto
auto vrf2
iface vrf2
  vrf-table auto
# Tenant SVIs - anycast GW
auto vlan140
iface vlan140
  address 172.16.120.4/24
  vlan-id 140
  vlan-raw-device bridge

```



```
address-virtual 00:00:5e:  
00:01:01 172.16.120.250/24  
    vrf vrf1  
auto vlan230  
iface vlan230  
    address 172.16.130.3/24  
    vlan-id 230  
    vlan-raw-device bridge  
    address-virtual 00:00:5e:  
00:01:01 172.16.130.250/24  
    vrf vrf2  
# L3 VLAN interface per tenant  
(for L3 VNI)  
auto vlan4001  
iface vlan4001  
    vlan-id 4001  
    vlan-raw-device bridge  
    vrf vrf1  
auto vlan4002  
iface vlan4002  
    vlan-id 4002  
    vlan-raw-device bridge  
    vrf vrf2
```

```
address-virtual 00:00:5e:  
00:01:01 172.16.120.250/24  
    vrf vrf1  
auto vlan240  
iface vlan240  
    address 172.16.130.4/24  
    vlan-id 240  
    vlan-raw-device bridge  
    address-virtual 00:00:5e:  
00:01:01 172.16.130.250/24  
    vrf vrf2  
# L3 VLAN interface per tenant  
(for L3 VNI)  
auto vlan4001  
iface vlan4001  
    vlan-id 4001  
    vlan-raw-device bridge  
    vrf vrf1  
auto vlan4002  
iface vlan4002  
    vlan-id 4002  
    vlan-raw-device bridge  
    vrf vrf2
```

#### leaf03 /etc/frr/frr.conf

```
cumulus@leaf03:~$ cat /etc/frr/  
frr.conf  
log file /var/log/frr/frr.log  
log timestamp precision 6  
!  
password CumulusLinux!  
enable password CumulusLinux!  
!  
vrf vrf1  
  vni 104001  
vrf vrf2  
  vni 104002  
!  
interface swp1  
  no ipv6 nd suppress-ra  
  ipv6 nd ra-interval 10  
!  
interface swp2  
  no ipv6 nd suppress-ra  
  ipv6 nd ra-interval 10  
!  
router bgp 65003
```

#### leaf04 /etc/frr/frr.conf

```
cumulus@leaf04:~$ cat /etc/frr/  
frr.conf  
log file /var/log/frr/frr.log  
log timestamp precision 6  
!  
password CumulusLinux!  
enable password CumulusLinux!  
!  
vrf vrf1  
  vni 104001  
vrf vrf2  
  vni 104002  
!  
interface swp1  
  no ipv6 nd suppress-ra  
  ipv6 nd ra-interval 10  
!  
interface swp2  
  no ipv6 nd suppress-ra  
  ipv6 nd ra-interval 10  
!  
router bgp 65004
```

```

bgp router-id 10.0.0.3
neighbor SPINE peer-group
neighbor SPINE remote-as
external
neighbor SPINE timers 10 30
neighbor swp1 interface peer-
group SPINE
neighbor swp2 interface peer-
group SPINE
!
address-family ipv4 unicast
  network 10.0.0.3/32
exit-address-family
!
address-family l2vpn evpn
  neighbor SPINE activate
  advertise-all-vni
exit-address-family
!
line vty
  exec-timeout 0 0
!
```

```

bgp router-id 10.0.0.4
neighbor SPINE peer-group
neighbor SPINE remote-as
external
neighbor SPINE timers 10 30
neighbor swp1 interface peer-
group SPINE
neighbor swp2 interface peer-
group SPINE
!
address-family ipv4 unicast
  network 10.0.0.4/32
exit-address-family
!
address-family l2vpn evpn
  neighbor SPINE activate
  advertise-all-vni
exit-address-family
!
router bgp 65004 vrf vrf1
  bgp router-id 172.16.120.4
  neighbor 172.16.120.100
  remote-as external
  address-family ipv4 unicast
    redistribute connected
  exit-address-family
!
router bgp 65004 vrf vrf2
  bgp router-id 172.16.130.4
  neighbor 172.16.130.100
  remote-as external
  address-family ipv4 unicast
    redistribute connected
  exit-address-family
!
line vty
  exec-timeout 0 0
!
```

*spine01 and spine02 Configurations***spine01 /etc/network/interfaces**

```
spine01 /etc/network/interfaces

cumulus@spine01:~$ cat /etc
/network/interfaces
# This file describes the
network interfaces available
on your system
# and how to activate them.
For more information, see
interfaces(5).
# The loopback network
interface
auto lo
iface lo inet loopback
auto eth0
iface eth0
    address 192.168.0.15/24
    gateway 192.168.0.2
auto lo:1
iface lo:1
    address 172.16.110.1/24
auto swp1
iface swp1
auto swp2
iface swp2
auto swp3
iface swp3
auto swp4
iface swp4
auto swp5
iface swp5
auto swp6
iface swp6
```

**spine02 /etc/network/interfaces**

```
spine02 /etc/network/interfaces

cumulus@spine02:~$ cat /etc
/network/interfaces
# This file describes the
network interfaces available
on your system
# and how to activate them.
For more information, see
interfaces(5).
# The loopback network
interface
auto lo
iface lo inet loopback
auto eth0
iface eth0
    address 192.168.0.15/24
    gateway 192.168.0.2
auto lo:1
iface lo:1
    address 172.16.110.2/24
auto swp1
iface swp1
auto swp2
iface swp2
auto swp3
iface swp3
auto swp4
iface swp4
auto swp5
iface swp5
auto swp6
iface swp6
```

**spine01 /etc/frr/frr.conf**

```
cumulus@spine01:~$ cat /etc/frr
/frr.conf
log file /var/log/frr/frr.log
log timestamp precision 6
!
password CumulusLinux!
```

**spine02 /etc/frr/frr.conf**

```
cumulus@spine02:~$ cat /etc/frr
/frr.conf
log file /var/log/frr/frr.log
log timestamp precision 6
!
password CumulusLinux!
```

```

enable password CumulusLinux!
!
router bgp 65100
  bgp router-id 172.16.110.1
  neighbor LEAF peer-group
  neighbor LEAF remote-as
  external
    neighbor LEAF timers 10 30
    neighbor swp1 interface peer-
    group LEAF
    neighbor swp2 interface peer-
    group LEAF
    neighbor swp3 interface peer-
    group LEAF
    neighbor swp4 interface peer-
    group LEAF
    neighbor BORDER-LEAF peer-
    group
    neighbor BORDER-LEAF remote-
    as external
    neighbor BORDER-LEAF timers
    10 30
    neighbor swp5 interface peer-
    group BORDER-LEAF
    neighbor swp6 interface peer-
    group BORDER-LEAF
  !
  address-family ipv4 unicast
    network 172.16.110.1/24
    neighbor LEAF activate
    neighbor BORDER-LEAF activate
    neighbor LEAF route-
    reflector-client
    neighbor BORDER-LEAF route-
    reflector-client
    exit-address-family
  !
  address-family l2vpn evpn
    neighbor LEAF activate
    neighbor BORDER-LEAF activate
    neighbor LEAF route-
    reflector-client
    neighbor BORDER-LEAF route-
    reflector-client
    exit-address-family
  !
  line vty
    exec-timeout 0 0
  !

```

```

enable password CumulusLinux!
!
router bgp 65100
  bgp router-id 172.16.110.2
  neighbor LEAF peer-group
  neighbor LEAF remote-as
  external
    neighbor LEAF timers 10 30
    neighbor swp1 interface peer-
    group LEAF
    neighbor swp2 interface peer-
    group LEAF
    neighbor swp3 interface peer-
    group LEAF
    neighbor swp4 interface peer-
    group LEAF
    neighbor BORDER-LEAF peer-
    group
    neighbor BORDER-LEAF remote-
    as external
    neighbor BORDER-LEAF timers
    10 30
    neighbor swp5 interface peer-
    group BORDER-LEAF
    neighbor swp6 interface peer-
    group BORDER-LEAF
  !
  address-family ipv4 unicast
    network 172.16.110.2/24
    neighbor LEAF activate
    neighbor BORDER-LEAF activate
    neighbor LEAF route-
    reflector-client
    neighbor BORDER-LEAF route-
    reflector-client
    exit-address-family
  !
  address-family l2vpn evpn
    neighbor LEAF activate
    neighbor BORDER-LEAF activate
    neighbor LEAF route-
    reflector-client
    neighbor BORDER-LEAF route-
    reflector-client
    exit-address-family
  !
  line vty
    exec-timeout 0 0
  !

```



*border-leaf01 and border-leaf02 Configurations*
**border-leaf01 /etc/network/interfaces**

```

cumulus@border-leaf01:~$ cat
/etc/network/interfaces
# This file describes the
network interfaces available
on your system
# and how to activate them.
For more information, see
interfaces(5).
# The loopback network
interface
auto lo
iface lo inet loopback
auto eth0
iface eth0 inet dhcp
auto lo:1
iface lo:1
    address 10.0.0.5/32
    #pre-up sysctl -w net.ipv4.
neigh.default.gc_thresh1=0
    #pre-up sysctl -w net.ipv4.
route.gc_timeout=60
    #pre-up sysctl -w net.ipv4.
neigh.default.
base_reachable_time_ms=240000
# Physical interfaces
auto swp1s0
iface swp1s0
auto swp1s1
iface swp1s1
auto swp1s2
iface swp1s2
    bridge-vids 2001 2002
auto swp1s3
iface swp1s3
    bridge-access 150
auto swp2s0
iface swp2s0
    bridge-access 250
auto vni150
iface vni150
    vxlan-id 10150
    vxlan-local-tunnelip
10.0.0.5
    bridge-learning off

```

**border-leaf02 /etc/network/interfaces**

```

cumulus@border-leaf02:~$ cat
/etc/network/interfaces
# This file describes the
network interfaces available
on your system
# and how to activate them.
For more information, see
interfaces(5).
# The loopback network
interface
auto lo
iface lo inet loopback
auto eth0
iface eth0
    address 192.168.0.15/24
    gateway 192.168.0.2
auto lo:1
iface lo:1
    address 10.0.0.6/32
    #pre-up sysctl -w net.ipv4.
neigh.default.gc_thresh1=0
    #pre-up sysctl -w net.ipv4.
route.gc_timeout=60
    #pre-up sysctl -w net.ipv4.
neigh.default.
base_reachable_time_ms=240000
# Physical interfaces
auto swp1
iface swp1
auto swp2
iface swp2
auto swp3
iface swp3
auto swp4
iface swp4
    bridge-access 160
auto swp5
iface swp5
    bridge-access 260
auto vni160
iface vni160
    vxlan-id 10160
    vxlan-local-tunnelip
10.0.0.6

```



```
bridge-access 150
bridge-arp-nd-suppress on
auto vni250
iface vni250
    vxlan-id 10250
    vxlan-local-tunnelip
10.0.0.5
    bridge-learning off
    bridge-access 250
    bridge-arp-nd-suppress on
# Tenant VRFs
auto vrf1
iface vrf1
    vrf-table auto
auto vrf2
iface vrf2
    vrf-table auto
# VxLAN interfaces (VLAN to
VNI mappings)
# Need only the L3 VxLAN
interfaces
auto vni4001
iface vni4001
    vxlan-id 104001
    vxlan-local-tunnelip
10.0.0.5
    bridge-learning off
    bridge-access 4001
auto vni4002
iface vni4002
    vxlan-id 104002
    vxlan-local-tunnelip
10.0.0.5
    bridge-learning off
    bridge-access 4002
# Bridge
auto bridge
iface bridge
    bridge-vlan-aware yes
    bridge-ports swp4 swp5
vni160 vni260 vni4001 vni4002
    bridge-stp on
    bridge-vids 160 260 2001
2002
# Tenant SVIs - anycast GW
auto vlan160
iface vlan160
    address 172.16.120.1/24
    vlan-id 160
    vlan-raw-device bridge
```

```
bridge-learning off
bridge-access 160
bridge-arp-nd-suppress on
auto vni260
iface vni260
    vxlan-id 10260
    vxlan-local-tunnelip
10.0.0.6
    bridge-learning off
    bridge-access 260
    bridge-arp-nd-suppress on
# Tenant VRFs
auto vrf1
iface vrf1
    vrf-table auto
auto vrf2
iface vrf2
    vrf-table auto
# VxLAN interfaces (VLAN to
VNI mappings)
# Need only the L3 VxLAN
interfaces
auto vni4001
iface vni4001
    vxlan-id 104001
    vxlan-local-tunnelip
10.0.0.6
    bridge-learning off
    bridge-access 4001
auto vni4002
iface vni4002
    vxlan-id 104002
    vxlan-local-tunnelip
10.0.0.6
    bridge-learning off
    bridge-access 4002
# Bridge
auto bridge
iface bridge
    bridge-vlan-aware yes
    bridge-ports swp4 swp5
vni160 vni260 vni4001 vni4002
    bridge-stp on
    bridge-vids 160 260 2001
2002
# Tenant SVIs - anycast GW
auto vlan160
iface vlan160
    address 172.16.120.1/24
    vlan-id 160
    vlan-raw-device bridge
```

```

    address-virtual 00:00:5e:
00:01:01 172.16.120.250/24
      vrf vrf1
auto vlan260
iface vlan260
    address 172.16.130.2/24
    vlan-id 260
    vlan-raw-device bridge
    address-virtual 00:00:5e:
00:01:01 172.16.130.250/24
      vrf vrf2
# L3 VLAN interface per tenant
(for L3 VNI)
auto vlan4001
iface vlan4001
    vlan-id 4001
    vlan-raw-device bridge
    vrf vrf1
auto vlan4002
iface vlan4002
    vlan-id 4002
    vlan-raw-device bridge
    vrf vrf2
# External-facing L3 VLAN
interface per tenant (towards
WAN edge)
#auto swp1s2.4001
#iface swp1s2.4001
#    address 172.16.100.2/30
#    vrf vrf1
#
#auto swp1s2.4002
#iface swp1s2.4002
#    address 172.16.100.6/30
#    vrf vrf2
#
# configuration below is a
workaround for RN-766
#
auto vlan2001
iface vlan2001
    vlan-id 2001
    vlan-raw-device bridge
    vrf vrf1
    address 172.16.100.2/30
auto vlan2002
iface vlan2002
    vlan-id 2002
    vlan-raw-device bridge
    vrf vrf2
    address 172.16.100.6/30

```

```

    address-virtual 00:00:5e:
00:01:01 172.16.120.250/24
      vrf vrf1
auto vlan260
iface vlan260
    address 172.16.130.2/24
    vlan-id 260
    vlan-raw-device bridge
    address-virtual 00:00:5e:
00:01:01 172.16.130.250/24
      vrf vrf2
# L3 VLAN interface per tenant
(for L3 VNI)
auto vlan4001
iface vlan4001
    vlan-id 4001
    vlan-raw-device bridge
    vrf vrf1
auto vlan4002
iface vlan4002
    vlan-id 4002
    vlan-raw-device bridge
    vrf vrf2
# External-facing L3 VLAN
interface per tenant (towards
WAN edge)
# auto swp3.4001
# iface swp3.4001
#    address 172.16.101.2/30
#    vrf vrf1
#
# auto swp3.4002
# iface swp3.4002
#    address 172.16.101.6/30
#    vrf vrf2
#
# configuration below is a
workaround for RN-766
#
auto vlan2001
iface vlan2001
    vlan-id 2001
    vlan-raw-device bridge
    vrf vrf1
    address 172.16.101.2/30
auto vlan2002
iface vlan2002
    vlan-id 2002
    vlan-raw-device bridge
    vrf vrf2

```



```
auto vni16001
iface vni16001
    vxlan-id 16001
    vxlan-local-tunnelip
10.0.0.5
    bridge-learning off
    bridge-access 2001
auto vni16002
iface vni16002
    vxlan-id 16002
    vxlan-local-tunnelip
10.0.0.5
    bridge-learning off
    bridge-access 2002
```

```
address 172.16.101.6
/30
auto vni16001
iface vni16001
    vxlan-id 16001
    vxlan-local-tunnelip
10.0.0.6
    bridge-learning off
    bridge-access 2001
auto vni16002
iface vni16002
    vxlan-id 16002
    vxlan-local-tunnelip
10.0.0.6
    bridge-learning off
    bridge-access 2002
```

#### border-leaf01 /etc/frr/frr.conf

```
cumulus@border-leaf01:~$ cat
/etc/frr/frr.conf
log file /var/log/frr/frr.log
log timestamp precision 6
!
password CumulusLinux!
enable password CumulusLinux!
!
vrf vrf1
    vni 104001
vrf vrf2
    vni 104002
!
interface swp1s0
    no ipv6 nd suppress-ra
    ipv6 nd ra-interval 10
!
interface swp1s1
    no ipv6 nd suppress-ra
    ipv6 nd ra-interval 10
!
router bgp 65005
    bgp router-id 10.0.0.5
    neighbor SPINE peer-group
    neighbor SPINE remote-as
        external
    neighbor SPINE timers 1200
        4800
```

#### border-leaf02 /etc/frr/frr.conf

```
cumulus@border-leaf02:~$ cat
/etc/frr/frr.conf
log file /var/log/frr/frr.log
log timestamp precision 6
!
password CumulusLinux!
enable password CumulusLinux!
!
vrf vrf1
    vni 104001
vrf vrf2
    vni 104002
!
interface swp1
    no ipv6 nd suppress-ra
    ipv6 nd ra-interval 10
!
interface swp2
    no ipv6 nd suppress-ra
    ipv6 nd ra-interval 10
!
router bgp 65005
    bgp router-id 10.0.0.6
    neighbor SPINE peer-group
    neighbor SPINE remote-as
        external
    neighbor SPINE timers 10 30
    neighbor swp1 interface peer-
        group SPINE
```

```

neighbor swp1s0 interface
peer-group SPINE
  neighbor swp1s1 interface
  peer-group SPINE
!
  address-family ipv4 unicast
    network 10.0.0.5/32
  exit-address-family
!
  address-family l2vpn evpn
    neighbor SPINE activate
    advertise-all-vni
  exit-address-family
!
router bgp 65005 vrf vrf1
  bgp router-id 172.16.100.2
  neighbor 172.16.100.1 remote-
as external
!
  address-family ipv4 unicast
    redistribute connected
  exit-address-family
!
  address-family l2vpn evpn
    advertise ipv4 unicast
  exit-address-family
!
router bgp 65005 vrf vrf2
  bgp router-id 172.16.100.6
  neighbor 172.16.100.5 remote-
as external
!
  address-family ipv4 unicast
    redistribute connected
  exit-address-family
!
  address-family l2vpn evpn
    advertise ipv4 unicast
  exit-address-family
!
line vty
  exec-timeout 0 0
!
```

```

neighbor swp2 interface peer-
group SPINE
!
  address-family ipv4 unicast
    network 10.0.0.6/32
  exit-address-family
!
  address-family l2vpn evpn
    neighbor SPINE activate
    advertise-all-vni
  exit-address-family
!
router bgp 65005 vrf vrf1
  bgp router-id 172.16.100.2
  neighbor 172.16.100.1 remote-
as external
!
  address-family ipv4 unicast
    redistribute connected
  exit-address-family
!
  address-family l2vpn evpn
    advertise ipv4 unicast
  exit-address-family
!
router bgp 65005 vrf vrf2
  bgp router-id 172.16.100.6
  neighbor 172.16.100.5 remote-
as external
!
  address-family ipv4 unicast
    redistribute connected
  exit-address-family
!
  address-family l2vpn evpn
    advertise ipv4 unicast
  exit-address-family
!
line vty
  exec-timeout 0 0
!
```

*router01 Configurations***router01 /etc/network/interfaces**

```
cumulus@router01:~$ cat /etc/network/interfaces
# This file describes the network interfaces available on your
system
# and how to activate them. For more information, see interfaces(5).
# The loopback network interface
auto lo
iface lo inet loopback
auto eth0
iface eth0
    address 192.168.0.15/24
    gateway 192.168.0.2
auto lo:1
iface lo:1
    address 120.0.0.1/32
    #pre-up sysctl -w net.ipv4.neigh.default.gc_thresh1=0
    #pre-up sysctl -w net.ipv4.route.gc_timeout=60
    #pre-up sysctl -w net.ipv4.neigh.default.
base_reachable_time_ms=240000
auto swp1
iface swp1
auto swp1.2001
iface swp1.2001
    address 172.16.100.1/24
auto swp1.2002
iface swp1.2002
    address 172.16.100.5/24
auto swp2
iface swp2
auto swp2.4001
iface swp2.4001
    address 172.16.100.1/24
auto swp2.4002
iface swp2.4002
    address 172.16.100.5/24
auto swp3
iface swp3
    address 81.1.1.1/24
auto swp4
iface swp4
    address 81.1.2.1/24
auto swp5
iface swp5
    address 81.1.3.1/24
auto swp6
```



```
iface swp6
    address 81.1.4.1/24
```

### router01 /etc/frr/frr.conf

```
cumulus@router01:~$ cat /etc/frr/frr.conf
log file /var/log/frr/frr.log
log timestamp precision 6
!
password CumulusLinux!
enable password CumulusLinux!
!
router bgp 65200
    bgp router-id 120.0.0.1
    neighbor 172.16.100.2 remote-as external
    neighbor 172.16.100.6 remote-as external
    neighbor 172.16.100.2 remote-as external
    neighbor 172.16.100.6 remote-as external
    !
    address-family ipv4 unicast
        redistribute connected route-map HOST_ALLOW
        exit-address-family
    !
    ip prefix-list HOSTS seq 1 permit 81.1.1.0/24
    ip prefix-list HOSTS seq 2 permit 81.1.2.0/24
    ip prefix-list HOSTS seq 3 permit 81.1.3.0/24
    ip prefix-list HOSTS seq 4 permit 81.1.4.0/24
    ip prefix-list HOSTS seq 5 deny any
    !
    route-map HOST_ALLOW permit 1
        match ip address prefix-list HOSTS
    !
    !
line vty
    exec-timeout 0 0
!
```

## Lightweight Network Virtualization Overview

- ! As of Cumulus Linux 3.7.4, the lightweight network virtualization feature (LNV) has been deprecated. The feature will be removed in Cumulus Linux 4.0. Cumulus Networks recommends you use [Ethernet virtual private network \(EVPN\)](#) (see page 501) for network virtualization.

Lightweight Network Virtualization (LNV) is a technique for deploying [VXLANs \(see page 490\)](#) without a central controller on bare metal switches. This solution requires no external controller or software suite; it runs the VXLAN service and registration daemons on Cumulus Linux itself. The data path between bridge entities is established on top of a layer 3 fabric by means of a simple service node coupled with traditional MAC address learning.

To see an example of a full solution before reading the following background information, [read this chapter \(see page 626\)](#).



LNV is a lightweight controller option. [Contact Cumulus Networks](#) with your scale requirements so we can make sure this is the right fit for you. There are also other controller options that can work on Cumulus Linux.



You cannot use LNV and [EVPN \(see page 501\)](#) at the same time.

## Contents

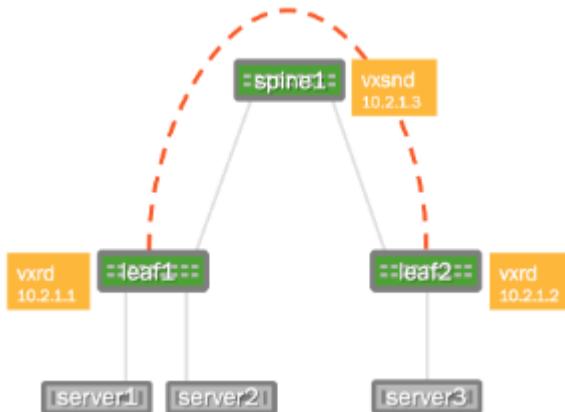
This topic describes ...

- LNV Concepts (see page 604)
  - Acquire the Forwarding Database at the Service Node (see page 604)
  - MAC Learning and Flooding (see page 604)
  - BUM Traffic (see page 605)
- Requirements (see page 606)
  - Hardware Requirements (see page 606)
  - Configuration Requirements (see page 606)
  - Install the LNV Packages (see page 606)
- Sample LNV Configuration (see page 606)
  - Network Connectivity (see page 607)
  - Layer 3 IP Addressing (see page 607)
  - Layer 3 Fabric (see page 609)
  - Host Configuration (see page 612)
- Configure the VLAN to VXLAN Mapping (see page 613)
- Verify the VLAN to VXLAN Mapping (see page 615)
- Enable and Manage Service Node and Registration Daemons (see page 615)
  - Enable the Service Node Daemon (see page 615)
  - Enable the Registration Daemon (see page 616)
  - Check the Daemon Status (see page 616)
- Configure the Registration Node (see page 617)
- Configure the Service Node (see page 619)
- Advanced LNV Usage (see page 620)

- Scale LNV by Load Balancing with Anycast (see page 620)
- Restart Network Removes vxsnrd Anycast IP Address from Loopback Interface (see page 625)
- Related Information (see page 626)

## LNV Concepts

Consider the following example deployment:



The two switches running Cumulus Linux, called leaf1 and leaf2, each have a bridge configured. These two bridges contain the physical switch port interfaces connecting to the servers as well as the logical VXLAN interface associated with the bridge. By creating a logical VXLAN interface on both leaf switches, the switches become VTEPs (virtual tunnel end points). The IP address associated with this VTEP is most commonly configured as its loopback address; in the image above, the loopback address is 10.2.1.1 for leaf1 and 10.2.1.2 for leaf2.

### *Acquire the Forwarding Database at the Service Node*

To connect these two VXLANs together and forward BUM (Broadcast, Unknown-unicast, Multicast) packets to members of a VXLAN, the service node needs to acquire the addresses of all the VTEPs for every VXLAN it serves. The service node daemon does this through a registration daemon running on each leaf switch that contains a VTEP participating in LNV. The registration process informs the service node of all the VXLANs to which the switch belongs.

### *MAC Learning and Flooding*

With LNV, as with traditional bridging of physical LANs or VLANs, a bridge automatically learns the location of hosts as a side effect of receiving packets on a port.

For example, when server1 sends a layer 2 packet to server3, leaf2 learns that the MAC address for server1 is located on that particular VXLAN and the VXLAN interface learns that the IP address of the VTEP for server1 is 10.2.1.1. So when server3 sends a packet to server1, the bridge on leaf2 forwards the packet out of the port to the VXLAN interface and the VXLAN interface sends it, encapsulated in a UDP packet, to the address 10.2.1.1.

But what if server3 sends a packet to some address that has yet to send it a packet (server2, for example)? In this case, the VXLAN interface sends the packet to the service node, which sends a copy to every other VTEP that belongs to the same VXLAN. This is called *service node replication* and is one of two techniques for handling BUM (Broadcast Unknown-unicast and Multicast) traffic.



## BUM Traffic

Cumulus Linux has two ways of handling BUM (Broadcast Unknown-unicast and Multicast) traffic:

- Head end replication
- Service node replication

Head end replication is enabled by default in Cumulus Linux.



You cannot have both service node and head end replication configured simultaneously, as this causes the BUM traffic to be duplicated; both the source VTEP and the service node send their own copy of each packet to every remote VTEP.

### Head End Replication

The Broadcom switch with the Tomahawk, Trident II+, and Trident II ASIC and the Mellanox switch with the Spectrum ASIC are capable of head end replication (HER), which is the ability to generate all the BUM traffic in hardware. The most scalable solution available with LNV is to have each VTEP (top of rack switch) generate all of its own BUM traffic instead of relying on an external service node. HER is enabled by default in Cumulus Linux.

Cumulus Linux verified support for up to 128 VTEPs with head end replication.

To disable head end replication, edit the `/etc/vxrd.conf` file and set `head_rep` to `False`.

### Service Node Replication

Cumulus Linux also supports service node replication for VXLAN BUM packets. This is useful with LNV if you have more than 128 VTEPs. However, it is not recommended because it forces the spine switches running the `vxsnd` (service node daemon) to replicate the packets in software instead of in hardware, unlike head end replication. If you are not using a controller but have more than 128 VTEPs, contact [Cumulus Networks](#).

To enable service node replication:

1. Disable head end replication; set `head_rep` to `False` in the `/etc/vxrd.conf` file.
2. Configure a service node IP address for every VXLAN interface using the `vxlan-svcnodeip` parameter:

```
cumulus@switch:~$ net add vxlan VXLAN vxlan svcnodeip IP_ADDRESS
```



You only specify this parameter when head end replication is disabled. For the loopback, the parameter is still named `vxrd-svcnode-ip`.

3. Edit the `/etc/vxsnd.conf` file and configure the following:

- Set the same service node IP address that you configured in the previous step:



```
svcnode_ip = <>
```

- To forward VXLAN data traffic, set the following variable to *True*:

```
enable_vxlan_listen = true
```

## Requirements

### Hardware Requirements

- Broadcom switches with the Tomahawk, Trident II+, or Trident II ASIC or Mellanox switches with the Spectrum ASIC running Cumulus Linux 2.5.4 or later. Please refer to the Cumulus Networks [hardware compatibility](#) list for a list of supported switch models.

### Configuration Requirements

- The VXLAN has an associated **VXLAN Network Identifier** (VNI), also interchangeably called a VXLAN ID.
- The VNI cannot be 0 or 16777215, as these two numbers are reserved values under Cumulus Linux.
- The VXLAN link and physical interfaces are added to the bridge to create the association between the port, VLAN, and VXLAN instance.
- Each bridge on the switch has only one VXLAN interface. Cumulus Linux does not support more than one VXLAN link in a bridge; however, a switch can have multiple bridges.
- An SVI (Switch VLAN Interface) or layer 3 address on the bridge is not supported. For example, you cannot ping from the leaf1 SVI to the leaf2 SVI through the VXLAN tunnel; you need to use server1 and server2 to verify.

### Install the LNV Packages

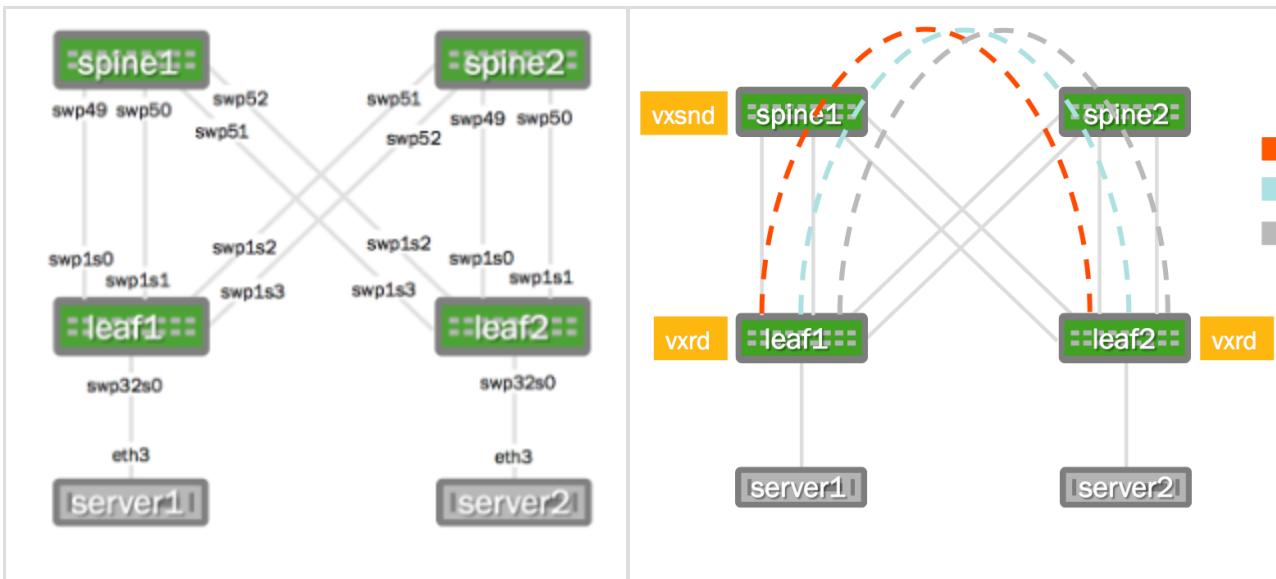
`vxflid` is installed by default on all new installations of Cumulus Linux 3.x. If you are upgrading from an earlier version, run `sudo -E apt-get install python-vxflid` to install the LNV package.

## Sample LNV Configuration

The following images illustrate the configuration that is referenced throughout this chapter.

Physical Cabling Diagram

Network Virtualization Diagram



- Want to try out configuring LNV and do not have a Cumulus Linux switch? Check out [Cumulus VX](#).

## Network Connectivity

There must be full network connectivity before you can configure LNV. The layer 3 IP addressing information as well as the OSPF configuration (`/etc/frr/frr.conf`) below is provided to make the LNV example easier to understand.

- i** OSPF is not a requirement for LNV, LNV just requires layer 3 connectivity. With Cumulus Linux this can be achieved with static routes, OSPF or BGP.

## Layer 3 IP Addressing

Here is the configuration for the IP addressing information used in this example.

spine1:	spine2:
<pre>cumulus@spine1:~\$ net add interface swp49 ip address 10.1.1.2/30 cumulus@spine1:~\$ net add interface swp50 ip address 10.1.1.6/30 cumulus@spine1:~\$ net add interface swp51 ip address 10.1.1.50/30</pre>	<pre>cumulus@spine2:~\$ net add interface swp49 ip address 10.1.1.18/30 cumulus@spine2:~\$ net add interface swp50 ip address 10.1.1.22/30 cumulus@spine2:~\$ net add interface swp51 ip address 10.1.1.34/30</pre>

```
cumulus@spine1:~$ net
add interface swp52 ip address
10.1.1.54/30
cumulus@spine1:~$ net
add loopback lo ip address
10.2.1.3/32
cumulus@spine1:~$ net pending
cumulus@spine1:~$ net commit
```

These commands create the following configuration:

```
cumulus@spine1:~$ cat /etc
/network/interfaces
auto lo
iface lo inet loopback
    address 10.2.1.3/32

auto eth0
iface eth0 inet dhcp

auto swp49
iface swp49
    address 10.1.1.2/30

auto swp50
iface swp50
    address 10.1.1.6/30

auto swp51
iface swp51
    address 10.1.1.50/30

auto swp52
iface swp52
    address 10.1.1.54/30
```

#### **leaf1:**

```
cumulus@leaf1:~$ net add
interface swp1 breakout 4x
cumulus@leaf1:~$ net add
interface swpl1s0 ip address
10.1.1.1/30
cumulus@leaf1:~$ net add
interface swpl1s1 ip address
10.1.1.5/30
```

```
cumulus@spine2:~$ net add
interface swp52 ip address
10.1.1.38/30
cumulus@spine2:~$ net add
loopback lo ip address 10.2.1.4
/32
cumulus@spine2:~$ net pending
cumulus@spine2:~$ net commit
```

These commands create the following configuration:

```
cumulus@spine2:~$ cat /etc
/network/interfaces
auto lo
iface lo inet loopback
    address 10.2.1.4/32

auto eth0
iface eth0 inet dhcp

auto swp49
iface swp49
    address 10.1.1.18/30

auto swp50
iface swp50
    address 10.1.1.22/30

auto swp51
iface swp51
    address 10.1.1.34/30

auto swp52
iface swp52
    address 10.1.1.38/30
```

#### **leaf2:**

```
cumulus@leaf2:~$ net add
interface swp1 breakout 4x
cumulus@leaf2:~$ net add
interface swpl1s0 ip address
10.1.1.17/30
cumulus@leaf2:~$ net add
interface swpl1s1 ip address
10.1.1.21/30
```



```
cumulus@leaf1:~$ net add
interface swp1s2 ip address
10.1.1.33/30
cumulus@leaf1:~$ net add
interface swp1s3 ip address
10.1.1.37/30
cumulus@leaf1:~$ net add
loopback lo ip address 10.2.1.1
/32
cumulus@leaf1:~$ net pending
cumulus@leaf1:~$ net commit
```

These commands create the following configuration:

```
cumulus@leaf1:~$ cat /etc
/network/interfaces
auto lo
iface lo inet loopback
    address 10.2.1.1/32

auto eth0
iface eth0 inet dhcp

auto swp1s0
iface swp1s0
    address 10.1.1.1/30

auto swp1s1
iface swp1s1
    address 10.1.1.5/30

auto swp1s2
iface swp1s2
    address 10.1.1.33/30

auto swp1s3
iface swp1s3
    address 10.1.1.37/30
```

```
cumulus@leaf2:~$ net add
interface swp1s2 ip address
10.1.1.49/30
cumulus@leaf2:~$ net add
interface swp1s3 ip address
10.1.1.53/30
cumulus@leaf2:~$ net add
loopback lo ip address 10.2.1.2
/32
cumulus@leaf2:~$ net pending
cumulus@leaf2:~$ net commit
```

These commands create the following configuration:

```
cumulus@leaf2:~$ cat /etc
/network/interfaces
auto lo
iface lo inet loopback
    address 10.2.1.2/32

auto eth0
iface eth0 inet dhcp

auto swp1s0
iface swp1s0
    address 10.1.1.17/30

auto swp1s1
iface swp1s1
    address 10.1.1.21/30

auto swp1s2
iface swp1s2
    address 10.1.1.49/30

auto swp1s3
iface swp1s3
    address 10.1.1.53/30
```

## Layer 3 Fabric

The service nodes and registration nodes must all be routable between each other. The layer 3 fabric on Cumulus Linux can either be [BGP \(see page 773\)](#) or [OSPF \(see page 756\)](#). In this example, OSPF is used to demonstrate full reachability. Click to expand the FRRouting configurations below.

**Click to expand the OSPF configuration ...**

FRRouting configuration using OSPF:

**spine1:**

```
cumulus@spine1:~$ net add ospf
network 10.2.1.3/32 area
0.0.0.0
cumulus@spine1:~$ net add
interface swp49 ospf network
point-to-point
cumulus@spine1:~$ net add
interface swp50 ospf network
point-to-point
cumulus@spine1:~$ net add
interface swp51 ospf network
point-to-point
cumulus@spine1:~$ net add
interface swp52 ospf network
point-to-point
cumulus@spine1:~$ net add
interface swp49 ospf area
0.0.0.0
cumulus@spine1:~$ net add
interface swp50 ospf area
0.0.0.0
cumulus@spine1:~$ net add
interface swp51 ospf area
0.0.0.0
cumulus@spine1:~$ net add
interface swp52 ospf area
0.0.0.0
cumulus@spine1:~$ net add ospf
router-id 10.2.1.3
cumulus@spine1:~$ net pending
cumulus@spine1:~$ net commit
```

These commands create the following configuration:

```
interface swp49
  ip ospf network point-to-point
  ip ospf area 0.0.0.0
!
interface swp50
  ip ospf network point-to-point
  ip ospf area 0.0.0.0
!
interface swp51
  ip ospf network point-to-point
  ip ospf area 0.0.0.0
```

**spine2:**

```
cumulus@spine2:~$ net add ospf
network 10.2.1.4/32 area
0.0.0.0
cumulus@spine2:~$ net add
interface swp49 ospf network
point-to-point
cumulus@spine2:~$ net add
interface swp50 ospf network
point-to-point
cumulus@spine2:~$ net add
interface swp51 ospf network
point-to-point
cumulus@spine2:~$ net add
interface swp52 ospf network
point-to-point
cumulus@spine2:~$ net add
interface swp49 ospf area
0.0.0.0
cumulus@spine2:~$ net add
interface swp50 ospf area
0.0.0.0
cumulus@spine2:~$ net add
interface swp51 ospf area
0.0.0.0
cumulus@spine2:~$ net add
interface swp52 ospf area
0.0.0.0
cumulus@spine2:~$ net add ospf
router-id 10.2.1.4
cumulus@spine2:~$ net pending
cumulus@spine2:~$ net commit
```

These commands create the following configuration:

```
interface swp49
  ip ospf network point-to-point
  ip ospf area 0.0.0.0
!
interface swp50
  ip ospf network point-to-point
  ip ospf area 0.0.0.0
!
interface swp51
  ip ospf network point-to-point
  ip ospf area 0.0.0.0
```



```
!
interface swp52
  ip ospf network point-to-point
  ip ospf area 0.0.0.0
!
router ospf
  ospf router-id 10.2.1.3
  network 10.2.1.3/32 area
  0.0.0.0
```

**leaf1:**

```
cumulus@leaf1:~$ net add ospf
network 10.2.1.1/32 area
0.0.0.0
cumulus@leaf1:~$ net add
interface swpl1s0 ospf network
point-to-point
cumulus@leaf1:~$ net add
interface swpl1s1 ospf network
point-to-point
cumulus@leaf1:~$ net add
interface swpl1s2 ospf network
point-to-point
cumulus@leaf1:~$ net add
interface swpl1s3 ospf network
point-to-point
cumulus@leaf1:~$ net add
interface swpl1s0 ospf area
0.0.0.0
cumulus@leaf1:~$ net add
interface swpl1s1 ospf area
0.0.0.0
cumulus@leaf1:~$ net add
interface swpl1s2 ospf area
0.0.0.0
cumulus@leaf1:~$ net add
interface swpl1s3 ospf area
0.0.0.0
cumulus@leaf1:~$ net add ospf
router-id 10.2.1.1
cumulus@leaf1:~$ net pending
cumulus@leaf1:~$ net commit
```

These commands create the following configuration:

```
!
interface swp52
  ip ospf network point-to-point
  ip ospf area 0.0.0.0
!
router ospf
  ospf router-id 10.2.1.4
  network 10.2.1.4/32 area
  0.0.0.0
```

**leaf2:**

```
cumulus@leaf2:~$ net add ospf
network 10.2.1.2/32 area
0.0.0.0
cumulus@leaf2:~$ net add
interface swpl1s0 ospf network
point-to-point
cumulus@leaf2:~$ net add
interface swpl1s1 ospf network
point-to-point
cumulus@leaf2:~$ net add
interface swpl1s2 ospf network
point-to-point
cumulus@leaf2:~$ net add
interface swpl1s3 ospf network
point-to-point
cumulus@leaf2:~$ net add
interface swpl1s0 ospf area
0.0.0.0
cumulus@leaf2:~$ net add
interface swpl1s1 ospf area
0.0.0.0
cumulus@leaf2:~$ net add
interface swpl1s2 ospf area
0.0.0.0
cumulus@leaf2:~$ net add
interface swpl1s3 ospf area
0.0.0.0
cumulus@leaf2:~$ net add ospf
router-id 10.2.1.2
cumulus@leaf2:~$ net pending
cumulus@leaf2:~$ net commit
```

These commands create the following configuration:

```

interface swp1s0
  ip ospf network point-to-point
  ip ospf area 0.0.0.0
!
interface swp1s1
  ip ospf network point-to-point
  ip ospf area 0.0.0.0
!
interface swp1s2
  ip ospf network point-to-point
  ip ospf area 0.0.0.0
!
interface swp1s3
  ip ospf network point-to-point
  ip ospf area 0.0.0.0
!
router ospf
  ospf router-id 10.2.1.1
  network 10.2.1.1/32 area
0.0.0.0

```

```

interface swp1s0
  ip ospf network point-to-point
  ip ospf area 0.0.0.0
!
interface swp1s1
  ip ospf network point-to-point
  ip ospf area 0.0.0.0
!
interface swp1s2
  ip ospf network point-to-point
  ip ospf area 0.0.0.0
!
interface swp1s3
  ip ospf network point-to-point
  ip ospf area 0.0.0.0
!
router ospf
  ospf router-id 10.2.1.2
  network 10.2.1.2/32 area
0.0.0.0

```

## Host Configuration

In this example, the servers are running Ubuntu 14.04. There needs to be a trunk mapped from server1 and server2 to the respective switch. In Ubuntu this is done with subinterfaces. You can expand the configurations below.

**Click to expand the host configurations ...**

### server1:

```

auto eth3.10
iface eth3.10 inet
static
  address 10.10.10.1/24
auto eth3.20
iface eth3.20 inet
static
  address 10.10.20.1/24
auto eth3.30
iface eth3.30 inet
static
  address 10.10.30.1/24

```

### server2:

```

auto eth3.10
iface eth3.10 inet
static
  address 10.10.10.2/24
auto eth3.20
iface eth3.20 inet
static
  address 10.10.20.2/24
auto eth3.30
iface eth3.30 inet
static
  address 10.10.30.2/24

```

On Ubuntu, it is more reliable to use `ifup` and `if down` to bring the interfaces up and down individually, rather than restarting networking entirely (there is no equivalent to `if reload` like there is in Cumulus Linux):



```
cumulus@server1:~$ sudo ifup eth3.10
Set name-type for VLAN subsystem. Should be visible in /proc/net/vlan
/config
Added VLAN with VID == 10 to IF -:eth3:-
cumulus@server1:~$ sudo ifup eth3.20
Set name-type for VLAN subsystem. Should be visible in /proc/net/vlan
/config
Added VLAN with VID == 20 to IF -:eth3:-
cumulus@server1:~$ sudo ifup eth3.30
Set name-type for VLAN subsystem. Should be visible in /proc/net/vlan
/config
Added VLAN with VID == 30 to IF -:eth3:-
```

## Configure the VLAN to VXLAN Mapping

Configure the VLANs and associated VXLANs. In this example, there are 3 VLANs and 3 VXLAN IDs (VNI). VLANs 10, 20 and 30 are used and associated with VNIs 10, 2000 and 30 respectively. The loopback address, used as the `vxlan-local-tunnelip`, is the only difference between leaf1 and leaf2 for this demonstration.

### leaf1:

```
cumulus@leaf1:~$ net add
loopback lo ip address 10.2.1.1
/32
cumulus@leaf1:~$ net add
loopback lo vxrd-src-ip
10.2.1.1
cumulus@leaf1:~$ net add
loopback lo vxrd-svcnode-ip
10.2.1.3
cumulus@leaf1:~$ net add vxlan
vni-10 vxlan id 10
cumulus@leaf1:~$ net add vxlan
vni-10 vxlan local-tunnelip
10.2.1.1
cumulus@leaf1:~$ net add vxlan
vni-10 bridge access 10
cumulus@leaf1:~$ net add vxlan
vni-2000 vxlan id 2000
cumulus@leaf1:~$ net add vxlan
vni-2000 vxlan local-tunnelip
10.2.1.1
cumulus@leaf1:~$ net add vxlan
vni-2000 bridge access 20
cumulus@leaf1:~$ net add vxlan
vni-30 vxlan id 30
```

### leaf2:

```
cumulus@leaf2:~$ net add
loopback lo ip address 10.2.1.2
/32
cumulus@leaf2:~$ net add
loopback lo vxrd-src-ip
10.2.1.2
cumulus@leaf2:~$ net add
loopback lo vxrd-svcnode-ip
10.2.1.3
cumulus@leaf2:~$ net add vxlan
vni-10 vxlan id 10
cumulus@leaf2:~$ net add vxlan
vni-10 vxlan local-tunnelip
10.2.1.2
cumulus@leaf2:~$ net add vxlan
vni-10 bridge access 10
cumulus@leaf2:~$ net add vxlan
vni-2000 vxlan id 2000
cumulus@leaf2:~$ net add vxlan
vni-2000 vxlan local-tunnelip
10.2.1.2
cumulus@leaf2:~$ net add vxlan
vni-2000 bridge access 20
cumulus@leaf2:~$ net add vxlan
vni-30 vxlan id 30
```

```
cumulus@leaf1:~$ net add vxlan
vni-30 vxlan local-tunnelip
10.2.1.1
cumulus@leaf1:~$ net add vxlan
vni-30 bridge access 30
cumulus@leaf1:~$ net add
bridge bridge ports swp32s0.10
cumulus@leaf1:~$ net pending
cumulus@leaf1:~$ net commit
```

These commands create the following configuration in the /etc/network/interfaces file:

```
auto lo
iface lo
    address 10.2.1.1/32
    vxrd-src-ip 10.2.1.1

auto swp32s0.10
iface swp32s0.10

auto bridge
iface bridge
    bridge-ports vni-10 vni-2000
    vni-30
    bridge-vids 10 20 30
    bridge-vlan-aware yes

auto vni-10
iface vni-10
    bridge-access 10
    mstpcctl-bpduguard yes
    mstpcctl-portbpdufilter yes
    vxlan-id 10
    vxlan-local-tunnelip 10.2.1.1

auto vni-2000
iface vni-2000
    bridge-access 20
    mstpcctl-bpduguard yes
    mstpcctl-portbpdufilter yes
    vxlan-id 2000
    vxlan-local-tunnelip 10.2.1.1

auto vni-30
iface vni-30
    bridge-access 30
    mstpcctl-bpduguard yes
    mstpcctl-portbpdufilter yes
```

```
cumulus@leaf2:~$ net add vxlan
vni-30 vxlan local-tunnelip
10.2.1.2
cumulus@leaf2:~$ net add vxlan
vni-30 bridge access 30
cumulus@leaf1:~$ net add
bridge bridge ports swp32s0.10
cumulus@leaf2:~$ net pending
cumulus@leaf2:~$ net commit
```

These commands create the following configuration in the /etc/network/interfaces file:

```
auto lo
iface lo
    address 10.2.1.2/32
    vxrd-src-ip 10.2.1.2

auto swp32s0.10
iface swp32s0.10

auto bridge
iface bridge
    bridge-ports vni-10 vni-2000
    vni-30
    bridge-vids 10 20 30
    bridge-vlan-aware yes

auto vni-10
iface vni-10
    bridge-access 10
    mstpcctl-bpduguard yes
    mstpcctl-portbpdufilter yes
    vxlan-id 10
    vxlan-local-tunnelip 10.2.1.2

auto vni-2000
iface vni-2000
    bridge-access 20
    mstpcctl-bpduguard yes
    mstpcctl-portbpdufilter yes
    vxlan-id 2000
    vxlan-local-tunnelip 10.2.1.2

auto vni-30
iface vni-30
    bridge-access 30
    mstpcctl-bpduguard yes
    mstpcctl-portbpdufilter yes
```



```
vxlan-id 30  
vxlan-local-tunnelip 10.2.1.1
```

```
vxlan-id 30  
vxlan-local-tunnelip 10.2.1.2
```



Why is vni-2000 not vni-20? For example, why not tie VLAN 20 to VNI 20, or why was 2000 used? VXLANs and VLANs do not need to be the same number. However if you are using fewer than 4096 VLANs, there is no reason not to make it easy and correlate VLANs to VXLANs. It is completely up to you.

## Verify the VLAN to VXLAN Mapping

Use the `brctl show` command to see the physical and logical interfaces associated with that bridge:

```
cumulus@leaf1:~$ brctl show  
bridge name      bridge id          STP enabled      interfaces  
bridge           8000.443839008404    yes            swp32s0.10  
                                vni-10  
                                vni-2000  
                                vni-30
```

As with any logical interfaces on Linux, the name does not matter (other than a 15-character limit). To verify the associated VNI for the logical name, use the `ip -d link show` command:

```
cumulus@leaf1:~$ ip -d link show vni-10  
43: vni-10: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue  
      master br-10 state UNKNOWN mode DEFAULT  
        link/ether 02:ec:ec:bd:7f:c6 brd ff:ff:ff:ff:ff:ff  
        vxlan id 10 srcport 32768 61000 dstport 4789 ageing 1800  
        bridge_slave
```

The `vxlid id 10` indicates the VXLAN ID/VNI is indeed 10 as the logical name suggests.

## Enable and Manage Service Node and Registration Daemons

Every VTEP must run the registration daemon (`vxrd`). Typically, every leaf switch acts as a VTEP. A minimum of 1 switch (a switch not already acting as a VTEP) must run the service node daemon (`vxsnd`). The instructions for enabling these daemons follows.

### Enable the Service Node Daemon

The service node daemon (`vxsnd`) is included in the Cumulus Linux repository as `vxfld-vxsnd`. The service node daemon can run on any switch running Cumulus Linux as long as that switch is not also a VXLAN VTEP. In this example, enable the service node only on the spine1 switch, then restart the service.



```
cumulus@spine1:~$ sudo systemctl enable vxsnd.service  
cumulus@spine1:~$ sudo systemctl restart vxsnd.service
```



Do not run `vxsnd` on a switch that is already acting as a VTEP.

### Enable the Registration Daemon

The registration daemon (`vxrd`) is included in the Cumulus Linux package as `vxfld-vxrd`. The registration daemon must run on each VTEP participating in LNV, so you must enable it on every TOR (leaf) switch acting as a VTEP, then restart the `vxrd` daemon. For example, on leaf1:

```
cumulus@leaf1:~$ sudo systemctl enable vxrd.service  
cumulus@leaf1:~$ sudo systemctl restart vxrd.service
```

Then enable and restart the `vxrd` daemon on leaf2:

```
cumulus@leaf2:~$ sudo systemctl enable vxrd.service  
cumulus@leaf2:~$ sudo systemctl restart vxrd.service
```

### Check the Daemon Status

To determine if the daemon is running, use the `systemctl status <daemon name>.service` command.

For the service node daemon:

```
cumulus@spine1:~$ sudo systemctl status vxsnd.service  
vxsnd.service - Lightweight Network Virt Discovery Svc and Replicator  
  Loaded: loaded (/lib/systemd/system/vxsnd.service; enabled)  
  Active: active (running) since Wed 2016-05-11 11:42:55 UTC; 10min  
ago  
    Main PID: 774 (vxsnd)  
      CGroup: /system.slice/vxsnd.service  
              774 /usr/bin/python /usr/bin/vxsnd  
  
May 11 11:42:55 cumulus vxsnd[774]: INFO: Starting (pid 774) ...
```

For the registration daemon:

```
cumulus@leaf1:~$ sudo systemctl status vxrd.service  
vxrd.service - Lightweight Network Virtualization Peer Discovery  
Daemon  
  Loaded: loaded (/lib/systemd/system/vxrd.service; enabled)
```



```
Active: active (running) since Wed 2016-05-11 11:42:55 UTC; 10min
ago
Main PID: 929 (vxrd)
CGroup: /system.slice/vxrd.service
         929 /usr/bin/python /usr/bin/vxrd

May 11 11:42:55 cumulus vxrd[929]: INFO: Starting (pid 929) ...
```

## Configure the Registration Node

The registration node was configured earlier in `/etc/network/interfaces` in the [VXLAN mapping \(see page 613\)](#) section above; no additional configuration is typically needed. However, if you need to modify the registration node configuration, edit `/etc/vxrd.conf`.

### Configuring the registration node in `/etc/vxrd.conf` ...

```
cumulus@leaf1:~$ sudo nano /etc/vxrd.conf
```

Then edit the `svcnod_ip` variable:

```
svcnod_ip = 10.2.1.3
```

Then perform the same on leaf2:

```
cumulus@leaf2:~$ sudo nano /etc/vxrd.conf
```

And again edit the `svcnod_ip` variable:

```
svcnod_ip = 10.2.1.3
```

Enable, then restart the registration node daemon for the change to take effect:

```
cumulus@leaf1:~$ sudo systemctl enable vxrd.service
cumulus@leaf1:~$ sudo systemctl restart vxrd.service
```

Restart the daemon on leaf2:

```
cumulus@leaf2:~$ sudo systemctl enable vxrd.service
cumulus@leaf2:~$ sudo systemctl restart vxrd.service
```

The complete list of options you can configure is listed below:

### Registration node options ...

Name	Description	Default
loglevel	The log level: DEBUG, INFO, WARNING, ERROR, CRITICAL.	INFO
logdest	The destination for log messages. The destination can be a file name, <code>stdout</code> , or <code>syslog</code> .	syslog
logfilesize	The log file size in bytes. Used when <code>logdest</code> is a file name.	512000
logbackupcount	The maximum number of log files stored on the disk. Used when <code>logdest</code> is a file name.	14
pidfile	The PIF file location for the <code>vxrd</code> daemon.	/var/run/vxrd.pid
udsfile	The file name for the Unix domain socket used for management.	/var/run/vxrd.sock
vxfld_port	The UDP port used for VXLAN control messages.	10001
svcnod_ip	The address to which registration daemons send control messages for registration and or BUM packets for replication. You can also configure this option in the <code>/etc/network/interfaces</code> file with the <code>vxrd-svcnode-ip</code> keyword.	
holdtime	The hold time (in seconds) for soft state, which is how long the service node waits before ageing out an IP address for a VNI. The <code>vxrd</code> includes this in the register messages it sends to a <code>vxsnd</code> .	90 seconds
src_ip	The local IP address to bind to for receiving control traffic from the service node daemon.	
refresh_rate	The number of times to refresh within the hold time. The higher this number, the more lost UDP refresh messages can be tolerated.	3 seconds
config_check_rate	The number of seconds to poll the system for current VXLAN membership.	5 seconds
head_rep	Enables self replication. Instead of using the service node to replicate BUM packets, it is done in hardware on the VTEP switch.	true



Use `1`, `yes`, `true`, or `on` for True for each relevant option. Use `0`, `no`, `false`, or `off` for False.



## Configure the Service Node

To configure the service node daemon, edit the `/etc/vxsnd.conf` configuration file.



For the example configuration, default values are used, except for the `svcnod_ip` field.

```
cumulus@spine1:~$ sudo nano /etc/vxsnd.conf
```

The address field is set to the loopback address of the switch running the `vxsnd` daemon.

```
svcnod_ip = 10.2.1.3
```

Enable, then restart the service node daemon for the change to take effect:

```
cumulus@spine1:~$ sudo systemctl enable vxsnd.service
cumulus@spine1:~$ sudo systemctl restart vxsnd.service
```

The complete list of options you can configure is listed below:

Name	Description	Default
loglevel	The log level: DEBUG, INFO, WARNING, ERROR, CRITICAL.	INFO
logdest	The destination for log messages. The destination can be a file name, <code>stdout</code> , or <code>syslog</code> .	syslog
logfilesize	The log file size in bytes. Used when <code>logdest</code> is a file name.	512000
logbackupcount	The maximum number of log files stored on disk. Used when <code>logdest</code> is a file name.	14
pidfile	The PID file location for the <code>vxrd</code> daemon.	<code>/var/run/vxrd.pid</code>
udsfile	The file name for the Unix domain socket used for management.	<code>/var/run/vxrd.sock</code>
vxld_port	The UDP port used for VXLAN control messages.	10001
svcnod_ip		0.0.0.0

Name	Description	Default
	The address to which registration daemons send control messages for registration and or BUM packets for replication.	
holdtime	The holdtime (in seconds) for soft state. This option is used when sending a register message to peers in response to learning a <vnid, addr> from a VXLAN data packet.	90
src_ip	The local IP address to bind to for receiving inter-vxsnd control traffic.	0.0.0.0
svcnodes_peers	A space-separated list of IP addresses with which the <code>vxsnd</code> shares its state.	
enable_vxlan_listen	When set to true, the service node listens for VXLAN data traffic.	true
install_svcnode_ip	When set to true, the <code>snd_peer_address</code> gets installed on the loopback interface. It gets withdrawn when the <code>vxsnd</code> is not in service. If set to true, you must define the <code>snd_peer_address</code> configuration variable.	false
age_check	Number of seconds to wait before checking the database to age out stale entries.	90 seconds



Use `1, yes, true, or on` for True for each relevant option. Use `0, no, false, or off` for False.

## Advanced LNV Usage

### Scale LNV by Load Balancing with Anycast

The above configuration assumes a single service node, which can quickly be overwhelmed by BUM traffic. To load balance BUM traffic across multiple service nodes, use [Anycast](#). Anycast enables BUM traffic to reach the topologically nearest service node instead of overwhelming a single service node.

### Enable the Service Node Daemon on Additional Spine Switches

In this example, spine1 already has the service node daemon enabled. Enable it on the spine2 switch, then restart the `vxsnd` daemon:

```
cumulus@spine2:~$ sudo systemctl enable vxsnd.service
cumulus@spine2:~$ sudo systemctl restart vxsnd.service
```



## Configure the Anycast Address on All Participating Service Nodes

### spine1:

Add the 10.10.10.10/32 address to the loopback address:

```
cumulus@spine1:~$ net add  
loopback lo ip address  
10.10.10.10/32  
cumulus@spine1:~$ net pending  
cumulus@spine1:~$ net commit
```

These commands create the following configuration in the /etc/network/interfaces file:

```
auto lo  
iface lo inet loopback  
    address 10.2.1.3/32  
    address 10.10.10.10/32
```

Verify the IP address is configured:

```
cumulus@spine1:~$ ip addr show  
lo  
1: lo: <LOOPBACK,UP,LOWER_UP>  
mtu 16436 qdisc noqueue state  
UNKNOWN  
    link/loopback 00:00:00:00:  
00:00 brd 00:00:00:00:00:00  
        inet 127.0.0.1/8 scope  
host lo  
    inet 10.2.1.3/32 scope  
global lo  
    inet 10.10.10.10/32 scope  
global lo  
    inet6 ::1/128 scope host  
        valid_lft forever  
preferred_lft forever
```

### spine2:

Add the 10.10.10.10/32 address to the loopback address:

```
cumulus@spine2:~$ net add  
loopback lo ip address  
10.10.10.10/32  
cumulus@spine2:~$ net pending  
cumulus@spine2:~$ net commit
```

These commands create the following configuration in the /etc/network/interfaces file:

```
auto lo  
iface lo inet loopback  
    address 10.2.1.4/32  
    address 10.10.10.10/32
```

Verify the IP address is configured:

```
cumulus@spine2:~$ ip addr show  
lo  
1: lo: <LOOPBACK,UP,LOWER_UP>  
mtu 16436 qdisc noqueue state  
UNKNOWN  
    link/loopback 00:00:00:00:  
00:00 brd 00:00:00:00:00:00  
        inet 127.0.0.1/8 scope  
host lo  
    inet 10.2.1.4/32 scope  
global lo  
    inet 10.10.10.10/32 scope  
global lo  
    inet6 ::1/128 scope host  
        valid_lft forever  
preferred_lft forever
```

## Configure the Service Node vxsnd.conf File

### spine1:

Use a text editor to edit the network configuration:

```
cumulus@spine1:~$ sudo nano  
/etc/vxsnd.conf
```

Change the following values:

```
svcnod_ip = 10.10.10.10  
svcnod_peers = 10.2.1.4  
src_ip = 10.2.1.3
```

This sets the address on which the service node listens to VXLAN messages to the configured Anycast address and sets it to sync with spine2.

Enable, then restart the `vxsnd` daemon:

```
cumulus@spine1:~$ sudo  
systemctl enable vxsnd.service  
cumulus@spine1:~$ sudo  
systemctl restart vxsnd.service
```

### spine2:

Use a text editor to edit the network configuration:

```
cumulus@spine2:~$ sudo nano  
/etc/vxsnd.conf
```

Change the following values:

```
svcnod_ip = 10.10.10.10  
svcnod_peers = 10.2.1.3  
src_ip = 10.2.1.4
```

This sets the address on which the service node listens to VXLAN messages to the configured Anycast address and sets it to sync with spine1.

Enable, then restart the `vxsnd` daemon:

```
cumulus@spine1:~$ sudo  
systemctl enable vxsnd.service  
cumulus@spine1:~$ sudo  
systemctl restart vxsnd.service
```



## Reconfigure the VTEPs (Leafs) to Use the Anycast Address

### leaf1:

Change the `vxrd-svcnode-ip` field to the anycast address:

```
cumulus@leaf1:~$ net add  
loopback lo vxrd-svcnode-ip  
10.10.10.10  
cumulus@leaf1:~$ net pending  
cumulus@leaf1:~$ net commit
```

These commands create the following configuration in the `/etc/network/interfaces` file:

```
auto lo  
iface lo inet loopback  
    address 10.2.1.1  
    vxrd-svcnode-ip 10.10.10.10
```

Verify the new service node is configured:

```
cumulus@leaf1:~$ ip -d link  
show vni-10  
35: vni-10: <BROADCAST,  
MULTICAST,UP,LOWER_UP> mtu  
1500 qdisc noqueue master br-  
10 state UNKNOWN mode DEFAULT  
    link/ether 46:c6:57:fc:1f:  
54 brd ff:ff:ff:ff:ff:ff  
        vxlan id 10 remote  
10.10.10.10 local 10.2.1.1  
srcport 32768 61000 dstport  
4789 ageing 1800 svcnode  
10.10.10.10  
        bridge_slave
```

```
cumulus@leaf1:~$ ip -d link  
show vni-2000  
39: vni-2000: <BROADCAST,  
MULTICAST,UP,LOWER_UP> mtu  
1500 qdisc noqueue master br-  
20 state UNKNOWN mode DEFAULT
```

### leaf2:

Change the `vxrd-svcnode-ip` field to the anycast address:

```
cumulus@leaf1:~$ net add  
loopback lo vxrd-svcnode-ip  
10.10.10.10  
cumulus@leaf1:~$ net pending  
cumulus@leaf1:~$ net commit
```

These commands create the following configuration in the `/etc/network/interfaces` file:

```
auto lo  
iface lo inet loopback  
    address 10.2.1.2  
    vxrd-svcnode-ip 10.10.10.10
```

Verify the new service node is configured:

```
cumulus@leaf2:~$ ip -d link  
show vni-10  
35: vni-10: <BROADCAST,  
MULTICAST,UP,LOWER_UP> mtu  
1500 qdisc noqueue master br-  
10 state UNKNOWN mode DEFAULT  
    link/ether 4e:03:a7:47:a7:  
9d brd ff:ff:ff:ff:ff:ff  
        vxlan id 10 remote  
10.10.10.10 local 10.2.1.2  
srcport 32768 61000 dstport  
4789 ageing 1800 svcnode  
10.10.10.10  
        bridge_slave
```

```
cumulus@leaf2:~$ ip -d link  
show vni-2000  
39: vni-2000: <BROADCAST,  
MULTICAST,UP,LOWER_UP> mtu  
1500 qdisc noqueue master br-  
20 state UNKNOWN mode DEFAULT
```

```

link/ether 4a:fd:88:c3:fa:
df brd ff:ff:ff:ff:ff:ff
    vxlan id 2000 remote
10.10.10.10 local 10.2.1.1
srcport 32768 61000 dstport
4789 ageing 1800 svcnode
10.10.10.10
    bridge_slave

cumulus@leaf1:~$ ip -d link
show vni-30
37: vni-30: <BROADCAST,
MULTICAST,UP,LOWER_UP> mtu
1500 qdisc noqueue master br-
30 state UNKNOWN mode DEFAULT
    link/ether 3e:b3:dc:f3:bd:
2b brd ff:ff:ff:ff:ff:ff
    vxlan id 30 remote
10.10.10.10 local 10.2.1.1
srcport 32768 61000 dstport
4789 ageing 1800 svcnode
10.10.10.10
    bridge_slave

```

**⚠** The `svcnode 10.10.10.10` means the interface has the correct service node configured.

Use the `vxrdctl vxlans` command to check the service node:

```

cumulus@leaf1:~$ vxrdctl vxlans
VNI      Local Addr      Svc
Node
===
=====
10       10.2.1.1
10.2.1.3
30       10.2.1.1
10.2.1.3
2000     10.2.1.1
10.2.1.3

```

```

link/ether 72:3a:bd:06:00:
b7 brd ff:ff:ff:ff:ff:ff
    vxlan id 2000 remote
10.10.10.10 local 10.2.1.2
srcport 32768 61000 dstport
4789 ageing 1800 svcnode
10.10.10.10
    bridge_slave

cumulus@leaf2:~$ ip -d link
show vni-30
37: vni-30: <BROADCAST,
MULTICAST,UP,LOWER_UP> mtu
1500 qdisc noqueue master br-
30 state UNKNOWN mode DEFAULT
    link/ether 22:65:3f:63:08:
bd brd ff:ff:ff:ff:ff:ff
    vxlan id 30 remote
10.10.10.10 local 10.2.1.2
srcport 32768 61000 dstport
4789 ageing 1800 svcnode
10.10.10.10
    bridge_slave

```

**⚠** The `svcnode 10.10.10.10` means the interface has the correct service node configured.

Use the `vxrdctl vxlans` command to check the service node:

```

cumulus@leaf2:~$ vxrdctl vxlans
VNI      Local Addr      Svc
Node
===
=====
10       10.2.1.2
10.2.1.3
30       10.2.1.2
10.2.1.3
2000     10.2.1.2
10.2.1.3

```



## *Test Connectivity*

Repeat the ping tests from the previous section. Here is the table again for reference:

VNI	server1	server2
10	10.10.10.1	10.10.10.2
2000	10.10.20.1	10.10.20.2
30	10.10.30.1	10.10.30.2

```
cumulus@server1:~$ ping 10.10.10.2
PING 10.10.10.2 (10.10.10.2) 56(84) bytes of data.
64 bytes from 10.10.10.2: icmp_seq=1 ttl=64 time=5.32 ms
64 bytes from 10.10.10.2: icmp_seq=2 ttl=64 time=0.206 ms
^C
--- 10.10.10.2 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1001ms
rtt min/avg/max/mdev = 0.206/2.767/5.329/2.562 ms

PING 10.10.20.2 (10.10.20.2) 56(84) bytes of data.
64 bytes from 10.10.20.2: icmp_seq=1 ttl=64 time=1.64 ms
64 bytes from 10.10.20.2: icmp_seq=2 ttl=64 time=0.187 ms
^C
--- 10.10.20.2 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1001ms
rtt min/avg/max/mdev = 0.187/0.914/1.642/0.728 ms

cumulus@server1:~$ ping 10.10.30.2
PING 10.10.30.2 (10.10.30.2) 56(84) bytes of data.
64 bytes from 10.10.30.2: icmp_seq=1 ttl=64 time=1.63 ms
64 bytes from 10.10.30.2: icmp_seq=2 ttl=64 time=0.191 ms
^C
--- 10.10.30.2 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1001ms
rtt min/avg/max/mdev = 0.191/0.913/1.635/0.722 ms
```

## *Restart Network Removes vxsnd Anycast IP Address from Loopback Interface*

If you have not configured a loopback anycast IP address in the `/etc/network/interfaces` file, but you have enabled the `vxsnd` (service node daemon) log to automatically add anycast IP addresses, when you restart networking (with `systemctl restart networking`), the anycast IP address gets removed from the loopback interface.

To prevent this issue from occurring, specify an anycast IP address for the loopback interface in both the `/etc/network/interfaces` file and the `vxsnd.conf` file. This way, in case `vxsnd` fails, you can withdraw the IP address.



## Related Information

- [tools.ietf.org/html/rfc7348](http://tools.ietf.org/html/rfc7348)
- [en.wikipedia.org/wiki/Anycast](http://en.wikipedia.org/wiki/Anycast)
- Network virtualization chapter, Cumulus Linux user guide (see page 490)

## LNV Full Example



As of Cumulus Linux 3.7.4, the lightweight network virtualization feature (LNV) has been deprecated. The feature will be removed in Cumulus Linux 4.0. Cumulus Networks recommends you use [Ethernet virtual private network \(EVPN\) \(see page 501\)](#) for network virtualization.

Lightweight Network Virtualization (LNV) is a technique for deploying [VXLANs \(see page 490\)](#) without a central controller on bare metal switches. This a full example complete with diagram. Refer to the [Lightweight Network Virtualization chapter \(see page 602\)](#) for more detailed information. This full example uses the **recommended way** of deploying LNV, which is to use anycast to load balance the service nodes.



LNV is a lightweight controller option. [Contact Cumulus Networks](#) with your scale requirements so we can make sure this is the right fit for you. There are also other controller options that can work on Cumulus Linux.

## Contents

### This topic describes ...

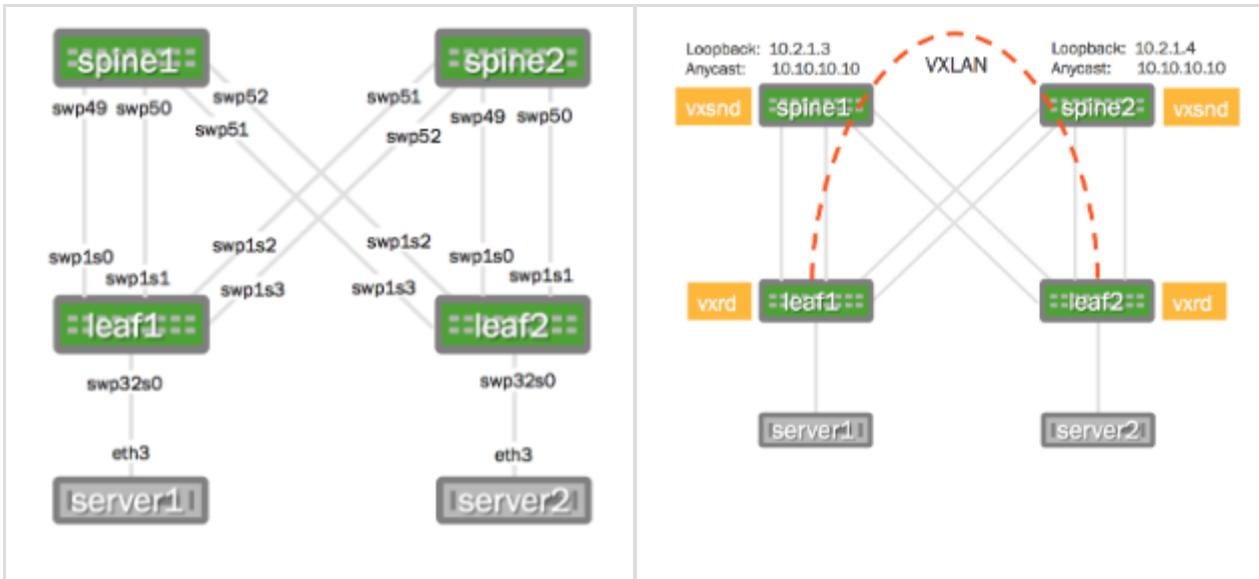
- Example LNV Configuration (see page 626)
  - Layer 3 IP Addressing (see page 627)
  - FRRouting Configuration (see page 629)
  - Host Configuration (see page 630)
  - Service Node Configuration (see page 632)
- Related Information (see page 633)

### Example LNV Configuration

The following images illustrate the configuration:

Physical Cabling Diagram

Network Virtualization Diagram



Want to try out configuring LNV and do not have a Cumulus Linux switch? Check out [Cumulus VX](#).

Feeling Overwhelmed? Come join a [Cumulus Boot Camp](#) and get instructor-led training!

## Layer 3 IP Addressing

Here is the configuration for the IP addressing information used in this example:

### spine1: /etc/network/interfaces

```
auto lo
iface lo inet loopback
    address 10.2.1.3/32
    address 10.10.10.10/32

auto eth0
iface eth0 inet dhcp

auto swp49
iface swp49
    address 10.1.1.2/30

auto swp50
iface swp50
    address 10.1.1.6/30
```

### spine2: /etc/network/interfaces

```
auto lo
iface lo inet loopback
    address 10.2.1.4/32
    address 10.10.10.10/32

auto eth0
iface eth0 inet dhcp

auto swp49
iface swp49
    address 10.1.1.18/30

auto swp50
iface swp50
    address 10.1.1.22/30
```

```
auto swp51
iface swp51
    address 10.1.1.50/30
```

```
auto swp52
iface swp52
    address 10.1.1.54/30
```

```
auto swp51
iface swp51
    address 10.1.1.34/30
```

```
auto swp52
iface swp52
    address 10.1.1.38/30
```

**leaf1:** /etc/network/interfaces

```
auto lo
iface lo inet loopback
    address 10.2.1.1/32
    vxrd-src-ip 10.2.1.1
    vxrd-svcnode-ip 10.10.10.10
```

```
auto eth0
iface eth0 inet dhcp
```

```
auto swp1s0
iface swp1s0
    address 10.1.1.1/30
```

```
auto swp1s1
iface swp1s1
    address 10.1.1.5/30
```

```
auto swp1s2
iface swp1s2
    address 10.1.1.33/30
```

```
auto swp1s3
iface swp1s3
    address 10.1.1.37/30
```

```
auto vni-10
iface vni-10
    vxlan-id 10
    vxlan-local-tunnelip 10.2.1.1
    mstpcctl-bpduguard yes
    mstpcctl-portbpdufilter yes
```

```
auto vni-2000
iface vni-2000
    vxlan-id 2000
    vxlan-local-tunnelip 10.2.1.1
    mstpcctl-bpduguard yes
    mstpcctl-portbpdufilter yes
```

**leaf2:** /etc/network/interfaces

```
auto lo
iface lo inet loopback
    address 10.2.1.2/32
    vxrd-src-ip 10.2.1.2
    vxrd-svcnode-ip 10.10.10.10
```

```
auto eth0
iface eth0 inet dhcp
```

```
auto swp1s0
iface swp1s0 inet static
    address 10.1.1.17/30
```

```
auto swp1s1
iface swp1s1 inet static
    address 10.1.1.21/30
```

```
auto swp1s2
iface swp1s2 inet static
    address 10.1.1.49/30
```

```
auto swp1s3
iface swp1s3 inet static
    address 10.1.1.53/30
```

```
auto vni-10
iface vni-10
    vxlan-id 10
    vxlan-local-tunnelip 10.2.1.2
    mstpcctl-bpduguard yes
    mstpcctl-portbpdufilter yes
```

```
auto vni-2000
iface vni-2000
    vxlan-id 2000
    vxlan-local-tunnelip 10.2.1.2
    mstpcctl-bpduguard yes
    mstpcctl-portbpdufilter yes
```



```
auto vni-30
iface vni-30
    vxlan-id 30
    vxlan-local-tunnelip 10.2.1.1
    mstpctl-bpduguard yes
    mstpctl-portbpdufilter yes

auto br-10
iface br-10
    bridge-ports swp32s0.10 vni-10

auto br-20
iface br-20
    bridge-ports swp32s0.20 vni-2000

auto br-30
iface br-30
    bridge-ports swp32s0.30 vni-30
```

```
auto vni-30
iface vni-30
    vxlan-id 30
    vxlan-local-tunnelip 10.2.1.2
    mstpctl-bpduguard yes
    mstpctl-portbpdufilter yes

auto br-10
iface br-10
    bridge-ports swp32s0.10 vni-10

auto br-20
iface br-20
    bridge-ports swp32s0.20 vni-2000

auto br-30
iface br-30
    bridge-ports swp32s0.30 vni-30
```

## FRRouting Configuration

The service nodes and registration nodes must all be routable between each other. The layer 3 fabric on Cumulus Linux can either be [BGP \(see page 773\)](#) or [OSPF \(see page 756\)](#). In this example, OSPF is used to demonstrate full reachability.

Here is the FRRouting configuration using OSPF:

**spine1:** /etc/frr/frr.conf

```
interface lo
    ip ospf area 0.0.0.0
interface swp49
    ip ospf network point-to-point
    ip ospf area 0.0.0.0
!
interface swp50
    ip ospf network point-to-point
    ip ospf area 0.0.0.0
!
interface swp51
    ip ospf network point-to-point
    ip ospf area 0.0.0.0
```

**spine2:** /etc/frr/frr.conf

```
interface lo
    ip ospf area 0.0.0.0
interface swp49
    ip ospf network point-to-point
    ip ospf area 0.0.0.0
!
interface swp50
    ip ospf network point-to-point
    ip ospf area 0.0.0.0
!
interface swp51
    ip ospf network point-to-point
    ip ospf area 0.0.0.0
```

```

!
interface swp52
  ip ospf network point-to-
  point
  ip ospf area 0.0.0.0
!
!
!
!
!
router-id 10.2.1.3
router ospf
  ospf router-id 10.2.1.3

```

```

!
interface swp52
  ip ospf network point-to-
  point
  ip ospf area 0.0.0.0
!
!
!
!
!
router-id 10.2.1.4
router ospf
  ospf router-id 10.2.1.4

```

**leaf1:** /etc/frr/frr.conf

```

interface lo
  ip ospf area 0.0.0.0
interface swp1s0
  ip ospf network point-to-
  point
  ip ospf area 0.0.0.0
!
interface swp1s1
  ip ospf network point-to-
  point
  ip ospf area 0.0.0.0
!
interface swp1s2
  ip ospf network point-to-
  point
  ip ospf area 0.0.0.0
!
interface swp1s3
  ip ospf network point-to-
  point
  ip ospf area 0.0.0.0
!
!
!
!
router-id 10.2.1.1
router ospf
  ospf router-id 10.2.1.1

```

**leaf2:** /etc/frr/frr.conf

```

interface lo
  ip ospf area 0.0.0.0
interface swp1s0
  ip ospf network point-to-
  point
  ip ospf area 0.0.0.0
!
interface swp1s1
  ip ospf network point-to-
  point
  ip ospf area 0.0.0.0
!
interface swp1s2
  ip ospf network point-to-
  point
  ip ospf area 0.0.0.0
!
interface swp1s3
  ip ospf network point-to-
  point
  ip ospf area 0.0.0.0
!
!
!
!
router-id 10.2.1.2
router ospf
  ospf router-id 10.2.1.2

```



## Host Configuration

In this example, the servers are running Ubuntu 14.04. You must map a trunk from server1 and server2 to the respective switch. In Ubuntu, this is done with subinterfaces.

### server1

```
auto eth3.10
iface eth3.10 inet
static
    address 10.10.10.1/24

auto eth3.20
iface eth3.20 inet
static
    address 10.10.20.1/24

auto eth3.30
iface eth3.30 inet
static
    address 10.10.30.1/24
```

### server2

```
auto eth3.10
iface eth3.10 inet
static
    address 10.10.10.2/24

auto eth3.20
iface eth3.20 inet
static
    address 10.10.20.2/24

auto eth3.30
iface eth3.30 inet
static
    address 10.10.30.2/24
```

## Service Node Configuration

**spine1**:/etc/vxsnd.conf

```
[common]
# Log level is one of DEBUG,
INFO, WARNING, ERROR, CRITICAL
#loglevel = INFO
# Destination for log
message. Can be a file name, 'stdout', or 'syslog'
#logdest = syslog
# log file size in bytes. Used
when logdest is a file
#logfilesize = 512000
# maximum number of log files
stored on disk. Used when
logdest is a file
#logbackupcount = 14
# The file to write the pid.
If using monit, this must
match the one
# in the vxsnd.rc
#pidfile = /var/run/vxsnd.pid
# The file name for the unix
domain socket used for mgmt.
#udsfile = /var/run/vxsnd.sock
# UDP port for vxflid control
messages
#vxflid_port = 10001
# This is the address to which
registration daemons send
control messages for
# registration and/or BUM
packets for replication
svcnodc_ip = 10.10.10.10
# Holdtime (in seconds) for
soft state. It is used when
sending a
# register msg to peers in
response to learning a <vni,
addr> from a
# VXLAN data pkt
#holdtime = 90
# Local IP address to bind to f
or receiving inter-vxsnd
control traffic
src_ip = 10.2.1.3
```

**spine2**:/etc/vxsnd.conf

```
[common]
# Log level is one of DEBUG,
INFO, WARNING, ERROR, CRITICAL
#loglevel = INFO
# Destination for log
message. Can be a file name, 'stdout', or 'syslog'
#logdest = syslog
# log file size in bytes. Used
when logdest is a file
#logfilesize = 512000
# maximum number of log files
stored on disk. Used when
logdest is a file
#logbackupcount = 14
# The file to write the pid.
If using monit, this must
match the one
# in the vxsnd.rc
#pidfile = /var/run/vxsnd.pid
# The file name for the unix
domain socket used for mgmt.
#udsfile = /var/run/vxsnd.sock
# UDP port for vxflid control
messages
#vxflid_port = 10001
# This is the address to which
registration daemons send
control messages for
# registration and/or BUM
packets for replication
svcnodc_ip = 10.10.10.10
# Holdtime (in seconds) for
soft state. It is used when
sending a
# register msg to peers in
response to learning a <vni,
addr> from a
# VXLAN data pkt
#holdtime = 90
# Local IP address to bind to f
or receiving inter-vxsnd
control traffic
src_ip = 10.2.1.4
```



```
[vxsnd]
# Space separated list of IP
addresses of vxsnd to share
state with
svcnode_peers = 10.2.1.4
# When set to true, the
service node will listen for
vxlan data traffic
# Note: Use 1, yes, true, or
on, for True and 0, no, false,
or off,
# for False
#enable_vxlan_listen = true
# When set to true, the
svcnode_ip will be installed
on the loopback
# interface, and it will be
withdrawn when the vxsnd is no
longer in
# service. If set to true,
the svcnode_ip configuration
# variable must be defined.
# Note: Use 1, yes, true, or
on, for True and 0, no, false,
or off,
# for False
#install_svcnode_ip = false
# Seconds to wait before
checking the database to age
out stale entries
#age_check = 90
```

```
[vxsnd]
# Space separated list of IP
addresses of vxsnd to share
state with
svcnode_peers = 10.2.1.3
# When set to true, the
service node will listen for
vxlan data traffic
# Note: Use 1, yes, true, or
on, for True and 0, no, false,
or off,
# for False
#enable_vxlan_listen = true
# When set to true, the
svcnode_ip will be installed
on the loopback
# interface, and it will be
withdrawn when the vxsnd is no
longer in
# service. If set to true,
the svcnode_ip configuration
# variable must be defined.
# Note: Use 1, yes, true, or
on, for True and 0, no, false,
or off,
# for False
#install_svcnode_ip = false
# Seconds to wait before
checking the database to age
out stale entries
#age_check = 90
```

### Related Information

- [tools.ietf.org/html/rfc7348](http://tools.ietf.org/html/rfc7348)
- [en.wikipedia.org/wiki/Anycast](http://en.wikipedia.org/wiki/Anycast)
- Detailed LNV Configuration Guide (see page 602)
- Cumulus Networks Training
- Network virtualization chapter, Cumulus Linux user guide (see page 490)

## VXLAN Active-Active Mode

VXLAN active-active mode allows a pair of MLAG (see page 440) switches to act as a single VTEP, providing active-active VXLAN termination for bare metal as well as virtualized workloads.

There are some differences whether you're deploying this with EVPN (see page 501) or LNV (see page 602). This chapter outlines the configurations for both options.



## Contents

This topic describes ...

- Terminology (see page 634)
- Configure VXLAN Active-active Mode (see page 635)
  - Active-active VTEP Anycast IP Behavior (see page 635)
  - Failure Scenario Behaviors (see page 636)
  - Check VXLAN Interface Configuration Consistency (see page 637)
  - Configure the Anycast IP Address (see page 637)
- Example VXLAN Active-Active Configuration (see page 638)
  - FRRouting Configuration (see page 638)
  - Layer 3 IP Addressing (see page 638)
  - Host Configuration (see page 642)
- Using Active-active Mode with LNV (see page 643)
  - Terminology (see page 643)
  - Configure the Loopback Interface for Active-active Mode (see page 644)
  - Enable the Registration Daemon (see page 645)
  - Configure a VTEP (see page 645)
  - Enable the Service Node Daemon (see page 646)
  - Configure the Service Node (see page 646)
- Troubleshooting (see page 648)
- Caveats and Errata (see page 649)
  - Use VLAN for Peer Link Only Once (see page 649)
  - Bonds with Vagrant in Cumulus VX (see page 649)
  - With LNV, Unique Node ID Required for vxrd in Cumulus VX (see page 650)
- Related Information (see page 651)

## Terminology

Term	Definition
VTEP	The virtual tunnel endpoint. This is an encapsulation and decapsulation point for VXLANs.
active-active VTEP	A pair of switches acting as a single VTEP.
ToR	The top of rack switch; also referred to as a leaf or access switch.
spine	The aggregation switch for multiple leafs. Specifically used when a data center is using a <a href="#">Clos network architecture</a> . Read more about spine-leaf architecture in this <a href="#">white paper</a> .



Term	Definition
exit leaf	A switch dedicated to peering the Clos network to an outside network; also referred to as a border leaf, service leaf, or edge leaf.
anycast	An IP address that is advertised from multiple locations. Anycast enables multiple devices to share the same IP address and effectively load balance traffic across them. With VXLAN, anycast is used to share a VTEP IP address between a pair of MLAG switches.
RIOT	Routing in and out of tunnels. A Broadcom feature for routing in and out of tunnels. Allows a VXLAN bridge to have a switch VLAN interface associated with it, and traffic to exit a VXLAN into the layer 3 fabric. Also called VXLAN Routing.
VXLAN routing	The industry standard term for the ability to route in and out of a VXLAN. Equivalent to the Broadcom RIOT feature.
clagd-vxlan-anycast-ip	The anycast address for the MLAG pair to share and bind to when MLAG is up and running.

## Configure VXLAN Active-active Mode

VXLAN active-active mode requires the following underlying technologies to work correctly.

Technology	More Information
MLAG	Refer to the <a href="#">MLAG chapter (see page )</a> for more detailed configuration information. Configurations for the demonstration are provided below.
OSPF or BGP	Refer to the <a href="#">OSPF chapter</a> or the <a href="#">BGP chapter (see page 773)</a> for more detailed configuration information. Configurations for the BGP demonstration are provided below.
STP	You must enable <a href="#">BPDU filter and BPDU guard (see page )</a> in the VXLAN interfaces if <a href="#">STP (see page 633)</a> is enabled in the bridge that is connected to the VXLAN. Configurations for the demonstration are provided below.

### Active-active VTEP Anycast IP Behavior

You must provision each individual switch within an MLAG pair with a virtual IP address in the form of an anycast IP address for VXLAN data-path termination. The VXLAN termination address is an anycast IP address that you configure as a `clagd` parameter (`clagd-vxlan-anycast-ip`) under the loopback interface. `clagd` dynamically adds and removes this address as the loopback interface address as follows:

1. When the switches boot up, `ifupdown2` places all VXLAN interfaces in a PROTO\_DOWN state. The configured anycast addresses are not configured yet.
2. MLAG peering takes place and a successful VXLAN interface consistency check between the switches occurs.

3. `c1agd` (the daemon responsible for MLAG) adds the anycast address to the loopback interface as a second address. It then changes the local IP address of the VXLAN interface from a unique address to the anycast virtual IP address and puts the interface in an UP state.



In order for the anycast address to activate, you must configure a VXLAN interface on each switch in the MLAG pair.

## *Failure Scenario Behaviors*

Scenario	Behavior
The peer link goes down.	The primary MLAG switch continues to keep all VXLAN interfaces up with the anycast IP address while the secondary switch brings down all VXLAN interfaces and places them in a PROTO_DOWN state. The secondary MLAG switch removes the anycast IP address from the loopback interface and changes the local IP address of the VXLAN interface to the configured unique IP address.
One of the switches goes down.	The other operational switch continues to use the anycast IP address.
<code>c1agd</code> is stopped.	All VXLAN interfaces are put in a PROTO_DOWN state. The anycast IP address is removed from the loopback interface and the local IP addresses of the VXLAN interfaces are changed from the anycast IP address to unique non-virtual IP addresses.
MLAG peering could not be established between the switches.	<code>c1agd</code> brings up all the VXLAN interfaces after the reload timer expires with the configured anycast IP address. This allows the VXLAN interface to be up and running on both switches even though peering is not established.
When the peer link goes down but the peer switch is up (the backup link is active).	All VXLAN interfaces are put into a PROTO_DOWN state on the secondary switch.
A configuration mismatch between the MLAG switches	The VXLAN interface is placed into a PROTO_DOWN state on the secondary switch.

## Check VXLAN Interface Configuration Consistency

The active-active configuration for a given VXLAN interface must be consistent between the MLAG switches for correct traffic behavior. MLAG ensures that the configuration consistency is met before bringing up the VXLAN interfaces.

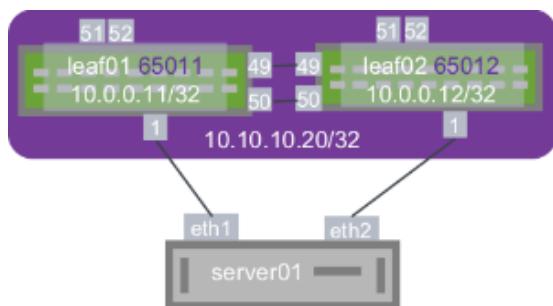
The consistency checks include:

- The anycast virtual IP address for VXLAN termination must be the same on each pair of switches.
- A VXLAN interface with the same VXLAN ID must be configured and administratively up on both switches.

You can use the `clagctl` command to check if any VXLAN switches are in a PROTO\_DOWN state.

## Configure the Anycast IP Address

With MLAG peering, both switches use an anycast IP address for VXLAN encapsulation and decapsulation. This allows remote VTEPs to learn the host MAC addresses attached to the MLAG switches against one logical VTEP, even though the switches independently encapsulate and decapsulate layer 2 traffic originating from the host. You can configure the anycast address under the loopback interface, as shown below.



### **leaf01 /etc/network/interfaces snippet**

```

auto lo
iface lo inet loopback
    address 10.0.0.11/32
    clagd-vxlan-anycast-ip 10.10.10.20

```

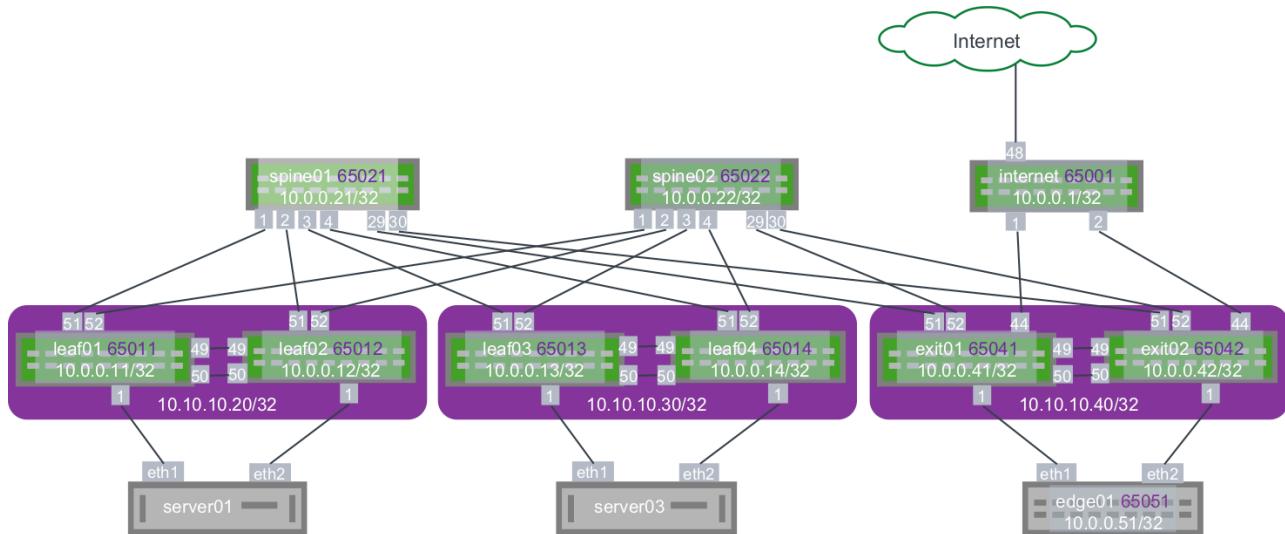
### **leaf02 /etc/network/interfaces snippet**

```

auto lo
iface lo inet loopback
    address 10.0.0.12/32
    clagd-vxlan-anycast-ip 10.10.10.20

```

## Example VXLAN Active-Active Configuration



Note the configuration of the local IP address in the VXLAN interfaces below. They are configured with individual IP addresses, which `cldgad` changes to anycast upon MLAG peering.

### FRRouting Configuration

You can configure the layer 3 fabric using [BGP \(see page 773\)](#) or [OSPF \(see page 756\)](#). The following example uses BGP unnumbered. The MLAG switch configuration for the topology above is shown below.

### Layer 3 IP Addressing

The IP address configuration for this example:

```
spine01: /etc/network
/interfaces

auto lo
iface lo inet loopback
    address 10.0.0.21/32

auto eth0
iface eth0 inet dhcp

# downlinks
auto swp1
iface swp1

auto swp2
iface swp2

auto swp3
```

```
spine02: /etc/network
/interfaces

auto lo
iface lo inet loopback
    address 10.0.0.22/32

auto eth0
iface eth0 inet dhcp

# downlinks
auto swp1
iface swp1

auto swp2
iface swp2

auto swp3
```



```
iface swp3  
  
auto swp4  
iface swp4  
  
auto swp29  
iface swp29  
  
auto swp30  
iface swp30
```

```
iface swp3  
  
auto swp4  
iface swp4  
  
auto swp29  
iface swp29  
  
auto swp30  
iface swp30
```

**leaf01: /etc/network/interfaces**

```
auto lo  
iface lo inet loopback  
    address 10.0.0.11/32  
    clagd-vxlan-anycast-ip  
    10.10.10.20  
  
auto eth0  
iface eth0 inet dhcp  
  
# peerlinks  
auto swp49  
iface swp49  
  
auto swp50  
iface swp50  
  
auto peerlink  
iface peerlink  
    bond-slaves swp49 swp50  
  
auto peerlink.4094  
iface peerlink.4094  
    address 169.254.1.1/30  
    clagd-peer-ip 169.254.1.2  
    clagd-backup-ip 10.0.0.12  
    clagd-sys-mac 44:38:39:FF:40:  
94  
  
# Downlinks  
auto swp1  
iface swp1  
  
auto bond0  
iface bond0  
    bond-slaves swp1
```

**leaf02: /etc/network/interfaces**

```
auto lo  
iface lo inet loopback  
    address 10.0.0.12/32  
    clagd-vxlan-anycast-ip  
    10.10.10.20  
  
auto eth0  
iface eth0 inet dhcp  
  
# peerlinks  
auto swp49  
iface swp49  
  
auto swp50  
iface swp50  
  
auto peerlink  
iface peerlink  
    bond-slaves swp49 swp50  
  
auto peerlink.4094  
iface peerlink.4094  
    address 169.254.1.2/30  
    clagd-peer-ip 169.254.1.1  
    clagd-backup-ip 10.0.0.11  
    clagd-sys-mac 44:38:39:FF:40:  
94  
  
# Downlinks  
auto swp1  
iface swp1  
  
auto bond0  
iface bond0  
    bond-slaves swp1
```

```

clag-id 1

auto bridge
iface bridge
    bridge-vlan-aware yes
    bridge-ports peerlink bond0
vni10 vni20
    bridge-vids 10 20

auto vlan10
iface vlan10

auto vlan20
iface vlan20

auto vni10
iface vni10
    vxlan-id 10
    vxlan-local-tunnelip
10.0.0.11
    bridge-access 10
    bridge-learning off
    mstpcctl-bpduguard yes
    mstpcctl-portbpdufilter yes
    bridge-arp-nd-suppress on

auto vni20
iface vni20
    vxlan-id 20
    vxlan-local-tunnelip
10.0.0.11
    bridge-access 20
    bridge-learning off
    mstpcctl-bpduguard yes
    mstpcctl-portbpdufilter yes
    bridge-arp-nd-suppress on

# uplinks
auto swp51
iface swp51

auto swp52
iface swp52

```

```

clag-id 1

auto bridge
iface bridge
    bridge-vlan-aware yes
    bridge-ports peerlink bond0
vni10 vni20
    bridge-vids 10 20

auto vlan10
iface vlan10

auto vlan20
iface vlan20

auto vni10
iface vni10
    vxlan-id 10
    vxlan-local-tunnelip
10.0.0.12
    bridge-access 10
    bridge-learning off
    mstpcctl-bpduguard yes
    mstpcctl-portbpdufilter yes
    bridge-arp-nd-suppress on

auto vni20
iface vni20
    vxlan-id 20
    vxlan-local-tunnelip
10.0.0.12
    bridge-access 20
    bridge-learning off
    mstpcctl-bpduguard yes
    mstpcctl-portbpdufilter yes
    bridge-arp-nd-suppress on

# uplinks
auto swp51
iface swp51

auto swp52
iface swp52

```

**leaf03: /etc/network/interfaces**

```

auto lo
iface lo inet loopback

```

**leaf04: /etc/network/interfaces**

```

auto lo
iface lo inet loopback

```



```
address 10.0.0.13/32
clagd-vxlan-anycast-ip
10.10.10.30

auto eth0
iface eth0 inet dhcp

# peerlinks
auto swp49
iface swp49

auto swp50
iface swp50p

auto peerlink
iface peerlink
    bond-slaves swp49 swp50

auto peerlink.4094
iface peerlink.4094
    address 169.254.1.1/30
    clagd-peer-ip 169.254.1.2
    clagd-backup-ip 10.0.0.14
    clagd-sys-mac 44:38:39:FF:40:
95

# Downlinks
auto swp1
iface swp1

auto bond0
iface bond0
    bond-slaves swp1
    clag-id 1

auto bridge
iface bridge
    bridge-vlan-aware yes
    bridge-ports peerlink bond0
vni10 vni20
    bridge-vids 10 20

auto vlan10
iface vlan10

auto vlan20
iface vlan20

auto vni10
iface vni10
    vxlan-id 10
```

```
address 10.0.0.14/32
clagd-vxlan-anycast-ip
10.10.10.30

auto eth0
iface eth0 inet dhcp

# peerlinks
auto swp49
iface swp49

auto swp50
iface swp50

auto peerlink
iface peerlink
    bond-slaves swp49 swp50

auto peerlink.4094
iface peerlink.4094
    address 169.254.1.2/30
    clagd-peer-ip 169.254.1.1
    clagd-backup-ip 10.0.0.13
    clagd-sys-mac 44:38:39:FF:40:
95

# Downlinks
auto swp1
iface swp1

auto bond0
iface bond0
    bond-slaves swp1
    clag-id 1

auto bridge
iface bridge
    bridge-vlan-aware yes
    bridge-ports peerlink bond0
vni10 vni20
    bridge-vids 10 20

auto vlan10
iface vlan10

auto vlan20
iface vlan20

auto vni10
iface vni10
    vxlan-id 10
```

```

vxlan-local-tunnelip
10.0.0.13
bridge-access 10
bridge-learning off
mstpcctl-bpduguard yes
mstpcctl-portbpdufilter yes
bridge-arp-nd-suppress on

auto vni20
iface vni20
  vxlan-id 20
  vxlan-local-tunnelip
10.0.0.13
  bridge-access 20
  bridge-learning off
  mstpcctl-bpduguard yes
  mstpcctl-portbpdufilter yes
  bridge-arp-nd-suppress on

# uplinks
auto swp51
iface swp51

auto swp52
iface swp52

```

```

vxlan-local-tunnelip
10.0.0.14
bridge-access 10
bridge-learning off
mstpcctl-bpduguard yes
mstpcctl-portbpdufilter yes
bridge-arp-nd-suppress on

auto vni20
iface vni20
  vxlan-id 20
  vxlan-local-tunnelip
10.0.0.14
  bridge-access 20
  bridge-learning off
  mstpcctl-bpduguard yes
  mstpcctl-portbpdufilter yes
  bridge-arp-nd-suppress on

# uplinks
auto swp51
iface swp51

auto swp52
iface swp52

```

## Host Configuration

In this example, the servers are running Ubuntu 14.04. A layer2 bond must be mapped from server01 and server03 to the respective switch. In Ubuntu this is done with subinterfaces.

```

server01

auto lo
iface lo inet loopback

auto lo
iface lo inet static
  address 10.0.0.31/32

auto eth0
iface eth0 inet dhcp

auto eth1
iface eth1 inet manual
  bond-master bond0

```

```

server03

auto lo
iface lo inet loopback

auto lo
iface lo inet static
  address 10.0.0.33/32

auto eth0
iface eth0 inet dhcp

auto eth1
iface eth1 inet manual
  bond-master bond0

```

```

auto eth2
iface eth2 inet manual
    bond-master bond0

auto bond0
iface bond0 inet static
    bond-slaves none
    bond-miimon 100
    bond-min-links 1
    bond-mode 802.3ad
    bond-xmit-hash-policy
layer3+4
    bond-lacp-rate 1
    address 172.16.1.101/24

auto bond0.10
iface bond0.10 inet static
    address 172.16.10.101/24

auto bond0.20
iface bond0.20 inet static
    address 172.16.20.101/24

```

```

auto eth2
iface eth2 inet manual
    bond-master bond0

auto bond0
iface bond0 inet static
    bond-slaves none
    bond-miimon 100
    bond-min-links 1
    bond-mode 802.3ad
    bond-xmit-hash-policy
layer3+4
    bond-lacp-rate 1
    address 172.16.1.103/24

auto bond0.10
iface bond0.10 inet static
    address 172.16.10.103/24

auto bond0.20
iface bond0.20 inet static
    address 172.16.20.103/24

```

## Using Active-active Mode with LNV

When using VXLAN active-active mode with [lightweight network virtualization \(see page 602\)](#) (LNV), follow the steps outlined above. In addition, the following configuration steps are needed:

- Configuring the loopback interface for active-active mode
- Enabling the registration daemon
- Configuring a VTEP
- Enabling the service node daemon
- Configuring the service node

### *Terminology*

Term	Definition
<code>vxrd</code>	The VXLAN registration daemon. The daemon runs on the switch that is mapping VLANs to VXLANs. You must configure the <code>vxrd</code> daemon to register to a service node. This turns the switch into a VTEP.
<code>vxsnd</code>	The VXLAN service node daemon that you can run to register multiple VTEPs.
<code>vxrd-src-ip</code>	The unique IP address to which the <code>vxrd</code> binds.



Term	Definition
vxrd-svcnode-ip	The service node anycast IP address in the topology. In this demonstration, this is an anycast IP address shared by both spine switches.
anycast	When an IP address is advertised from multiple locations. Allows multiple devices to share the same IP and effectively load balance traffic across them. With VXLAN, anycast is used in two places: <ol style="list-style-type: none"><li>1. To share a VTEP IP address between a pair of MLAG switches.</li><li>2. To load balance traffic for service nodes (for example, service nodes share an IP address).</li></ol>

### Configure the Loopback Interface for Active-active Mode

You configure active-active mode as you would for EVPN, as described above, adding two more configuration options to the loopback interface: the vxrd IP address and the service node IP address.

Continuing with the example configuration above, the loopback interface configuration on the leaf switches would look like this:

#### NCLU commands

```
cumulus@leaf01:~$ net add
loopback lo vxrd-src-ip
10.0.0.11
cumulus@leaf01:~$ net add
loopback lo vxrd-svcnode-ip
10.10.10.10
cumulus@leaf01:~$ net pending
cumulus@leaf01:~$ net commit
```

#### NCLU commands

```
cumulus@leaf02:~$ net add
loopback lo vxrd-src-ip
10.0.0.12
cumulus@leaf02:~$ net add
loopback lo vxrd-svcnode-ip
10.10.10.10
cumulus@leaf02:~$ net pending
cumulus@leaf02:~$ net commit
```

#### leaf01 /etc/network/interfaces snippet

```
auto lo
iface lo inet loopback
    address 10.0.0.11/32
    vxrd-src-ip 10.0.0.11
    vxrd-svcnode-ip 10.10.10.10
    clagd-vxlan-anycast-ip
    10.10.10.20
```

#### leaf02 /etc/network/interfaces snippet

```
auto lo
iface lo inet loopback
    address 10.0.0.12/32
    vxrd-src-ip 10.0.0.12
    vxrd-svcnode-ip 10.10.10.10
    clagd-vxlan-anycast-ip
    10.10.10.20
```

**NCLU commands**

```
cumulus@leaf03:~$ net add
loopback lo vxrd-src-ip
10.0.0.13
cumulus@leaf03:~$ net add
loopback lo vxrd-svcnode-ip
10.10.10.10
cumulus@leaf03:~$ net pending
cumulus@leaf03:~$ net commit
```

**NCLU commands**

```
cumulus@leaf04:~$ net add
loopback lo vxrd-src-ip
10.0.0.14
cumulus@leaf04:~$ net add
loopback lo vxrd-svcnode-ip
10.10.10.10
cumulus@leaf04:~$ net pending
cumulus@leaf04:~$ net commit
```

**leaf03 /etc/network/interfaces snippet**

```
auto lo
iface lo inet loopback
    address 10.0.0.13/32
    vxrd-src-ip 10.0.0.13
    vxrd-svcnode-ip 10.10.10.10
    clagd-vxlan-anycast-ip
    10.10.10.30
```

**leaf04 /etc/network/interfaces snippet**

```
auto lo
iface lo inet loopback
    address 10.0.0.14/32
    vxrd-src-ip 10.0.0.14
    vxrd-svcnode-ip 10.10.10.10
    clagd-vxlan-anycast-ip
    10.10.10.30
```

### Enable the Registration Daemon

You must enable the registration daemon (`vxrd`) on each ToR switch acting as a VTEP that is participating in the VXLAN. The daemon is installed by default.

1. Open the `/etc/default/vxrd` configuration file in a text editor.
2. Enable the daemon, then save the file.

```
START=yes
```

3. Restart the `vxrd` daemon.

```
cumulus@leaf0X:~$ sudo systemctl restart vxrd.service
```

### Configure a VTEP

The registration node is already configured in `/etc/network/interfaces`; no additional configuration is typically needed. However, you can configure the VTEP in the `/etc/vxrd.conf` file instead, which has additional configuration knobs available.



## Enable the Service Node Daemon

1. Open the /etc/default/vxsnd configuration file in a text editor.
2. Enable the daemon, then save the file:

```
START=yes
```

3. Restart the daemon.

```
cumulus@spine0X:~$ sudo systemctl restart vxsnd.service
```

## Configure the Service Node

To configure the service node daemon, edit the /etc/vxsnd.conf configuration file:

### spine01: /etc/vxsnd.conf

```
svcnodes_ip = 10.10.10.10
src_ip = 10.0.0.21
svcnodes_peers = 10.0.0.21
10.0.0.22
```

### Full configuration of vxsnd.conf

```
[common]
# Log level is one of DEBUG,
INFO, WARNING, ERROR, CRITICAL
#loglevel = INFO
# Destination for log
message. Can be a file name,
'stdout', or 'syslog'
#logdest = syslog
# log file size in bytes. Used
when logdest is a file
#logfilesize = 512000
# maximum number of log files
stored on disk. Used when
logdest is a file
#logbackupcount = 14
# The file to write the pid.
If using monit, this must
match the one
```

### spine02: /etc/vxsnd.conf

```
svcnodes_ip = 10.10.10.10
src_ip = 10.0.0.22
svcnodes_peers = 10.0.0.21
10.0.0.22
```

### Full configuration of vxsnd.conf

```
[common]
# Log level is one of DEBUG,
INFO, WARNING, ERROR, CRITICAL
#loglevel = INFO
# Destination for log
message. Can be a file name,
'stdout', or 'syslog'
#logdest = syslog
# log file size in bytes. Used
when logdest is a file
#logfilesize = 512000
# maximum number of log files
stored on disk. Used when
logdest is a file
#logbackupcount = 14
# The file to write the pid.
If using monit, this must
match the one
```



```
# in the vxsnd.rc
#pidfile = /var/run/vxsnd.pid
# The file name for the unix
domain socket used for mgmt.
#udsfile = /var/run/vxsnd.sock
# UDP port for vxfld control
messages
#vxfld_port = 10001
# This is the address to which
registration daemons send
control messages for
# registration and/or BUM
packets for replication
svcnode_ip = 10.10.10.10
# Holdtime (in seconds) for
soft state. It is used when
sending a
# register msg to peers in
response to learning a <vni,
addr> from a
# VXLAN data pkt
#holdtime = 90
# Local IP address to bind to
for receiving inter-vxsnd
control traffic
src_ip = 10.0.0.21
[vxsnd]
# Space separated list of IP
addresses of vxsnd to share
state with
svcnode_peers = 10.0.0.21
10.0.0.22
# When set to true, the
service node will listen for
vxlan data traffic
# Note: Use 1, yes, true, or
on, for True and 0, no, false,
or off,
# for False
#enable_vxlan_listen = true
# When set to true, the
svcnode_ip will be installed
on the loopback
# interface, and it will be
withdrawn when the vxsnd is no
longer in
# service. If set to true,
the svcnode_ip configuration
# variable must be defined.
```

```
# in the vxsnd.rc
#pidfile = /var/run/vxsnd.pid
# The file name for the unix
domain socket used for mgmt.
#udsfile = /var/run/vxsnd.sock
# UDP port for vxfld control
messages
#vxfld_port = 10001
# This is the address to which
registration daemons send
control messages for
# registration and/or BUM
packets for replication
svcnode_ip = 10.10.10.10
# Holdtime (in seconds) for
soft state. It is used when
sending a
# register msg to peers in
response to learning a <vni,
addr> from a
# VXLAN data pkt
#holdtime = 90
# Local IP address to bind to
for receiving inter-vxsnd
control traffic
src_ip = 10.0.0.22
[vxsnd]
# Space separated list of IP
addresses of vxsnd to share
state with
svcnode_peers = 10.0.0.21
10.0.0.22
# When set to true, the
service node will listen for
vxlan data traffic
# Note: Use 1, yes, true, or
on, for True and 0, no, false,
or off,
# for False
#enable_vxlan_listen = true
# When set to true, the
svcnode_ip will be installed
on the loopback
# interface, and it will be
withdrawn when the vxsnd is no
longer in
# service. If set to true,
the svcnode_ip configuration
# variable must be defined.
```

```
# Note: Use 1, yes, true, or
on, for True and 0, no, false,
or off,
# for False
#install_svcnode_ip = false
# Seconds to wait before
checking the database to age
out stale entries
#age_check = 90
```

```
# Note: Use 1, yes, true, or
on, for True and 0, no, false,
or off,
# for False
#install_svcnode_ip = false
# Seconds to wait before
checking the database to age
out stale entries
#age_check = 90
```

## Troubleshooting

In addition to [troubleshooting single-attached configurations \(see page 665\)](#), there is now the MLAG daemon (`clagd`) to consider. The `clagctl` command gives the output of MLAG behavior and any inconsistencies that might arise between a MLAG pair.

```
cumulus@leaf01$ clagctl
The peer is alive
    Our Priority, ID, and Role: 32768 44:38:39:00:00:35 primary
    Peer Priority, ID, and Role: 32768 44:38:39:00:00:36 secondary
        Peer Interface and IP: peerlink.4094 169.254.1.2
            VxLAN Anycast IP: 10.10.10.30
                Backup IP: 10.0.0.14 (inactive)
                System MAC: 44:38:39:ff:40:95
CLAG Interfaces
Our Interface      Peer Interface      CLAG Id
Conflicts          Proto-Down Reason
-----  -----  -----
-----  -----  -----
bond0      bond0      1
-
vxlan20    vxlan20    -
-
vxlan1    vxlan1    -
-
vxlan10   vxlan10   -
```

The additions to normal MLAG behavior are the following:

Output	Explanation
VXLAN Anycast IP: 10.10.10.30	The anycast IP address being shared by the MLAG pair for VTEP termination is in use and is 10.10.10.30.
Conflicts: -	There are no conflicts for this MLAG Interface.

Output	Explanation
Proto-Down Reason: -	The VXLAN is up and running (there is no Proto-Down).

In the next example the `vxlan-id` on VXLAN10 is switched to the wrong `vxlan-id`. When the `clagctl` command is run, you see that VXLAN10 goes down because this switch is the secondary switch and the peer switch takes control of VXLAN. The reason code is `vxlan-single` indicating that there is a `vxlan-id` mis-match on VXLAN10.

```
cumulus@leaf02$ clagctl
The peer is alive
    Peer Priority, ID, and Role: 32768 44:38:39:00:00:11 primary
    Our Priority, ID, and Role: 32768 44:38:39:00:00:12 secondary
        Peer Interface and IP: peerlink.4094 169.254.1.1
        VxLAN Anycast IP: 10.10.10.20
            Backup IP: 10.0.0.11 (inactive)
        System MAC: 44:38:39:ff:40:94
CLAG Interfaces
Our Interface      Peer Interface      CLAG Id
Conflicts          Proto-Down Reason
-----           -----
-----           -----
        bond0      bond0              1
-
        vxlan20    vxlan20           -
-
        vxlan1     vxlan1             -
-
        vxlan10    -                 vxlan-single
-
```

## Caveats and Errata

### Use VLAN for Peer Link Only Once

Do not reuse the VLAN used for the peer link layer 3 subinterface for any other interface in the system. A high VLAN ID value is recommended. For more information on VLAN ID ranges, refer to the [VLAN-aware bridge chapter \(see page 417\)](#).

### Bonds with Vagrant in Cumulus VX

Bonds (or LACP Etherchannels) fail to work in a Vagrant setup unless the link is set to *promiscuous* mode. This is a limitation on virtual topologies only, and is not needed on real hardware.

```
auto swp49
iface swp49
```



```
#for vagrant so bonds work correctly
post-up ip link set $IFACE promisc on

auto swp50
iface swp50
#for vagrant so bonds work correctly
post-up ip link set $IFACE promisc on
```

For more information on using Cumulus VX and Vagrant, refer to the [Cumulus VX documentation](#).

### *With LNV, Unique Node ID Required for vxrd in Cumulus VX*

vxrd requires a unique `node_id` for each individual switch. This `node_id` is based off the first interface's MAC address; when using certain virtual topologies like Vagrant, both leaf switches within an MLAG pair can generate the same exact unique `node_id`. You must configure one of the `node_ids` manually (or make sure the first interface always has a unique MAC address), as they are not unique.

To verify the `node_id` that gets configured by your switch, use the `vxrdctl get config` command:

```
cumulus@leaf01$ vxrdctl get config
{
    "concurrency": 1000,
    "config_check_rate": 60,
    "debug": false,
    "eventlet_backdoor_port": 9000,
    "head_rep": true,
    "holdtime": 90,
    "logbackupcount": 14,
    "logdest": "syslog",
    "logfilesize": 512000,
    "loglevel": "INFO",
    "max_packet_size": 1500,
    "node_id": 13,
    "pidfile": "/var/run/vxrd.pid",
    "refresh_rate": 3,
    "src_ip": "10.2.1.50",
    "svcnode_ip": "10.10.10.10",
    "udsfile": "/var/run/vxrd.sock",
    "vxfld_port": 10001
}
```

To set the `node_id` manually:

1. Open `/etc/vxrd.conf` in a text editor.
2. Set the `node_id` value within the `common` section, then save the file:

```
[common]
node_id = 13
```



Ensure that each leaf has a separate `node_id` so that active-active mode can function correctly.

## Related Information

- Network virtualization chapter, Cumulus Linux user guide (see page 490)

## VXLAN Routing

VXLAN routing, sometimes referred to as *inter-VXLAN routing*, provides IP routing between VXLAN VNIs in overlay networks. The routing of traffic is based on the inner header or the overlay tenant IP address.

Because VXLAN routing is fundamentally routing, it is most commonly deployed with a control plane, such as Ethernet Virtual Private Network ([EVPN \(see page 501\)](#)). You can set up static routing too, either with or without the Cumulus [Lightweight Network Virtualization \(see page 602\)](#) (LNV) for MAC distribution and BUM handling.

This topic describes the platform and hardware considerations for VXLAN routing. For a detailed description of different VXLAN routing models and configuration examples, refer to [EVPN \(see page 501\)](#).

VXLAN routing supports full layer 3 multi-tenancy; all routing occurs in the context of a [VRF \(see page 847\)](#). Also, VXLAN routing is supported for dual-attached hosts where the associated VTEPs function in active-active mode ([see page 633](#)).

## Contents

### This topic describes ...

- Supported Platforms (see page 651)
- VXLAN Routing Data Plane and the Broadcom Trident II+, Trident3, Maverick, Tomahawk, and Tomahawk+ Platforms (see page )
  - Trident II+, Trident3, and Maverick (see page )
  - Tomahawk and Tomahawk+ (see page )
- VXLAN Routing Data Plane and Broadcom Trident II Platforms (see page 653)
- VXLAN Routing Data Plane and the Mellanox Spectrum Platform (see page 655)

## Supported Platforms

The following chipsets support VXLAN routing:

- Broadcom Trident II+, Trident3, and Maverick
- Broadcom Tomahawk and Tomahawk+, using an internal loopback on one or more switch ports
- Broadcom Trident II, static VXLAN routing only, using an external loopback on one or more switch ports
- Mellanox Spectrum



- Using ECMP with VXLAN routing is supported only on RIOT-capable Broadcom switches (Trident 3, Maverick, Trident 2+) in addition to Tomahawk, Tomahawk+ and Mellanox Spectrum-A1 switches.



- For additional restrictions and considerations for VXLAN routing with EVPN, refer to [the EVPN chapter \(see page 501\)](#).

## VXLAN Routing Data Plane and the Broadcom Trident II+, Trident3, Maverick, Tomahawk, and Tomahawk+ Platforms

### Trident II+, Trident3, and Maverick

The Trident II+, Trident3, and Maverick ASICs provide native support for VXLAN routing, also referred to as Routing In and Out of Tunnels (RIOT).

You can specify a VXLAN routing profile in the `vxlan_routing_overlay.profile` field of the `/usr/lib/python2.7/dist-packages/cumulus/__chip_config/bcm/datapath.conf` file to control the maximum number of overlay next hops (adjacency entries). The profile is one of the following:

- `default`: 15% of the underlay next hops are set apart for overlay (8k next hops are reserved)
- `mode-1`: 25% of the underlay next hops are set apart for overlay
- `mode-2`: 50% of the underlay next hops are set apart for overlay
- `mode-3`: 80% of the underlay next hops are set apart for overlay
- `disable`: disables VXLAN routing

The following shows an example of the *VXLAN Routing Profile* section of the `datapath.conf` file where the `default` profile is enabled.

```
...
# Specify a VxLan Routing Profile - the profile selected determines
# the
# maximum number of overlay next hops that can be allocated.
# This is supported only on TridentTwoPlus and Maverick
#
# Profile can be one of {'default', 'mode-1', 'mode-2', 'mode-3',
# 'disable'}
# default: 15% of the overall nexthops are for overlay.
# mode-1: 25% of the overall nexthops are for overlay.
# mode-2: 50% of the overall nexthops are for overlay.
# mode-3: 80% of the overall nexthops are for overlay.
# disable: VxLan Routing is disabled
#
# By default VxLan Routing is enabled with the default profile.
vxlan_routing_overlay.profile = default
```

The Trident II+ and Trident3 ASICs support a maximum of 48k underlay next hops.

For any profile you specify, you can allocate a *maximum* of 2K (2048) VXLAN SVI interfaces.

To disable the VXLAN routing capability on a Trident II+ or Trident3 switch, set the `vxlan_routing_overlay.profile` field to `disable`.



## Tomahawk and Tomahawk+

The Tomahawk and Tomahawk+ ASICs do not support RIOT natively; you must configure the switch ports for VXLAN routing to use internal loopback (also referred to as *internal hyperloop*). The internal loopback facilitates the recirculation of packets through the ingress pipeline to achieve VXLAN routing.

For routing **into** a VXLAN tunnel, the first pass of the ASIC performs routing and routing rewrites of the packet MAC source and destination address and VLAN, then packets recirculate through the internal hyperloop for VXLAN encapsulation and underlay forwarding on the second pass.

For routing **out of** a VXLAN tunnel, the first pass performs VXLAN decapsulation, then packets recirculate through the hyperloop for routing on the second pass.

You only need to configure a number of switch ports that must be in internal loopback mode based on the amount of bandwidth required. No additional configuration is necessary.

To configure one or more switch ports for loopback mode, edit the `/etc/cumulus/ports.conf` file and change the port speed to `loopback`. In the example below, `swp8` and `swp9` are configured for loopback mode:

```
cumulus@switch:~$ sudo nano /etc/cumulus/ports.conf  
...  
7=4x10G  
8=loopback  
9=loopback  
10=100G  
...  
...
```

After you save your changes to the `ports.conf` file, [restart `switchd`](#) (see page 207) for the changes to take effect.



VXLAN routing using internal loopback is supported only with [VLAN-aware bridges](#) (see page 415); you cannot use a bridge in [traditional mode](#) (see page 427).

## VXLAN Routing Data Plane and Broadcom Trident II Platforms

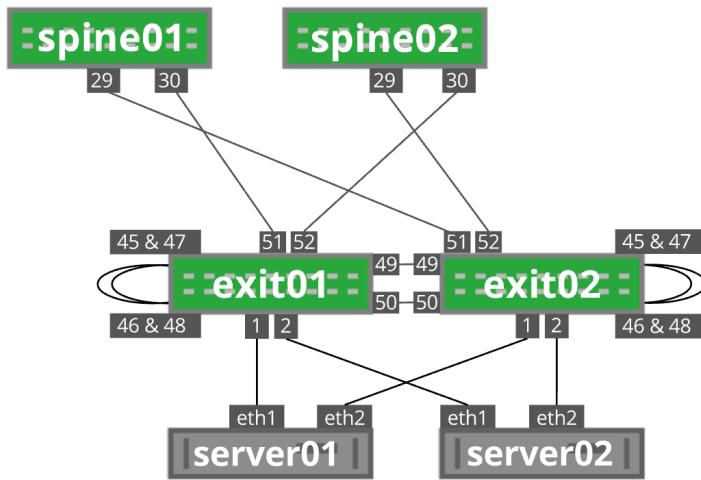
The Trident II ASIC does not support RIOT natively or VXLAN routing using internal loopback. To achieve VXLAN routing in a deployment using Trident II switches, use an external gateway. For routing without an external gateway, you must loopback one or more switch ports using an external loopback cable. This is also referred to as *external hyperloop*.



On Broadcom Trident II switches, only static VXLAN routing is supported with the use of external loopback.

External hyperloop is set up so that the port at one end of the loopback is a layer 2 port attached to the bridge while the port at the other end is configured with a layer 3 interface. The layer 3 interface is configured with the gateway IP address for the corresponding VLAN/VNI. Traffic exiting a VXLAN tunnel is bridged out the layer 2 port if it needs to be routed (exactly as it would if it were going to an external gateway) but at the other end, because traffic is addressed to the gateway IP address, it gets regular routing treatment. For redundancy and increased bandwidth, two or more pairs of ports are typically put into an external hyperloop and bonded together.

The following diagram illustrates the configuration and operation of an external hyperloop.



In the above diagram, VTEPs *exit01* and *exit02* are acting as VXLAN layer 3 gateways. On *exit01*, two pairs of ports are externally looped back (swp45, swp46) and (swp47, swp48). The ports swp46 and swp48 are bonded together and act as the layer 2 end; therefore, this bond interface (named *inside*) is a member of the bridge. The ports swp45 and swp47 are bonded together (named *outside*) and act as the layer 3 end with SVIs configured for VLANs 100 and 200 with the corresponding gateway IP addresses. Because the two layer 3 gateways are in an [MLAG](#) (see page 440) configuration, they use a virtual IP address as the gateway IP. The relevant interface configuration on *exit01* is as follows:

```
## some output removed for brevity (such as peerlink and host-facing
bonds) ##

auto bridge
iface bridge
    bridge-vlan-aware yes
    bridge-ports inside server01 server02 vni-10 vni-20 peerlink
    bridge-vids 100 200
    bridge-pvid 1           # sets native VLAN to 1, an unused VLAN
    mstpcctl-treepriority 8192

auto outside
iface outside
    bond-slaves swp45 swp47
    alias hyperloop outside
    mstpcctl-bpduguard yes
    mstpcctl-portbpdufilter yes
```



```
auto inside
iface inside
    bond-slaves swp46 swp48
    alias hyperloop inside
    mstpctl-bpduguard yes
    mstpctl-portbpdufilter yes

auto VLAN100GW
iface VLAN100GW
    bridge-ports outside.100
    address 172.16.100.2/24
    address-virtual 44:38:39:FF:01:90 172.16.100.1/24

auto VLAN200GW
iface VLAN200GW
    bridge-ports outside.200
    address 172.16.200.2/24
    address-virtual 44:38:39:FF:02:90 172.16.200.1/24

auto vni-10
iface vni-10
    vxlan-id 10
    vxlan-local-tunnelip 10.0.0.11
    bridge-access 100

auto vni-20
iface vni-20
    vxlan-id 20
    vxlan-local-tunnelip 10.0.0.11
    bridge-access 200
```

For the external hyperloop to work correctly, you must configure the following `switchd` flag:

```
cumulus@exit01:mgmt-vrf:/root$ sudo nano /etc/cumulus/switchd.conf
halbcm.per_vlan_router_mac_lookup = TRUE
```

After you save your changes to the `switchd.conf` file, [restart `switchd`](#) (see page 207) for the change to take effect.



Setting `halbcm.per_vlan_router_mac_lookup = TRUE` limits the Trident II switch to a configurable 512 local IP addresses (SVIs and so on). Use this only as a last resort. This is only a limitation on this specific ASIC.

## VXLAN Routing Data Plane and the Mellanox Spectrum Platform

There is no special configuration required for VXLAN routing on the Mellanox Spectrum platform.



## VXLAN Scale

On Broadcom Trident II and Tomahawk switches running Cumulus Linux, there is a limit to the number of VXLANs you can configure simultaneously. The limit most often given is 2000 VXLANs, but you might want to get more specific and know exactly the limit for your specific design.



- While this limitation does apply to Trident II+, Trident3, or Maverick ASICs, Cumulus Linux supports the same number of VXLANs on these ASICs as it does for Trident II or Tomahawk ASICs. Mellanox Spectrum ASICs do not have a limitation on the number of VXLANs that they can support.

The limit is a physical to virtual mapping where a switch can hold 15000 mappings in hardware before you encounter hash collisions. There is also an upper limit of around 3000 VLANs you can configure before you hit the reserved range (Cumulus Linux uses 3000-3999 by default). Cumulus Networks typically uses a soft number because the math is unique to each environment. An internal VLAN is consumed by each layer 3 port, subinterface, [traditional bridge \(see page 427\)](#), and the [VLAN-aware bridge \(see page 415\)](#). Therefore, the number of configurable VLANs is:

$$\text{(total configurable 802.1q VLANs) - (reserved VLANs) - (physical or logical interfaces)} = \\ \text{4094-999-eth0-loopback} = \mathbf{3093} \text{ by default (without any other configuration)}$$

The equation for the number of configurable VXLANs looks like this:

$$\text{(number of trunks) * (VXLAN/VLANs per trunk)} = 15000 - \text{(Linux logical and physical interfaces)}$$

For example, on a 10Gb switch with  $48 * 10$  G ports and  $6 * 40$ G uplinks, you can calculate for X, the amount of configurable VXLANs:

$$48 * X = 15000 - (48 \text{ downlinks} + 6 \text{ uplinks} + 1 \text{ loopback} + 1 \text{ eth0} + 1 \text{ bridge})$$

$$48 * X = 14943$$

$$X = \mathbf{311} \text{ VXLANs}$$

Similarly, you can apply this logic to a 32 port 100G switch where 16 ports are broken up to  $4 * 25$  Gbps ports, for a total of  $64 * 25$  Gbps ports:

$$64 * X = 15000 - (64 \text{ downlinks} + 16 \text{ uplinks} + 1 \text{ loopback} + 1 \text{ eth0} + 1 \text{ bridge})$$

$$64 * X = 14917$$

$$X = \mathbf{233} \text{ VXLANs}$$

However, not all ports are trunks for all VXLANs (or at least not all the time). It is much more common for subsets of ports to be used for different VXLANs. For example, a 10G ( $48 * 10$ G +  $6 * 40$ G uplinks) can have the following configuration:

Ports	Trunks
swp1-20	100 VXLAN/VLANs
swp21-30	100 VXLAN/VLANs
swp31-48	X VXLAN/VLANs

The equation now looks like this:

$$20 \text{ swps} * 100 \text{ VXLANs} + 10 \text{ swps} * 100 \text{ VXLANs} + 18 \text{ swps} * X \text{ VXLANs} + (48 \text{ downlinks} + 6 \text{ uplinks} + \text{loopback} + 1 \text{ eth0} + 1 \text{ bridge}) = 15000$$



20 swps \* 100 VXLANS + 10 swps \* 100 VXLANS + 18 swps \* X VXLANS = 14943

18 \* X = 11943

663 = VXLANS (still configurable) for a total of **863**

## Hybrid Cloud Connectivity with QinQ and VXLANS

*QinQ* is an amendment to the [IEEE 802.1Q specification](#) that provides the capability for multiple [VLAN tags](#) (see page 433) to be inserted into a single Ethernet frame.

The primary use case for QinQ with VXLAN is where a service provider who offers multi-tenant layer 2 connectivity between different customers' data centers (private clouds) may also need to connect those data centers to public cloud providers. Public clouds often has a mandatory QinQ handoff interface, where the outer tag is for the customer and the inner tag is for the service.

In Cumulus Linux, you map QinQ packets to VXLANS through:

- *Single tag translation*, where you map a customer to a VNI and preserve the service as an inner VLAN inside a VXLAN packet.
- *Double tag translation*, where you map a customer and service to a VNI.

QinQ is available on the following switches:

- Broadcom Tomahawk 2, Tomahawk+, Tomahawk, Trident3, Trident II+ and Trident II switches.
- Mellanox switches, only with [VLAN-aware bridges](#) (see page 415) with 802.1ad and only with single tag translation.

## Contents

### This topic describes ...

- Remove the Early Access QinQ Metapackage (see page 657)
- Configure Single Tag Translation (see page 658)
  - Configure the Public Cloud-facing Switch (see page 658)
  - Configure the Customer-facing Edge Switch (see page 659)
  - View the Configuration (see page 660)
- Configure Double Tag Translation (see page 661)
- Caveats and Errata (see page 664)
  - Feature Limitations (see page 664)
  - Long Interface Names (see page 664)

## Remove the Early Access QinQ Metapackage

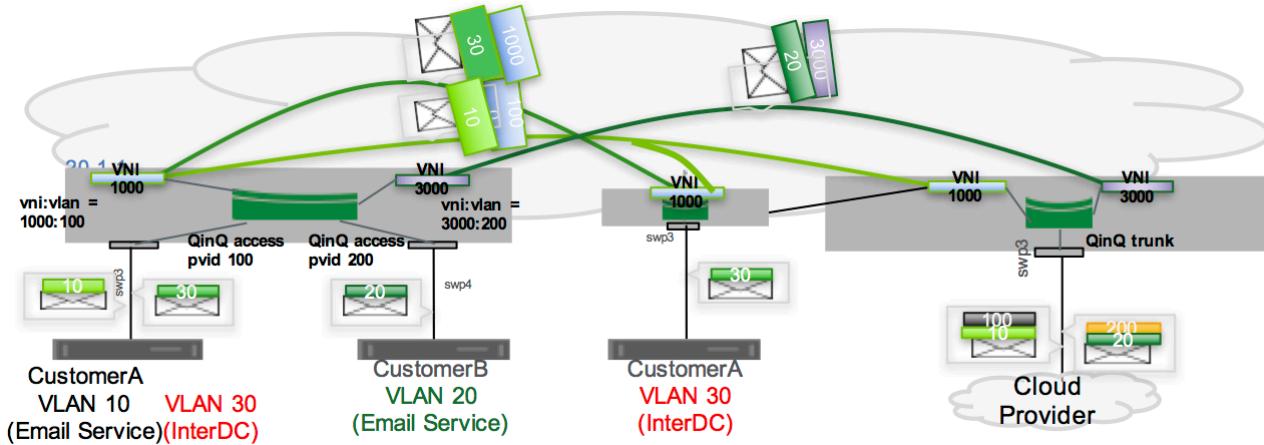
If you are upgrading Cumulus Linux from a version earlier than 3.4.0 and had installed the early access QinQ metapackage, you need to remove the `cumulus-qinq` metapackage before upgrading to Cumulus Linux 3.4.0 or later. To remove the `cumulus-qinq` metapackage, read the [early access feature](#) article.

## Configure Single Tag Translation

Single tag translation adheres to traditional QinQ service model. The customer-facing interface is a QinQ access port with the outer S-tag being the PVID, representing the customer. The S-tag is translated to a VXLAN VNI. The inner C-tag, which represents the service, is transparent to the provider. The public cloud handoff interface is a QinQ trunk where packets on the wire carry both the S-tag and the C-tag.

Single tag translation leverages [VLAN-aware bridge mode \(see page 415\)](#) with the use of the 802.1ad VLAN protocol (the only supported protocol at the time of writing). Hence, it is more scalable.

An example configuration could look like the following:



You configure two switches: one at the service provider edge that faces the customer (the switch on the left above), and one on the public cloud handoff edge (the righthand switch above).



All edges need to support QinQ with VXLANs to correctly interoperate.

### Configure the Public Cloud-facing Switch

For the switch facing the public cloud:

- Configure the bridge with `vlan_protocol` set to `802.1ad`.
- The VNI maps back to S-tag (customer).
- A trunk port connected to the public cloud is the QinQ trunk, and packets are double tagged, where the S-tag is for the customer and the C-tag is for the service.

To configure the public cloud-facing switch, run the following [NCLU \(see page 88\)](#) commands:

```
cumulus@switch:~$ net add vxlan vni-1000 vxlan id 1000
cumulus@switch:~$ net add vxlan vni-1000 vxlan local-tunnelip 10.0.0.1
cumulus@switch:~$ net add vxlan vni-1000 bridge access 100
cumulus@switch:~$ net add vxlan vni-3000 vxlan id 3000
cumulus@switch:~$ net add vxlan vni-3000 vxlan local-tunnelip 10.0.0.1
cumulus@switch:~$ net add vxlan vni-3000 bridge access 200
cumulus@switch:~$ net add vxlan vni-1000 bridge learning off
cumulus@switch:~$ net add vxlan vni-3000 bridge learning off
```



```
cumulus@switch:~$ net add bridge bridge vlan-protocol 802.1ad
cumulus@switch:~$ net add bridge bridge ports swp3,vni-1000,vni-3000
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands create the following configuration in the /etc/network/interfaces file:

```
auto vni-1000
iface vni-1000
    bridge-access 100
    bridge-learning off
    vxlan-id 1000
    vxlan-local-tunnelip 10.0.0.1

auto vni-3000
iface vni-3000
    bridge-access 200
    bridge-learning off
    vxlan-id 3000
    vxlan-local-tunnelip 10.0.0.1

auto bridge
iface bridge
    bridge-ports swp3 vni-1000 vni-3000
    bridge-vids 100 200
    bridge-vlan-aware yes
    bridge-vlan-protocol 802.1ad
```

## Configure the Customer-facing Edge Switch

For the switch facing the customer:

- Configure the bridge with `vlan_protocol` set to `802.1ad`.
- The customer interface is the QinQ access port, the PVID is the S-tag (customer) and is mapped to a VNI.
- The service VLAN tags (C-tags) are preserved during VXLAN encapsulation.

To configure the customer-facing switch, run the following [NCLU \(see page 88\)](#) commands:

```
cumulus@switch:~$ net add interface swp3 bridge access 100
cumulus@switch:~$ net add interface swp4 bridge access 200
cumulus@switch:~$ net add vxlan vni-1000 vxlan id 1000
cumulus@switch:~$ net add vxlan vni-1000 vxlan local-tunnelip 10.0.0.1
cumulus@switch:~$ net add vxlan vni-1000 bridge access 100
cumulus@switch:~$ net add vxlan vni-3000 vxlan id 3000
cumulus@switch:~$ net add vxlan vni-3000 vxlan local-tunnelip 10.0.0.1
cumulus@switch:~$ net add vxlan vni-3000 bridge access 200
cumulus@switch:~$ net add vxlan vni-1000 bridge learning off
cumulus@switch:~$ net add vxlan vni-3000 bridge learning off
```



```
cumulus@switch:~$ net add bridge bridge ports swp3,swp4,vni-1000,vni-3000
cumulus@switch:~$ net add bridge bridge vlan-protocol 802.1ad
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands create the following configuration in the /etc/network/interfaces file:

```
auto vni-1000
iface vni-1000
    bridge-access 100
    bridge-learning off
    vxlan-id 1000
    vxlan-local-tunnelip 10.0.0.1

auto vni-3000
iface vni-3000
    bridge-access 200
    bridge-learning off
    vxlan-id 3000
    vxlan-local-tunnelip 10.0.0.1

auto swp3
iface swp3
    bridge-access 100

auto swp4
iface swp4
    bridge-access 200

auto bridge
iface bridge
    bridge-ports swp3 swp4 vni-1000 vni-3000
    bridge-vids 100 200
    bridge-vlan-aware yes
    bridge-vlan-protocol 802.1ad
```

## *View the Configuration*

In the output below, customer A is on VLAN 100 (S-TAG) and customer B is on VLAN 200 (S-TAG).

To check the public cloud-facing switch, use `net show bridge vlan`:

```
cumulus@switch:~$ net show bridge vlan

Interface      VLAN   Flags          VNI
-----  -----  -----
swp3           1   PVID, Egress Untagged
                100
```



	200		
vni-1000	100	PVID, Egress Untagged	1000
vni-3000	200	PVID, Egress Untagged	3000

To check the customer-facing switch, use `net show bridge vlan`:

```
cumulus@switch:~$ net show bridge vlan
Interface      VLAN   Flags          VNI
-----  -----  -----
swp3           100    PVID, Egress Untagged
swp4           200    PVID, Egress Untagged
vni-1000       100    PVID, Egress Untagged  1000
vni-3000       200    PVID, Egress Untagged  3000
```

To verify that the bridge is configured for QinQ, run `ip -d link show bridge` and look for `vlan_protocol 802.1ad` in the output:

```
cumulus@switch:~$ sudo ip -d link show bridge
287: bridge: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue
state UP mode DEFAULT group default
    link/ether 06:a2:ae:de:e3:43 brd ff:ff:ff:ff:ff:ff promiscuity 0
        bridge forward_delay 1500 hello_time 200 max_age 2000 ageing_time
        30000 stp_state 2 priority 32768 vlan_filtering 1 vlan_protocol 802.1
        ad bridge_id 8000.6:a2:ae:de:e3:43 designated_root 8000.6:a2:ae:de:e3:
        43 root_port 0 root_path_cost 0 topology_change 0
        topology_change_detected 0 hello_timer 0.00 tcn_timer 0.00
        topology_change_timer 0.00 gc_timer 64.29 vlan_default_pvid 1
        vlan_stats_enabled 1 group_fwd_mask 0 group_address 01:80:c2:00:00:08
        mcast_snooping 0 mcast_router 1 mcast_query_use_ifaddr 0
        mcast_querier 0 mcast_hash_elasticity 4096 mcast_hash_max 4096
        mcast_last_member_count 2 mcast_startup_query_count 2
        mcast_last_member_interval 100 mcast_membership_interval 26000
        mcast_querier_interval 25500 mcast_query_interval 12500
        mcast_query_response_interval 1000 mcast_startup_query_interval 3125
        mcast_stats_enabled 1 mcast_igmp_version 2 mcast_mld_version 1
        nf_call_iptables 0 nf_call_ip6tables 0 nf_call_arptables 0
        addrgenmode eui64
```

## Configure Double Tag Translation

Double tag translation involves a bridge with double-tagged member interfaces, where a combination of the C-tag and S-tag map to a VNI. You create the configuration only at the edge facing the public cloud. The VXLAN configuration at the customer-facing edge doesn't need to change.

The double tag is always a cloud connection. The customer-facing edge is either single-tagged or untagged. At the public cloud handoff point, the VNI maps to double VLAN tags, with the S-tag indicating the customer and the C-tag indicating the service.



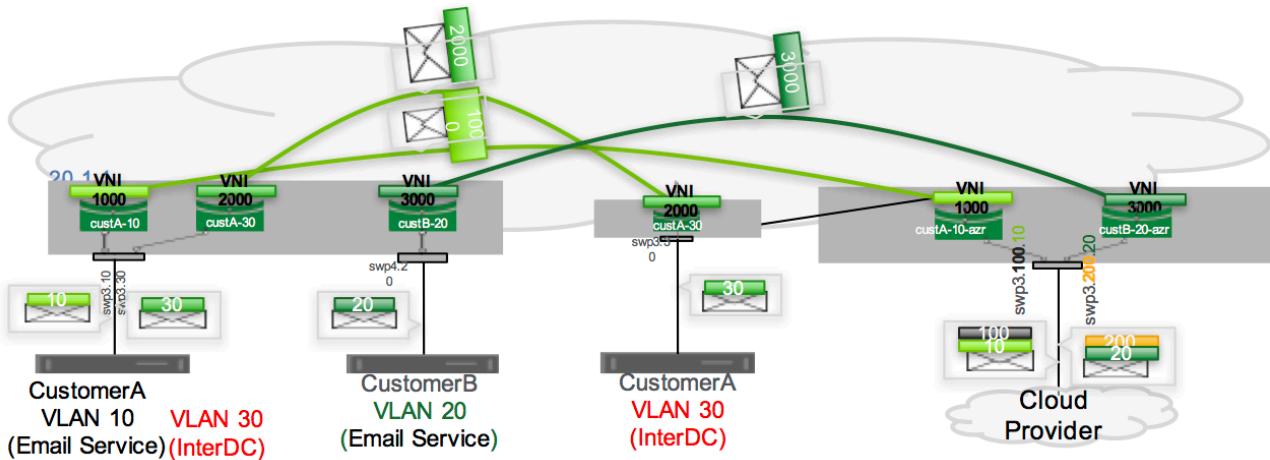
 The configuration in Cumulus Linux uses the outer tag for the customer and the inner tag for the service.

You configure a double-tagged interface by stacking the VLANs in the following manner: <port>.<outer tag>.<inner tag>. For example, consider swp1.100.10: the outer tag is VLAN 100, which represents the customer, and the inner tag is VLAN 10, which represents the service.

The outer tag or *TPID* (tagged protocol identifier) needs the `vlan_protocol` to be specified. It can be either *802.1Q* or *802.1ad*. If *802.1ad* is used, it must be specified on the lower VLAN device, such as *swp3.100* in the example below.

 Double tag translation only works with bridges in [traditional mode \(see page 427\)](#) (not VLAN-aware mode).

An example configuration could look like the following:



To configure the switch for double tag translation using the above example, edit the `/etc/network/interfaces` file in a text editor and add the following:

```

auto swp3.100
iface swp3.100
    vlan_protocol 802.1ad

auto swp3.100.10
iface swp3.100.10
    mstpctl-portbpdufilter yes
    mstpctl-bpduguard yes

auto vni1000
iface vni1000
    vxlan-local-tunnelip 10.0.0.1
    mstpctl-portbpdufilter yes
    mstpctl-bpduguard yes
    vxlan-id 1000

auto custA-10-azr

```

```
iface custA-10-azr
    bridge-ports swp3.100.10 vni1000
    bridge-vlan-aware no
    bridge-learning vni1000=off
```

You can check the configuration with the `brctl show` command:

```
cumulus@switch:~$ sudo brctl show
bridge name      bridge id
custA-10-azr    8000.00020000004b
100.10          STP enabled
                yes
                interfaces
                swp3.
                vni1000
                swp3.
                vni3000
                swp3.
```

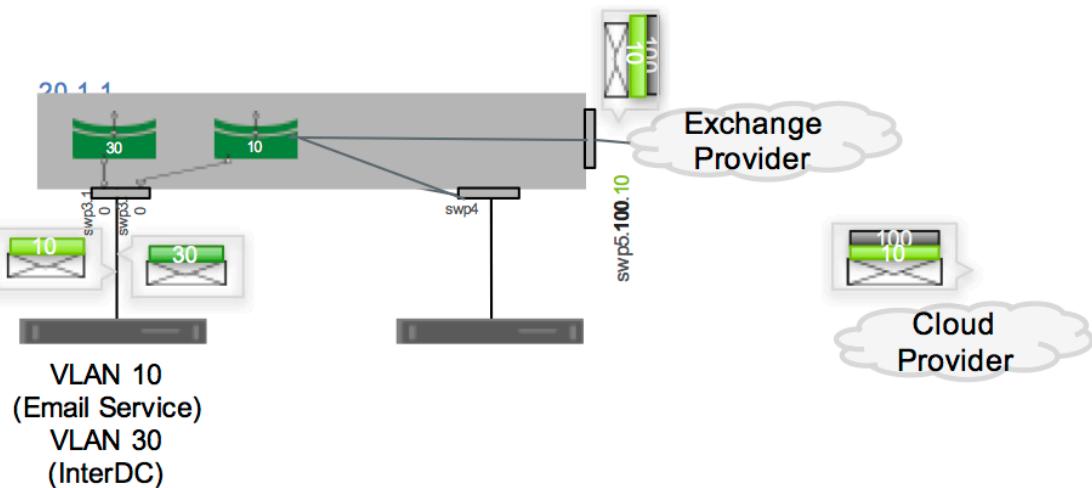


If the bridge is not VXLAN-enabled, the configuration looks like this:

```
auto swp5.100
iface swp5.100
    vlan-protocol 802.1ad

auto swp5.100.10
iface swp5.100.10
    mstpctl-portbpdufilter yes
    mstpctl-bpduguard yes

auto br10
iface br10
    bridge-ports swp3.10    swp4    swp5.100.10
    bridge-vlan-aware no
```





## Caveats and Errata

### Feature Limitations

- `iptables` match on double-tagged interfaces is not supported.
- Single-tagged translation supports only VLAN-aware bridge mode with the bridge's VLAN 802.1ad protocol.
- MLAG (see page 440) is only supported with single-tagged translation.
- No layer 2 protocol (STP BPDU, LLDP) tunneling support.
- Mixing 802.1Q and 802.1ad subinterfaces on the same switch port is not supported.
- When configuring bridges in traditional mode (see page 427), all VLANs that are members of the same switch port must use the same `vlan_protocol`.
- When using switches with Mellanox Spectrum ASICs in an MLAG pair:
  - The peerlink (peerlink.4094) between the MLAG pair should be configured for VLAN protocol 802.1ad.
  - The peerlink cannot be used as a backup datapath in the event that one of the MLAG peers loses all uplinks.
- For switches with the Spectrum ASIC (but not the Spectrum 2), when the bridge VLAN protocol is 802.1ad and is VXLAN-enabled, either:
  - All bridge ports are access ports, except for the MLAG peerlink.
  - All bridge ports are VLAN trunks.

This means the switch terminating the cloud provider connections (double-tagged) cannot have local clients; these clients must be on a separate switch.

### Long Interface Names

The Linux kernel limits interface names to 15 characters in length. For QinQ interfaces, this limit can be reached fairly easily.

To work around this issue, you'll need to create two VLANs as nested VLAN raw devices, one for the outer tag and one for the inner tag. For example, you can't create an interface called `swp50s0.1001.101`, since it has 16 characters in its name. Instead, you'll create VLANs with IDs 1001 and 101 as follows by editing `/etc/network/interfaces` and adding a configuration like the following:

```
auto vlan1001
iface vlan1001
    vlan-id 1001
    vlan-raw-device swp50s0
    vlan-protocol 802.1ad

auto vlan1001-101
iface vlan1001-101
    vlan-id 101
    vlan-raw-device vlan1001
```

```
auto bridge101
iface bridge101
    bridge-ports vlan1001-101 vxlan1000101
```

## Troubleshooting VXLANS

This topic discusses various ways you can verify and troubleshoot VXLANS.

### Contents

#### This topic covers ...

- Verify the Registration Node Daemon (see page 665)
- Verify the Service Node Daemon (see page 666)
- Verify Traffic Flow and Check Counters (see page 666)
- Ping to Test Connectivity (see page 667)
- Troubleshoot with MAC Addresses (see page 669)
- Check the Service Node Configuration (see page 669)

### Verify the Registration Node Daemon

Use the `vxrdctl vxlans` command to see the configured VNIs, the local address being used to source the VXLAN tunnel, and the service node being used.

```
cumulus@leaf1:~$ vxrdctl vxlans
VNI      Local Addr      Svc
Node
===
=====
10       10.2.1.1
10.2.1.3
30       10.2.1.1
10.2.1.3
2000     10.2.1.1
10.2.1.3
```

```
cumulus@leaf2:~$ vxrdctl vxlans
VNI      Local Addr      Svc
Node
===
=====
10       10.2.1.2
10.2.1.3
30       10.2.1.2
10.2.1.3
2000     10.2.1.2
10.2.1.3
```

Use the `vxrdctl peers` command to see configured VNIs and all VTEPs (leaf switches) within the network that have them configured.

```
cumulus@leaf1:~$ vxrdctl peers
VNI      Peer Addrs
```

```
cumulus@leaf2:~$ vxrdctl peers
VNI      Peer Addrs
```

```
====      =====
10        10.2.1.1,
10.2.1.2
30        10.2.1.1,
10.2.1.2
2000      10.2.1.1,
10.2.1.2
====      =====
10        10.2.1.1,
10.2.1.2
30        10.2.1.1,
10.2.1.2
2000      10.2.1.1,
10.2.1.2
```



When head end replication mode is disabled, the command does not work.

Use the `vxrdctl peers` command to see the other VTEPs (leaf switches) and the VNIs with which they are associated. This does not show anything unless you enabled head end replication mode by setting the `head_rep` option to `True`. Otherwise, replication is done by the service node.

```
cumulus@leaf2:~$ vxrdctl peers
Head-end replication is turned off on this device.
This command will not provide any output
```

## Verify the Service Node Daemon

Use the `vxsndctl fdb` command to verify which VNIs belong to which VTEP (leaf switches).

```
cumulus@spine1:~$ vxsndctl fdb
VNI      Address      Ageout
====      =====      =====
10        10.2.1.1      82
10        10.2.1.2      77
30        10.2.1.1      82
30        10.2.1.2      77
2000      10.2.1.1      82
2000      10.2.1.2      77
```

## Verify Traffic Flow and Check Counters

VXLAN transit traffic information is stored in a flat file located in `/cumulus/switchd/run/stats/vxlan/all`.

```
cumulus@leaf1:~$ cat /cumulus/switchd/run/stats/vxlan/all
VNI                      : 10
Network In Octets          : 1090
Network In Packets         : 8
Network Out Octets         : 1798
```



Network Out Packets	:	13
Total In Octets	:	2818
Total In Packets	:	27
Total Out Octets	:	3144
Total Out Packets	:	39
VN Interface	:	vni: 10, swp32s0.10
Total In Octets	:	1728
Total In Packets	:	19
Total Out Octets	:	552
Total Out Packets	:	18
VNI	:	30
Network In Octets	:	828
Network In Packets	:	6
Network Out Octets	:	1224
Network Out Packets	:	9
Total In Octets	:	2374
Total In Packets	:	23
Total Out Octets	:	2300
Total Out Packets	:	32
VN Interface	:	vni: 30, swp32s0.30
Total In Octets	:	1546
Total In Packets	:	17
Total Out Octets	:	552
Total Out Packets	:	17
VNI	:	2000
Network In Octets	:	676
Network In Packets	:	5
Network Out Octets	:	1072
Network Out Packets	:	8
Total In Octets	:	2030
Total In Packets	:	20
Total Out Octets	:	2042
Total Out Packets	:	30
VN Interface	:	vni: 2000, swp32s0.20
Total In Octets	:	1354
Total In Packets	:	15
Total Out Octets	:	446

## Ping to Test Connectivity

To test the connectivity across the VXLAN tunnel with an ICMP echo request (ping), make sure to ping from the server rather than the switch itself.



SVIs (switch VLAN interfaces) are not supported when using VXLAN. There cannot be an IP address on the bridge that also contains a VXLAN.

Following is the IP address information used in this example configuration.



VNI	server1	server2
10	10.10.10.1	10.10.10.2
2000	10.10.20.1	10.10.20.2
30	10.10.30.1	10.10.30.2

Test connectivity between VNI 10 connected servers by pinging from server1:

```
cumulus@server1:~$ ping 10.10.10.2
PING 10.10.10.2 (10.10.10.2) 56(84) bytes of data.
64 bytes from 10.10.10.2: icmp_seq=1 ttl=64 time=3.90 ms
64 bytes from 10.10.10.2: icmp_seq=2 ttl=64 time=0.202 ms
64 bytes from 10.10.10.2: icmp_seq=3 ttl=64 time=0.195 ms
^C
--- 10.10.10.2 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2002ms
rtt min/avg/max/mdev = 0.195/1.432/3.900/1.745 ms
cumulus@server1:~$
```

The other VNIs were also tested and can be viewed in the expanded output below.

Test connectivity between VNI-2000 connected servers by pinging from server1:

```
cumulus@server1:~$ ping 10.10.20.2
PING 10.10.20.2 (10.10.20.2) 56(84) bytes of data.
64 bytes from 10.10.20.2: icmp_seq=1 ttl=64 time=1.81 ms
64 bytes from 10.10.20.2: icmp_seq=2 ttl=64 time=0.194 ms
64 bytes from 10.10.20.2: icmp_seq=3 ttl=64 time=0.206 ms
^C
--- 10.10.20.2 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2000ms
rtt min/avg/max/mdev = 0.194/0.739/1.819/0.763 ms
```

Test connectivity between VNI-30 connected servers by pinging from server1:

```
cumulus@server1:~$ ping 10.10.30.2
PING 10.10.30.2 (10.10.30.2) 56(84) bytes of data.
64 bytes from 10.10.30.2: icmp_seq=1 ttl=64 time=1.85 ms
64 bytes from 10.10.30.2: icmp_seq=2 ttl=64 time=0.239 ms
64 bytes from 10.10.30.2: icmp_seq=3 ttl=64 time=0.185 ms
64 bytes from 10.10.30.2: icmp_seq=4 ttl=64 time=0.212 ms
^C
--- 10.10.30.2 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3000ms
```



```
rtt min/avg/max/mdev = 0.185/0.622/1.853/0.711 ms
```

## Troubleshoot with MAC Addresses

Because there is no SVI, there is no way to ping from the server to the directly attached leaf (top of rack) switch without cabling the switch to itself. The easiest way to see if the server can reach the leaf switch is to check the MAC address table of the leaf switch.

First, obtain the MAC address of the server:

```
cumulus@server1:~$ ip addr show eth3.10 | grep ether  
link/ether 90:e2:ba:55:f0:85 brd ff:ff:ff:ff:ff:ff
```

Next, check the MAC address table of the leaf switch:

```
cumulus@leaf1:~$ brctl showmacs br-10  
port name mac addr      vlan   is local?    ageing timer  
vni-10  46:c6:57:fc:1f:54  0       yes          0.00  
swp32s0.10 90:e2:ba:55:f0:85  0       no           75.87  
vni-10  90:e2:ba:7e:a9:c1  0       no           75.87  
swp32s0.10 ec:f4:bb:fc:67:a1  0       yes          0.00
```

90:e2:ba:55:f0:85 appears in the MAC address table, which indicates that connectivity is occurring between leaf1 and server1.

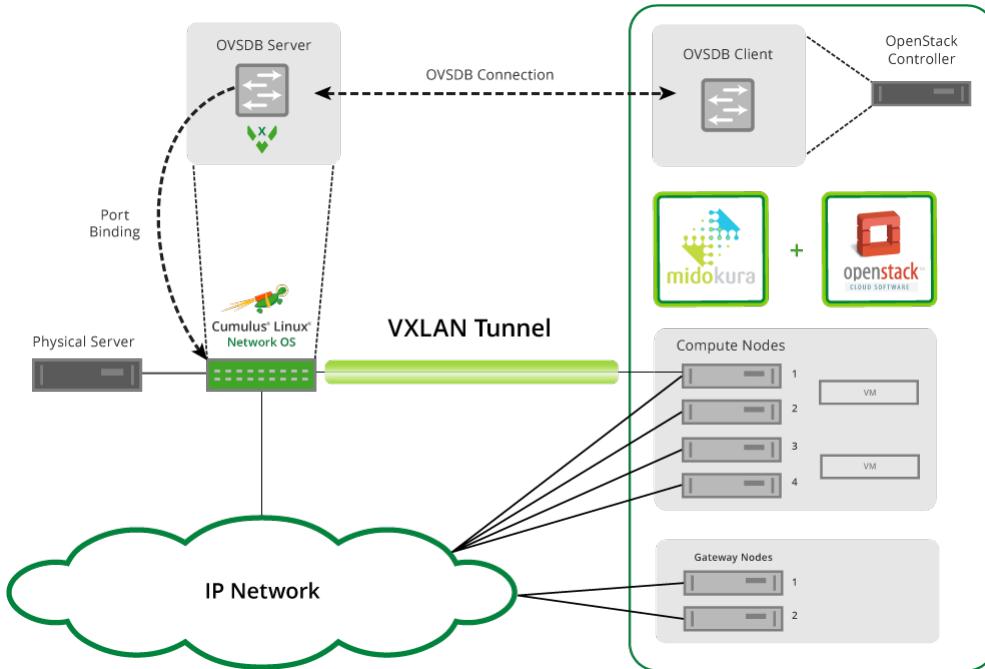
## Check the Service Node Configuration

Use the `ip -d link show` command to verify the service node, VNI, and administrative state of a particular logical VNI interface:

```
cumulus@leaf1:~$ ip -d link show vni-10  
35: vni-10: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue  
    master br-10 state UNKNOWN mode DEFAULT  
        link/ether 46:c6:57:fc:1f:54 brd ff:ff:ff:ff:ff:ff  
        vxlan id 10 remote 10.2.1.3 local 10.2.1.1 srcport 32768 dstport 61000  
        dstport 4789 ageing 1800 svcnode 10.2.1.3  
        bridge_slave
```

## Integrating Hardware VTEPs with Midokura MidoNet and OpenStack

Cumulus Linux seamlessly integrates with the MidoNet OpenStack infrastructure, where the switches provide the VTEP gateway for terminating VXLAN tunnels from within MidoNet. MidoNet connects to the OVSDB server running on the Cumulus Linux switch, and exchanges information about the VTEPs and MAC addresses associated with the OpenStack Neutron networks. This provides seamless Ethernet connectivity between virtual and physical server infrastructures.



## Contents

### This topic describes ...

- Getting Started (see page 671)
- Configure the MidoNet Integration on the Switch (see page 671)
  - Configure the MidoNet Integration Using the Configuration Script (see page 672)
  - Configure the MidoNet Integration Manually (see page 672)
- Configure MidoNet VTEP and Port Bindings (see page 673)
  - From the MidoNet Manager GUI (see page 673)
  - From the MidoNet CLI (see page 677)
- Troubleshooting (see page 679)
  - Control Plane Troubleshooting (see page 679)
    - Verify VTEP and OVSDB Services (see page 679)
    - Verify OVSDB-server Connections (see page 680)
    - Verify the VXLAN Bridge and VTEP Interfaces (see page 680)
  - Datapath Troubleshooting (see page 681)



- Verify IP Reachability (see page 681)
- MidoNet VXLAN Encapsulation (see page 681)
- Inspect the OVSDB (see page 682)
  - List the Physical Switch (see page 682)
  - List the Logical Switch (see page 683)
  - List Local or Remote MAC Addresses (see page 683)
  - Show Open Vswitch Database (OVSDB) Data (see page 683)

## Getting Started

Make sure you have a layer 2 gateway; a Tomahawk, Trident II+ or Trident II switch running Cumulus Linux. Cumulus Linux includes OVSDB server (`ovsdb-server`) and VTEPd (`ovs-vtep`), which support **VLAN-aware bridges** (see page 415).

To integrate a VXLAN with MidoNet, you need to:

- Configure the MidoNet integration on the switch
- Configure the MidoNet VTEP and port bindings
- Verify the VXLAN configuration

For more information about MidoNet, see the MidoNet Operations Guide, version 1.8 or later.



There is no support for **VXLAN routing** (see page 651) in the Trident II chipset; use a loopback interface (**hyperloop** (see page 653)) instead.

## Configure the MidoNet Integration on the Switch

Before you start to configure the MidoNet tunnel zones and VTEP binding, and connect virtual ports to the VXLAN, you need to enable and start the `openvswitch-vtep` service, and configure the MidoNet integration on the switch. This creates the VTEP gateway and initializes the OVS database server.

Start the `openvswitch-vtep` Service

To enable and start the `openvswitch-vtep` service, run the following command:

```
cumulus@switch:~$ sudo systemctl enable openvswitch-vtep.service
cumulus@switch:~$ sudo systemctl start openvswitch-vtep.service
```



In previous versions of Cumulus Linux, you had to edit the `/etc/default/openvswitch-vtep` file and then start the `openvswitch-vtep` service. Now, you just have to enable and start the `openvswitch-vtep` service.



## Configure the MidoNet Integration Using the Configuration Script

The `vtep-bootstrap` script is available so you can perform the configuration automatically. For information, read `man vtep-bootstrap`. This script requires three parameters, in this order:

- The switch name (the name of the switch that is the VTEP gateway).
- The tunnel IP address (the datapath IP address of the VTEP).
- The management IP address (the IP address of the management interface on the switch).

```
cumulus@switch:~$ sudo vtep-bootstrap sw11 10.111.1.1 10.50.20.21 --  
no_encryption  
Executed:  
  define physical switch  
  ().  
Executed:  
  define local tunnel IP address on the switch  
  ().  
Executed:  
  define management IP address on the switch  
  ().  
Executed:  
  restart a service  
  (Killing ovs-vtep (28170).  
Killing ovsdb-server (28146).  
Starting ovsdb-server.  
Starting ovs-vtep.).
```



Because MidoNet does not have a controller, you need to use a dummy IP address (for example, 1.1.1.1) for the controller parameter in the script. After the script completes, delete the VTEP manager, as it is not needed and will otherwise fill the logs with inconsequential error messages:

```
cumulus@switch:~$ sudo vtep-ctl del-manager
```

## Configure the MidoNet Integration Manually

If you do not use the configuration script, you must initialize the OVS database instance manually and create the VTEP.

Perform the following commands in order (see the automated script example above for values):

1. Define the switch in OVSDB:

```
cumulus@switch:~$ sudo vtep-ctl add-ps <switch_name>
```



2. Define the VTEP tunnel IP address:

```
cumulus@switch:~$ sudo vtep-ctl set Physical_switch  
<switch_name> tunnel_ips=<tunnel_ip>
```

3. Define the management interface IP address:

```
cumulus@switch:~$ sudo vtep-ctl set Physical_switch  
<switch_name> management_ips=<management_ip>
```

4. Restart the OVSDB server and vtepd:

```
cumulus@switch:~$ sudo systemctl restart openvswitch-vtep.service
```

The switch is now ready to connect to MidoNet. The rest of the configuration is performed from the MidoNet Manager GUI or using the MidoNet API.

## Configure MidoNet VTEP and Port Bindings

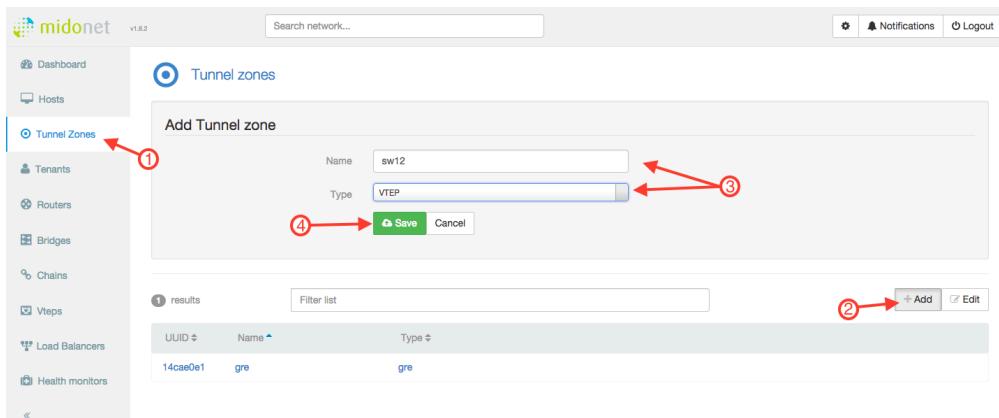
This part of the configuration sets up MidoNet and OpenStack to connect the virtualization environment to the Cumulus Linux switch. The `midonet-agent` is the networking component that manages the VXLAN, while the Open Virtual Switch (OVS) client on the OpenStack controller node communicates MAC address information between the `midonet-agent` and the Cumulus Linux OVS database (OVSDB) server.

You can configure the MidoNet VTEP and port bindings from the MidoNet Manager GUI or the MidoNet CLI.

### *From the MidoNet Manager GUI*

#### *Create a Tunnel Zone*

1. Click **Tunnel Zones** in the menu on the left side.
2. Click **Add**.
3. Give the tunnel zone a **Name** and select **VTEP** for the **Type**.
4. Click **Save**.



## Add Hosts to a Tunnel Zone

After you create the tunnel zone, click the name of the tunnel zone to view the hosts table.

UUID	Name	Type
14cae0e1	gre	gre
ba07877a	sw12	vtep

The tunnel zone is a construct used to define the VXLAN source address used for the tunnel. The address of this host is used for the source of the VXLAN encapsulation and traffic transits into the routing domain from this point. Therefore, the host must have layer 3 reachability to the Cumulus Linux switch tunnel IP.

Next, add a host entry to the tunnel zone:

1. Click **Add**.
2. Select a host from the **Host** list.
3. Provide the tunnel source **IP Address** to use on the selected host.
4. Click **Save**.



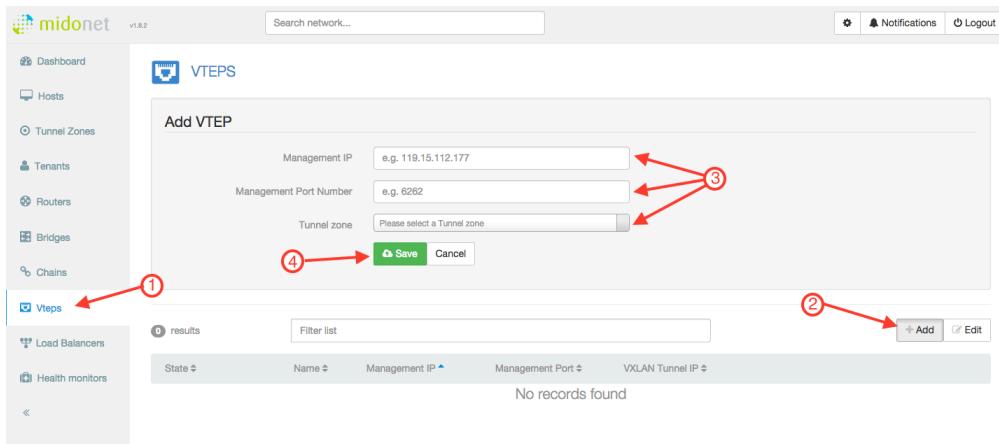
The screenshot shows the midonet web interface with the 'Hosts' menu selected. A modal window titled 'Add Host' is open, prompting for 'Host' and 'IP address'. Step numbers 1 through 4 are overlaid on the interface: 1 points to the 'Add' button in the host list; 2 points to the 'Host' dropdown in the modal; 3 points to the 'IP address' input field in the modal; 4 points to the 'Save' button in the modal.

The host list now displays the new entry:

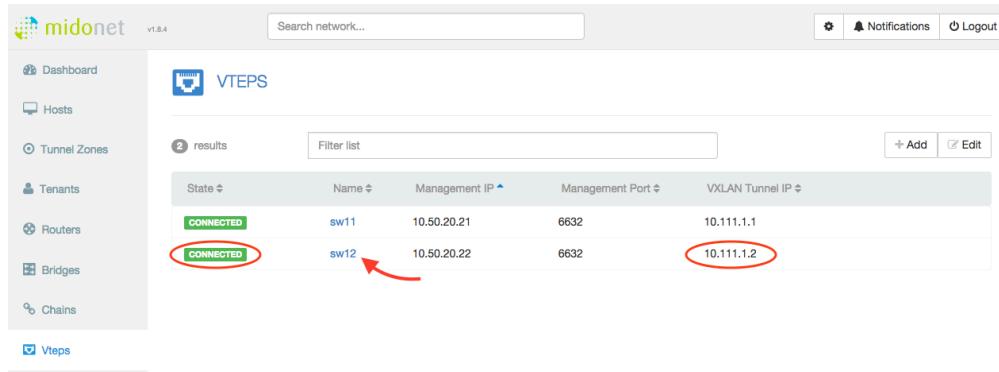
The screenshot shows the midonet web interface with the 'Hosts' menu selected. A single entry is listed in the table: Host ID 4d03509b, IP 10.50.21.182, and Name os-compute1. The 'Add' button is visible at the top right of the list.

## Create the VTEP

1. Click the **Vteps** menu on the left side.
2. Click **Add**.
3. Fill out the fields using the same information you used earlier on the switch for the bootstrap procedure:
  - **Management IP** is typically the eth0 address of the switch. This tells the OVS-client to connect to the OVSDB-server on the Cumulus Linux switch.
  - **Management Port Number** is the PTCP port you configured in the `ovs-ctl-vtep` script earlier (the example uses 6632).
  - **Tunnel Zone** is the name of the zone you created in the previous procedure.
4. Click **Save**.



The new VTEP appears in the list below. MidoNet then initiates a connection between the OpenStack Controller and the Cumulus Linux switch. If the OVS client successfully connects to the OVSDB server, the VTEP entry displays the switch name and VXLAN tunnel IP address, which you specified during the bootstrapping process.



State	Name	Management IP	Management Port	VXLAN Tunnel IP
CONNECTED	sw11	10.50.20.21	6632	10.111.1.1
CONNECTED	sw12	10.50.20.22	6632	10.111.1.2

## Bind Ports to the VTEP

Now that connectivity is established to the switch, you need to add a physical port binding to the VTEP on the Cumulus Linux switch:

1. Click **Add**.
2. In the **Port Name** list, select the port on the Cumulus Linux switch that you are using to connect to the VXLAN segment.
3. Specify the **VLAN ID** (enter 0 for untagged).
4. In the **Bridge** list, select the MidoNet bridge that the instances (VMs) are using in OpenStack.
5. Click **Save**.



Port name: swp11s0 (2)  
VLAN ID: 0 (3)  
Bridge: internal (4)  
Save (5)

Add

You see the port binding displayed in the binding table under the VTEP.

After the port is bound, this automatically configures a VXLAN bridge interface, and includes the VTEP interface and the port bound to the bridge. Now the OpenStack instances (VMs) are able to ping the hosts connected to the bound port on the Cumulus switch. The Troubleshooting section below demonstrates the verification of the VXLAN data and control planes.

### From the MidoNet CLI

To get started with the MidoNet CLI, you can access the CLI prompt on the OpenStack Controller:

```
root@os-controller:~# midonet-cli  
midonet>
```

From the MidoNet CLI, the commands explained in this section perform the same operations depicted in the previous section with the MidoNet Manager GUI.

1. Create a tunnel zone with a name and type vtep:

```
midonet> tunnel-zone create name sw12 type vtep  
tzonel
```

2. The tunnel zone is a construct used to define the VXLAN source address used for the tunnel. The address of this host is used for the source of the VXLAN encapsulation and traffic transits into the routing domain from this point. Therefore, the host must have layer 3 reachability to the Cumulus Linux switch tunnel IP.

- First, obtain the list of available hosts connected to the Neutron network and the MidoNet bridge.
- Next, get a listing of all the interfaces.
- Finally, add a host entry to the tunnel zone ID returned in the previous step and specify which interface address to use.

```

midonet> list host
host host0 name os-computel alive true
host host1 name os-network alive true
midonet> host host0 list interface
iface midonet host_id host0 status 0 addresses [] mac 02:4b:38:92:dd:ce mtu 1500 type Virtual endpoint DATAPATH
iface lo host_id host0 status 3 addresses [u'127.0.0.1', u'169.254.169.254', u'0:0:0:0:0:0:0:1'] mac 00:00:00:00:00:00
mtu 65536 type Virtual endpoint LOCALHOST
iface virbr0 host_id host0 status 1 addresses [u'192.168.122.1'] mac 22:6e:63:90:1f:69 mtu 1500 type Virtual endpoint UNKNOWN
iface tap7cfccf84c-26 host_id host0 status 3 addresses [u'fe80:0:0:0:e822:94ff:fee2:d41b'] mac ea:22:94:e2:d4:1b mtu 6500
0 type Virtual endpoint DATAPATH
iface eth1 host_id host0 status 3 addresses [u'10.111.0.182', u'fe80:0:0:0:5054:ff:fe85:acd6'] mac 52:54:00:85:ac:d6
mtu 1500 type Physical endpoint PHYSICAL
iface tapfd4abcea-df host_id host0 status 3 addresses [u'fe80:0:0:0:14b3:45ff:fe94:5b07'] mac 16:b3:45:94:5b:07 mtu 6500
0 type Virtual endpoint DATAPATH
iface eth0 host_id host0 status 3 addresses [u'10.50.21.182', u'fe80:0:0:0:5054:ff:feef:c5dc'] mac 52:54:00:ef:c5:dc
mtu 1500 type Physical endpoint PHYSICAL
midonet> tunnel-zone tzone0 add member host host0 address 10.111.0.182
zone tzone0 host host0 address 10.111.0.182

```

Repeat this procedure for each OpenStack host connected to the Neutron network and the MidoNet bridge.

3. Create a VTEP and assign it to the tunnel zone ID returned in the previous step. The management IP address (the destination address for the VXLAN or remote VTEP) and the port must be the same ones you configure in the `vtep-bootstrap` script or the manual bootstrapping:

```

midonet> vtep add management-ip 10.50.20.22 management-port 6632
tunnel-zone tzone0
name sw12 description sw12 management-ip 10.50.20.22 management-
port 6632 tunnel-zone tzone0 connection-state CONNECTED

```



In this step, MidoNet initiates a connection between the OpenStack Controller and the Cumulus Linux switch. If the OVS client successfully connects to the OVSDB server, the returned values should show the name and description matching the `switch-name` parameter specified in the bootstrap process.



Verify the connection-state as CONNECTED. If ERROR is returned, you must debug. Typically this only fails if the `management-ip` and or the `management-port` settings are incorrect.

4. The VTEP binding uses the information provided to MidoNet from the OVSDB server, providing a list of ports that the hardware VTEP can use for layer 2 attachment. This binding virtually connects the physical interface to the overlay switch, and joins it to the Neutron bridged network.

First, get the UUID of the Neutron network behind the MidoNet bridge:

```
midonet> list bridge
bridge bridge0 name internal state up
bridge bridge1 name internal2 state up
midonet> show bridge bridge1 id
6c9826da-6655-4fe3-a826-4dcba6477d2d
```

Next, create the VTEP binding using the UUID and the switch port being bound to the VTEP on the remote end. If there is no VLAN ID, set `vlan` to 0:

```
midonet> vtep name sw12 binding add network-id 6c9826da-6655-4
fe3-a826-4dcba6477d2d physical-port swp11s0 vlan 0
management-ip 10.50.20.22 physical-port swp11s0 vlan 0 network-
id 6c9826da-6655-4fe3-a826-4dcba6477d2d
```

At this point, the VTEP is connected and the layer 2 overlay is operational. From the openstack instance (VM), you can ping a physical server connected to the port bound to the hardware switch VTEP.

## Troubleshooting

As with any complex system, there is a control plane and data plane.

### *Control Plane Troubleshooting*

In this solution, the control plane consists of the connection between the OpenStack Controller and each Cumulus Linux switch running the `ovsdb-server` and `vtep` daemons.

### *Verify VTEP and OVSDB Services*

First, it is important that the OVSDB server and `ovs-vtep` daemon are running. Verify this is the case:

```
cumulus@switch12:~$ systemctl status openvswitch-vtep.service
```

```
ovsdb-server is running with pid 17440
ovs-vtep is running with pid 17444
```

### Verify OVSDB-server Connections

From the OpenStack Controller host, verify that it can connect to the `ovsdb-server`. Telnet to the switch IP address on port 6632:

```
root@os-controller:~# telnet 10.50.20.22 6632
Trying 10.50.20.22...
Connected to 10.50.20.22.
Escape character is '^]'.
<Ctrl+c>
Connection closed by foreign host.
```

If the connection fails, verify IP reachability from the host to the switch. If that succeeds, it is likely that the bootstrap process did not set up port 6632. Redo the bootstrapping procedures above.

```
root@os-controller:~# ping -c1 10.50.20.22
PING 10.50.20.22 (10.50.20.22) 56(84) bytes of data.
64 bytes from 10.50.20.22: icmp_seq=1 ttl=63 time=0.315 ms
--- 10.50.20.22 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 0.315/0.315/0.315/0.000 ms
```

### Verify the VXLAN Bridge and VTEP Interfaces

After creating the VTEP in MidoNet and adding an interface binding, you see the **br-vxln** and **vxln** interfaces on the switch. Verify that the VXLAN bridge and VTEP interface are created and UP:

```
cumulus@switch12:~$ sudo brctl show
bridge name     bridge id               STP      enabled interfaces
bridge          8000.00e0ec2749a2    no        swp11s0
                           vxln10006
cumulus@switch12:~$ sudo ip -d link show vxln10006
55: vxln10006: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue
    master br-vxln10006 state UNKNOWN mode DEFAULT
    link/ether 72:94:eb:b6:6c:c3 brd ff:ff:ff:ff:ff:ff
    vxlan id 10006 local 10.111.1.2 port 32768 61000 nolearning ageing 3
00 svcnode 10.111.0.182
        bridge_slave
```

Next, look at the bridging table for the VTEP and the forwarding entries. The bound interface and the VTEP are listed along with the MAC addresses of those interfaces. When the hosts attached to the bound port send data, those MACs are learned and entered into the bridging table, as well as the OVSDB.

```

cumulus@switch12:~$ brctl showmacs br-vxln10006
port name      mac addr          vlan   is local?   ageing timer
swp11s0        00:e0:ec:27:49:a2    0       yes        0.00
swp11s0        64:ae:0c:32:f1:41    0       no         0.01
vxln10006      72:94:eb:b6:6c:c3    0       yes        0.00

cumulus@switch12:~$ sudo bridge fdb show br-vxln10006
fa:16:3e:14:04:2e dev vxln10004 dst 10.111.0.182 vlan 65535 self
permanent
00:e0:ec:27:49:a2 dev swp11s0 vlan 0 master br-vxln10004 permanent
b6:71:33:3b:a7:83 dev vxln10004 vlan 0 master br-vxln10004 permanent
64:ae:0c:32:f1:41 dev swp11s0 vlan 0 master br-vxln10004

```

## Datapath Troubleshooting

If you have verified the control plane is correct, and you still cannot get data between the OpenStack instances and the physical nodes on the switch, there might be something wrong with the data plane. The data plane consists of the actual VXLAN encapsulated path, between one of the OpenStack nodes running the `midolman` service. This is typically the compute nodes, but can include the MidoNet gateway nodes. If the OpenStack instances can ping the tenant router address but cannot ping the physical device connected to the switch (or vice versa), then something is wrong in the data plane.

## Verify IP Reachability

First, there must be IP reachability between the encapsulating node, and the address you bootstrapped as the tunnel IP on the switch. Verify the OpenStack host can ping the tunnel IP. If this does not work, check the routing design and fix the layer 3 problem first.

```

root@os-compute1:~# ping -c1 10.111.1.2
PING 10.111.1.2 (10.111.1.2) 56(84) bytes of data.
64 bytes from 10.111.1.2: icmp_seq=1 ttl=62 time=0.649 ms
--- 10.111.1.2 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 0.649/0.649/0.649/0.000 ms

```

## MidoNet VXLAN Encapsulation

If the instance (VM) cannot ping the physical server or the reply is not returning, look at the packets on the OpenStack node. Initiate a ping from the OpenStack instance, then use `tcpdump` to see the VXLAN data. This example displays a successful `tcpdump`.

```

root@os-compute1:~# tcpdump -i eth1 -l -nnn -vvv -X -e port 4789
52:54:00:85:ac:d6 > 00:e0:ec:26:50:36, ethertype IPv4 (0x0800),
length 148: (tos 0x0, ttl 255, id 7583, offset 0, flags [none], proto
UDP (17), length 134)
  10.111.0.182.41568 > 10.111.1.2.4789: [no cksum] VXLAN, flags [I] (0x
08), vni 10008

```

```

fa:16:3e:14:04:2e > 64:ae:0c:32:f1:41, ethertype IPv4 (0x0800),
length 98: (tos 0x0, ttl 64, id 64058, offset 0, flags [DF], proto
ICMP (1), length 84)
  10.111.102.104 > 10.111.102.2: ICMP echo request, id 15873, seq 0,
length 64
  0x0000: 4500 0086 1d9f 0000 ff11 8732 0a6f 00b6 E.....2.o...
  0x0010: 0a6f 0102 a260 12b5 0072 0000 0800 0000 .o....`....r....
  0x0020: 0027 1800 64ae 0c32 f141 fa16 3e14 042e .'..d...2.A..>...
  0x0030: 0800 4500 0054 fa3a 4000 4001 5f26 0a6f ..E..T.:@. @_&.o
  0x0040: 6668 0a6f 6602 0800 f9de 3e01 0000 4233 fh.of....>...B3
  0x0050: 7dec 0000 0000 0000 0000 0000 0000 0000 }.....
  0x0060: 0000 0000 0000 0000 0000 0000 0000 0000 .....
  0x0070: 0000 0000 0000 0000 0000 0000 0000 0000 .....
  0x0080: 0000 0000 0000 ..... .
00:e0:ec:26:50:36 > 52:54:00:85:ac:d6, ethertype IPv4 (0x0800),
length 148: (tos 0x0, ttl 62, id 2689, offset 0, flags [none], proto
UDP (17), length 134)
  10.111.1.2.63385 > 10.111.0.182.4789: [no cksum] VXLAN, flags [I] (0x
08), vni 10008
64:ae:0c:32:f1:41 > fa:16:3e:14:04:2e, ethertype IPv4 (0x0800),
length 98: (tos 0x0, ttl 255, id 64058, offset 0, flags [DF], proto
ICMP (1), length 84)
  10.111.102.2 > 10.111.102.104: ICMP echo reply, id 15873, seq 0,
length 64
  0x0000: 4500 0086 0a81 0000 3e11 5b51 0a6f 0102 E.....>.[Q.o..
  0x0010: 0a6f 00b6 f799 12b5 0072 0000 0800 0000 .o.....r.....
  0x0020: 0027 1800 fa16 3e14 042e 64ae 0c32 f141 .'....>...d...2.A
  0x0030: 0800 4500 0054 fa3a 4000 ff01 a025 0a6f ..E..T.:@....%o
  0x0040: 6602 0a6f 6668 0000 01df 3e01 0000 4233 f..ofh....>...B3
  0x0050: 7dec 0000 0000 0000 0000 0000 0000 0000 }.....
  0x0060: 0000 0000 0000 0000 0000 0000 0000 0000 .....
  0x0070: 0000 0000 0000 0000 0000 0000 0000 0000 .....
  0x0080: 0000 0000 0000 ..... .

```

## Inspect the OVSDB

These commands show you the information installed in the OVSDB. This database is structured using the *physical switch* ID, with one or more *logical switch* IDs associated with it. The bootstrap process creates the physical switch and MidoNet creates the logical switch after the control session is established.

### List the Physical Switch

```
cumulus@switch12:~$ vtep-ctl list-ps
sw12
```



## List the Logical Switch

```
cumulus@switch12:~$ vtep-ctl list-ls  
mn-6c9826da-6655-4fe3-a826-4dcba6477d2d
```

## List Local or Remote MAC Addresses

These commands show the MAC addresses learned from the connected port bound to the logical switch or the MAC addresses advertised from MidoNet. The *unknown-dst* entries are installed to satisfy the ethernet flooding of unknown unicast and are important for learning.

```
cumulus@switch12:~$ vtep-ctl list-local-macs mn-6c9826da-6655-4fe3-  
a826-4dcba6477d2d  
ucast-mac-local  
  64:ae:0c:32:f1:41 -> vxlan_over_ipv4/10.111.1.2  
mcast-mac-local  
  unknown-dst -> vxlan_over_ipv4/10.111.1.2  
  
cumulus@switch12:~$ vtep-ctl list-remote-macs mn-6c9826da-6655-4fe3-  
a826-4dcba6477d2d  
ucast-mac-remote  
  fa:16:3e:14:04:2e -> vxlan_over_ipv4/10.111.0.182  
mcast-mac-remote  
  unknown-dst -> vxlan_over_ipv4/10.111.0.182oh
```

## Show Open Vswitch Database (OVSDDB) Data

The `ovsdb-client dump` command is large but shows all of the information and tables used in communication between the OVS client and server.

[Click to expand the output ...](#)

```
cumulus@switch12:~$ ovsdb-client dump  
Arp_Sources_Local table  
_uuid locator src_mac  
-----  
Arp_Sources_Remote table  
_uuid locator src_mac  
-----  
Global table  
_uuid managers switches  
-----  
-----  
76672d6a-2740-4c8d-9618-9e8dfb4b0bd7 [ ] [6d459554-0c75-4170-bb3d-  
117eb4cef4d]
```

```

Logical_Binding_Stats table
_uuid bytes_from_local bytes_to_local packets_from_local
packets_to_local
-----
d2e378b4-61c1-4daf-9aec-a7fd352d3193 5782569 1658250 21687 14589

Logical_Router table
_uuid description name static_routes switch_binding
-----
Logical_Switch table
_uuid description name tunnel_key
-----
44d162dc-0372-4749-a802-5b153c7120ec "" "mn-6c9826da-6655-4fe3-a826-
4dcba6477d2d" 10006

Manager table
_uuid inactivity_probe is_connected max_backoff other_config status
target
-----
Mcast_Macs_Local table
MAC _uuid ipaddr locator_set logical_switch
-----
Mcast_Macs_Remote table
MAC _uuid ipaddr locator_set logical_switch
-----
unknown-dst 25eaf29a-c540-46e3-8806-3892070a2de5 "" 7a4c000a-244e-
4b37-8f25-fd816c1a80dc 44d162dc-0372-4749-a802-5b153c7120ec

Physical_Locator table
_uuid dst_ip encapsulation_type
-----
2fcf8b7e-e084-4bcb-b668-755ae7ac0bfb "10.111.0.182" "vxlan_over_ipv4"
3f78dbb0-9695-42ef-a31f-aaaf525147f1 "10.111.1.2" "vxlan_over_ipv4"

Physical_Locator_Set table
_uuid locators
-----
6c04d477-18d0-41df-8d52-dc7b17845ebe [2fcf8b7e-e084-4bcb-b668-
755ae7ac0bfb]
7a4c000a-244e-4b37-8f25-fd816c1a80dc [3f78dbb0-9695-42ef-a31f-
aaaf525147f1]

Physical_Port table
_uuid description name port_fault_status vlan_bindings vlan_stats
-----
```



```
bf69fcbb-36b3-4dbc-a90d-fc7412e57076 "swp1" "swp1" [] {} {}
bf38137d-3a14-454e-8df0-9c56e4b4e640 "swp10" "swp10" [] {} {}
69585fff-4360-4177-901d-8360ade5391b "swp11s0" "swp11s0" [] {0=44d162d
c-0372-4749-a802-5b153c7120ec} {0=d2e378b4-61c1-4daf-9aec-
a7fd352d3193}
2a2d04fa-7190-41fe-8cee-318fcbafb2ea "swp11s1" "swp11s1" [] {} {}
684f99d5-426c-45c8-b964-211489f45599 "swp11s2" "swp11s2" [] {} {}
47cc66fb-ef8a-4a9b-a497-1844b89f7d32 "swp11s3" "swp11s3" [] {} {}
5be3a052-be0f-4258-94cb-5e8be9afb896 "swp12" "swp12" [] {} {}
631b19bd-3022-4353-bb2d-f498b0c1cb17 "swp13" "swp13" [] {} {}
3001c904-b152-4dc4-9d8e-718f24ffa439 "swp14" "swp14" [] {} {}
a6f8a88a-3877-4f81-b9b4-d75394a09d2c "swp15" "swp15" [] {} {}
7cb681f4-2206-4c70-85b7-23b60963cd21 "swp16" "swp16" [] {} {}
3943fb6a-0b49-4806-a014-2bcd4d469537 "swp17" "swp17" [] {} {}
109a9911-d6c7-4142-b6c9-7c985506abb4 "swp18" "swp18" [] {} {}
93b85c31-be38-4384-8b7a-9696764f9ba9 "swp19" "swp19" [] {} {}
bcfb2920-6676-494c-9dcb-b474123b7e59 "swp2" "swp2" [] {} {}
4223559a-dal1c-4c34-b8bf-bff7ced376ad "swp20" "swp20" [] {} {}
6bbccda8-d7e5-4b19-b978-4ec7f5b868e0 "swp21" "swp21" [] {} {}
c6876886-8386-4e34-a307-931909fca58f "swp22" "swp22" [] {} {}
c5a88dd6-d931-4b2c-9baa-a0abfb9d41f5 "swp23" "swp23" [] {} {}
124d1e01-a187-4427-819f-21de66e76f13 "swp24" "swp24" [] {} {}
55b49814-b5c5-405e-8e9f-898f3df4f872 "swp25" "swp25" [] {} {}
b2b2cd14-662d-45a5-87c1-277acbccdffd "swp26" "swp26" [] {} {}
c35f55f5-8ec6-4fed-bef4-49801cd0934c "swp27" "swp27" [] {} {}
a44c5402-6218-4f09-bf1e-518f41a5546e "swp28" "swp28" [] {} {}
a9294152-2b32-4058-8796-23520ffb7379 "swp29" "swp29" [] {} {}
e0ee993a-8383-4701-a766-d425654dbb7f "swp3" "swp3" [] {} {}
d9db91a6-1c10-4154-9269-84877ffaa79b4 "swp30" "swp30" [] {} {}
b26ce4dd-b771-4d7b-8647-41fa97aa40e3 "swp31" "swp31" [] {} {}
652c6cd1-0823-4585-bb78-658e6ca2abfc "swp32" "swp32" [] {} {}
5b15372b-89f0-4e14-a50b-b6c6f937d33d "swp4" "swp4" [] {} {}
e00741f1-ba34-47c5-ae23-9269c5d1a871 "swp5" "swp5" [] {} {}
7096abaf-eebf-4ee3-b0cc-276224bc3e71 "swp6" "swp6" [] {} {}
439afb62-067e-4bbe-a0d9-ee33a23d2a9c "swp7" "swp7" [] {} {}
54f6c9df-01a1-4d96-9dcf-3035a33fffb3e "swp8" "swp8" [] {} {}
c85ed6cd-a7d4-4016-b3e9-34df592072eb "swp9s0" "swp9s0" [] {} {}
cf382ed6-60d3-43f5-8586-81f4f0f2fb28 "swp9s1" "swp9s1" [] {} {}
c32a9ff9-fd11-4399-815f-806322f26ff5 "swp9s2" "swp9s2" [] {} {}
9a7e42c4-228f-4b55-b972-7c3b8352c27d "swp9s3" "swp9s3" [] {} {}

Physical_Switch table
_uuid description management_ips name ports switch_fault_status
tunnel_ips tunnels
-----
```



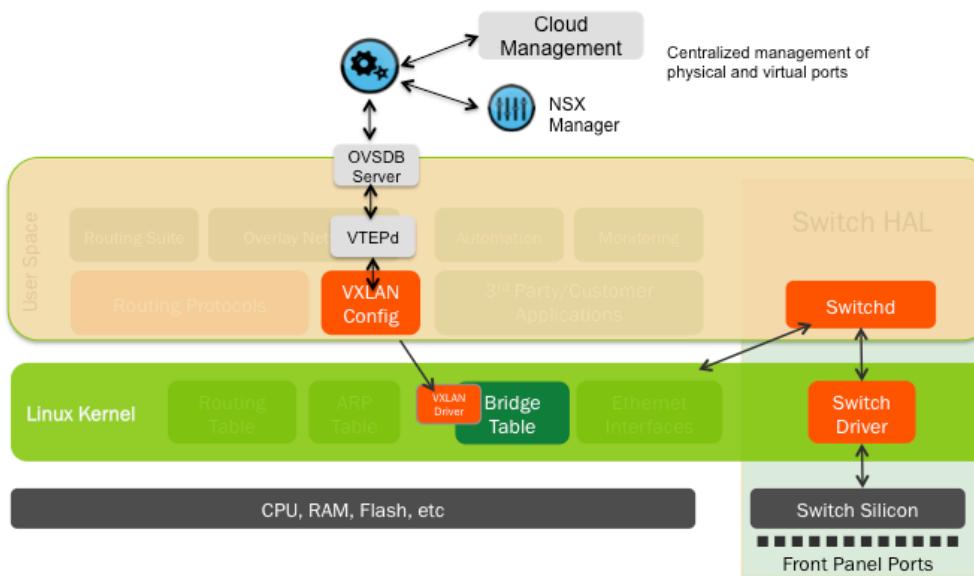
```
6d459554-0c75-4170-bb3d-117eb4ce1f4d "sw12" ["10.50.20.22"] "sw12"
[109a9911-d6c7-4142-b6c9-7c985506abb4, 124d1e01-a187-4427-819f-
21de66e76f13, 2a2d04fa-7190-41fe-8cee-318fcbafb2ea, 3001c904-b152-
4dc4-9d8e-718f24ffa439, 3943fb6a-0b49-4806-a014-2bcd4d469537,
4223559a-da1c-4c34-b8bf-bff7ced376ad, 439afb62-067e-4bbe-a0d9-
ee33a23d2a9c, 47cc66fb-ef8a-4a9b-a497-1844b89f7d32, 54f6c9df-01a1-
4d96-9dcf-3035a33ffb3e, 55b49814-b5c5-405e-8e9f-898f3df4f872,
5b15372b-89f0-4e14-a50b-b6c6f937d33d, 5be3a052-be0f-4258-94cb-
5e8be9afb896, 631b19bd-3022-4353-bb2d-f498b0c1cb17, 652c6cd1-0823-4585-
-bb78-658e6ca2abfc, 684f99d5-426c-45c8-b964-211489f45599, 69585fff-436
0-4177-901d-8360ade5391b, 6bbccda8-d7e5-4b19-b978-4ec7f5b868e0,
7096abaf-eebf-4ee3-b0cc-276224bc3e71, 7cb681f4-2206-4c70-85b7-
23b60963cd21, 93b85c31-be38-4384-8b7a-9696764f9ba9, 9a7e42c4-228f-
4b55-b972-7c3b8352c27d, a44c5402-6218-4f09-bf1e-518f41a5546e,
a6f8a88a-3877-4f81-b9b4-d75394a09d2c, a9294152-2b32-4058-8796-23520
ffb7379, b26ce4dd-b771-4d7b-8647-41fa97aa40e3, b2b2cd14-662d-45a5-
87c1-277acbccdfdf, bcfb2920-6676-494c-9dc9-b474123b7e59, bf38137d-
3a14-454e-8df0-9c56e4b4e640, bf69fcbb-36b3-4dbc-a90d-fc7412e57076,
c32a9ff9-fd11-4399-815f-806322f26ff5, c35f55f5-8ec6-4fed-bef4-
49801cd0934c, c5a88dd6-d931-4b2c-9baa-a0abfb9d41f5, c6876886-8386-4
e34-a307-931909fca58f, c85ed6cd-a7d4-4016-b3e9-34df592072eb, cf382ed6-
60d3-43f5-8586-81f4f0f2fb28, d9db91a6-1c10-4154-9269-84877faa79b4,
e00741f1-ba34-47c5-ae23-9269c5d1a871, e0ee993a-8383-4701-a766-
d425654dbb7f] [] ["10.111.1.2"] [062eaf89-9bd5-4132-8b6b-09db254325af]
Tunnel table
_uuid bfd_config_local bfd_config_remote bfd_params bfd_status local
remote
-----
-----
-----
-----
062eaf89-9bd5-4132-8b6b-09db254325af {bfd_dst_ip="169.254.1.0",
bfd_dst_mac="00:23:20:00:00:01"} {} {} {} 3f78dbb0-9695-42ef-a31f-
aaaf525147f1 2fcf8b7e-e084-4bcb-b668-755ae7ac0bfb
Ucast_Macs_Local table
MAC uuid ipaddr locator logical switch
```

```
"64:ae:0c:32:f1:41" 47a83a7c-bd2d-4c02-9814-8222229c592f "" 3f78dbb0-9
695-42ef-a31f-aaaf525147f1 44d162dc-0372-4749-a802-5b153c7120ec
Ucast_Macs_Remote table
MAC _uuid ipaddr locator logical_switch

"fa:16:3e:14:04:2e" 65605488-9ee5-4c8e-93e5-7b1cc15cfcc7 "" 2fcf8b7e-
e084-4bcb-b668-755ae7ac0bfb 44d162dc-0372-4749-a802-5b153c7120ec
```

## Integrating Hardware VTEPs with VMware NSX-V

Switches running Cumulus Linux can integrate with VMware NSX-V to act as hardware VTEP gateways. The VMware NSX-V controller provides consistent provisioning across virtual and physical server infrastructures.



Cumulus Linux also supports integration with VMware NSX in high availability mode. Refer to [OVSDDB Server High Availability](#) (see page 712).

## Contents

This topic describes ...

- Getting Started (see page 688)
- Configure the Switch for NSX-V Integration (see page 688)
  - Start the `openvswitch-vtep` Service (see page 688)
  - Configure the NSX-V Integration Using the Configuration Script (see page 689)
  - Configure the NSX-V Integration Manually (see page 690)



- Provision VMware NSX-V (see page 692)
  - Configure the Switch as a VTEP Gateway (see page 692)
- Configure the Transport and Logical Layers (see page 693)
  - Configure the Transport Layer (see page 693)
  - Configure the Logical Layer (see page 695)
  - Define Logical Switch Ports (see page 697)
- Verify the VXLAN Configuration (see page 698)

## Getting Started

Before you integrate VXLANs with NSX-V, make sure you have a layer 2 gateway; a Broadcom Tomahawk, Trident II+, Trident II, Maverick or Mellanox Spectrum switch running Cumulus Linux. Cumulus Linux includes OVSDB server (`ovsdb-server`) and VTEPd (`ovs-vtep`), which support **VLAN-aware bridges** (see page 415).

To integrate a VXLAN with NSX-V, you need to:

- Configure the NSX-V integration on the switch.
- Configure the transport and logical layers from the NSX Manager.
- Verify the VXLAN configuration.



Cumulus Linux supports security protocol version TLSv1.2 for SSL connections between the OVSDB server and the NSX controller.

The OVSDB server cannot select the loopback interface as the source IP address, causing top of rack registration to the controller to fail. To work around this issue, run the `net add bgp redistribute connected` command followed by the `net commit` command.

## Configure the Switch for NSX-V Integration

Before you start configuring the gateway service, and logical switches and ports that comprise the VXLAN, you need to enable and start the `openvswitch-vtep` service, and configure the NSX integration on the switch, either using the script or performing the manual configuration.

### *Start the openvswitch-vtep Service*

To enable and start the `openvswitch-vtep` service, run the following command:

```
cumulus@switch:~$ sudo systemctl enable openvswitch-vtep.service
cumulus@switch:~$ sudo systemctl start openvswitch-vtep.service
```



In previous versions of Cumulus Linux, you had to edit the `/etc/default/openvswitch-vtep` file and then start the `openvswitch-vtep` service. Now, you just have to enable and start the `openvswitch-vtep` service.



## Configure the NSX-V Integration Using the Configuration Script

A script is available so you can configure the NSX-V integration on the switch automatically.

In a terminal session connected to the switch, run the `vtep-bootstrap` command with these options:

- `controller_ip` is the IP address of the NSX controller (192.168.100.17 in the example command below).
- The ID for the VTEP (`vtep7` in the example command below).
- The datapath IP address of the VTEP (172.16.20.157 in the example command below). This is the VXLAN anycast IP address.
- The IP address of the management interface on the switch (192.168.100.157 in the example command below). This interface is used for control traffic.

```
cumulus@switch:~$ vtep-bootstrap vtep7 --controller_ip 192.168.100.17
172.16.20.157 192.168.100.157
Executed:
  create certificate on a switch, to be used for authentication
with controller
  ().
Executed:
  sign certificate
    (vtep7-req.pem      Tue Sep 11 21:11:27 UTC 2018
     fingerprint a4cda030fe5e458c0d7ba44e22f52650f01bcd75) .
Executed:
  define physical switch
  ().
Executed:
  define NSX controller IP address in OVSDB
  ().
Executed:
  define local tunnel IP address on the switch
  ().
Executed:
  define management IP address on the switch
  ().
Executed:
  restart a service
  ().
```

Run the following commands in the order shown to complete the configuration process:

```
cumulus@switch:~$ sudo systemctl restart openvswitch-vtep.service
cumulus@switch:~$ sudo ifreload -a
cumulus@switch:~$ sudo systemctl restart networking.service
```



## Configure the NSX-V Integration Manually



You can configure the NSX-V integration manually for standalone mode only; manual configuration for OVSDB server high availability is not supported.

If you do not want to use the configuration script to configure the NSX-V integration on the switch automatically, you can configure the integration manually, which requires you to perform the following steps:

- Generate a certificate and key pair for authentication by NSX-V.
- Configure a switch as a VTEP gateway.

### Generate the Credentials Certificate

In Cumulus Linux, generate a certificate that the NSX controller uses for authentication.

1. In a terminal session connected to the switch, run the following commands:

```
cumulus@switch:~$ sudo ovs-pki init
Creating controllerca...
Creating switchca...
cumulus@switch:~$ sudo ovs-pki req+sign cumulus

cumulus-req.pem Wed Oct 23 05:32:49 UTC 2013
    fingerprint b587c9fe36f09fb371750ab50c430485d33a174a

cumulus@switch:~$ ls -l
total 12
-rw-r--r-- 1 root root 4028 Oct 23 05:32 cumulus-cert.pem
-rw----- 1 root root 1679 Oct 23 05:32 cumulus-privkey.pem
-rw-r--r-- 1 root root 3585 Oct 23 05:32 cumulus-req.pem
```

2. In the `/usr/share/openvswitch/scripts/ovs-ctl-vtep` file, make sure the lines containing **private-key**, **certificate**, and **bootstrap-ca-cert** point to the correct files; **bootstrap-ca-cert** is obtained dynamically the first time the switch talks to the controller:

```
# Start ovsdb-server.
set ovsdb-server "$DB_FILE"
set "$@" -vANY:CONSOLE:EMER -vANY:SYSLOG:ERR -vANY:FILE:INFO
set "$@" --remote=unix:"$DB_SOCK"
set "$@" --remote=db:Global,managers
set "$@" --remote=tcp:$LOCALIP
set "$@" --private-key=/root/cumulus-privkey.pem
set "$@" --certificate=/root/cumulus-cert.pem
set "$@" --bootstrap-ca-cert=/root/controller.cacert
set "$@" --ssl-protocols=TLSv1,TLSv1.1,TLSv1.2
```



If files have been moved or regenerated, restart the OVSDB server and VTEPd:

```
cumulus@switch:~$ sudo systemctl restart openvswitch-vtep.service
```

3. Define the NSX Controller Cluster IP address in OVSDB. This causes the OVSDB server to start contacting the NSX controller:

```
cumulus@switch:~$ sudo vtep-ctl set-manager ssl:192.168.100.17:6632
```

4. Define the local IP address on the VTEP for VXLAN tunnel termination. First, find the physical switch name as recorded in OVSDB:

```
cumulus@switch:~$ sudo vtep-ctl list-ps  
vtep7
```

Then set the tunnel source IP address of the VTEP. This is the datapath address of the VTEP, which is typically an address on a loopback interface on the switch that is reachable from the underlying layer 3 network:

```
cumulus@switch:~$ sudo vtep-ctl set Physical_Switch vtep7  
tunnel_ips=172.16.20.157
```

After you generate the certificate, keep the terminal session active; you need to paste the certificate into NSX Manager when you configure the VTEP gateway.

### *Enable ovs-vtep to Use the VLAN-aware Bridge*

By default, in stand-alone mode, the ovs-vtep daemon creates traditional bridges for each VXLAN VTEP. To use the VLAN-aware bridge with the VTEPs, edit the `/usr/share/openvswitch/scripts/ovs-ctl-vtep` file and uncomment the `--enable-vlan-aware-mode` line:

```
# Start ovs-vtep  
set ovs-vtep unix:"$DB_SOCKET"  
set "$@" -vconsole:emer -vsyslog:err -vfile:info  
#set "$@" --enable-vlan-aware-mode
```

Then restart the OVSDB server and VTEPd:

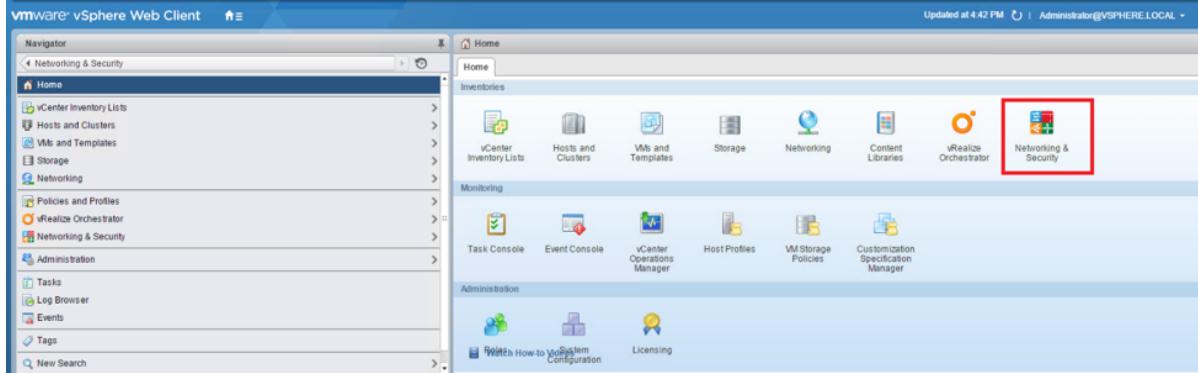
```
cumulus@switch:~$ sudo systemctl restart openvswitch-vtep.service
```

## Provision VMware NSX-V

### Configure the Switch as a VTEP Gateway

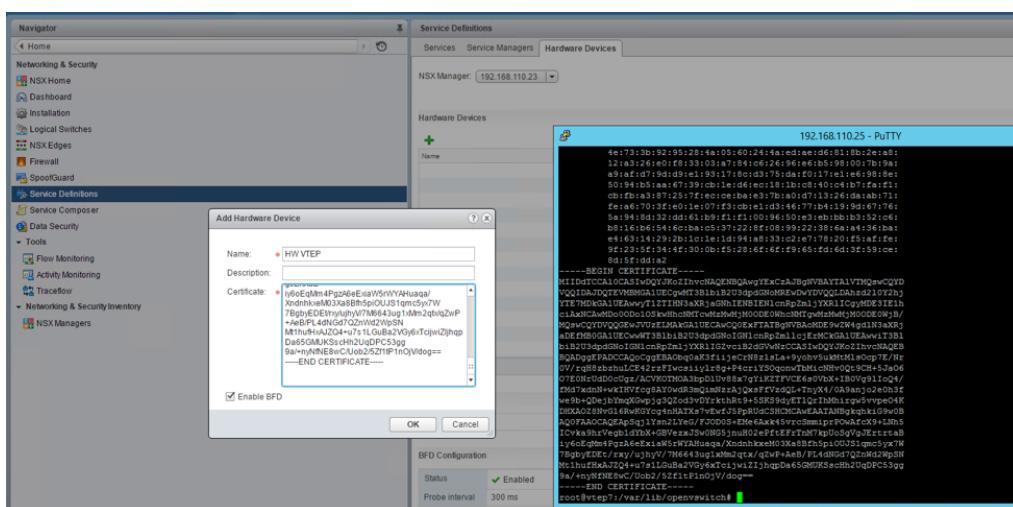
After you create a certificate, connect to NSX Manager in a browser to configure a Cumulus Linux switch as a hardware VTEP gateway. In this example, the IP address of the NSX Manager is 192.168.110.23.

1. In NSX Manager, add a new HW VTEP gateway. Click the **Network & Security** icon, **Service Definitions** category, then the **Hardware Devices** tab. Under **Hardware Devices**, click **+**. The Create Add Hardware Devices window opens.



2. In the **Name** field, provide a name for the HW VTEP gateway.
3. Enable the BFD service to the service nodes. Select the **Enable BFD** check box.
4. From the terminal session connected to the switch where you generated the certificate, copy the certificate and paste it into the **Certificate** text field. Copy only the bottom portion, including the BEGIN CERTIFICATE and END CERTIFICATE lines. For example, copy all the highlighted text in the terminal terminal and paste it into NSX Manager:

```
cumulus@switch:~$ cd /var/lib/openvswitch
cumulus@switch:/var/lib/openvswitch$ ls
conf.db  pki  vtep7-cert.pem  vtep7-privkey.pem  vtep7-req.pem
cumulus@switch:/var/lib/openvswitch$ cat vtep7-cert.pem
```





5. Click **OK** to save the gateway.

The screenshot shows the vSphere Web Client interface. The main pane displays the 'Hardware Devices' section, which lists a single entry: HWVTEP. The table includes columns for Name, Management IP Address, Connectivity, BFD Enabled, and Logical Switches. The status is shown as 'Up' with a green checkmark for BFD Enabled and 1 Logical Switch. The left sidebar has the 'Service Definitions' category selected under 'Networking & Security'. The top status bar indicates 'Not secure' and shows the URL https://192.168.110.4/vsphere-client/?csp#extensionId%3Dcom.vmware.vshield.plugin.common.networksecurity.serviceinsertion.navigateView. The bottom status bar shows 'Activate Windows' and 'Windows 10 Pro 21H2 (Build 19045.321)'

After communication is established between the switch and the controller, a `controller.cacert` file is downloaded onto the switch.

Verify that the controller and switch handshake is successful. In a terminal connected to the switch, run this command:

```
cumulus@switch:~$ sudo ovsdb-client dump -f list | grep -A 7 "Manager"
Manager table
_uuid : 2693ea2e-306-4c23-ac03-934ala304077
_inactivity_probe : []
_is_connected : true
_max_backoff : []
_other_config : {}
_status : {sec_since_connect="557", state=ACTIVE}
_target : "ssl:192.168.110.110:6640"
```

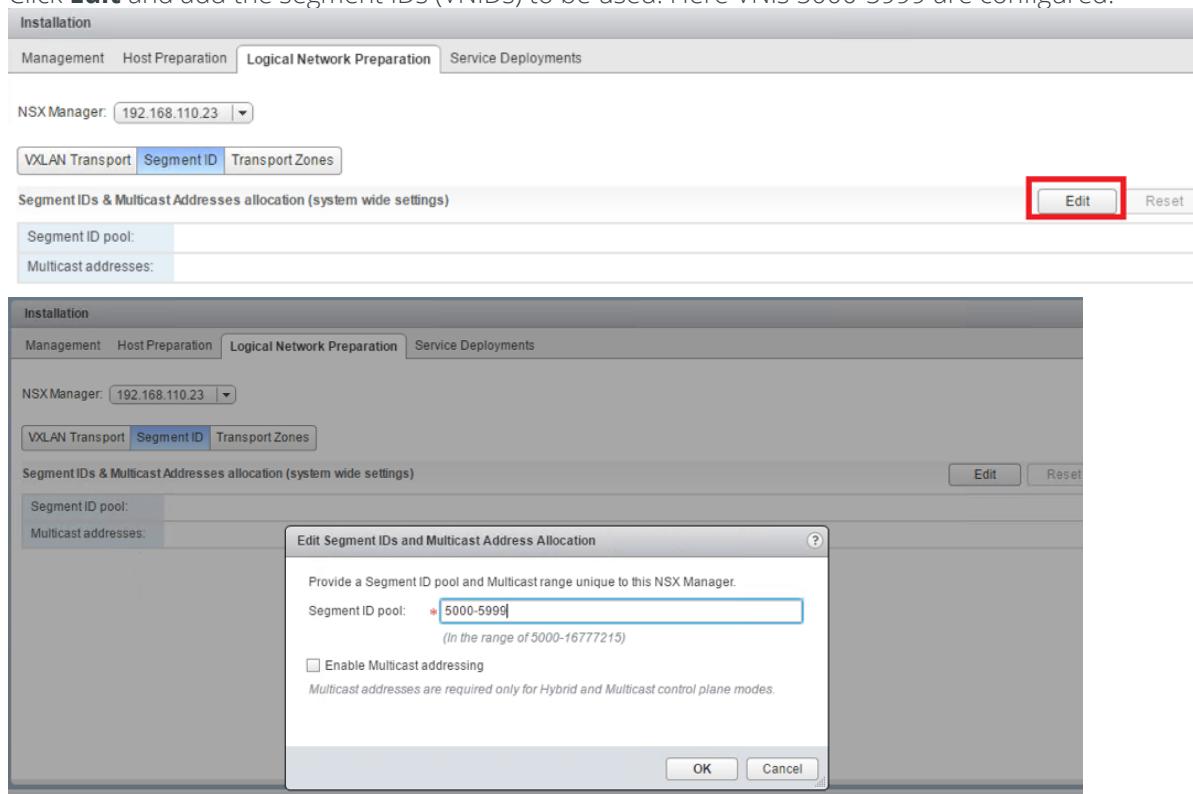
## Configure the Transport and Logical Layers

### Configure the Transport Layer

After you finish configuring NSX-V integration on the switch, configure the transport zone and segment ID.

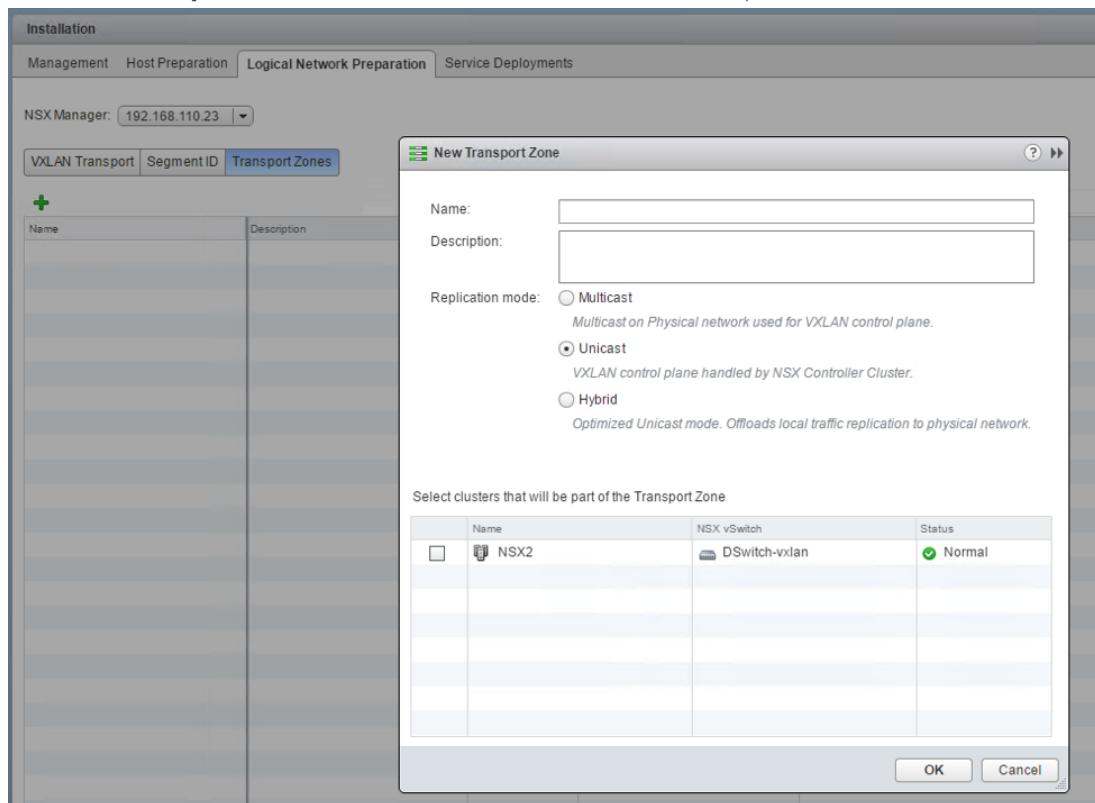
1. In NSX Manager, click the **Logical Network Preparation** tab in the **Installation** category, then click the **Segment ID** tab.

- Click **Edit** and add the segment IDs (VNIDs) to be used. Here VNIs 5000-5999 are configured.



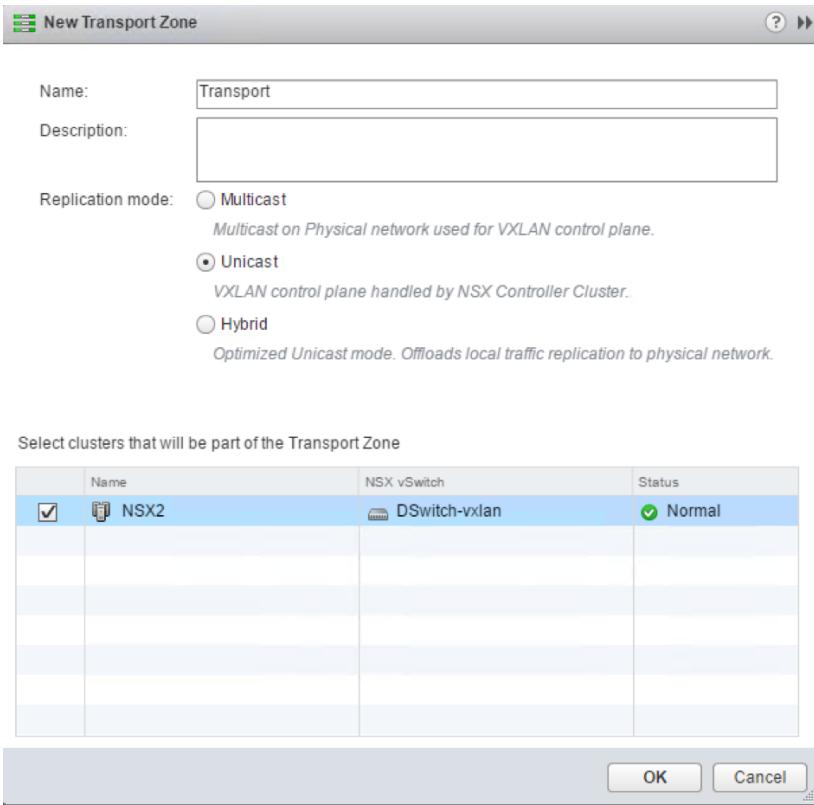
The screenshot shows the Cumulus Installation interface under the Logical Network Preparation tab. In the 'Segment IDs & Multicast Addresses allocation (system wide settings)' section, the 'Segment ID pool' field contains '5000-5999'. The 'Edit' button is highlighted with a red box. Below this, a modal dialog titled 'Edit Segment IDs and Multicast Address Allocation' is displayed, also showing the segment ID pool as '5000-5999'.

- Click **OK** to save and provision the segment IDs.
- Click the **Transport Zones** tab, choose the name of the transport zone.



The screenshot shows the Cumulus Installation interface under the Logical Network Preparation tab. In the 'Transport Zones' section, a 'New Transport Zone' dialog is open. The 'Name:' field is empty, and the 'Replication mode:' radio button is set to 'Unicast'. Below the dialog, a table lists clusters: NSX2 (Name), DSwitch-vxlan (NSX vSwitch), and Normal (Status). The 'Unicast' radio button is highlighted with a red box.

5. Select **Unicast** to choose the NSX-V Controller Cluster to handle the VXLAN control plane.



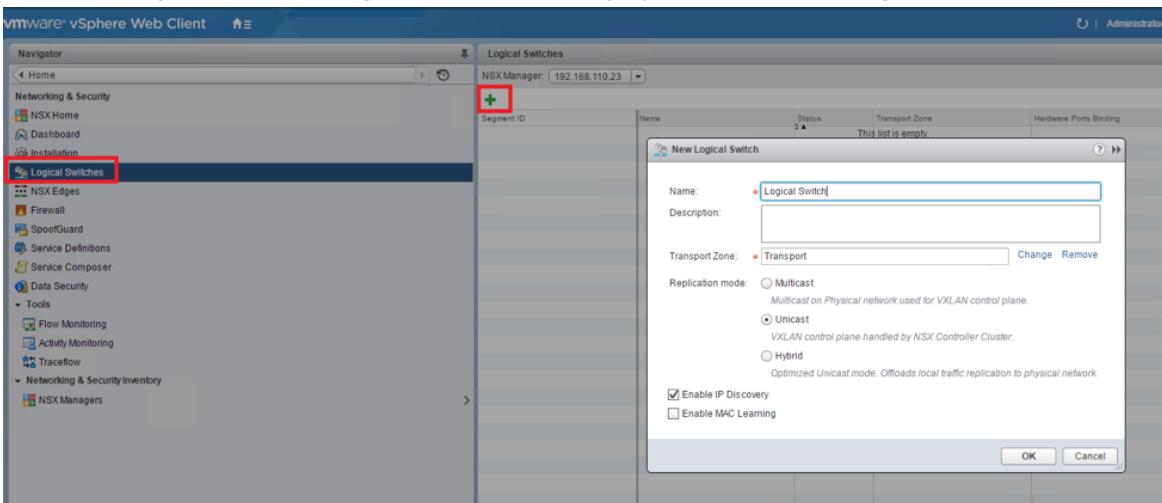
6. Click **OK** to save the new transport zone.

## *Configure the Logical Layer*

To complete the integration with NSX-V, you need to configure the logical layer, which requires defining a logical switch (the VXLAN instance) and all the logical ports needed.

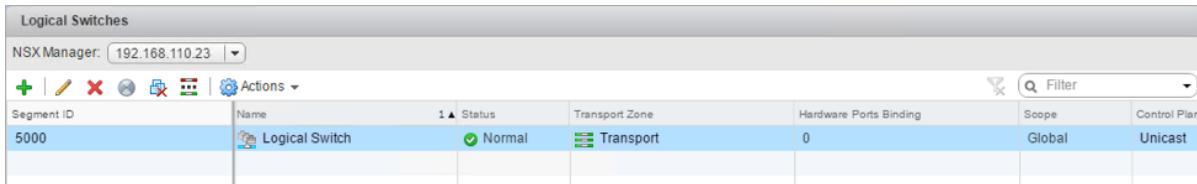
To define the logical switch:

1. In NSX Manager, select the **Logical Switches** category. Click **+** to add a logical switch instance.



2. In the **Name** field, enter a name for the logical switch.

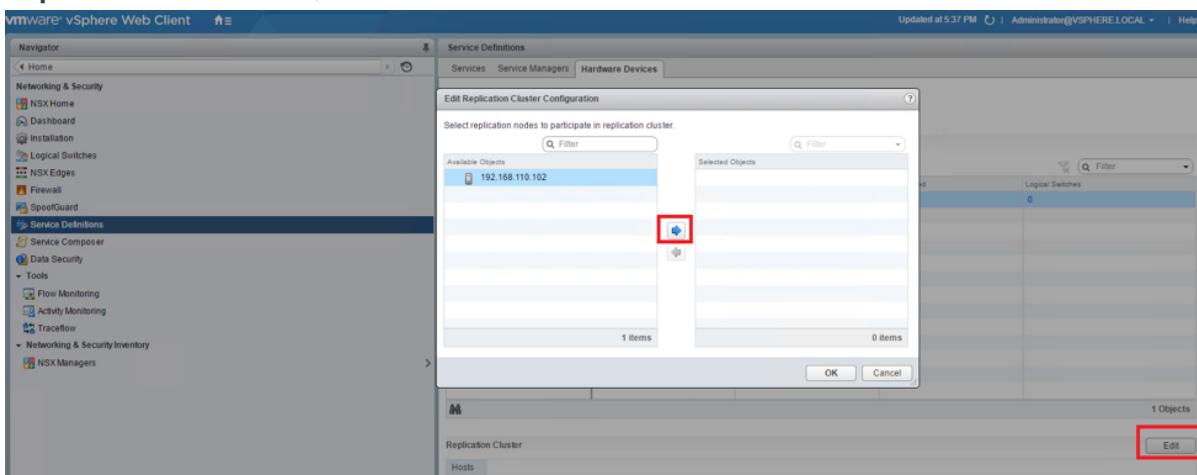
3. In the **Transport Zone** field, add the transport zone that you created earlier.
4. In the **Replication Mode** field, select **Unicast** for replication by the service node. Then check the **Enable IP Discovery** check box.
5. Click **OK**.



The screenshot shows a table titled "Logical Switches" with one row. The columns are: Segment ID (5000), Name (Logical Switch), Status (Normal), Transport Zone (Transport), Hardware Ports Binding (0), Scope (Global), and Control Plane (Unicast). The "Actions" column contains icons for edit, delete, and other management functions.

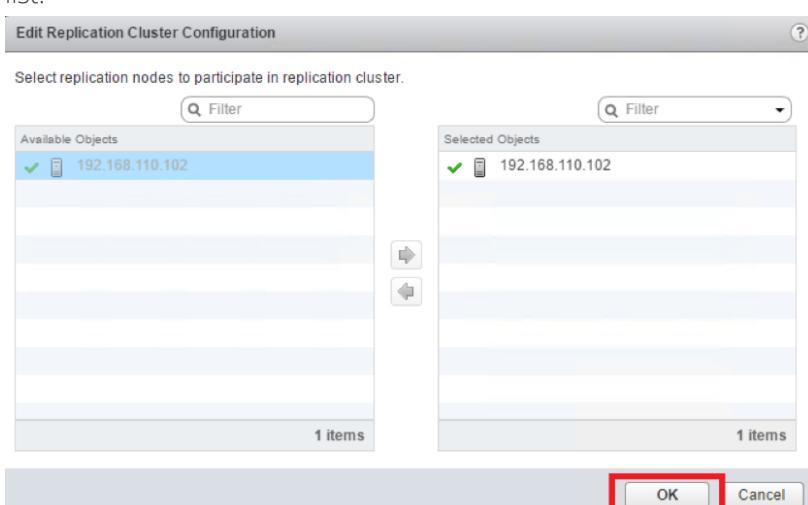
To configure the Replication Cluster:

1. Select the **Service Definitions** category, then click the **Hardware Devices** tab. Next to the **Replication Cluster** field, click **Edit**.



The screenshot shows the "Edit Replication Cluster Configuration" dialog. On the left, the "Available Objects" list contains "192.168.110.102". On the right, the "Selected Objects" list is empty. A red box highlights the green arrow icon between the two lists. At the bottom right of the dialog are "OK" and "Cancel" buttons. The main vSphere Web Client interface shows the "Service Definitions" category selected in the left sidebar.

2. Hypervisors connected to the NSX controller for replication appear in the **Available Objects** list. Select the required service nodes, then click the green arrow to move them to the **Selected Objects** list.



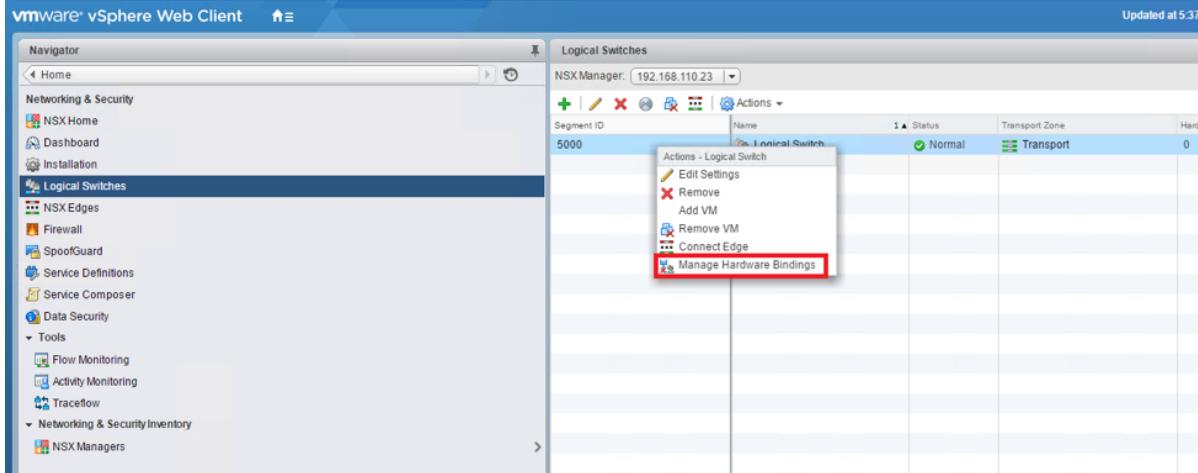
The screenshot shows the "Edit Replication Cluster Configuration" dialog with the "Selected Objects" list containing "192.168.110.102". A red box highlights the "OK" button at the bottom of the dialog. The "Available Objects" list is also visible on the left.

3. Click **OK** to save the replication node configuration.

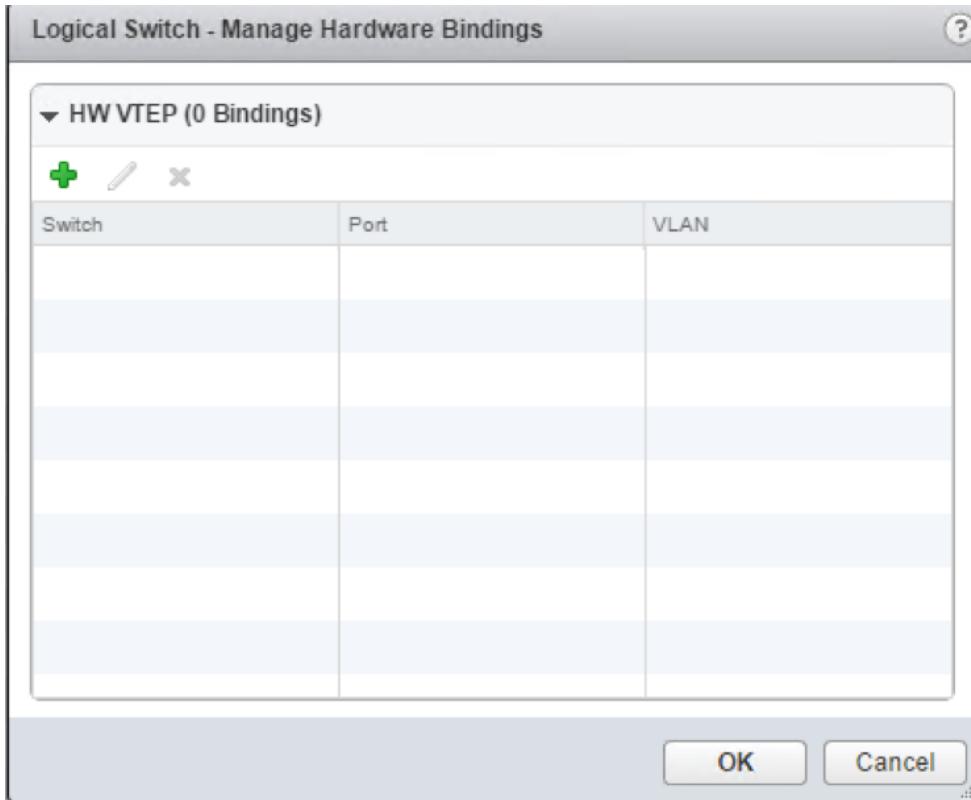
## Define Logical Switch Ports

To define the logical switch ports (you can define a VLAN-to-VNI binding for each switch port associated with a particular logical switch):

1. In NSX Manager, add a new logical switch port. Click the **Logical Switches** category. Under **Actions**, click **Manage Hardware Bindings**. The Manage Hardware Binding wizard appears.

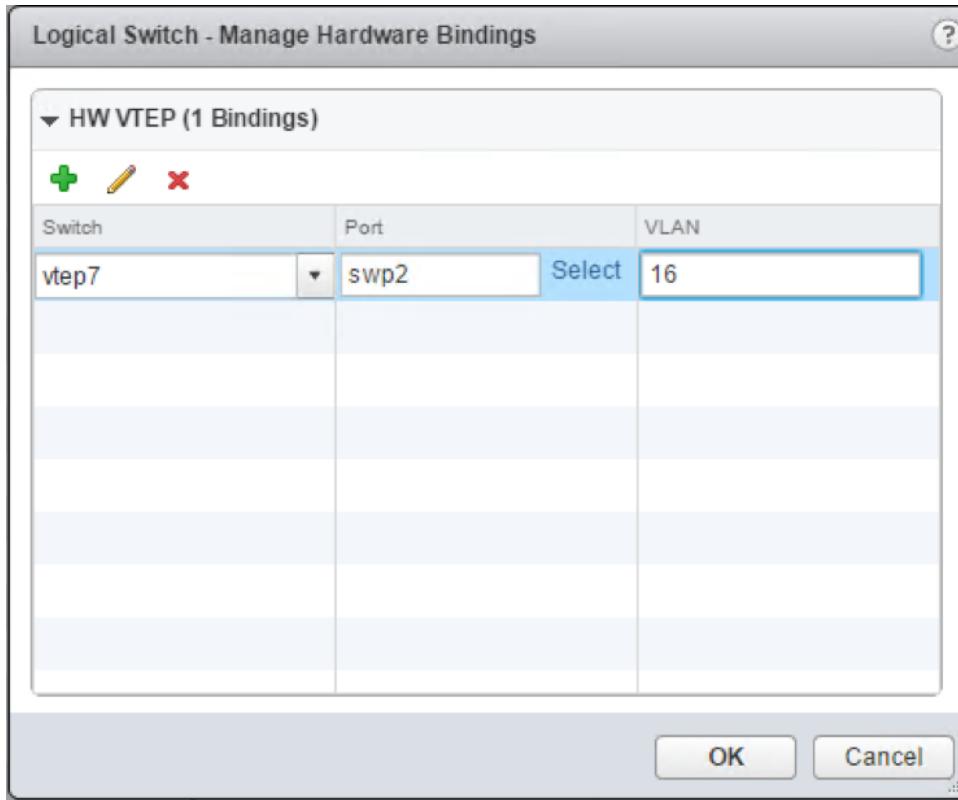


2. Click **+** to add a logical port to the logical switch.



3. Select the logical switch that you created earlier (5000).
4. Select the switch port and the corresponding VLAN binding for logical switch 5000. This creates the logical switch port and also maps VLAN 16 of switch port swp2 to VNI 5000.

- Click **OK** to save the logical switch port. Connectivity is established. Repeat this procedure for each logical switch port you want to define.



## Verify the VXLAN Configuration

After configuration is complete, you can verify the VXLAN configuration using either or both of these Cumulus Linux commands in a terminal connected to the switch:

```
cumulus@switch:/var/lib/openvswitch$ ip -d link show vxln5000
65: vxln5000: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 9152 qdisc noqueue
    master br-vxln5000 state UNKNOWN mode DEFAULT group default
        link/ether da:d1:23:44:c4:5e brd ff:ff:ff:ff:ff:ff promiscuity 1
        vxlan id 5000 local 172.16.20.157 srcport 0 0 dstport 4789 ageing 300
            bridge_slave state forwarding priority 8 cost 100 hairpin off
            guard off root_block off fastleave off learning on flood on port_id 0x8006
            port_no 0x6 designated_port 32774 designated_cost 0
            designated_bridge 8000.16:28:56:cc:97:e5 designated_root 8000.16:28:56:cc:97:e5
            hold_timer 0.00 message_age_timer 0.00
            forward_delay_timer 0.00 topology_change_ack 0 config_pending 0
            proxy_arp off proxy_arp_wifi off mcast_router 1 mcast_fast_leave off
            mcast_flood on neigh_suppress off addrgenmode eui64
```

```
cumulus@switch:/var/lib/openvswitch$ bridge fdb show
```

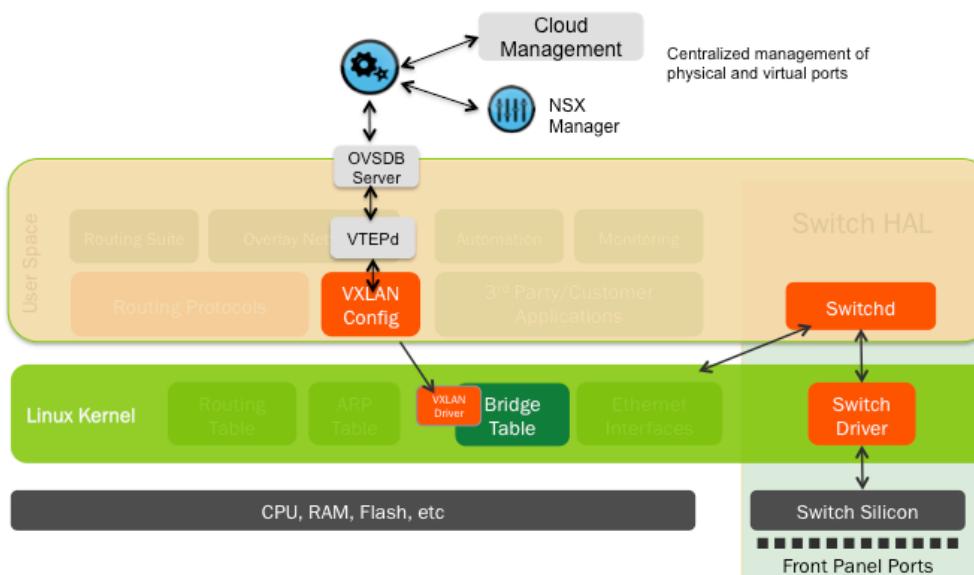
```
b6:fb:be:89:99:65 dev vxln5000 master br-vxln5000 permanent
00:50:56:b5:3f:d2 dev vxln5000 master br-vxln5000 static
00:00:00:00:00:00 dev vxln5000 dst 172.16.1.11 self permanent
00:50:56:b5:3f:d2 dev vxln5000 dst 172.16.1.11 self static
36:cc:7a:bc:b9:e1 dev vxln0 master br-vxln0 permanent
00:23:20:00:00:01 dev dummy0 master br-vxln0 permanent
00:23:20:00:00:01 dev dummy 5000 master br-vxln5000 permanent
7c:fe:90:0b:c5:7e dev swp2.16 master br-vxln5000 permanent
```

To check that the active OVSDB server is connected to the NSX controller, run the `ovsdb-client dump Manager` command:

```
cumulus@switch:~$ sudo ovsdb-client dump Manager
Manager table
_uuid                                inactivity_probe is_connected
max_backoff other_config status        target
-----
-----
e700ad21-8fd8-4f09-96dc-fa7cc6e498d8 30000      true
[]          {}           {sec_since_connect="68", state=ACTIVE} "ssl:
54.0.0.2:6632"
```

## Integrating Hardware VTEPs with VMware NSX-MH

Switches running Cumulus Linux can integrate with VMware NSX Multi-Hypervisor (MH) to act as hardware VTEP gateways. The VMware NSX-MH controller provides consistent provisioning across virtual and physical server infrastructures.



Cumulus Linux also supports integration with VMware NSX in high availability mode. Refer to [OVSDB Server High Availability \(see page 712\)](#).

## Contents

This topic describes ...

- Getting Started (see page 700)
- Configure the Switch for NSX-MH Integration (see page 700)
  - Start the openvswitch-vtep Service (see page 700)
  - Configure the NSX-MH Integration Using the Configuration Script (see page 701)
  - Configure the NSX-MH Integration Manually (see page 702)
- Provision VMware NSX-V (see page 704)
  - Configure the Switch as a VTEP Gateway (see page 704)
- Configure the Transport and Logical Layers (see page 706)
  - Configure the Transport Layer (see page 706)
  - Configure the Logical Layer (see page 707)
  - Define Logical Switch Ports (see page 709)
- Verify the VXLAN Configuration (see page 711)

## Getting Started

Before you integrate VXLANs with NSX-MH, make sure you have a layer 2 gateway; a Broadcom Tomahawk, Trident II+, Trident II, Maverick, or Mellanox Spectrum switch running Cumulus Linux. Cumulus Linux includes OVSDB server (`ovsdb-server`) and VTEPd (`ovs-vtep`), which support **VLAN-aware bridges** (see [page 415](#)).

To integrate a VXLAN with NSX-MH, you need to:

- Configure the NSX-MH integration on the switch.
- Configure the transport and logical layers from the NSX Manager.
- Verify the VXLAN configuration.



Cumulus Linux supports security protocol version TLSv1.2 for SSL connections between the OVSDB server and the NSX controller.

The OVSDB server cannot select the loopback interface as the source IP address, causing top of rack registration to the controller to fail. To work around this issue, run the `net add bgp redistribute connected` command followed by the `net commit` command.

## Configure the Switch for NSX-MH Integration

Before you start configuring the gateway service, logical switches, and ports that comprise the VXLAN, you need to enable and start the `openvswitch-vtep` service, and configure the NSX integration on the switch, either using the script or performing the manual configuration.



## Start the openvswitch-vtep Service

To enable and start the `openvswitch-vtep` service, run the following command:

```
cumulus@switch:~$ sudo systemctl enable openvswitch-vtep.service
cumulus@switch:~$ sudo systemctl start openvswitch-vtep.service
```



In previous versions of Cumulus Linux, you had to edit the `/etc/default/openvswitch-vtep` file and then start the `openvswitch-vtep` service. Now, you just have to enable and start the `openvswitch-vtep` service.

## Configure the NSX-MH Integration Using the Configuration Script

A script is available so you can configure the NSX-MH integration on the switch automatically.

In a terminal session connected to the switch, run the `vtep-bootstrap` command with these options:

- `controller_ip` is the IP address of the NSX controller (192.168.100.17 in the example command below).
- The ID for the VTEP (`vtep7` in the example command below).
- The datapath IP address of the VTEP (172.16.20.157 in the example command below). This is the VXLAN anycast IP address.
- The IP address of the management interface on the switch (192.168.100.157 in the example command below). This interface is used for control traffic.

```
cumulus@switch:~$ vtep-bootstrap --controller_ip 192.168.100.17 vtep7
172.16.20.157 192.168.100.157
Executed:
    create certificate on a switch, to be used for authentication
with controller
().
Executed:
    sign certificate
    (vtep-req.pem      Tue Sep 11 21:11:27 UTC 2018
     fingerprint a4cda030fe5e458c0d7ba44e22f52650f01bcd75).
Executed:
    define physical switch
().
Executed:
    define NSX controller IP address in OVSDB
().
Executed:
    define local tunnel IP address on the switch
().
Executed:
    define management IP address on the switch
```

```
( ).  
Executed:  
    restart a service  
( ).
```

Run the following commands in the order shown to complete the configuration process:

```
cumulus@switch:~$ sudo systemctl restart openvswitch-vtep.service  
cumulus@switch:~$ sudo ifreload -a  
cumulus@switch:~$ sudo systemctl restart networking.service
```

### *Configure the NSX-MH Integration Manually*



You can configure the NSX-V integration manually for standalone mode only; manual configuration for OVSDB server high availability is not supported.

If you do *not* want to use the configuration script to configure the NSX-MH integration on the switch automatically, you can configure the integration manually, which requires you to perform the following steps:

- Generate a certificate and key pair for authentication by NSX.
- Configure the switch as a VTEP gateway.

### *Generate the Credentials Certificate*

In Cumulus Linux, generate a certificate that the NSX controller uses for authentication.

1. In a terminal session connected to the switch, run the following commands:

```
cumulus@switch:~$ sudo ovs-pki init  
Creating controllerca...  
Creating switchca...  
cumulus@switch:~$ sudo ovs-pki req+sign cumulus  
  
cumulus-req.pem Wed Oct 23 05:32:49 UTC 2013  
        fingerprint b587c9fe36f09fb371750ab50c430485d33a174a  
  
cumulus@switch:~$ ls -l  
total 12  
-rw-r--r-- 1 root root 4028 Oct 23 05:32 cumulus-cert.pem  
-rw----- 1 root root 1679 Oct 23 05:32 cumulus-privkey.pem  
-rw-r--r-- 1 root root 3585 Oct 23 05:32 cumulus-req.pem
```

2. In the /usr/share/openvswitch/scripts/ovs-ctl-vtep file, make sure the lines containing **private-key**, **certificate**, and **bootstrap-ca-cert** point to the correct files; **bootstrap-ca-cert** is obtained dynamically the first time the switch talks to the controller:



```
# Start ovsdb-server.  
set ovsdb-server "$DB_FILE"  
set "$@" -vANY:CONSOLE:EMER -vANY:SYSLOG:ERR -vANY:FILE:INFO  
set "$@" --remote=unix:$DB_SOCK  
set "$@" --remote=db:Global,managers  
set "$@" --remote=ptcp:6633:$LOCALIP  
set "$@" --private-key=/root/cumulus-privkey.pem  
set "$@" --certificate=/root/cumulus-cert.pem  
set "$@" --bootstrap-ca-cert=/root/controller.cacert
```

If files have been moved or regenerated, restart the OVSDB server and VTEPd:

```
cumulus@switch:~$ sudo systemctl restart openvswitch-vtep.service
```

3. Define the NSX controller cluster IP address in OVSDB. This causes the OVSDB server to start contacting the NSX controller:

```
cumulus@switch:~$ sudo vtep-ctl set-manager ssl:192.168.100.17:66  
32
```

4. Define the local IP address on the VTEP for VXLAN tunnel termination. First, find the physical switch name as recorded in OVSDB:

```
cumulus@switch:~$ sudo vtep-ctl list-ps  
vtep7
```

Then set the tunnel source IP address of the VTEP. This is the datapath address of the VTEP, which is typically an address on a loopback interface on the switch that is reachable from the underlying layer 3 network:

```
cumulus@switch:~$ sudo vtep-ctl set Physical_Switch vtep7  
tunnel_ip=172.16.20.157
```

After you generate the certificate, keep the terminal session active; you need to paste the certificate into NSX Manager when you configure the VTEP gateway.

### *Enable ovs-vtepd to Use the VLAN-aware Bridge*

By default, in stand-alone mode, the ovs-vtep daemon creates traditional bridges for each VXLAN VTEP. To use the VLAN-aware bridge with the VTEPs, edit the /usr/share/openvswitch/scripts/ovs-ctl-vtep file and uncomment the --enable-vlan-aware-mode line:

```
# Start ovs-vtepd  
set ovs-vtepd unix:$DB_SOCK"
```

```
set "$@" -vconsole:emer -vsyslog:err -vfile:info
#set "$@" --enable-vlan-aware-mode
```

Then restart the OVSDB server and VTEPd:

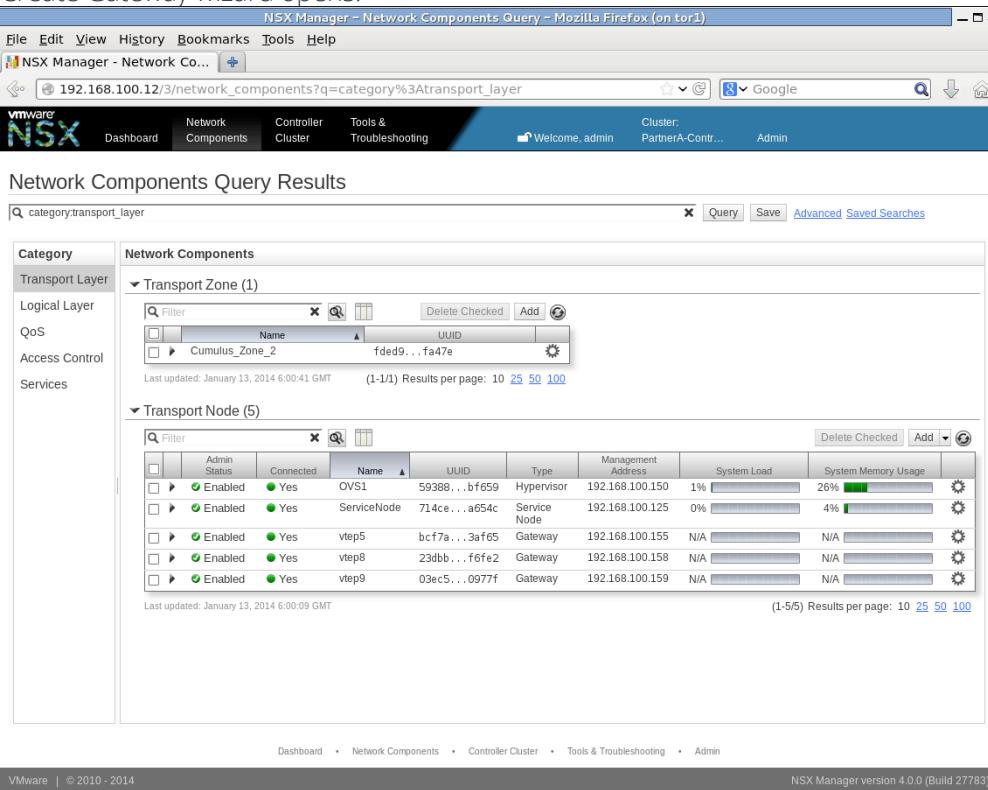
```
cumulus@switch:~$ sudo systemctl restart openvswitch-vtep.service
```

## Provision VMware NSX-V

### Configure the Switch as a VTEP Gateway

After you create a certificate, connect to NSX Manager in a browser to configure a Cumulus Linux switch as a VTEP gateway. In this example, the IP address of the NSX Manager is 192.168.100.12.

1. In NSX Manager, add a new gateway. Click the **Network Components** tab, then the **Transport Layer** category. Under **Transport Node**, click **Add**, then select **Manually Enter All Fields**. The Create Gateway wizard opens.



The screenshot shows the VMware NSX Manager interface with the following details:

- Network Components Query Results** table:
 

Category	Network Components											
Transport Layer	▼ Transport Zone (1) <table border="1"> <thead> <tr> <th>Name</th> <th>UUID</th> </tr> <tr> <td>Cumulus_Zone_2</td> <td>fded9...fa47e</td> </tr> </thead> </table>								Name	UUID	Cumulus_Zone_2	fded9...fa47e
Name	UUID											
Cumulus_Zone_2	fded9...fa47e											
Last updated: January 13, 2014 6:00:41 GMT	(1-1/1) Results per page: 10 <a href="#">25</a> <a href="#">50</a> <a href="#">100</a>											

  
 ▼ Transport Node (5)
 

Name	Type	Management Address	System Load	System Memory Usage
OVS1	Hypervisor	192.168.100.150	1%	26%
ServiceNode	Service Node	192.168.100.125	0%	4%
vtep5	Gateway	192.168.100.155	N/A	N/A
vtep8	Gateway	192.168.100.158	N/A	N/A
vtep9	Gateway	192.168.100.159	N/A	N/A

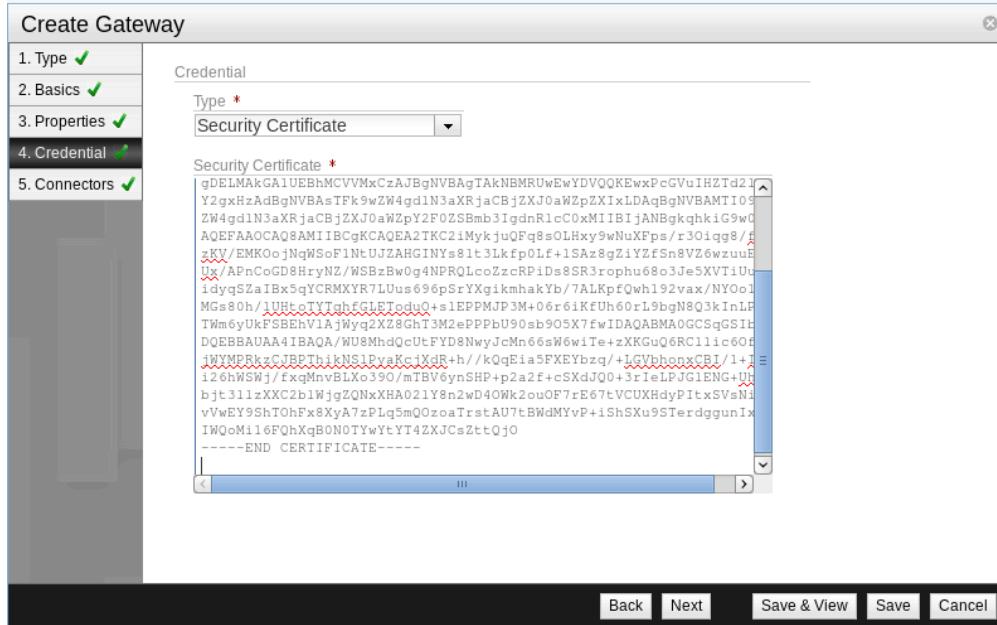
 Last updated: January 13, 2014 6:00:09 GMT
 (1-5/5) Results per page: 10 [25](#) [50](#) [100](#)

2. In the Create Gateway dialog, select **Gateway** for the **Transport Node Type**, then click **Next**.
3. In the **Display Name** field, provide a name for the gateway, then click **Next**.
4. Enable the VTEP service. Select the **VTEP Enabled** checkbox, then click **Next**.

5. From the terminal session connected to the switch where you generated the certificate, copy the certificate and paste it into the **Security Certificate** text field. Copy only the bottom portion, including the `BEGIN CERTIFICATE` and `END CERTIFICATE` lines. For example, copy all the highlighted text in the terminal:

```
ubuntu@tor1: ~
87:3fe:a76:6b:67:fe:71:25:dd:25:0d:3e:de:b2:1e:2c:f2:
46:94:43:46:f9:48:43:6e:3b:77:96:5c:d7:5c:2d:9b:95:68:
e0:65:03:71:5c:70:34:da:56:3c:9f:6c:03:e0:e5:a4:da:8b:
8e:17:ba:c4:eb:bb:55:09:45:77:23:8:71:45:99:b0:d8:
ba:bd:9c:04:63:d1:a1:c4:e8:45:c:f5:f2:03:bcc:f2:ea:ae:
66:40:ec:e0:69:3a:ec:cb:4:05:b1:b4:15:9d:31:b6:cfc:f2:a24:
a1:49:7b:bd:49:37:ab:76:08:2e:9c:8c:44:21:b4:28:23:2d:
7:a15:08:57:a8:1d:0d:d1:36:30:62:d6:13:e1:95:c9:0a:c6:
6d:b5:08:ce
-----BEGIN CERTIFICATE-----
MIIDdzCA18CAQYwDQYJKoZIhvCNQEEBQAwYEcxAJBgNVBAYTA1VTMQswCQYD
VQIIEWJDUTQEVBMG4lUECHMT3B1b2B23dpQhNfRcvUwYDVQQLewhd21OY2hj
YTE7DkG4lUEAxMyT2TlH3aXRjaGHN1ENB1cnRpZmlJYXRICgMDEzER1
YqAylqyhxNzowDQoNCkwHhcNMThxJ1zTcxIz8xJhNMToMjIzMTcMzAxhjCB
gDELMAkG4lUEBhMCVWmxCzA1BgNvB9eTAhNBMRUuewYDQ0KExwFcGwIHZTd210
Y2gxHxZdQgNVB9eTFk9uZl4gd1N3aXRjaCBjZXJ0aWZpZXIxLDAeBwNVBAMTI09w
ZM49d1N3aXRjaCBjZXJ0aWZpYF02SBmB31gdhR1CoXhIB1jAnBqkqhig9wOB
AQEFRA0CQ0AQM1IBCgKCAQDEh2TK21MjkjUqF9sULHx9uMuFps/r301qg8/P
zkV/EMK0oJNqSf1NTUJZAHG1Nys81tLkfP0Lf15a8g2Y1ZF9n8V26zuwE8
Ux/APnCoD8HryNz/WSBzBw0g4NPRQLcoZccRP1D8sR3rphu68o3Je5XVtUuZ
idyg5ZaIBx5gYCRMXYR7LlJus636gSrYqiknhakYb/7ALKpfQwh192vax/NYoo1
MGs80h/1UhtoTYTghfGLETodu0+1sLEPPMJP3h+06+61KFUh60rL9bN803kInLPN
TMs6yUKFSBEHV1Ajlwyq2XZBghT3M2ePPPBu90sb905X7fwIDAQABMA0GCSqGS1b3
DQEBAUAA41BHQwJU8WhdQoUFYD8WmJyJchm66sWbw1Te+zXKGQ6RC11ic60f
jIMMPRkzJBPThikNS1PyaKo,jKdR+h//kQoEiaFKEYbzq/*LGvbphonCBI/1+IG
i26hlmSMjfxqhnBLXo390/TBv6ynSHP+p2a2f+cSxdJQO+3r1eLPJG1ENG+UhD
bjt311zXXC2b1UjgZDNxHA021Y8n2wD40Wk2ouOF7rE67tVCUXHdyPiTxSVsNi6
vWxEY95hTOhFx8YqA7zLq5mQzoaTrstAU7BwdMYvP+iShSXu9SterdggunIx
IWQoMi16FQhXqBONOTyWytYT4ZXJCzsTtQj0
-----END CERTIFICATE-----
root@vtcp-1:~#
```

Paste it into NSX Manager, then click **Next**:



6. In the Connectors dialog, click **Add Connector** to add a transport connector. This defines the tunnel endpoint that terminates the VXLAN tunnel and connects NSX to the physical gateway. You must choose a tunnel **Transport Type** of **VXLAN**. Choose an existing transport zone for the connector or click **Create** to create a new transport zone.
7. Define the IP address of the connector (the underlay IP address on the switch for tunnel termination).
8. Click **OK** to save the connector, then click **Save** to save the gateway.

After communication is established between the switch and the controller, a `controller.cacert` file downloads onto the switch.

Verify that the controller and switch handshake is successful. In a terminal connected to the switch, run this command:

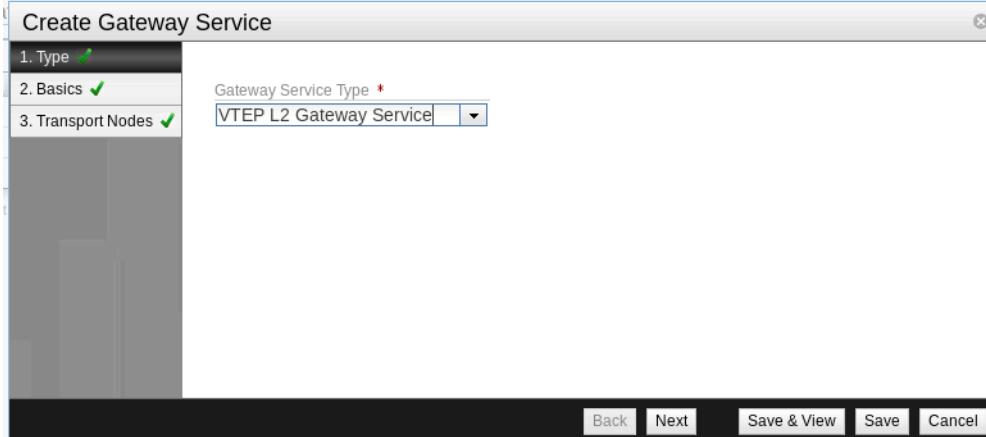
```
cumulus@switch:~$ sudo ovsdb-client dump -f list | grep -A 7 "Manager"
Manager table
_uuid              : 505f32af-9acb-4182-a315-022e405aa479
_inactivity_probe   : 30000
_is_connected       : true
_max_backoff        : []
_other_config        :
_status             : {sec_since_connect="18223",
sec_since_disconnect="18225", state=ACTIVE}
_target              : "ssl:192.168.100.17:6632"
```

## Configure the Transport and Logical Layers

### Configure the Transport Layer

After you finish configuring the NSX-MH integration on the switch, configure the transport layer. For each host-facing switch port to be associated with a VXLAN instance, define a **Gateway Service** for the port.

1. In NSX Manager, add a new gateway service. Click the **Network Components** tab, then the **Services** category. Under **Gateway Service**, click **Add**. The Create Gateway Service wizard opens.
2. In the Create Gateway Service dialog, select *VTEP L2 Gateway Service* as the **Gateway Service Type**.



3. Provide a **Display Name** for the service to represent the VTEP in NSX.
4. Click **Add Gateway** to associate the service with the gateway you created earlier.
5. In the **Transport Node** field, choose the name of the gateway you created earlier.
6. In the **Port ID** field, choose the physical port on the gateway (for example, swp10) that will connect to a logical layer 2 segment and carry data traffic.
7. Click **OK** to save this gateway in the service, then click **Save** to save the gateway service.

The gateway service shows up as type *VTEP L2* in NSX.



The screenshot shows the NSX Manager interface for querying network components. The left sidebar has a 'Category' tree with 'Services' selected. The main panel displays a table titled 'Network Components' under the 'Gateway Service (5)' category. The table columns are Name, UUID, Type, and # Transport Nodes. The data shows five entries, each with a delete icon and a gear icon:

	Name	UUID	Type	# Transport Nodes
<input type="checkbox"/>	vtep-1-swp2s0	9d13e...d3ea3	VTEP L2	1
<input type="checkbox"/>	vtep-1-swp2s1	343a7...00ce6	VTEP L2	1
<input type="checkbox"/>	vtep5-swp1	958f1...a7dd4	VTEP L2	1
<input type="checkbox"/>	vtep8-swp1	f02ba...29ff8	VTEP L2	1
<input type="checkbox"/>	vtep9-swp1	ca9e1...aed98	VTEP L2	1

Below the table, it says 'Last updated: January 13, 2014 6:14:50 GMT' and '(1-5/5) Results per page: 10 25 50 100'. At the bottom of the interface, there are links for Dashboard, Network Components, Controller Cluster, Tools & Troubleshooting, Admin, and a note 'NSX Manager version 4.0.0 (Build 27783)'.

Next, configure the logical layer on NSX.

### Configure the Logical Layer

To complete the integration with NSX, you need to configure the logical layer, which requires defining a logical switch (the VXLAN instance) and all the logical ports needed.

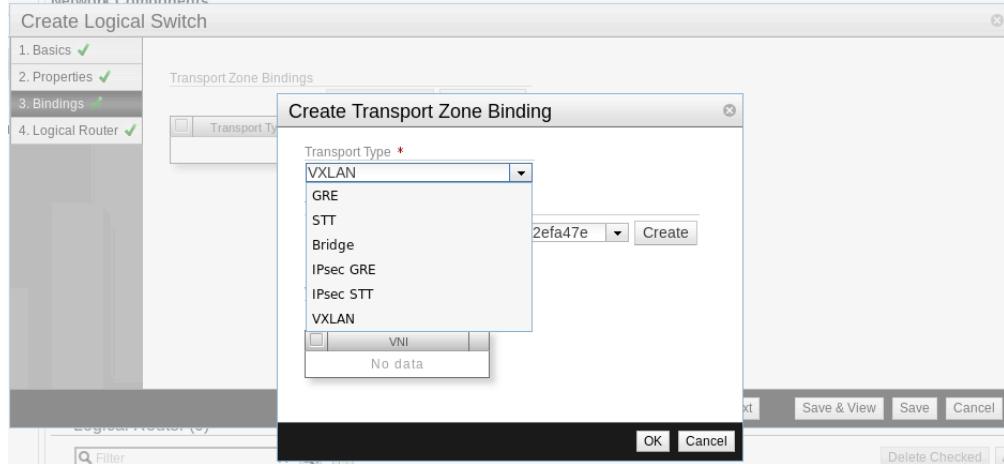
To define the logical switch:

1. In NSX Manager, add a new logical switch. Click the **Network Components** tab, then the **Logical Layer** category. Under **Logical Switch**, click **Add**. The Create Logical Switch wizard opens.
2. In the **Display Name** field, enter a name for the logical switch, then click **Next**.

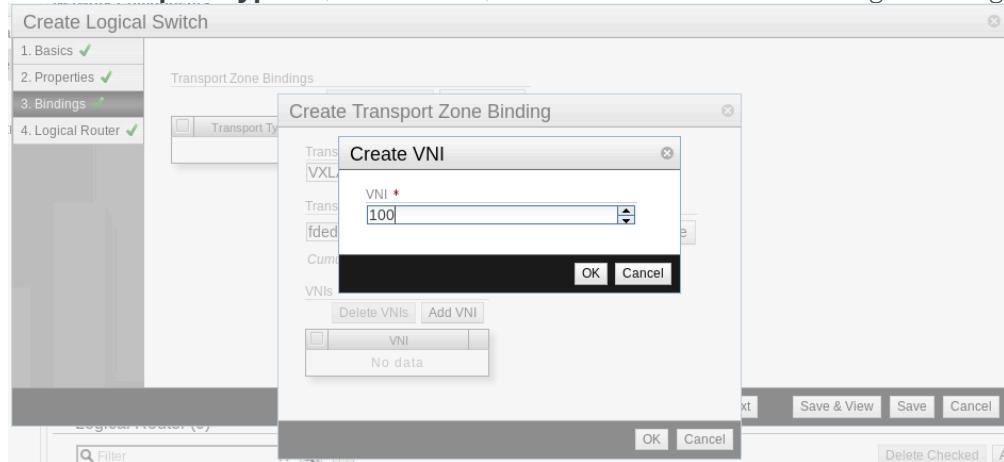
The screenshot shows the 'Create Logical Switch' wizard step 1: Basics. The 'Display Name' field is filled with 'vxlan100'. Below it is a 'Tags' section with a 'Delete Tags' button, an 'Add Tag' button, and a table showing 'No data'. At the bottom are 'Back', 'Next', 'Save & View', 'Save', and 'Cancel' buttons.

3. Under **Replication Mode**, select **Service Nodes**, then click **Next**.

4. Specify the transport zone bindings for the logical switch. Click **Add Binding**. The Create Transport Zone Binding dialog opens.



5. In the **Transport Type** list, select **VXLAN**, then click **OK** to add the binding to the logical switch.



6. In the **VNI** field, assign the switch a VNI ID, then click **OK**.



Do not use 0 or 16777215 as the VNI ID; these are reserved values under Cumulus Linux.

7. Click **Save** to save the logical switch configuration.



The screenshot shows the NSX Manager - Network Components Query interface in Mozilla Firefox. The URL is 192.168.100.123/network\_components?q=category%3Alogical\_layer. The interface includes a navigation bar with VMware NSX, Dashboard, Network Components, Controller Cluster, Tools & Troubleshooting, and Admin. A search bar at the top has the query "category:logical\_layer". The main content area displays "Network Components Query Results" with three sections: Logical Switch (3), Logical Switch Port (2), and Logical Router (0). Each section has a table with columns like Name, UUID, Fabric, and Status (Up/Down).

Category	Network Components								
Transport Layer									
Logical Layer	<b>▼ Logical Switch (3)</b>								
QoS									
Access Control									
Services									

Fabric	Name	UUID	Logical Switch Ports	Logical Router	Transport Zone Bindings	Replication Mode	Port Isolation
vxlan100	47a37...b1790	-	0	-	1	Service Node	Disabled
LS-B	80b3e...36454	-	1	-	1	Service Node	Disabled
LS-A	c1be3...fb689	-	1	-	1	Service Node	Disabled

Last updated: January 13, 2014 15:12:16 GMT (1-3/3) Results per page: 10 25 50 100

Admin	Link	Fabric	Message	Name	Port	Switch Name	UUID	Attachment	Attached MAC
v1	-	LS-A	-	3db81...e2af	VIF: 5e690...42df	52:54:00:15:44:34	-	-	-
v2	-	LS-B	-	a080d...b5588	VIF: 0afff...a8571	52:54:00:92:25:bd	-	-	-

Last updated: January 13, 2014 9:03:07 GMT (1-2/2) Results per page: 10 25 50 100

Fabric	Name	UUID	Distributed	NAT Synchronization	Replication Mode	Logical Router Ports	Routing Type	L3 Gateway Service
No Logical Routers								

Dashboard • Network Components • Controller Cluster • Tools & Troubleshooting • Admin

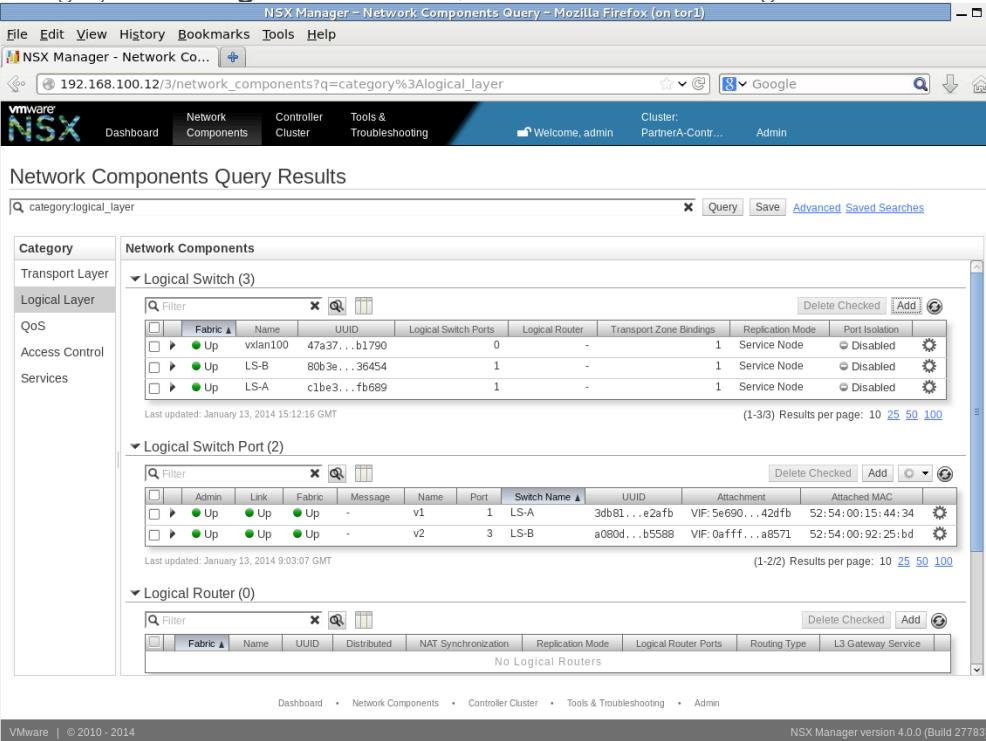
VMware | © 2010 - 2014 NSX Manager version 4.0.0 (Build 27783)

## Define Logical Switch Ports

Logical switch ports can be virtual machine VIF interfaces from a registered OVS or a VTEP gateway service instance on this switch, as defined above in the Configuring the Transport Layer. You can define a VLAN binding for each VTEP gateway service associated with the particular logical switch.

To define the logical switch ports:

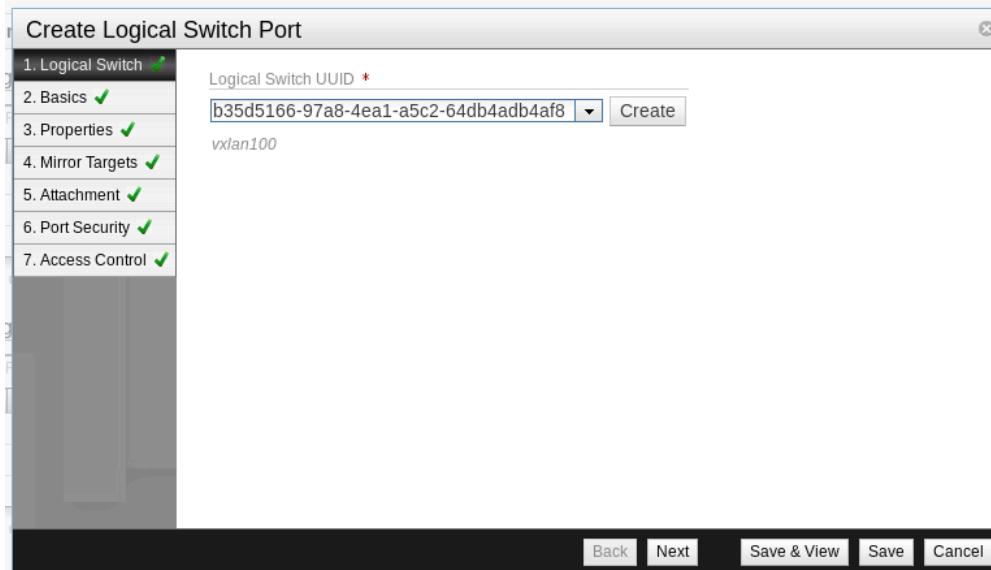
- In NSX Manager, add a new logical switch port. Click the **Network Components** tab, then the **Logical Layer** category. Under **Logical Switch Port**, click **Add**. The Create Logical Switch Port



The screenshot shows the NSX Manager interface with the 'Network Components' tab selected. In the left sidebar, 'Logical Layer' is chosen. The main area displays 'Network Components Query Results' for 'Logical Switch' and 'Logical Switch Port'. The 'Logical Switch' table lists three entries: vxlan100, LS-B, and LS-A. The 'Logical Switch Port' table lists two entries: v1 and v2. Both tables include columns for Fabric, Name, UUID, Logical Switch Ports, Logical Router, Transport Zone Bindings, Replication Mode, and Port Isolation.

wizard opens.

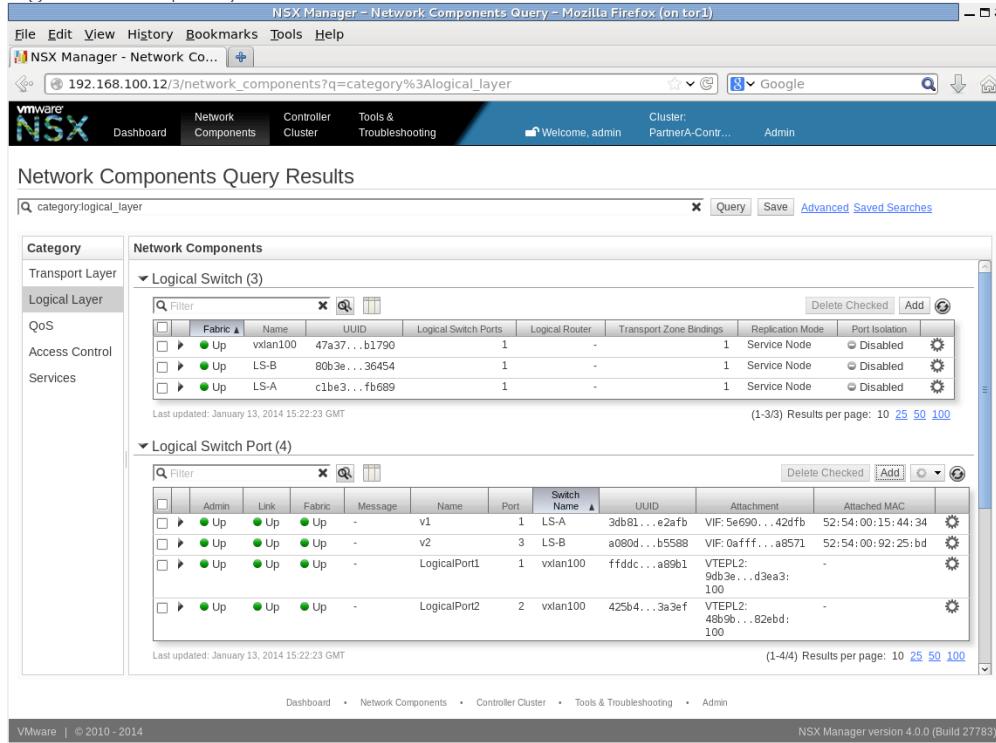
- In the **Logical Switch UUID** list, select the logical switch you created above, then click **Create**.



The screenshot shows the 'Create Logical Switch Port' wizard. The left sidebar lists steps: 1. Logical Switch (checked), 2. Basics (checked), 3. Properties (checked), 4. Mirror Targets (checked), 5. Attachment (checked), 6. Port Security (checked), and 7. Access Control (checked). The main panel shows the 'Logical Switch UUID' field with the value 'b35d5166-97a8-4ea1-a5c2-64db4adb4af8' selected. Below it is a note 'vxlan100'. At the bottom are buttons for Back, Next, Save & View, Save, and Cancel.

- In the **Display Name** field, provide a name for the port that indicates it is the port that connects the gateway, then click **Next**.
- In the **Attachment Type** list, select *VTEP L2 Gateway*.
- In the **VTEP L2 Gateway Service UUID** list, choose the name of the gateway service you created earlier.
- In the **VLAN** list, you can choose a VLAN if you want to connect only traffic on a specific VLAN of the physical network. Leave it blank to handle all traffic.

7. Click **Save** to save the logical switch port. Connectivity is established. Repeat this procedure for each logical switch port you want to define.



The screenshot shows the NSX Manager interface for Network Components Query. On the left, a sidebar lists categories: Transport Layer, Logical Layer (selected), QoS, Access Control, and Services. The main area displays two tables:

- Logical Switch (3)**: Shows three entries. The first entry is vxlan100, which is up, has a UUID of 47a37...b1790, and one logical switch port. The second and third entries are LS-B and LS-A respectively, both up, with UUIDs 80b3e...36454 and c1be3...fb689, and one logical switch port each.
- Logical Switch Port (4)**: Shows four entries. The first two are v1 and v2, which are up, connected to LS-A and LS-B respectively, with UUIDs 3db81...e2af and a080d...b5598, and attached to ports 1 and 3. The next two are LogicalPort1 and LogicalPort2, which are up, connected to vxlan100, with UUIDs fffdc...a89b1 and 425b4...3a3ef, and attached to ports 1 and 2.

Both tables have filters, delete, and add buttons at the top. The bottom of each table shows the last update time (January 13, 2014) and results per page (10, 25, 50, 100).

## Verify the VXLAN Configuration

After configuration is complete, verify the VXLAN configuration in a terminal connected to the switch using these Cumulus Linux commands:

```
cumulus@switch1:~$ sudo ip -d link show vxln100
71: vxln100: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue
    master br-vxln100 state UNKNOWN mode DEFAULT
        link/ether d2:ca:78:bb:7c:9b brd ff:ff:ff:ff:ff:ff
        vxlan id 100 local 172.16.20.157 port 32768 61000 nolearning
        ageing 1800 svchnode 172.16.21.125
```

or

```
cumulus@switch1:~$ sudo bridge fdb show
52:54:00:ae:2a:e0 dev vxln100 dst 172.16.21.150 self permanent
d2:ca:78:bb:7c:9b dev vxln100 permanent
90:e2:ba:3f:ce:34 dev swp2s1.100
90:e2:ba:3f:ce:35 dev swp2s0.100
44:38:39:00:48:0e dev swp2s1.100 permanent
44:38:39:00:48:0d dev swp2s0.100 permanent
```

Use the `ovsdb-client dump` command to troubleshoot issues on the switch. This command verifies that the controller and switch handshake is successful (and works only for VXLANs integrated with NSX):

```
cumulus@switch:~$ sudo ovsdb-client dump -f list | grep -A 7 "Manager"
Manager table
_uuid : 505f32af-9acb-4182-a315-022e405aa479
inactivity_probe : 30000
is_connected : true
max_backoff : []
other_config : {}
status : {sec_since_connect="18223",
sec_since_disconnect="18225", state=ACTIVE}
target : "ssl:192.168.100.17:6632"
```

## OVSDB Server High Availability

### ! Early Access Feature

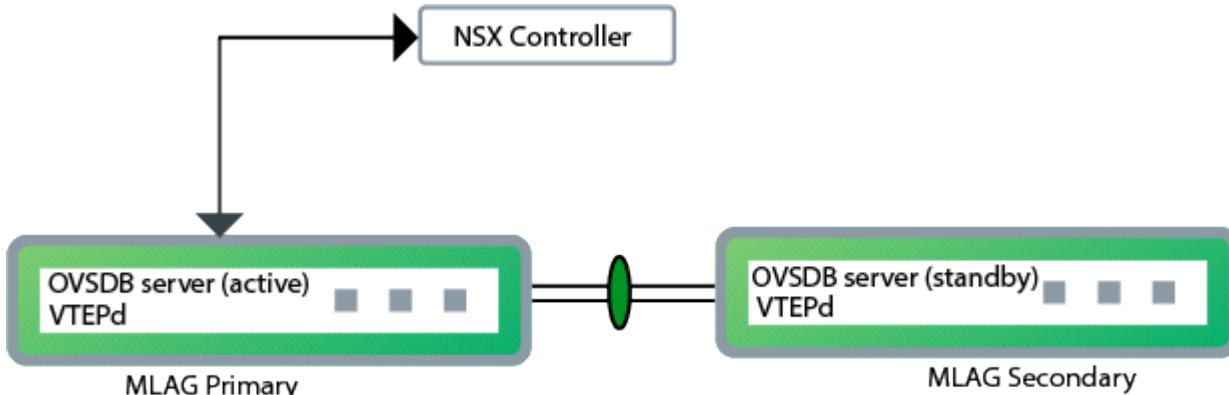
OVSDB server high availability is an [early access feature](#) in Cumulus Linux 3.7.

Cumulus Linux supports integration with VMware NSX in both *standalone mode* and *OVSDB server high availability mode* (where the data plane is running in active-active mode). For information about VMware NSX in standalone mode and for a description of the components that work together to integrate VMware NSX and Cumulus Linux, see [Integrating Hardware VTEPs with VMware NSX-MH \(see page 699\)](#) or [Integrating Hardware VTEPs with VMware NSX-V \(see page 687\)](#).

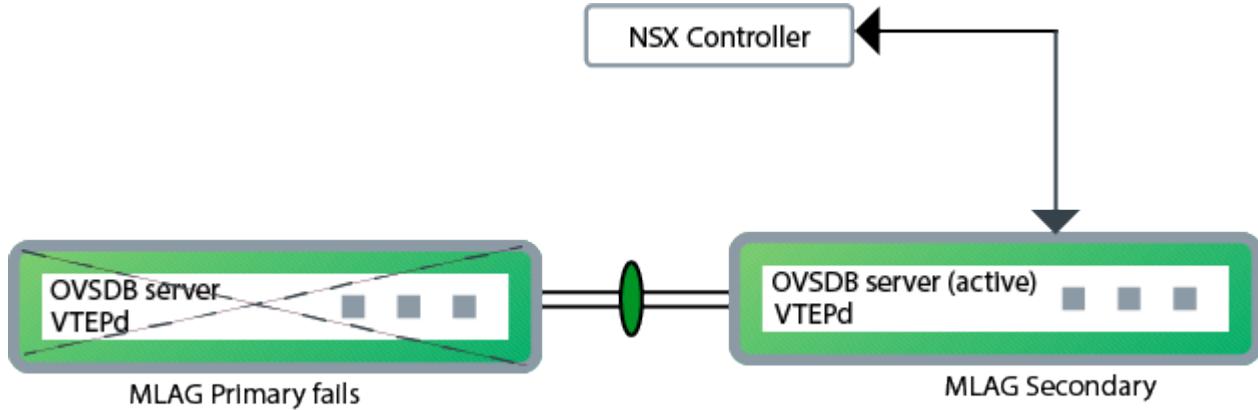
With OVSDB server high availability mode, you use two peer Cumulus Linux switches in an MLAG configuration. Both the MLAG primary and MLAG secondary switch contain OVSDB server and VTEPd. The OVSDB servers synchronize their databases with each other and always maintain the replicated state unless failover occurs; for example, the peer link bond breaks, a switch fails, or the OVSDB server goes down. Both of the VTEPd components talk to the active OVSDB server to read the configuration and then push the configuration to the kernel. Only the active OVSDB server communicates with the NSX controller, unless failover occurs and then the standby OVSDB server takes over automatically. Although the Cumulus switches are configured as an MLAG pair, the NSX controller sees them as a single system (the NSX controller is not aware that multiple switches exist).

The following examples show OVSDB server high availability mode.

**Example 1:** The OVSDB server on the MLAG primary switch is active. The OVSDB server on the MLAG secondary switch is the hot standby. Only the active OVSDB server communicates with the NSX controller.



**Example 2:** If failover occurs, the OVSDB server on the MLAG secondary switch becomes the active OVSDB server and communicates with the NSX controller.



When the OVSDB server on the MLAG primary switch starts responding again, it resynchronizes its database, becomes the active OVSDB server, and connects to the controller. At the same time, the OVSDB server on the MLAG secondary switch stops communicating with the NSX controller, synchronizes with the now active OVSDB server, and takes the standby role again.

## Contents

This topic describes ...

- Getting Started (see page 713)
- Configure the NSX Integration on the Switch (see page 715)
- Configure the Transport and Logical Layers (see page 717)
- Troubleshooting (see page 717)

## Getting Started

Before you configure OVSDB server high availability, make sure you have **two switches running Cumulus Linux in an MLAG configuration**. Cumulus Linux includes OVSDB server (`ovsdb-server`) and VTEPd (`ovs-vtep`), which support [VLAN-aware bridges](#) (see page 415).

The following example configuration in the `/etc/network/interfaces` file shows the *minimum* MLAG configuration required (the MLAG peerlink configuration and the dual-connected bonds on the peer switches). The dual-connected bonds are identified in the NSX controller by their `cflag-id` (single-connected bonds or ports are identified by their usual interface names prepended with the name of the particular switch to which they belong). When you create the Gateway Service for the dual-connected bonds (described in [Configuring the Transport and Logical Layers \(see page 717\)](#), below), make sure to select the `cflag-id` named interfaces instead of the underlying individual physical ports. All the logical network configurations are provisioned by the NSX controller.

```

auto peerlink-3
iface peerlink-3
    bond-slaves swp5 swp6
    bond-mode 802.3ad
    bond-min-links 1
    bond-lacp-rate 1
    mtu 9202

```



```
alias Local Node/s leaf01 and Ports swp5 swp6 <==> Remote Node/s
leaf02 and Ports swp5 swp6

auto peerlink-3.4094
iface peerlink-3.4094
    address 10.0.0.24/32
    address 169.254.0.9/29
    mtu 9202
    alias clag and vxlan communication primary path
    clagd-priority 4096
    clagd-sys-mac 44:38:39:ff:ff:02
    clagd-peer-ip 169.254.0.10
    clagd-args --vm --debug 0x0
    # post-up sysctl -w net.ipv4.conf.peerlink-3/4094.accept_local=1
    clagd-backup-ip 10.0.0.25

auto hostbond4
iface hostbond4
    bond-slaves swp7
    bond-mode 802.3ad
    bond-min-links 1
    bond-lACP-rate 1
    mtu 9152
    alias Local Node/s leaf01 and Ports swp7 <==> Remote Node/s hostd-
01 and Ports swp1
    clag-id 1

auto hostbond5
iface hostbond5
    bond-slaves swp8
    bond-mode 802.3ad
    bond-min-links 1
    bond-lACP-rate 1
    mtu 9152
    alias Local Node/s leaf01 and Ports swp8 <==> Remote Node/s hostd-
02 and Ports swp1
    clag-id 2
```

To configure OVSDB server high availability, you need to:

- Determine on which switch you want to run the active OVSDB server (the MLAG primary switch or the MLAG secondary switch).
- Configure the NSX integration on both switches.
- Configure the Transport and Logical Layers from the NSX Manager.
- Verify the VXLAN Configuration.



The OVSDB server cannot select the loopback interface as the source IP address, causing top of rack registration to the controller to fail. To work around this issue, run the `net add bgp redistribute connected` command followed by the `net commit` command.



## Configure the NSX Integration on the Switch

Before you start configuring the gateway service, the logical switches, and ports that comprise the VXLAN, you need to enable and start the `openvswitch-vtep` service, then run the configuration script **on both the MLAG primary and MLAG secondary switches**. Follow these steps:

1. Enable and start the `openvswitch-vtep` service:

```
cumulus@switch:~$ sudo systemctl enable openvswitch-vtep.service
cumulus@switch:~$ sudo systemctl start openvswitch-vtep.service
```

2. Run the configuration script provided with Cumulus Linux:

- a. On the switch where you want to run the active OVSDB server, run the `vtep-bootstrap` command with these options:

- `--db_ha active` specifies that the OVSDB server on this switch is the *active* server.
- `--db_ha_vip` is any unused IP address in the subnet used by the peerlink control subinterface (4094 is typically used). This creates a /32 route that can be reached from either MLAG switch (169.254.0.11:9998 in the example below).
- `--db_ha_repl_sv` specifies the IP address of the **active** OVSDB server (169.254.0.9:9999 in the example command below). The standby OVSDB server uses this IP address to synchronize the database.
- `--controller_port` is the port used to communicate with the NSX controller.
- `--controller_ip` is the IP address of the NSX controller (192.168.100.17 in the example command below).
- The ID for the VTEP (`vtep7` in the example command below).
- The datapath IP address of the VTEP (172.16.20.157 in the example command below). This is the VXLAN anycast IP address.
- The IP address of the management interface on the switch (192.168.100.157 in the example command below). This interface is used for control traffic.

```
cumulus@switch:~$ vtep-bootstrap --db_ha active --
db_ha_vip 169.254.0.11:9998 --db_ha_repl_sv 169.254.0.9:9999 --controller_ip 192.168.100.17 vtep7 172.16.20.157
192.168.100.157
Executed:
    create certificate on a switch, to be used for
    authentication with controller
    (').
Executed:
    sign certificate
        (vtep7-req.pem      Tue Sep 11 21:11:27 UTC 2018
         fingerprint
         a4cda030fe5e458c0d7ba44e22f52650f01bcd75).
Executed:
    define physical switch
```

```

( ).

Executed:
    define NSX controller IP address in OVSDB
    ().

Executed:
    define local tunnel IP address on the switch
    ().

Executed:
    define management IP address on the switch
    ().

Executed:
    restart a service
    ().


```

- b. On the switch where you want to run the standby OVSDB server, run the the `vtep-bootstrap` command with the same options as above but replace `db_ha active` with `db_ha standby`:

```

cumulus@switch:~$ vtep-bootstrap --db_ha standby --
db_ha_vip 169.254.0.11:9998 --db_ha_repl_sv 169.254.0.9:
9999 --controller_ip 192.168.100.17 vtep7 172.16.20.157
192.168.100.157
Executed:
    create certificate on a switch, to be used for
    authentication with controller
    ().

Executed:
    sign certificate
    (vtep7-req.pem      Tue Sep 11 21:11:27 UTC 2018
     fingerprint
a4cda030fe5e458c0d7ba44e22f52650f01bcd75).

Executed:
    define physical switch
    ().

Executed:
    define NSX controller IP address in OVSDB
    ().

Executed:
    define local tunnel IP address on the switch
    ().

Executed:
    define management IP address on the switch
    ().

Executed:
    restart a service
    ().


```

- c. From the switch running the active OVSDB server, copy the certificate files (`hostname-cert.pem` and `hostname-privkey.pem`) to the same location on the switch with the standby OVSDB server.



The certificate and key pairs for authenticating with the NSX controller are generated automatically when you run the configuration script and are stored in the /home/cumulus directory. The same certificate must be used for both switches.

- d. On the switch running the *active* OVSDB server and then the switch running the *standby* OVSDB server, run the following commands in the order shown to complete the configuration process:

```
cumulus@switch:~$ sudo systemctl restart openvswitch-vtep.service
cumulus@switch:~$ sudo ifreload -a
cumulus@switch:~$ sudo systemctl restart networking.service
```

For information about the configuration script, read `man vtep-bootstrap` or run the command `vtep-bootstrap --help`.

## Configure the Transport and Logical Layers

After you finish configuring the NSX integration on both the MLAG primary and MLAG secondary switch, you need to configure the transport and logical layers from the NSX Manager. Refer to [Configuring the Transport and Logical Layers \(NSX-MH\)](#) (see page 706) or [Configuring the Transport and Logical Layers \(NSX-V\)](#) (see page 693)).

## Troubleshooting

After you configure OVSDB server high availability, you can check that configuration is successful.

To check the sync status on the *active* OVSDB server, run the following command:

```
cumulus@switch:~$ sudo ovs-appctl -t /var/run/openvswitch/ovsdb-server.`pidof ovsdb-server`.ctl ovsdb-server/sync-status
state: active
```

To check the sync status on the *standby* OVSDB server, run the following command:

```
cumulus@switch:~$ sudo ovs-appctl -t /var/run/openvswitch/ovsdb-server.`pidof ovsdb-server`.ctl ovsdb-server/sync-status
state: backup
replicating: tcp:169.254.0.9:9999
database: hardware_vtep
```

To check that the active OVSDB server is connected to the NSX controller, run the `ovsdb-client dump Manager` command:

```
cumulus@switch:~$ sudo ovsdb-client dump Manager
```

```

Manager table
 _uuid                                inactivity_probe  is_connected
 max_backoff  other_config  status          target
 -----
 -----
 e700ad21-8fd8-4f09-96dc-fa7cc6e498d8 30000           true
 [ ]           {}           {sec_since_connect="68", state=ACTIVE} "ssl:
54.0.0.2:6632"

```

To make sure the MLAG configuration is correct, run the `clagctl` command:

```
cumulus@switch:~$ sudo clagctl
```

The following example command output shows that MLAG *is* configured correctly on the active OVSDB server:

```

cumulus@switch:~$ sudo clagctl
The peer is alive
Our Priority, ID, and Role: 4096 00:02:00:00:00:46 primary
Peer Priority, ID, and Role: 8192 00:02:00:00:00:4e secondary
Peer Interface and IP: peerlink-3.4094 169.254.0.10
VxLAN Anycast IP: 36.0.0.1
Backup IP: 27.0.0.22 (active)
System MAC: 44:38:39:ff:ff:01
CLAG Interfaces
Our Interface Peer Interface CLAG Id Conflicts Proto-Down Reason
-----
-----
 vxln14567102 vxln14567102 - - -
 vxln14567103 vxln14567103 - - -

```

The following example command output shows that MLAG *is not* configured correctly on the active OVSDB server or that the peer is down:

```

cumulus@switch:~$ sudo clagctl
The peer is not alive
Our Priority, ID, and Role: 4096 00:02:00:00:00:46 primary
Peer Interface and IP: peerlink-3.4094 169.254.0.10
VxLAN Anycast IP: 36.0.0.1
Backup IP: 27.0.0.22 (inactive)
System MAC: 44:38:39:ff:ff:01
CLAG Interfaces
Our Interface Peer Interface CLAG Id Conflicts Proto-Down Reason
-----
-----
 vxln14567102 - - -
 vxln14567103 - - -

```



To make sure that the BFD sessions are up and running, run the `ptmctl -b` command.

```
cumulus@switch:~$ sudo ptmctl -b  
-----  
port    peer        state   local      type       diag  vrf  
-----  
vxln0  54.0.0.4   Up      36.0.0.1  singlehop  N/A   N/A  
vxln0  54.0.0.3   Up      36.0.0.1  singlehop  N/A   N/A
```



When `switchd` and networking services are restarted, the BFD sessions might be interrupted. If you notice that the sessions are down, restart the `openvswitch-vtep.service`.

If you encounter interface or VXLAN bridge configuration issues after adding the hardware bindings, run the `ifreload -a` command to reload all network interfaces.

```
cumulus@switch:~$ sudo ifreload -a
```

If you still encounter issues with high availability after you restart `openvswitch-vtep.service`, run `ifreload -a`, and restart `networking.service`, reboot the switch running the `standby` OVSDB server.

```
cumulus@switch:~$ sudo reboot
```



# Layer 3

## Routing

This chapter discusses routing on switches running Cumulus Linux.

### Contents

#### This topic describes ...

- Manage Static Routes (see page 720)
  - Static Multicast Routes (see page 721)
  - Static Routing via ip route (see page 721)
  - Apply a Route Map for Route Updates (see page 723)
- Configure a Gateway or Default Route (see page 723)
- Supported Route Table Entries (see page 723)
  - Forwarding Table Profiles (see page 723)
  - Number of Supported Route Entries, by Platform (see page 724)
  - TCAM Resource Profiles for Mellanox Switches (see page 726)
- Caveats and Errata (see page 726)
  - Don't Delete Routes via Linux Shell (see page 727)
  - Add IPv6 Default Route with src Address on eth0 Fails without Adding Delay (see page 727)
- Related Information (see page 728)

### Manage Static Routes

You manage static routes using [NCLU](#) (see page 88) or the Cumulus Linux `ip route` command. The routes are added to the `FRRouting` routing table, and are then updated into the kernel routing table as well.

To add a static route, run:

```
cumulus@switch:~$ net add routing route 203.0.113.0/24 198.51.100.2
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands create the following configuration in the `/etc/frr/frr.conf` file:

```
!
ip route 203.0.113.0/24 198.51.100.2
!
```

To delete a static route, run:



```
cumulus@switch:~$ net del routing route 203.0.113.0/24 198.51.100.2
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

To view static routes, run:

```
cumulus@switch:~$ net show route static
RIB entry for static
=====
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, P - PIM, T - Table,
       > - selected route, * - FIB route
S>* 203.0.113.0/24 [1/0] via 198.51.100.2, swp3
```

### Static Multicast Routes

Static mroutes are also managed with NCLU, or with the `ip route` command. To add an mroute:

```
cumulus@switch:~$ net add routing mroute 230.0.0.0/24
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands create the following configuration in the `/etc/frr/frr.conf` file:

```
!
ip mroute 230.0.0.0/24
!
```

To delete an mroute, run:

```
cumulus@switch:~$ net del routing mroute 230.0.0.0/24
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

To view mroutes, open the FRRouting CLI, and run the following command:

```
cumulus@switch:~$ sudo vtysh
switch# show ip rpf 230.0.0.0
Routing entry for 230.0.0.0/24 using Multicast RIB
  Known via "static", distance 1, metric 0, best
    * directly connected, swp31s0
```



## Static Routing via ip route

A static route can also be created by adding `post-up ip route add` command to a switch port configuration. For example:

```
cumulus@switch:~$ net add interface swp3 ip address 198.51.100.1/24
cumulus@switch:~$ net add interface swp3 post-up routing route add
203.0.113.0/24 via 198.51.100.2
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands produce the following configuration in the `/etc/network/interfaces` file:

```
auto swp3
iface swp3
    address 198.51.100.1/24
    post-up ip route add 203.0.113.0/24 via 198.51.100.2
```



If an IPv6 address is assigned to a DOWN interface, the associated route is still installed into the routing table. The type of IPv6 address doesn't matter: link local, site local and global all exhibit the same problem.

If the interface is bounced up and down, then the routes are no longer in the route table.

The `ip route` command allows manipulating the kernel routing table directly from the Linux shell. See `man ip(8)` for details. FRRouting monitors the kernel routing table changes and updates its own routing table accordingly.

To display the routing table:

```
cumulus@switch:~$ ip route show
default via 10.0.1.2 dev eth0
10.0.1.0/24 dev eth0 proto kernel scope link src 10.0.1.52
192.0.2.0/24 dev swp1 proto kernel scope link src 192.0.2.12
192.0.2.10/24 via 192.0.2.1 dev swp1 proto zebra metric 20
192.0.2.20/24 proto zebra metric 20
    nexthop via 192.0.2.1 dev swp1 weight 1
    nexthop via 192.0.2.2 dev swp2 weight 1
192.0.2.30/24 via 192.0.2.1 dev swp1 proto zebra metric 20
192.0.2.40/24 dev swp2 proto kernel scope link src 192.0.2.42
192.0.2.50/24 via 192.0.2.2 dev swp2 proto zebra metric 20
192.0.2.60/24 via 192.0.2.2 dev swp2 proto zebra metric 20
192.0.2.70/24 proto zebra metric 30
    nexthop via 192.0.2.1 dev swp1 weight 1
    nexthop via 192.0.2.2 dev swp2 weight 1
198.51.100.0/24 dev swp3 proto kernel scope link src 198.51.100.1
198.51.100.10/24 dev swp4 proto kernel scope link src 198.51.100.11
```



```
198.51.100.20/24 dev br0 proto kernel scope link src 198.51.100.21
```

## Apply a Route Map for Route Updates

To apply a [route map](#) to filter route updates from Zebra into the Linux kernel:

```
cumulus@switch:$ net add routing protocol static route-map <route-map-name>
```

## Configure a Gateway or Default Route

On each switch, it's a good idea to create a *gateway* or *default route* for traffic destined outside the switch's subnet, or local network. All such traffic passes through the gateway, which is a host on the same network that routes packets to their destination beyond the local network.

In the following example, you create a default route in the routing table — 0.0.0.0/0 — which indicates any IP address can get sent to the gateway, which is another switch with the IP address 10.1.0.1.

```
cumulus@switch:~$ net add routing route 0.0.0.0/0 10.1.0.1
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

## Supported Route Table Entries

Cumulus Linux — via `switchd` — advertises the maximum number of route table entries that are supported on a given switch architecture, including:

- L3 IPv4 LPM (longest prefix match) entries, which have a mask that is less than /32
- L3 IPv6 LPM entries, which have a mask that is /64 or less
- L3 IPv6 LPM entries, which have a mask that is greater than /64
- L3 IPv4 neighbor (or host) entries, which are the next hops seen in `ip neighbor`
- L3 IPv6 neighbor entries, which are the next hops seen in `ip -6 neighbor`
- ECMP next hops, which are IP address entries in a router's routing table that specify the next closest /most optimal router in its routing path
- MAC addresses

In addition, switches on the Tomahawk, Trident II, Trident II+, and Trident3 platforms are configured to manage route table entries using Algorithm Longest Prefix Match (ALPM). In ALPM mode, the hardware can store significantly more route entries.

You can use `cl-resource-query` (see page 941) to determine the current table sizes on a given switch.

## Forwarding Table Profiles

Mellanox Spectrum and some Broadcom ASICs provide the ability to configure the allocation of forwarding table resources and mechanisms. Cumulus Linux provides a number of generalized profiles for the platforms described below. These profiles work only with layer 2 and layer 3 unicast forwarding.

Cumulus Linux defines these profiles as *default*, *l2-heavy*, *v4-lpm-heavy* and *v6-lpm-heavy*. Choose the profile that best suits your network architecture and specify the profile name for the `forwarding_table.profile` variable in the `/etc/cumulus/datapath/traffic.conf` file.

```
cumulus@switch:~$ cat /etc/cumulus/datapath/traffic.conf | grep
forwarding_table -B 4
# Manage shared forwarding table allocations
# Valid profiles -
# default, l2-heavy, v4-lpm-heavy, v6-lpm-heavy
#
forwarding_table.profile = default
```

After you specify a different profile, [restart `switchd`](#) (see page 207) for the change to take effect. You can see the forwarding table profile when you run `cl-resource-query`.



Broadcom ASICs other than Maverick, Tomahawk/Tomahawk+, Trident II, Trident II+, and Trident3 support only the *default* profile.



For Broadcom ASICs, the maximum number of IP multicast entries is 8k.

### *Number of Supported Route Entries, by Platform*

The following tables list the number of MAC addresses, layer 3 neighbors and LPM routes validated for each forwarding table profile for the various supported platforms. If you are not specifying any profiles as described above, the *default* values are the ones that the switch will use.



The values in the following tables reflect results from our testing on the different platforms we support, and may differ from published manufacturers' specifications provided about these chipsets.

### *Mellanox Spectrum Switches*

<b>Profile</b>	<b>MAC Addresses</b>	<b>L3 Neighbors</b>	<b>Longest Prefix Match (LPM)</b>
default	40k	32k (IPv4) and 16k (IPv6)	64k (IPv4) or 28k (IPv6-long)
l2-heavy	88k	48k (IPv4) and 40k (IPv6)	8k (IPv4) and 8k (IPv6-long)
l2-heavy-1	180K	8k (IPv4) and 8k (IPv6)	8k (IPv4) and 8k (IPv6-long)
v4-lpm-heavy	8k	8k (IPv4) and 16k (IPv6)	80k (IPv4) and 16k (IPv6-long)



Profile	MAC Addresses	L3 Neighbors	Longest Prefix Match (LPM)
v4-lpm-heavy-1	8k	8k (IPv4) and 2k (IPv6)	176k (IPv4) and 2k (IPv6-long)
v6-lpm-heavy	40k	8k (IPv4) and 40k (IPv6)	8k (IPv4) and 64k (IPv6-long)

### Broadcom Tomahawk/Tomahawk+ Switches

Profile	MAC Addresses	L3 Neighbors	Longest Prefix Match (LPM)
default	40k	40k	64k (IPv4) or 8k (IPv6-long)
I2-heavy	72k	72k	8k (IPv4) or 2k (IPv6-long)
v4-lpm-heavy, v6-lpm-heavy	8k	8k	128k (IPv4) or 20k (IPv6-long)

### Broadcom Trident II/Trident II+/Trident3 Switches

Profile	MAC Addresses	L3 Neighbors	Longest Prefix Match (LPM)
default	32k	16k	128k (IPv4) or 20k (IPv6-long)
I2-heavy	160k	96k	8k (IPv4) or 2k (IPv6-long)
v4-lpm-heavy, v6-lpm-heavy	32k	16k	128k (IPv4) or 20k (IPv6-long)

### Broadcom Helix4 Switches

Note that Helix4 switches do not have profiles

MAC Addresses	L3 Neighbors	Longest Prefix Match (LPM)
24k	12k	7.8k (IPv4) or 2k (IPv6-long)



For Broadcom switches, IPv4 and IPv6 entries are not carved in separate spaces so it is not possible to define explicit numbers in the L3 Neighbors column of the tables shown above. However, note that an IPv6 entry takes up twice the space of an IPv4 entry.

## TCAM Resource Profiles for Mellanox Switches

The Mellanox Spectrum ASIC provides the ability to configure the TCAM resource allocation, which is shared between IP multicast forwarding entries and ACL tables. Cumulus Linux provides a number of general profiles for this platform: *default*, *ipmc-heavy* and *acl-heavy*. Choose the profile that best suits your network architecture and specify that profile name in the `tcam_resource.profile` variable in the `/usr/lib/python2.7/dist-packages/cumulus/__chip_config/mlx/datapath.conf` file.

```
cumulus@switch:~$ cat /usr/lib/python2.7/dist-packages/cumulus
/__chip_config/mlx/datapath.conf | grep -B3 "tcam_resource"
#TCAM resource forwarding profile

1. Valid profiles -
2. default, ipmc-heavy, acl-heavy, ipmc-max
tcam_resource.profile = default
```

After you specify a different profile, [restart `switchd`](#) (see page 207) for the change to take effect.

When [nonatomic updates](#) (see page 150) are enabled (that is, the `acl.non_atomic_update_mode` is set to *TRUE* in `/etc/cumulus/switchd.conf` file), the maximum number of mroute and ACL entries for each profile are as follows:

<b>Profile</b>	<b>Mroute Entries</b>	<b>ACL Entries</b>
default	1000	500 (IPv6) or 1000 (IPv4)
ipmc-heavy	8500	1000 (IPv6) or 1500 (IPv4)
acl-heavy	450	2000 (IPv6) or 3500 (IPv4)
ipmc-max	13000	1000 (IPv6) or 2000 (IPv4)

When [nonatomic updates](#) (see page 150) are disabled (that is, the `acl.non_atomic_update_mode` is set to *FALSE* in `/etc/cumulus/switchd.conf` file), the maximum number of mroute and ACL entries for each profile are as follows:

<b>Profile</b>	<b>Mroute Entries</b>	<b>ACL Entries</b>
default	1000	250 (IPv6) or 500 (IPv4)
ipmc-heavy	8500	500 (IPv6) or 750 (IPv4)
acl-heavy	450	1000 (IPv6) or 1750 (IPv4)
ipmc-max	13000	500 (IPv6) or 1000 (IPv4)



## Caveats and Errata

### *Don't Delete Routes via Linux Shell*

Static routes added via FRRouting can be deleted via Linux shell. This operation, while possible, should be avoided. Routes added by FRRouting should only be deleted by FRRouting, otherwise FRRouting might not be able to clean up all its internal state completely and incorrect routing can occur as a result.

### *Add IPv6 Default Route with src Address on eth0 Fails without Adding Delay*

Attempting to install an IPv6 default route on eth0 with a source address fails at reboot or when running `ifup` on eth0.

The first execution of `ifup -dv` returns this warning and does not install the route:

```
cumulus@switch:~$ sudo ifup -dv eth0
warning: eth0: post-up cmd '/sbin/ip route add default via 2001:620:5cal:160::1 /src 2001:620:5cal:160::45 dev eth0' failed (RTNETLINK answers: Invalid argument)<<<<<<
```

Running `ifup` a second time on eth0 successfully installs the route.

There are two ways you can work around this issue.

- Add a sleep 2 to the eth0 interface in `/etc/network/interfaces`:

```
cumulus@switch:~$ net add interface eth0 ipv6 address 2001:620:5cal:160::45/64 post-up /bin/sleep 2s
cumulus@switch:~$ net add interface eth0 post-up /sbin/ip route add default via 2001:620:5cal:160::1 src 2001:620:5call:160::45 dev eth0
```

- Exclude the `src` parameter to the `ip route add` that causes the need for the delay. If the `src` parameter is removed, the route is added correctly.

```
cumulus@switch:~$ net add interface eth0 post-up /sbin/ip route add default via 2001:620:5cal:160::1 dev eth0
```

```
cumulus@switch:~$ ifdown eth0
Stopping NTP server: ntpd.
Starting NTP server: ntpd.
cumulus@switch:~$ ip -6 r s
cumulus@switch:~$ ifup eth0
Stopping NTP server: ntpd.
Starting NTP server: ntpd.
cumulus@switch:~$ ip -6 r s
```



```
2001:620:5ca1:160::/64 dev eth0 proto kernel metric 256
fe80::/64 dev eth0 proto kernel metric 256
default via 2001:620:5ca1:160::1 dev eth0 metric 1024
```

## Related Information

- Linux IP - [ip route command](#)
- FRRouting docs - [static route commands](#)

# Introduction to Routing Protocols

This chapter discusses the various routing protocols, and how to configure them.

## Contents

**This topic describes ...**

- [Routing Protocols \(see page 728\)](#)
- [Configure Routing Protocols \(see page 728\)](#)
- [Protocol Tuning \(see page 729\)](#)

## Routing Protocols

A *routing protocol* dynamically computes reachability between various end points. This enables communication to work around link and node failures, and additions and withdrawals of various addresses.

*IP routing protocols* are typically distributed; that is, an instance of the routing protocol runs on each of the routers in a network.



Cumulus Linux does **not** support running multiple instances of the same protocol on a router.

*Distributed routing protocols* compute reachability between end points by disseminating relevant information and running a routing algorithm on this information to determine the routes to each end station. To scale the amount of information that needs to be exchanged, routes are computed on address prefixes rather than on every end point address.

## Configure Routing Protocols

A routing protocol needs to know three pieces of information, at a minimum:

- Who am I (my identity)
- To whom to disseminate information
- What to disseminate

Most routing protocols use the concept of a router ID to identify a node. Different routing protocols answer the last two questions differently.

The way they answer these questions affects the network design and thereby configuration. For example, in a link-state protocol such as OSPF (see [Open Shortest Path First \(OSPF\) Protocol \(see page 756\)](#)) or IS-IS, complete local information (links and attached address prefixes) about a node is disseminated to every



other node in the network. Since the state that a node has to keep grows rapidly in such a case, link-state protocols typically limit the number of nodes that communicate this way. They allow for bigger networks to be built by breaking up a network into a set of smaller subnetworks (which are called areas or levels), and by advertising summarized information about an area to other areas.

Besides the two critical pieces of information mentioned above, protocols have other parameters that can be configured. These are usually specific to each protocol.

## Protocol Tuning

Most protocols provide certain tunable parameters that are specific to convergence during changes.

Wikipedia defines [convergence](#) as the “state of a set of routers that have the same topological information about the network in which they operate”. It is imperative that the routers in a network have the same topological state for the proper functioning of a network. Without this, traffic can be blackholed, and thus not reach its destination. It is normal for different routers to have differing topological states during changes, but this difference should vanish as the routers exchange information about the change and recompute the forwarding paths. Different protocols converge at different speeds in the presence of changes.

A key factor that governs how quickly a routing protocol converges is the time it takes to detect the change. For example, how quickly can a routing protocol be expected to act when there is a link failure. Routing protocols classify changes into two kinds: hard changes such as link failures, and soft changes such as a peer dying silently. They're classified differently because protocols provide different mechanisms for dealing with these failures.

It is important to configure the protocols to be notified immediately on link changes. This is also true when a node goes down, causing all of its links to go down.

Even if a link doesn't fail, a routing peer can crash. This causes that router to usually delete the routes it has computed or worse, it makes that router impervious to changes in the network, causing it to go out of sync with the other routers in the network because it no longer shares the same topological information as its peers.

The most common way to detect a protocol peer dying is to detect the absence of a heartbeat. All routing protocols send a heartbeat (or “hello”) packet periodically. When a node does not see a consecutive set of these hello packets from a peer, it declares its peer dead and informs other routers in the network about this. The period of each heartbeat and the number of heartbeats that need to be missed before a peer is declared dead are two popular configurable parameters.

If you configure these timers very low, the network can quickly descend into instability under stressful conditions when a router is not able to keep sending the heartbeats quickly as it is busy computing routing state; or the traffic is so much that the hellos get lost. Alternately, configuring this timer to very high values also causes blackholing of communication because it takes much longer to detect peer failures. Usually, the default values initialized within each protocol are good enough for most networks. Cumulus Networks recommends you do not adjust these settings.

## Network Topology

In computer networks, *topology* refers to the structure of interconnecting various nodes. Some commonly used topologies in networks are star, hub and spoke, leaf and spine, and broadcast.

## Contents

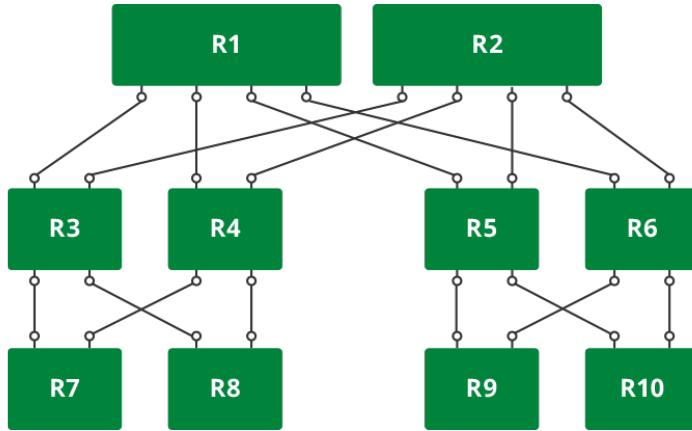
### This topic describes ...

- Clos Topologies (see page 730)

- Over-Subscribed and Non-Blocking Configurations (see page 730)
- Containing the Failure Domain (see page 731)
- Load Balancing (see page 731)

## Clos Topologies

In the vast majority of modern data centers, [Clos or fat tree topology](#) is very popular. This topology is shown in the figure below. It is also commonly referred to as leaf-spine topology. We shall use this topology throughout the routing protocol guide.



This topology allows the building of networks of varying size using nodes of different port counts and/or by increasing the tiers. The picture above is a three-tiered Clos network. We number the tiers from the bottom to the top. Thus, in the picture, the lowermost layer is called tier 1 and the topmost tier is called tier 3.

The number of end stations (such as servers) that can be attached to such a network is determined by a very simple mathematical formula.

In a 2-tier network, if each node is made up of  $m$  ports, then the total number of end stations that can be connected is  $m^2/2$ . In more general terms, if tier-1 nodes are  $m$ -port nodes and tier-2 nodes are  $n$ -port nodes, then the total number of end stations that can be connected are  $(m*n)/2$ . In a three tier network, where tier-3 nodes are  $o$ -port nodes, the total number of end stations that can be connected are  $(m*n*o)/2^{(\text{number of tiers}-1)}$ .

Let's consider some practical examples. In many data centers, it is typical to connect 40 servers to a top-of-rack (ToR) switch. The ToRs are all connected via a set of spine switches. If a ToR switch has 64 ports, then after hooking up 40 ports to the servers, the remaining 24 ports can be hooked up to 24 spine switches of the same link speed or to a smaller number of higher link speed switches. For example, if the servers are all hooked up as 10GE links, then the ToRs can connect to the spine switches via 40G links. So, instead of connecting to 24 spine switches with 10G links, the ToRs can connect to 6 spine switches with each link being 40G. If the spine switches are also 64-port switches, then the total number of end stations that can be connected is 2560 ( $40*64$ ) stations.

In a three tier network of 64-port switches, the total number of servers that can be connected are  $(40*64*64)/2^{(3-1)} = 40960$ . As you can see, this kind of topology can serve quite a large network with three tiers.

## Over-Subscribed and Non-Blocking Configurations

In the above example, the network is *over-subscribed*; that is, 400G of bandwidth from end stations (40 servers \* 10GE links) is serviced by only 240G of inter-rack bandwidth. The over-subscription ratio is 0.6 ( $240/400$ ).



This can lead to congestion in the network and hot spots. Instead, if network operators connected 32 servers per rack, then 32 ports are left to be connected to spine switches. Now, the network is said to be [rearrangably non-blocking](#). Now any server in a rack can talk to any other server in any other rack without necessarily blocking traffic between other servers.

In such a network, the total number of servers that can be connected are  $(64*64)/2 = 2048$ . Similarly, a three-tier version of the same can serve up to  $(64*64*64)/4 = 65536$  servers.

## Containing the Failure Domain

Traditional data centers were built using just two spine switches. This means that if one of those switches fails, the network bandwidth is cut in half, thereby greatly increasing network congestion and adversely affecting many applications. To avoid this, vendors typically try and make the spine switches resilient to failures by providing such features as dual control line cards and attempting to make the software highly available. In many cases, HA is among the top two or three causes of software failure (and thereby switch failure).

To support a fairly large network with just two spine switches also means that these switches have a large port count. This can make the switches quite expensive.

If the number of spine switches were to be merely doubled, the effect of a single switch failure is halved. With 8 spine switches, the effect of a single switch failure only causes a 12% reduction in available bandwidth.

So, in modern data centers, people build networks with anywhere from 4 to 32 spine switches.

## Load Balancing

In a Clos network, traffic is load balanced across the multiple links using equal cost multi-pathing (ECMP).

Routing algorithms compute shortest paths between two end stations where shortest is typically the lowest path cost. Each link is assigned a metric or cost. By default, a link's cost is a function of the link speed. The higher the link speed, the lower its cost. A 10G link has a higher cost than a 40G or 100G link, but a lower cost than a 1G link. Thus, the link cost is a measure of its traffic carrying capacity.

In the modern data center, the links between tiers of the network are homogeneous; that is, they have the same characteristics (same speed and therefore link cost) as the other links. As a result, the first hop router can pick any of the spine switches to forward a packet to its destination (assuming that there is no link failure between the spine and the destination switch). Most routing protocols recognize that there are multiple equal-cost paths to a destination and enable any of them to be selected for a given traffic flow.

## FRRouting Overview

Cumulus Linux uses FRRouting to provide the routing protocols for dynamic routing. FRRouting provides many routing protocols, of which Cumulus Linux supports the following:

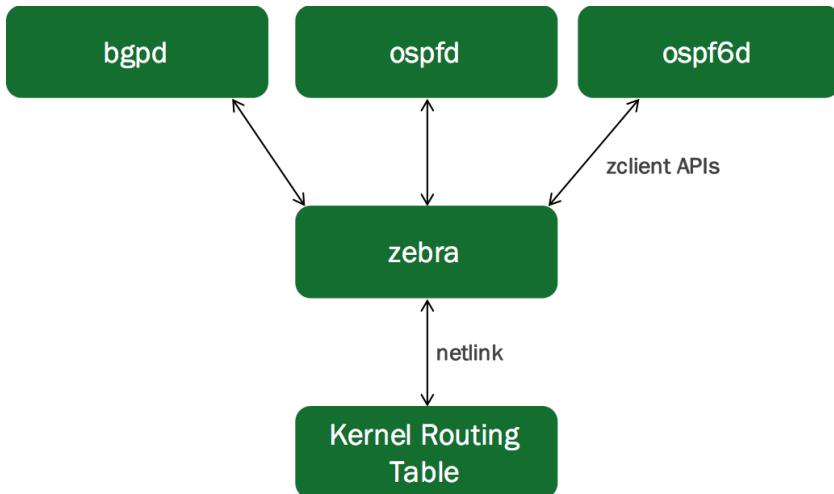
- Open Shortest Path First ([v2 \(see page 756\)](#) and [v3 \(see page 770\)](#))
- Border Gateway Protocol ([see page 773](#))

## Contents

### This topic describes ...

- Architecture ([see page 732](#))
- About zebra ([see page 732](#))
- Related Information ([see page 732](#))

## Architecture



As shown in the figure above, the FRRouting suite consists of various protocol-specific daemons and a protocol-independent daemon called `zebra`. Each of the protocol-specific daemons are responsible for running the relevant protocol and building the routing table based on the information exchanged.

It is not uncommon to have more than one protocol daemon running at the same time. For example, at the edge of an enterprise, protocols internal to an enterprise (called IGP for Interior Gateway Protocol) such as [OSPF \(see page 756\)](#) or RIP run alongside the protocols that connect an enterprise to the rest of the world (called EGP or Exterior Gateway Protocol) such as [BGP \(see page 773\)](#).

## About `zebra`

`zebra` is the daemon that resolves the routes provided by multiple protocols (including static routes specified by the user) and programs these routes in the Linux kernel via `netlink` (in Linux). `zebra` does more than this, of course. The [FRRouting documentation](#) defines `zebra` as the IP routing manager for FRRouting that "provides kernel routing table updates, interface lookups, and redistribution of routes between different routing protocols."

## Related Information

- [frrouting.org](#)
- [GitHub](#)

## Upgrading from Quagga to FRRouting

Cumulus Linux 3.4 and later releases replace Quagga with FRRouting. This section outlines the upgrade process for users currently using Quagga.



These instructions only apply to upgrading to Cumulus Linux 3.4 or later from releases earlier than 3.4. New image installations contain `frr` instead of `quagga` or `quagga-compat`. If you are using any automation tools to configure your network and are installing a new Cumulus Linux image, make sure your automation tools refer to FRR and not to Quagga.



If you are upgrading Cumulus Linux using `apt-get upgrade`, existing automation that references Quagga continues to work until you upgrade to FRR. Once you perform the following upgrade steps, your automation **must** reference FRR instead of Quagga.



Upgrading to Cumulus Linux 3.4 or later results in both `quagga.service` and `frr.service` being present on the system, until `quagga.service` is removed. These services have been configured to conflict with each other; starting one service automatically stops the other, as they cannot run concurrently.

1. Run the following commands to begin the upgrade process:

```
cumulus@switch:~$ sudo -E apt-get update  
cumulus@switch:~$ sudo -E apt-get upgrade
```



At the end of the `apt-get upgrade` process, the output shows details of the upgrade process, regarding the Quagga to FRR switchover.

```
Unpacking quagga-compat (1.0.0+c13u15-1)  
...  
[476/476]  
Selecting previously unselected package frr.  
Preparing to unpack .../frr_3.1+c13u1_amd64.deb ...  
Unpacking frr (3.1+c13u1) ...  
Processing triggers for man-db (2.7.0.2-5) ...  
Setting up frr (3.1+c13u1) ...  
Setting up quagga-compat (1.0.0+c13u15-1) ...  
+-----  
-----+  
| Your system has been upgraded to use Cumulus Linux's  
new routing protocol |  
| suite, FRRouting. The 'quagga' package is now a dummy  
transitional package |  
| and may be  
removed.  
|  
|  
| As part of this upgrade, please take note of the  
following information: |  
|  
| - The location of your configuration files has changed  
to /etc/frr. |
```



```
|     In order to enable a seamless transition, FRRouting  
will continue to          |  
|     read all configuration files from /etc/quagga until  
the transition is          |  
|  
completed.  
  
|  
|  
|     - In the interest of stability, action is required on  
your part to          |  
|     complete the transition to FRRouting. For  
instructions on how to do          |  
|     this, please refer to the Cumulus Linux  
documentation.          |  
+-----+  
-----+  
Setting up quagga (1.0.0+cl3u14-1) ...  
Processing triggers for libc-bin (2.19-18+deb8u10) ...  
Creating post-apt snapshot... 245 done.  
root@dell-s6000-16:/etc#
```

Once the upgrade process is completed, the switch is in the following state:

```
cumulus@switch:~$ sudo systemctl list-unit-files | grep "quagga\|frr"  
frr.service                         enabled  
quagga.service                      enabled  
cumulus@switch:~$ sudo systemctl status frr  
frr.service - Cumulus Linux FRR  
   Loaded: loaded (/etc/systemd/system/frr.service; enabled)  
   Active: inactive (dead) since Fri 2017-07-28 18:54:59 UTC; 3 days  
ago  
cumulus@switch:~$ sudo systemctl status quagga  
quagga.service - Quagga (Transitional)  
   Loaded: loaded (/lib/systemd/system/quagga.service; enabled)  
   Active: active (running) since Fri 2017-07-28 18:55:49 UTC; 3 days  
ago  
     Process: 29436 ExecStop=/usr/lib/frr/quagga stop (code=exited,  
status=0/SUCCESS)  
     Process: 29772 ExecStart=/usr/lib/frr/quagga start (code=exited,  
status=0/SUCCESS)  
   CGroup: /system.slice/quagga.service  
           29791 /usr/lib/frr/zebra -s 90000000 --daemon -A 127.0.0.1  
-q  
           29798 /usr/lib/frr/bgpd --daemon -A 127.0.0.1 -q  
           29805 /usr/lib/frr/ripd --daemon -A 127.0.0.1 -q  
           29812 /usr/lib/frr/ospfd --daemon -A 127.0.0.1 -q  
           29819 /usr/lib/frr/ospf6d --daemon -A ::1 -q
```



```
29825 /usr/lib/frr/watchfrr -q -adz -r /usr/sbin  
/servicebBquaggabBrestartbB% -s /usr/sbin/servicebBquaggabBstartbB%  
-k /usr/sbin/servicebBquaggabBstopbB% -b bB -t 90 zebra bgpd ripd  
ospfd ospf6d
```

The output below shows the FRR / Quagga package status:

```
cumulus@switch:~$ dpkg -l quagga\* frr\*  
interacting with quagga  
rc quagga 1.0.0+cl3u14-  
1 amd64 transitional package  
ii quagga-compat 1.0.0+cl3u15-  
1 all Quagga compatibility for  
FRRouting  
ii frr 3.1  
+cl3u1 amd64 BGP/OSPF/RIP  
routing daemon
```



Cumulus 3.4 and later releases do not support or implement `python-clcmd`. While the package remains, the related commands have been removed.

To complete the transition to FRR:

1. Migrate all `/etc/quagga/*` files to `/etc/frr/*`.



The `vtysh.conf` file should not be moved, as it is unlikely any configuration is in the file. However, if there is necessary configuration in place, copy the contents into `/etc/frr/vtysh.conf`.

2. Merge the current `Quagga.conf` file with the new `frr.conf` file. Keep the default configuration for `frr.conf` in place, and add the additional configuration sections from `Quagga.conf`.
3. Enable the daemons needed for your installation in `/etc/frr/daemons`.
4. Manually update the log file locations to `/var/log/frr` or `syslog`.
5. Remove the compatibility package:



This step stops the Quagga compatibility mode, causing routing to go down.

```
cumulus@switch:~$ sudo -E apt-get remove quagga quagga-compat  
quagga-doc
```



Removing the `quagga-compat` package also removes `quagga.service`. However, the `/etc/quagga` directory is not removed in this step, as it is left in place for reference.

6. Purge the Quagga packages:

```
cumulus@switch:~$ sudo dpkg -P quagga quagga-compat
```



This step deletes all Quagga configuration files. Please ensure you back up your configuration.



Cumulus Networks does not recommend reinstalling the `quagga` and `quagga-compat` packages once they have been removed. While they can be reinstalled to continue migration iterations, limited testing has taken place, and configuration issues may occur.

7. Start FRR without Quagga compatibility mode:

```
cumulus@switch:~$ sudo systemctl start frr.service
cumulus@switch:~$ sudo systemctl -l status frr.service
```

## Troubleshooting

If the `systemctl -l status frr` output shows an issue, edit the configuration files to correct it, and repeat the process. If issues persist, you can return to Quagga compatibility mode for further testing:

```
cumulus@switch:~$ sudo -E apt-get install quagga-compat
cumulus@switch:~$ sudo systemctl stop frr.service
cumulus@switch:~$ sudo systemctl disable frr.service
```



Several configuration migration iterations may be necessary to ensure the configuration is behaving the same in both Quagga and FRR.

Once further testing is complete, run the following commands to reset the FRR installation, and then repeat the steps from the beginning of this section to upgrade to FRR:

```
cumulus@switch:~$ sudo systemctl reset-failed frr.service
cumulus@switch:~$ sudo systemctl enable frr.service
```



# Configuring FRRouting

This section provides an overview of configuring FRRouting, the routing software package that provides a suite of routing protocols so you can configure routing on your switch.

## Contents

### This topic describes ...

- Configure FRRouting (see page 737)
  - Enable and Start FRRouting (see page 738)
  - Integrated Configurations (see page 738)
  - Restore the Default Configuration (see page 739)
- Interface IP Addresses and VRFs (see page 740)
- FRRouting vtysh Modal CLI (see page 740)
- Reload the FRRouting Configuration (see page 745)
- FRR Logging (see page 745)
- Caveats (see page 746)
  - Obfuscated Passwords (see page 746)
  - Duplicate Hostnames (see page 746)
- Related Information (see page 746)

## Configure FRRouting

FRRouting does not start by default in Cumulus Linux. Before you run FRRouting, make sure all you have enabled relevant daemons that you intend to use — `zebra`, `bgpd`, `ospfd`, `ospf6d` or `pimd` — in the `/etc/frr/daemons` file.



Cumulus Networks has not tested RIP, RIPv6, IS-IS and Babel.

The `zebra` daemon must always be enabled. The others you can enable according to how you plan to route your network — using [BGP \(see page 773\)](#) for example, instead of [OSPF \(see page 756\)](#).

Before you start FRRouting, you need to enable the corresponding daemons. Edit the `/etc/frr/daemons` file and set to yes each daemon you are enabling. For example, to enable BGP, set both `zebra` and `bgpd` to yes:

```
zebra=yes (* this one is mandatory to bring the others up)
bgpd=yes
ospfd=no
ospf6d=no
ripd=no
ripngd=no
isisd=no
babeld=no
pimd=no
```



## Enable and Start FRRouting

Once you enable the appropriate daemons, then you need to enable and start the FRRouting service.

```
cumulus@switch:~$ sudo systemctl enable frr.service
cumulus@switch:~$ sudo systemctl start frr.service
```

- ✓ All the routing protocol daemons (`bgpd`, `ospfd`, `ospf6d`, `ripd`, `ripngd`, `isisd` and `pimd`) are dependent on `zebra`. When you start `frr`, `systemd` determines whether `zebra` is running; if `zebra` is not running, it starts `zebra`, then starts the dependent service, such as `bgpd`.  
In general, if you restart a service, its dependent services also get restarted. For example, running `systemctl restart frr.service` restarts any of the routing protocol daemons that are enabled and running.  
For more information on the `systemctl` command and changing the state of daemons, read [Services and Daemons in Cumulus Linux \(see page 192\)](#).

## Integrated Configurations

By default in Cumulus Linux, FRRouting saves the configuration of all daemons in a single integrated configuration file, `frr.conf`.

You can disable this mode by running the following command in the [vtysh FRRouting CLI \(see page 740\)](#):

```
cumulus@switch:~$ sudo vtysh
switch# configure terminal
switch(config)# no service integrated-vtysh-config
```

To enable the integrated configuration file mode again, run:

```
switch(config)# service integrated-vtysh-config
```

If you disable the integrated configuration mode, FRRouting saves each daemon-specific configuration file in a separate file. At a minimum for a daemon to start, that daemon must be enabled and its daemon-specific configuration file must be present, even if that file is empty.

You save the current configuration by running:

```
switch# write mem
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
switch# exit
```



```
cumulus@switch:~$
```



You can use `write file` instead of `write mem`.

When the integrated configuration mode disabled, the output looks like this:

```
switch# write mem
Building Configuration...
Configuration saved to /etc/frr/zebra.conf
Configuration saved to /etc/frr/bgpd.conf
[OK]
```

### *Restore the Default Configuration*

If you need to restore the FRRouting configuration to the default running configuration, you need to delete the `frr.conf` file and restart the `frr` service. You should back up `frr.conf` (or any configuration files you may remove, see the note below) before proceeding.

1. Confirm `service integrated-vtysh-config` is enabled:

```
cumulus@switch:~$ net show configuration | grep integrated
      service integrated-vtysh-config
```

2. Remove `/etc/frr/frr.conf`:

```
cumulus@switch:~$ sudo rm /etc/frr/frr.conf
```

3. Restart FRRouting:

```
cumulus@switch:~$ sudo systemctl restart frr.service
```



If for some reason you disabled `service integrated-vtysh-config`, then you should remove all the configuration files (such as `zebra.conf` or `ospf6d.conf`) instead of `frr.conf` in step 2 above.



## Interface IP Addresses and VRFs

FRRouting inherits the IP addresses and any associated routing tables for the network interfaces from the `/etc/network/interfaces` file. This is the recommended way to define the addresses; do **not** create interfaces using FRRouting. For more information, see [Configuring IP Addresses \(see page 229\)](#) and [Virtual Routing and Forwarding - VRF \(see page 847\)](#).

## FRRouting vtysh Modal CLI

FRRouting provides a CLI – `vtysh` – for configuring and displaying the state of the protocols. It is invoked by running:

```
cumulus@switch:~$ sudo vtysh

Hello, this is FRRouting (version 0.99.23.1+cl3u2).
Copyright 1996-2005 Kunihiro Ishiguro, et al.

switch#
```

`vtysh` provides a Cisco-like modal CLI, and many of the commands are similar to Cisco IOS commands. By modal CLI, we mean that there are different modes to the CLI, and certain commands are only available within a specific mode. Configuration is available with the `configure terminal` command, which is invoked thus:

```
switch# configure terminal
switch(config)#
```

The prompt displays the mode the CLI is in. For example, when the interface-specific commands are invoked, the prompt changes to:

```
switch(config)# interface swp1
switch(config-if)#
```

When the routing protocol specific commands are invoked, the prompt changes to:

```
switch(config)# router ospf
switch(config-router)#
```

At any level, "?" displays the list of available top-level commands at that level:

```
switch(config-if)# ?
bandwidth      Set bandwidth informational parameter
description    Interface specific description
end           End current mode and change to enable mode
```



exit	Exit current mode and down to previous mode
ip	IP Information
ipv6	IPv6 Information
isis	IS-IS commands
link-detect	Enable link detection on <b>interface</b>
list	Print command list
mpls-te	MPLS-TE specific commands
multicast	Set multicast flag to <b>interface</b>
no	Negate a command or set its defaults
ptm-enable	Enable neighbor check with specified topology
quit	Exit current mode and down to previous mode
shutdown	Shutdown the selected <b>interface</b>

?-based completion is also available to see the parameters that a command takes:

```
switch(config-if)# bandwidth ?
<1-10000000> Bandwidth in kilobits
switch(config-if)# ip ?
address Set the IP address of an interface
irdp Alter ICMP Router discovery preference this interface
ospf OSPF interface commands
rip Routing Information Protocol
router IP router interface commands
```

Displaying state can be done at any level, including the top level. For example, to see the routing table as seen by zebra, you use:

```
switch# show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, T - Table,
       > - selected route, * - FIB route
B>* 0.0.0.0/0 [20/0] via fe80::4638:39ff:fe00:c, swp29, 00:11:57
   *           via fe80::4638:39ff:fe00:52, swp30, 00:11:57
B>* 10.0.0.1/32 [20/0] via fe80::4638:39ff:fe00:c, swp29, 00:11:57
   *           via fe80::4638:39ff:fe00:52, swp30, 00:11:57
B>* 10.0.0.11/32 [20/0] via fe80::4638:39ff:fe00:5b, swp1, 00:11:57
B>* 10.0.0.12/32 [20/0] via fe80::4638:39ff:fe00:2e, swp2, 00:11:58
B>* 10.0.0.13/32 [20/0] via fe80::4638:39ff:fe00:57, swp3, 00:11:59
B>* 10.0.0.14/32 [20/0] via fe80::4638:39ff:fe00:43, swp4, 00:11:59
C>* 10.0.0.21/32 is directly connected, lo
B>* 10.0.0.51/32 [20/0] via fe80::4638:39ff:fe00:c, swp29, 00:11:57
   *           via fe80::4638:39ff:fe00:52, swp30, 00:11:57
B>* 172.16.1.0/24 [20/0] via fe80::4638:39ff:fe00:5b, swp1, 00:11:57
   *           via fe80::4638:39ff:fe00:2e, swp2, 00:11:57
B>* 172.16.3.0/24 [20/0] via fe80::4638:39ff:fe00:57, swp3, 00:11:59
   *           via fe80::4638:39ff:fe00:43, swp4, 00:11:59
```

To run the same command at a config level, you prepend do to it:

```
switch(config-router)# do show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, T - Table,
       > - selected route, * - FIB route
B>* 0.0.0.0/0 [20/0] via fe80::4638:39ff:fe00:c, swp29, 00:05:17
   *           via fe80::4638:39ff:fe00:52, swp30, 00:05:17
B>* 10.0.0.1/32 [20/0] via fe80::4638:39ff:fe00:c, swp29, 00:05:17
   *           via fe80::4638:39ff:fe00:52, swp30, 00:05:17
B>* 10.0.0.11/32 [20/0] via fe80::4638:39ff:fe00:5b, swp1, 00:05:17
B>* 10.0.0.12/32 [20/0] via fe80::4638:39ff:fe00:2e, swp2, 00:05:18
B>* 10.0.0.13/32 [20/0] via fe80::4638:39ff:fe00:57, swp3, 00:05:18
B>* 10.0.0.14/32 [20/0] via fe80::4638:39ff:fe00:43, swp4, 00:05:18
C>* 10.0.0.21/32 is directly connected, lo
B>* 10.0.0.51/32 [20/0] via fe80::4638:39ff:fe00:c, swp29, 00:05:17
   *           via fe80::4638:39ff:fe00:52, swp30, 00:05:17
B>* 172.16.1.0/24 [20/0] via fe80::4638:39ff:fe00:5b, swp1, 00:05:17
   *           via fe80::4638:39ff:fe00:2e, swp2, 00:05:17
B>* 172.16.3.0/24 [20/0] via fe80::4638:39ff:fe00:57, swp3, 00:05:18
   *           via fe80::4638:39ff:fe00:43, swp4, 00:05:18
```

Running single commands with `vtysh` is possible using the `-c` option of `vtysh`:

```
cumulus@switch:~$ sudo vtysh -c 'sh ip route'
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, A - Babel,
       > - selected route, * - FIB route

K>* 0.0.0.0/0 via 192.168.0.2, eth0
C>* 192.0.2.11/24 is directly connected, swp1
C>* 192.0.2.12/24 is directly connected, swp2
B>* 203.0.113.30/24 [200/0] via 192.0.2.2, swp1, 11:05:10
B>* 203.0.113.31/24 [200/0] via 192.0.2.2, swp1, 11:05:10
B>* 203.0.113.32/24 [200/0] via 192.0.2.2, swp1, 11:05:10
C>* 127.0.0.0/8 is directly connected, lo
C>* 192.168.0.0/24 is directly connected, eth0
```

Running a command multiple levels down is done thus:

```
cumulus@switch:~$ sudo vtysh -c 'configure terminal' -c 'router ospf'
-c 'area 0.0.0.1 range 10.10.10.0/24'
```

Notice that the commands also take a partial command name (for example, `sh ip route` above) as long as the partial command name is not aliased:

```
cumulus@switch:~$ sudo vtysh -c 'sh ip r'
% Ambiguous command.
```



A command or feature can be disabled in FRouting by prepending the command with `no`. For example:

```
cumulus@switch:~$ sudo vtysh
switch# configure terminal
switch(config)# router ospf
switch(config-router)# no area 0.0.0.1 range 10.10.10.0/24
switch(config-router)# exit
switch(config)# exit
switch# write mem
switch# exit
cumulus@switch:~$
```

The current state of the configuration can be viewed using the `show running-config` command:

```
switch# show running-config
Building configuration...

Current configuration:
!
username cumulus nopassword
!
service integrated-vtysh-config
!
vrf mgmt
!
interface lo
link-detect
!
interface swp1
ipv6 nd ra-interval 10
link-detect
!
interface swp2
ipv6 nd ra-interval 10
link-detect
!
interface swp3
ipv6 nd ra-interval 10
link-detect
!
interface swp4
ipv6 nd ra-interval 10
link-detect
!
interface swp29
ipv6 nd ra-interval 10
link-detect
!
interface swp30
```



```
 ipv6 nd ra-interval 10
 link-detect
 !
 interface swp31
 link-detect
 !
 interface swp32
 link-detect
 !
 interface vagrant
 link-detect
 !
 interface eth0 vrf mgmt
 ipv6 nd suppress-ra
 link-detect
 !
 interface mgmt vrf mgmt
 link-detect
 !
 router bgp 65020
 bgp router-id 10.0.0.21
 bgp bestpath as-path multipath-relax
 bgp bestpath compare-routerid
 neighbor fabric peer-group
 neighbor fabric remote-as external
 neighbor fabric description Internal Fabric Network
 neighbor fabric capability extended-nexthop
 neighbor swp1 interface peer-group fabric
 neighbor swp2 interface peer-group fabric
 neighbor swp3 interface peer-group fabric
 neighbor swp4 interface peer-group fabric
 neighbor swp29 interface peer-group fabric
 neighbor swp30 interface peer-group fabric
 !
 address-family ipv4 unicast
 network 10.0.0.21/32
 neighbor fabric activate
 neighbor fabric prefix-list dc-spine in
 neighbor fabric prefix-list dc-spine out
 exit-address-family
 !
 ip prefix-list dc-spine seq 10 permit 0.0.0.0/0
 ip prefix-list dc-spine seq 20 permit 10.0.0.0/24 le 32
 ip prefix-list dc-spine seq 30 permit 172.16.1.0/24
 ip prefix-list dc-spine seq 40 permit 172.16.2.0/24
 ip prefix-list dc-spine seq 50 permit 172.16.3.0/24
 ip prefix-list dc-spine seq 60 permit 172.16.4.0/24
 ip prefix-list dc-spine seq 500 deny any
 !
 ip forwarding
 ipv6 forwarding
 !
```



```
line vty
!
end
```



If you attempt to configure a routing protocol that has not been started, `vtysh` silently ignores those commands.

Alternately, if you do not want to use a modal CLI to configure FRRouting, you can use a suite of Cumulus Linux-specific commands (see page 747) instead.

## Reload the FRRouting Configuration

If you make a change to your routing configuration, you need to reload FRRouting so your changes take place. *FRRouting reload* enables you to apply only the modifications you make to your FRRouting configuration, synchronizing its running state with the configuration in `/etc/frr/frr.conf`. This is useful for optimizing automation of FRRouting in your environment or to apply changes made at runtime.



FRRouting reload only applies to an integrated service configuration, where your FRRouting configuration is stored in a single `frr.conf` file instead of one configuration file per FRRouting daemon (like `zebra` or `bgpd`).

To reload your FRRouting configuration after you've modified `/etc/frr/frr.conf`, run:

```
cumulus@switch:~$ sudo systemctl reload frr.service
```

Examine the running configuration and verify that it matches the config in `/etc/frr/frr.conf`:

```
cumulus@switch:~$ net show configuration
```

If the running configuration is not what you expected, [submit a support request](#) and supply the following information:

- The current running configuration (run `net show configuration` and output the contents to a file)
- The contents of `/etc/frr/frr.conf`
- The contents of `/var/log/frr/frr-reload.log`

## FRR Logging

By default, Cumulus Linux configures FRR with syslog severity level 6 (informational). Log output is written to the `/var/log/frr/frr.log` file.





To write debug messages to the log file, you must run the `log syslog debug` command to configure FRR with syslog severity 7 (debug); otherwise, when you issue a debug command such as, `debug bgp neighbor-events`, no output is sent to `/var/log/frr/frr.log`. However, when you manually define a log target with the `log file /var/log/frr/debug` command, FRR automatically defaults to severity 7 (debug) logging and the output is logged to `/var/log/frr/frr.log`.

## Caveats

### *Obfuscated Passwords*

In FRRouting, Cumulus Linux stores obfuscated passwords for BGP and OSPF (ISIS, OSPF area, and BGP neighbor passwords). All passwords in configuration files and those displayed in show commands are obfuscated. The obfuscation algorithm protects passwords from casual viewing. The system can retrieve the original password when needed.

### *Duplicate Hostnames*

If you change the hostname, either through NCLU or with the `hostname` command in `vtysh`, the switch can have two hostnames in the FRR configuration. For example:

```
Spine01# conf t
Spine01(config)# hostname Spine01-1
Spine01-1(config)# do sh run
Building configuration...
Current configuration:
!
frr version 4.0+cl3u1
frr defaults datacenter
hostname Spine01
hostname Spine01-1

...
```



Accidentally configuring the same numbered BGP neighbor using both the `neighbor x.x.x.x` and `neighbor swp# interface` commands results in two neighbor entries being present for the same IP in the configuration and operationally. You can correct this issue by updating the configuration and restarting the FRR service.

## Related Information

- [FRR BGP documentation](#)
- [FRR IPv6 support](#)
- [FRR Zebra documentation](#)



## Comparing NCLU and vtysh Commands

Using [NCLU \(see page 88\)](#) is the primary way to [configure routing \(see page 737\)](#) in Cumulus Linux. However, an alternative exists in the the `vtysh` modal CLI. The available commands are as follows:

The following table compares the various FRRouting commands with their Cumulus Linux NCLU counterparts.

Action	NCLU Commands	FRRouting Commands
Display the routing table	<pre>cumulus@switch: ~\$ net show route</pre>	<pre>switch# show ip route</pre>
Create a new neighbor	<pre>cumulus@switch: ~\$ net add bgp autonomous- system 65002 cumulus@switch: ~\$ net add bgp neighbor 14.0.0.2 2</pre>	<pre>switch(config) # router bgp 65 002 switch(config- router)# neighbor 14.0.0. 22</pre>
Redistribute routing information from static route entries into RIP tables	<pre>cumulus@switch: ~\$ net add bgp redistribute static in</pre>	<pre>switch(config) # router bgp 65 002 switch(config- router)# redistribute static in</pre>
Define a <a href="#">static route (see page 720)</a>	<pre>cumulus@switch: ~\$ net add routing route 155 .1.2.20/24 bridge 45</pre>	<pre>switch(config) # ip route 155. 1.2.20/24 bridge 45</pre>
Configure an IPv6 address		

Action	NCLU Commands	FRouting Commands
	<pre>cumulus@switch: ~\$ net add <b>interface</b> <b>ace</b> swp3 ipv6 address 3002:2123 :1234:1abc::21/64</pre>	<pre>switch(config) # <b>int</b> swp3 switch(config-i f)# <b>ipv6</b> address 3002:21 23:1234:1abc::2 1/64</pre>
Enable topology checking ( <a href="#">PTM (see page 360)</a> )	<pre>cumulus@switch: ~\$ net add routing ptm- enable</pre>	<pre>switch(config) # ptm-enable</pre>
Configure <a href="#">MTU (see page 242)</a> in IPv6 network discovery for an interface	<pre>cumulus@switch: ~\$ sudo cl-ra <b>interface</b> <b>swp3</b> set mtu 9000</pre>	<pre>switch(config) # <b>int</b> swp3 switch(config-i f)# <b>ipv6 nd</b> mtu 9000</pre>
Set the OSPF interface priority	<pre>cumulus@switch: ~\$ net add <b>interface</b> <b>ace</b> swp3 ospf6 priority 120</pre>	<pre>switch(config) # <b>int</b> swp3 switch(config-i f)# <b>ip ospf6</b> priority 120</pre>
Configure timing for OSPF SPF calculations	<pre>cumulus@switch: ~\$ net add ospf6 timers throttle spf 40 50 60</pre>	<pre>switch(config) # <b>router ospf6</b> switch(config- ospf6)# <b>timer throttle spf</b> 40 50 60</pre>
Configure the OSPF Hello packet interval in number of seconds for an interface		



Action	NCLU Commands	FRRouting Commands
	<pre>cumulus@switch: ~\$ net add interf ace swp4 ospf6 hello-interval 60</pre>	<pre>switch(config) # int swp4 switch(config-i f)# ipv6 ospf6 hello- interval 60</pre>
Display BGP (see page 773) information	<pre>cumulus@switch: ~\$ net show bgp summary</pre>	<pre>switch# show ip bgp summary</pre>
Display OSPF debugging status	<pre>cumulus@switch: ~\$ net show debugs</pre>	<pre>switch# show debugging ospf</pre>

## Address Resolution Protocol - ARP

Address Resolution Protocol ( ARP ) is a communication protocol used for discovering the link layer address, such as a MAC address , associated with a given network layer address . ARP is defined by [RFC 826](#). The Cumulus Linux ARP implementation differs from standard Debian Linux ARP behavior in a few ways because Cumulus Linux is an operating system for routers/switches rather than servers. This chapter describes the differences in ARP behavior, why the changes were made, where the changes were implemented, and how to change port-specific values.

### Contents

#### This topic describes ...

- Standard Debian ARP Behavior and the Tunable ARP Parameters (see page 749)
- ARP Tunable Parameter Settings in Cumulus Linux (see page 750)
- Change Tunable ARP Parameters (see page 752)
- Change Port-specific ARP Parameters (see page 754)
- Configure Proxy ARP (see page 755)

### Standard Debian ARP Behavior and the Tunable ARP Parameters

Debian has these five tunable ARP parameters:

- arp\_accept



- arp\_announce
- arp\_filter
- arp\_ignore
- arp\_notify

These parameters are described in the [Linux documentation](#), but snippets for each parameter description are included in the table below and are highlighted in *italics*.

In a standard Debian installation, all of these ARP parameters are set to *0*, leaving the router as wide open and unrestricted as possible. These settings are based on the assertion made long ago that Linux IP addresses are a property of the device, not a property of an individual interface. Thus an ARP request or reply could be sent on one interface containing an address residing on a different interface. While this unrestricted behavior makes sense for a server, it is not the normal behavior of a router. Routers expect the MAC/IP address mappings supplied by ARP to match the physical topology, with the IP addresses matching the interfaces on which they reside. With these tunable ARP parameters, Cumulus Linux has been able to specify the behavior to match the expectations of a router.

## ARP Tunable Parameter Settings in Cumulus Linux

The ARP tunable parameters are set to the following values by default in Cumulus Linux. Each parameter is described in detail, including why Cumulus Networks chose the value used.

Parameter	Setting	Type	Description
arp_accept	0	BOOL	<p><i>Define behavior for gratuitous ARP frames whose IP is not already present in the ARP table:</i></p> <p><i>0 - Don't create new entries in the ARP table.</i></p> <p><i>1 - Create new entries in the ARP table.</i></p> <p>Cumulus Linux uses the default <code>arp_accept</code> behavior of not creating new entries in the ARP table when a gratuitous ARP is seen on an interface or when an ARP reply packet is received. However, an individual interface can have the <code>arp_accept</code> behavior set differently than the remainder of the switch if needed. For information on how to apply this port-specific behavior, <a href="#">see below (see page )</a>.</p>
arp_announce	2	INT	<p><i>Define different restriction levels for announcing the local source IP address from IP packets in ARP requests sent on interface:</i></p> <p><i>0 - (default) Use any local address, configured on any interface.</i></p> <p><i>1 - Try to avoid local addresses that are not in the target's subnet for this interface. This mode is useful when target hosts reachable via this interface require the source IP address in ARP requests to be part of their logical network configured on the receiving interface. When we generate the request we will check all our subnets that include the target IP and will preserve the source address if it is from such subnet. If there is no such subnet we select source address according to the rules for level 2.</i></p> <p><i>2 - Always use the best local address for this target. In this mode we ignore the source address in the IP packet and try to select local address that we prefer for talks with the target host. Such local address is selected by looking for primary IP addresses on all our subnets on the outgoing interface that include the target IP address. If no suitable local address is</i></p>



Parameter	Setting	Type	Description
			<p><i>found we select the first local address we have on the outgoing interface or on all other interfaces, with the hope we will receive reply for our request and even sometimes no matter the source IP address we announce.</i></p> <p>The default Debian behavior with <code>arp_announce</code> set to 0 is to send gratuitous ARPs or ARP requests using any local source IP address, not limiting the IP source of the ARP packet to an address residing on the interface used to send the packet. This reflects the historically held view in Linux that IP addresses reside <i>inside</i> the device and are not considered a property of a specific interface.</p> <p>Routers expect a different relationship between the IP address and the physical network. Adjoining routers look for MAC/IP addresses to reach a next-hop residing on a connecting interface for transiting traffic. By setting the <code>arp_announce</code> parameter to 2, Cumulus Linux uses the best local address for each ARP request, preferring primary addresses on the interface used to send the ARP. This most closely matches traditional router ARP request behavior.</p>
arp_filter	0	BOOL	<p><i>0 - (default) The kernel can respond to ARP requests with addresses from other interfaces. This may seem wrong but it usually makes sense, because it increases the chance of successful communication. IP addresses are owned by the complete host on Linux, not by particular interfaces. Only for more complex setups like load-balancing, does this behavior cause problems.</i></p> <p><i>1 - Allows you to have multiple network interfaces on the same subnet, and have the ARPs for each interface be answered based on whether or not the kernel would route a packet from the ARP'd IP address out of that interface (therefore you must use source based routing for this to work). In other words, it allows control of which cards (usually 1) will respond to an ARP request.</i></p> <p><i>arp_filter for the interface will be enabled if at least one of conf/{all, interface}/arp_filter is set to TRUE, it will be disabled otherwise.</i></p> <p>Cumulus Linux uses the default Debian Linux <code>arp_filter</code> setting of 0. The <code>arp_filter</code> is primarily used when multiple interfaces reside in the same subnet and is used to allow/disallow which interfaces respond to ARP requests. In the case of OSPF (see page 756) using IP unnumbered interfaces, many interfaces appear to be in the same subnet, and so actually contain the same address. If multiple interfaces are used between a pair of routers, having <code>arp_filter</code> set to 1 causes forwarding to fail.</p> <p>The <code>arp_filter</code> parameter is set to allow a response on any interface in the subnet, where the <code>arp_ignore</code> setting (below) to limit cross-interface ARP behavior.</p>
arp_ignore	1	INT	<p><i>Define different modes for sending replies in response to received ARP requests that resolve local target IP addresses:</i></p>



Parameter	Setting	Type	Description
			<p>0 - (default) Reply for any local target IP address, configured on any interface.</p> <p>1 - Reply only if the target IP address is local address configured on the incoming interface.</p> <p>2 - Reply only if the target IP address is local address configured on the incoming interface and both with the sender's IP address are part from same subnet on this interface.</p> <p>3 - Do not reply for local addresses configured with scope host, only resolutions for global and link addresses are replied.</p> <p>4-7 - Reserved</p> <p>8 - Do not reply for all local addresses.</p> <p>The maximum value from <code>conf/{all,interface}/arp_ignore</code> is used when the ARP request is received on the {interface}.</p> <p>The default Debian <code>arp_ignore</code> parameter allows the device to reply to an ARP request for any IP address on any interface. While this matches the expectation that an IP address belongs to the device, not an interface, it can cause some unexpected and undesirable behavior on a router.</p> <p>For example, if the <code>arp_ignore</code> parameter were set to 0 and an ARP request is received on one interface for the IP address residing on a different interface, the switch responds with an ARP reply even if the interface of the target address is down. This can cause a loss of traffic due to incorrect understanding about the reachability of next-hops, and also makes troubleshooting extremely challenging for some failure conditions.</p> <p>In Cumulus Linux, the <code>arp_ignore</code> value is set to 1 so that it only replies to ARP requests on the interface that contains the target IP address. This acts much more like a traditional router and provides simplicity in troubleshooting and operation.</p>
arp_notify	1	BOOL	<p>Define mode for notification of address and device changes.</p> <p>0 - (default) Do nothing.</p> <p>1 - Generate gratuitous arp requests when device is brought up or hardware address changes.</p> <p>The default Debian <code>arp_notify</code> setting is to remain silent when an interface is brought up or the hardware address is changed. Since Cumulus Linux often acts as a next-hop for many end hosts, it immediately notifies attached devices when an interface comes up or the address changes. This speeds up convergence on the new information and provides the most rapid support for changes.</p>

## Change Tunable ARP Parameters

You can change the ARP parameter settings in several places, including:



- `/proc/sys/net/ipv4/conf/all/arp*` (all interfaces)
- `/proc/sys/net/ipv4/conf/default/arp*` (default for future interfaces)
- `/proc/sys/net/ipv4/conf/swp*/arp*` (individual interfaces)

The ARP parameter changes in Cumulus Linux use the *default* file locations.

The *all* and *default* locations sound similar, with the exception of which interfaces are impacted, but they operate in significantly different ways. The *all* location can **potentially** change the value for **all** interfaces running IP, both now and in the future. The reason for this uncertainty is that the *all* value is applied to each parameter using either *MAX* or *OR* logic between the *all* and any *port-specific* settings, as the following table shows:

ARP Parameter	Condition
arp_accept	OR
arp_announce	MAX
arp_filter	OR
arp_ignore	MAX
arp_notify	MAX

For example, if the `/proc/sys/net/conf/all/arp_ignore` value is set to `1` and the `/proc/sys/net/conf/swp1/arp_ignore` value is set to `0`, to try to disable it on a per-port basis, interface `swp1` still uses the value of `1` in its operation. While it may appear that the port-specific setting should override the global *all* setting, it does not actually work that way. Instead, the MAX value between the *all* value and port-specific value defines the actual behavior. This lack of simplicity has led Cumulus Networks to implement the ARP parameter changes using the *default* location instead.

The *default* location `/proc/sys/net/ipv4/conf/default/arp*` defines the values for all future IP interfaces. Changing the *default* setting of an ARP parameter does not impact interfaces that already contain an IP address. If changes are being made to a running system that already has IP addresses assigned to it, port-specific settings should be used instead.



The way the *default* setting is implemented in Linux, the value of the *default* parameter is copied to every port-specific location, excluding those that already have an IP address assigned, as previously mentioned. Therefore, there is not any complicated logic between the *default* setting and the *port-specific* setting like there is when using the *all* location. This makes the application of particular port-specific policies much simpler and more deterministic.

To determine the current ARP parameter settings for each of the the locations, use the following mechanism; other methods are available but this one is quite simple:

```
cumulus@switch:~$ sudo grep . /proc/sys/net/ipv4/conf/all/arp*
/proc/sys/net/ipv4/conf/all/arp_accept:0
/proc/sys/net/ipv4/conf/all/arp_announce:0
/proc/sys/net/ipv4/conf/all/arp_filter:0
```



```
/proc/sys/net/ipv4/conf/all/arp_ignore:0  
/proc/sys/net/ipv4/conf/all/arp_notify:0  
  
cumulus@switch:~$ sudo grep . /proc/sys/net/ipv4/conf/default/arp*  
/proc/sys/net/ipv4/conf/default/arp_accept:0  
/proc/sys/net/ipv4/conf/default/arp_announce:2  
/proc/sys/net/ipv4/conf/default/arp_filter:0  
/proc/sys/net/ipv4/conf/default/arp_ignore:1  
/proc/sys/net/ipv4/conf/default/arp_notify:1  
  
cumulus@switch:~$ sudo grep . /proc/sys/net/ipv4/conf/swp1/arp*  
/proc/sys/net/ipv4/conf/swp1/arp_accept:0  
/proc/sys/net/ipv4/conf/swp1/arp_announce:2  
/proc/sys/net/ipv4/conf/swp1/arp_filter:0  
/proc/sys/net/ipv4/conf/swp1/arp_ignore:1  
/proc/sys/net/ipv4/conf/swp1/arp_notify:1  
cumulus@switch:~$
```

Note that Cumulus Linux implements this change at boot time using the `arp.conf` file at the following location:

```
cumulus@switch:~$ cat /etc/sysctl.d/arp.conf  
net.ipv4.conf.default.arp_announce = 2  
net.ipv4.conf.default.arp_notify = 1  
net.ipv4.conf.default.arp_ignore=1  
cumulus@switch:~$
```

## Change Port-specific ARP Parameters

The simplest way to configure port-specific ARP parameters in a running device is with the following command:

```
cumulus@switch:~$ sudo sh -c "echo 0 > /proc/sys/net/ipv4/conf/swp1  
/arp_ignore"  
cumulus@switch:~$ sudo grep . /proc/sys/net/ipv4/conf/swp1/arp*  
/proc/sys/net/ipv4/conf/swp1/arp_accept:0  
/proc/sys/net/ipv4/conf/swp1/arp_announce:2  
/proc/sys/net/ipv4/conf/swp1/arp_filter:0  
/proc/sys/net/ipv4/conf/swp1/arp_ignore:0  
/proc/sys/net/ipv4/conf/swp1/arp_notify:1  
cumulus@switch:~$
```

To make the change persist through reboots, edit the `/etc/sysctl.d/arp.conf` file and add your port-specific ARP setting.



## Configure Proxy ARP

The proxy ARP setting is a kernel setting that you can manipulate using `sysctl` or `sysfs`. Proxy ARP works with IPv4 only, since ARP is an IPv4-only protocol.

You need to set `/proc/sys/net/ipv4/conf/<INTERFACE>/proxy_arp` to 1:

```
cumulus@switch:~$ net add interface swp1 post-up "echo 1 > /proc/sys  
/net/ipv4/conf/swp1/proxy_arp"  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

These commands create the following snippet in the `/etc/network/interfaces` file:

```
auto swp1  
iface swp1  
    post-up echo 1 > /proc/sys/net/ipv4/conf/swp1/proxy_arp
```

If you're running two interfaces in the same broadcast domain, which is typically seen when using [VRR \(see page 474\)](#), as it creates a "-v0" interface in the same broadcast domain, make sure to use `sysctl` or `sysfs` to let the kernel know, so that both interfaces do not respond with proxy ARP replies. To do so, set `/proc/sys/net/ipv4/conf/<INTERFACE>/medium_id` to 2 on both the interface and the -v0 interface. Continuing with the previous example:

```
cumulus@switch:~$ net add interface swp1 post-up "echo 2 > /proc/sys  
/net/ipv4/conf/swp1/medium_id"  
cumulus@switch:~$ net add interface swp1-v0 post-up "echo 1 > /proc  
/sys/net/ipv4/conf/swp1-v0/proxy_arp"  
cumulus@switch:~$ net add interface swp1-v0 post-up "echo 2 > /proc  
/sys/net/ipv4/conf/swp1-v0/medium_id"  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

These commands create the following snippet in the `/etc/network/interfaces` file:

```
auto swp1  
iface swp1  
    post-up echo 1 > /proc/sys/net/ipv4/conf/swp1/proxy_arp  
    post-up echo 2 > /proc/sys/net/ipv4/conf/swp1/medium_id  
  
auto swp1-v0  
iface swp1-v0  
    post-up echo 1 > /proc/sys/net/ipv4/conf/swp1-v0/proxy_arp  
    post-up echo 2 > /proc/sys/net/ipv4/conf/swp1-v0/medium_id
```



If you're running proxy ARP on a VRR interface, add a post-up line to the VRR interface stanza similar to the following. For example, if `vlan100` is the VRR interface for the configuration above:

```
cumulus@switch:~$ net add vlan 100 post-up "echo 1 > /proc/sys/net
/ipv4/conf/swp1/proxy_arp && echo 1 > /proc/sys/net/ipv4/conf/swp1-v0
/proxy_arp && echo 2 > /proc/sys/net/ipv4/conf/swp1/medium_id && echo
2 > /proc/sys/net/ipv4/conf/swp1-v0/medium_id"
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

## Open Shortest Path First - OSPF

OSPF maintains the view of the network topology conceptually as a directed graph. Each router represents a vertex in the graph. Each link between neighboring routers represents a unidirectional edge and each link has an associated weight (called cost) that is either automatically derived from its bandwidth or administratively assigned. Using the weighted topology graph, each router computes a shortest path tree (SPT) with itself as the root, and applies the results to build its forwarding table. The computation is generally referred to as *SPF computation* and the resultant tree as the *SPF tree*.

An LSA (*link-state advertisement*) is the fundamental quantum of information that OSPF routers exchange with each other. It seeds the graph building process on the node and triggers SPF computation. LSAs originated by a node are distributed to all the other nodes in the network through a mechanism called *flooding*. Flooding is done hop-by-hop. OSPF ensures reliability by using link state acknowledgement packets. The set of LSAs in a router's memory is termed *link-state database* (LSDB), a representation of the network graph. Therefore, OSPF ensures a consistent view of LSDB on each node in the network in a distributed fashion (eventual consistency model); this is key to the protocol's correctness.

This topic describes OSPFv2, which is a [link-state routing protocol](#) for IPv4. For IPv6 commands, refer to [Open Shortest Path First v3 - OSPFv3](#) (see page 770)

## Contents

### This topic describes ...

- Scalability and Areas (see page 757)
- Configure OSPFv2 (see page 757)
  - Enable the OSPF and Zebra Daemons (see page 757)
  - Configure OSPF (see page 758)
  - Define Custom OSPF Parameters on the Interfaces (see page 759)
  - OSPF SPF Timer Defaults (see page 759)
  - Configure MD5 Authentication for OSPF Neighbors (see page 759)
- Scaling Tips (see page 760)
  - Summarization (see page 760)
  - Stub Areas (see page 761)
  - Multiple ospfd Instances (see page 762)
  - Auto-cost Reference Bandwidth (see page 766)
- Unnumbered Interfaces (see page 767)

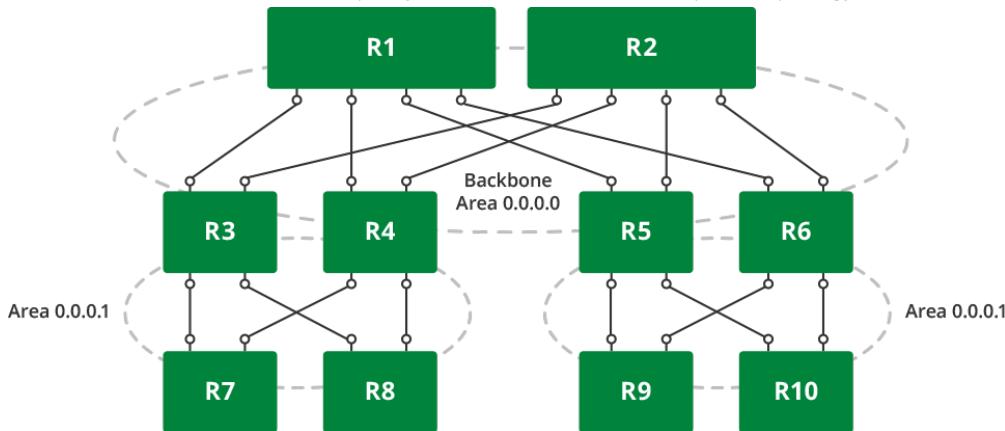
- Apply a Route Map for Route Updates (see page 768)
- ECMP (see page 768)
- Topology Changes and OSPF Reconvergence (see page 768)
- Troubleshooting (see page 769)
- Related Information (see page 769)

## Scalability and Areas

An increase in the number of nodes affects:

- Memory footprint to hold the entire network topology
- Flooding performance
- SPF computation efficiency

The OSPF protocol advocates hierarchy as a *divide and conquer* approach to achieve high scale. You can divide the topology into areas, resulting in a two-level hierarchy. Area 0 (or 0.0.0.0), called the backbone area, is the top level of the hierarchy. Packets traveling from one non-zero area to another must go through the backbone area. For example, you can divide the leaf-spine topology into the following areas:



- Routers R3, R4, R5, R6 are *area border routers* (ABRs). These routers have links to multiple areas and perform a set of specialized tasks, such as SPF computation per area and summarization of routes across areas.
- Most of the LSAs have an area-level flooding scope. These include router LSA, network LSA, and summary LSA.
- Where ABRs do not connect to multiple non-zero areas, you can use the same area address.

## Configure OSPFv2

To configure OSPF, you need to:

- Enable the OSPF daemon
- Configure OSPF
- Define custom OSPF parameters on the interfaces



## Enable the OSPF and Zebra Daemons

To enable OSPF, enable the `zebra` and `ospf` daemons, as described in [Configuring FRRouting \(see page 737\)](#), then start the FRRouting service:

```
cumulus@switch:~$ sudo systemctl enable frr.service
cumulus@switch:~$ sudo systemctl start frr.service
```

## Configure OSPF

Before you configure OSPF, you need to identify:

- Which router has the router ID
- With which device the router communicates
- What information to advertise (the prefix reachability)

To configure OSPF, specify the router ID, an IP subnet prefix, and an area address. All the interfaces on the router whose IP address matches the `network` subnet are put into the specified area. The OSPF process starts bringing up peering adjacency on those interfaces. It also advertises the interface IP addresses formatted into LSAs (of various types) to the neighbors for proper reachability.

The subnets can be as coarse as possible to cover the most number of interfaces on the router that should run OSPF.

```
cumulus@switch:~$ net add ospf router-id 0.0.0.1
cumulus@switch:~$ net add ospf network 10.0.0.0/16 area 0.0.0.0
cumulus@switch:~$ net add ospf network 192.0.2.0/16 area 0.0.0.1
```



You can configure OSPF per interface instead of using the `net add ospf network` command. However, you cannot use both configuration methods at the same time. Here is an example of configuring OSPF per interface:

```
cumulus@switch:~$ net add interface swp1 ospf area 0.0.0.0
```

There may be interfaces where it is undesirable to bring up OSPF adjacency. For example, in a data center topology, the host-facing interfaces do not need to run OSPF; however the corresponding IP addresses still need to be advertised to neighbors. In this scenario, you can use the `passive-interface` option.

```
cumulus@switch:~$ net add ospf passive-interface swp10
cumulus@switch:~$ net add ospf passive-interface swp11
```

As an alternative, you can use the `passive-interface default` command to put all interfaces as passive and selectively remove certain interfaces:



```
R3# configure terminal  
R3(config)# router ospf  
R3(config-router)# passive-interface default  
R3(config-router)# no passive-interface swp1
```

To specify what information to advertise (the prefix reachability), you can use the redistribution method. Redistribution loads the database unnecessarily with type-5 LSAs. Only use this method to generate real external prefixes (for example, prefixes learned from BGP). Generate local prefixes using `network` and/or `passive-interface` statements.

```
cumulus@switch:~$ net add ospf redistribute connected
```

### *Define Custom OSPF Parameters on the Interfaces*

You can define additional custom parameters for OSPF, such as the network type (point-to-point or broadcast) and the timer tuning, such as a hello interval.

```
cumulus@switch:~$ net add interface swp1 ospf network point-to-point  
cumulus@switch:~$ net add interface swp1 ospf hello-interval 5
```

The OSPF configuration is saved in the `/etc/frr/frr.conf` file.

### *OSPF SPF Timer Defaults*

OSPF uses the following timers to prevent consecutive SPFs from overburdening the CPU:

- 0 ms from initial event until SPF runs
- 50 ms between consecutive SPF runs (the number doubles with each SPF, until it reaches the value of C)
- 5000 ms maximum between SPFs

### *Configure MD5 Authentication for OSPF Neighbors*

Simple text passwords have largely been deprecated in FRRouting, in favor of MD5 hash authentication.

To configure MD5 authentication:

1. Create a key and a key ID for MD5 with the `net add interface <interface> ospf message-digest-key <KEYID> md5 <KEY>` command.  
`KEYID` is a value between 1 and 255 that represents the key used to create the message digest. This value must be consistent across all routers on a link.  
`KEY` is a value that has an upper range of 16 characters (longer strings are truncated) and represents the actual message digest key that is associated with the given `KEYID`.  
The following example command creates key ID 1 with the message digest key `thisisthekey`:

```
cumulus@switch:~$ net add interface swp1 ospf message-digest-key  
1 md5 thisisthekey
```



You can remove existing MD5 authentication hashes with the `net del interface <interface> ospf message-digest-key <KEYID> md5 <KEY>` command.

2. Enable authorization with the `net add interface <interface> ospf authentication message-digest` command.

```
cumulus@switch:~$ net add interface swp1 ospf authentication
message-digest
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands creates the following configuration in the `/etc/frr/frr.conf` file:

```
cumulus@switch:~$ sudo cat /etc/frr/frr.conf
...
interface swp1
  ip ospf area 0.0.0.0
  ip ospf authentication message-digest
  ip ospf message-digest-key 1 md5 thisisthekey
  ip ospf network point-to-point
  ...
  ...
```

## Scaling Tips

Here are some tips for how to scale out OSPF.

### *Summarization*

By default, an ABR creates a summary (type-3) LSA for each route in an area and advertises it in adjacent areas. Prefix range configuration optimizes this behavior by creating and advertising one summary LSA for multiple routes.

To configure a range:

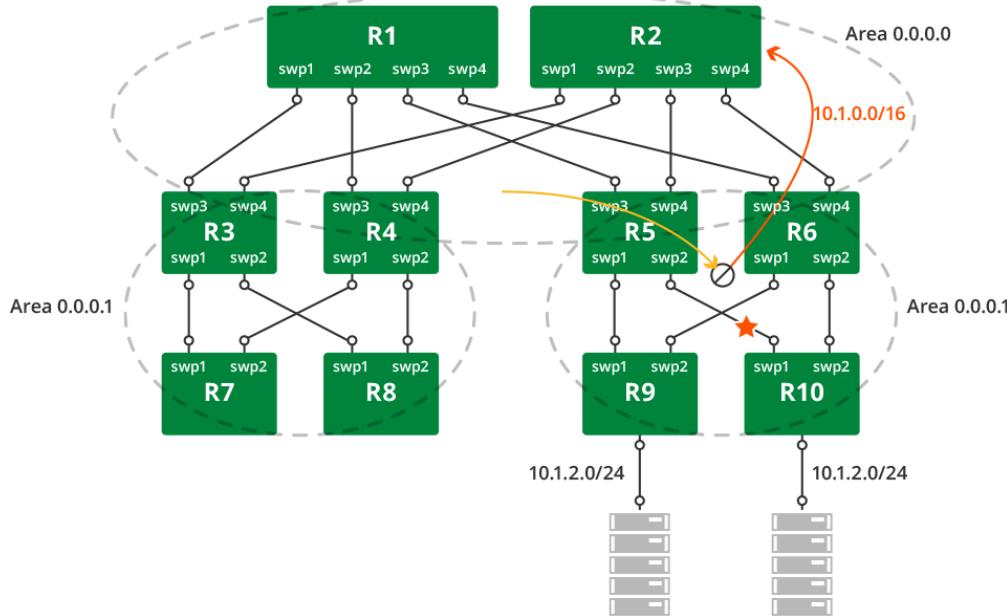
```
cumulus@switch:~$ sudo vtysh
switch# configure terminal
switch(config)# router ospf
switch(config-router)# area 0.0.0.1 range 30.0.0.0/8
switch(config-router)# exit
switch(config)# exit
switch# write mem
switch# exit
cumulus@switch:~$
```



Summarize in the direction to the backbone. The backbone receives summarized routes and injects them to other areas already summarized.



Summarization can cause non-optimal forwarding of packets during failures. Here is an example scenario:



As shown in the diagram, the ABRs in the right non-zero area summarize the host prefixes as 10.1.0.0/16. When the link between R5 and R10 fails, R5 will send a worse metric for the summary route (metric for the summary route is the maximum of the metrics of intra-area routes that are covered by the summary route). Upon failure of the R5-R10 link, the metric for 10.1.2.0/24 goes higher at R5 as the path is R5-R9-R6-R10). As a result, other backbone routers shift traffic destined to 10.1.0.0/16 towards R6. This breaks ECMP and is an under-utilization of network capacity for traffic destined to 10.1.1.0/24.

## Stub Areas

Nodes in an area receive and store intra-area routing information and summarized information about other areas from the ABRs. In particular, a good summarization practice about inter-area routes through prefix range configuration helps scale the routers and keeps the network stable.

Then there are external routes. External routes are the routes redistributed into OSPF from another protocol. They have an AS-wide flooding scope. In many cases, external link states make up a large percentage of the LSDB.

*Stub areas* alleviate this scaling problem. A stub area is an area that does not receive external route advertisements.

To configure a stub area:

```
cumulus@switch:~$ net add ospf area 0.0.0.1 stub
```



Stub areas still receive information about networks that belong to other areas of the same OSPF domain. Especially, if summarization is not configured (or is not comprehensive), the information can be overwhelming for the nodes. *Totally stubby areas* address this issue. Routers in totally stubby areas keep in their LSDB information about routing within their area, plus the default route.

To configure a totally stubby area:

```
cumulus@switch:~$ net add ospf area 0.0.0.1 stub no-summary
```

Here is a brief tabular summary of the area type differences:

Type	Behavior
Normal non- zero area	LSA types 1, 2, 3, 4 area-scoped, type 5 externals, inter-area routes summarized
Stub area	LSA types 1, 2, 3, 4 area-scoped, No type 5 externals, inter-area routes summarized
Totally stubby area	LSA types 1, 2 area-scoped, default summary, No type 3, 4, 5 LSA types allowed

### Multiple `ospfd` Instances

The `ospfd` daemon can have multiple independent processes.



- Multiple `ospfd` processes are only supported in the default VRF.
- You can run multiple `ospfd` instances with OSPFv2 only.
- FRRouting supports up to five instances and the instance ID must be a value between 1 and 65535.

To configure multi-instance OSPF:

1. Edit `/etc/frr/daemons` and add `ospfd_instances="instance1 instance2 ..."` to the `ospfd` line, specifying an instance ID for each separate instance. For example, the following configuration has OSPF enabled with 2 `ospfd` instances, 11 and 22:

```
cumulus@switch:~$ cat /etc/frr/daemons
zebra=yes
bgpd=no
ospfd=yes ospfd_instances="11 22"
ospf6d=no
ripd=no
ripngd=no
isisd=no
```

2. After you modify the `daemons` file, restart FRRouting:



```
cumulus@switch:~$ sudo systemctl restart frr.service
```

3. Configure each instance:

```
cumulus@switch:~$ net add interface swp1 ospf instance-id 11
cumulus@switch:~$ net add interface swp1 ospf area 0.0.0.0
cumulus@switch:~$ net add ospf router-id 1.1.1.1
cumulus@switch:~$ net add interface swp2 ospf instance-id 22
cumulus@switch:~$ net add interface swp2 ospf area 0.0.0.0
cumulus@switch:~$ net add ospf router-id 1.1.1.1
```

4. Confirm the configuration:

```
cumulus@switch:~$ net show configuration ospf

hostname zebra
log file /var/log/frr/zebra.log
username cumulus nopassword

service integrated-vtysh-config

interface eth0
    ipv6 nd suppress-ra
    link-detect

interface lo
    link-detect

interface swp1
    ip ospf 11 area 0.0.0.0
    link-detect

interface swp2
    ip ospf 22 area 0.0.0.0
    link-detect

interface swp45
    link-detect

interface swp46
    link-detect

interface swp47
    link-detect

interface swp48
    link-detect
```



```
interface swp49
link-detect

interface swp50
link-detect

interface swp51
link-detect

interface swp52
link-detect

interface vagrant
link-detect

router ospf 11
ospf router-id 1.1.1.1

router ospf 22
ospf router-id 1.1.1.1

ip forwarding
ipv6 forwarding

line vty

end
```

5. Confirm that all the OSPF instances are running:

```
cumulus@switch:~$ ps -ax | grep ospf
21135 ? Sss 0:00 /usr/lib/frr/ospfd --daemon -A
127.0.0.1 -n 11
21139 ? Sss 0:00 /usr/lib/frr/ospfd --daemon -A
127.0.0.1 -n 22
21160 ? Sss 0:01 /usr/lib/frr/watchfrr -adz -r /usr
/sbin/servicebBfrrrbBrestartbB%s -s /usr/sbin
/servicebBquaggabBstartbB%s -k /usr/sbin/servicebBfrrrbBstopbB%s -
b bB -t 30 zebra ospfd-11 ospfd-22 pimd
22021 pts/3 S+ 0:00 grep ospf
```

### Caveats

You can use the `redistribute ospf` option in your `frr.conf` file works with this so you can route between the instances. Specify the instance ID for the other OSPF instance. For example:

```
cumulus@switch:~$ cat /etc/frr/frr.conf
```



```
hostname zebra
log file /var/log/frr/zebra.log
username cumulus nopassword
!
service integrated-vtysh-config
!

...
!

router ospf 11
  ospf router-id 1.1.1.1
!
router ospf 22
  ospf router-id 1.1.1.1
  redistribute ospf 11
!
...
...
```



Don't specify a process ID unless you are using multi-instance OSPF.



If you disabled the [integrated \(see page 738\)](#) FRRouting configuration, you must create a separate `ospfd` configuration file for each instance. The `ospfd.conf` file must include the instance ID in the file name. Continuing with our example, you would create `/etc/frr/ospfd-11.conf` and `/etc/frr/ospfd-22.conf`.

```
cumulus@switch:~$ cat /etc/frr/ospfd-11.conf
!
hostname zebra
log file /var/log/frr/zebra.log
username cumulus nopassword
!
service integrated-vtysh-config
!
interface eth0
  ipv6 nd suppress-ra
  link-detect
!
interface lo
  link-detect
!
interface swp1
  ip ospf 11 area 0.0.0.0
  link-detect
!
interface swp2
```

```

ip ospf 22 area 0.0.0.0
link-detect
!
interface swp45
link-detect
!
interface swp46
link-detect
!
interface swp47
link-detect
!
interface swp48
link-detect
!
interface swp49
link-detect
!
interface swp50
link-detect
!
interface swp51
link-detect
!
interface swp52
link-detect
!
interface vagrant
link-detect
!
router ospf 11
ospf router-id 1.1.1.1
!
router ospf 22
ospf router-id 1.1.1.1
!
ip forwarding
ipv6 forwarding
!
line vty
!
```

### *Auto-cost Reference Bandwidth*

*Auto-cost reference bandwidth* provides the ability to dynamically calculate the OSPF interface cost to cater for higher speed links. You specify the bandwidth in Mbps and this value is used to calculate the link speed. The default value is 100000, for 100Gbps link speed. The cost of interfaces with link speeds lower than 100Gbps is higher.

- ✓ It is a good idea to specify that the bandwidth setting should be a consistent value across all OSPF routers; otherwise routing loops can occur.

To configure the auto-cost reference bandwidth for 90Gbps, run the following commands:

```
cumulus@switch:~$ net add ospf auto-cost reference-bandwidth 90000  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

These commands create the following configuration in the `/etc/frr/frr.conf` file:

```
cumulus@switch:~$ cat /etc/frr/frr.conf  
...  
router ospf  
auto-cost reference-bandwidth 90000  
...
```

## Unnumbered Interfaces

Unnumbered interfaces are interfaces without unique IP addresses. In OSPFv2, configuring unnumbered interfaces reduces the links between routers into pure topological elements, which dramatically simplifies network configuration and reconfiguration. In addition, the routing database contains only the real networks, so the memory footprint is reduced and SPF is faster.



Unnumbered is usable for point-to-point interfaces only.



If there is a `network <network number>/<mask> area <area ID>` command present in the FRRouting configuration, the `ip ospf area <area ID>` command is rejected with the error "Please remove network command first." This prevents you from configuring other areas on some of the unnumbered interfaces. You can use either the `network area` command or the `ospf area` command in the configuration, but not both.



Unless the Ethernet media is intended to be used as a LAN with multiple connected routers, we recommend configuring the interface as point-to-point. It has the additional advantage of a simplified adjacency state machine; there is no need for DR/BDR election and *LSA reflection*. See [RFC5309](#) for a more detailed discussion.

To configure an unnumbered interface, take the IP address of another interface (called the *anchor*) and use that as the IP address of the unnumbered interface:

```
cumulus@switch:~$ net add loopback lo ip address 192.0.2.1/32
cumulus@switch:~$ net add interface swp1 ip address 192.0.2.1/32
cumulus@switch:~$ net add interface swp2 ip address 192.0.2.1/32
```

These commands create the following configuration in the `/etc/network/interfaces` file:

```
auto lo
iface lo inet loopback
    address 192.0.2.1/32

auto swp1
iface swp1
    address 192.0.2.1/32

auto swp2
iface swp2
    address 192.0.2.1/32
```

To enable OSPF on an unnumbered interface:

```
cumulus@switch:~$ net add interface swp1 ospf area 0.0.0.1
```

## Apply a Route Map for Route Updates

To apply a [route map](#) to filter route updates from Zebra into the Linux kernel:

```
cumulus@switch:$ net add routing protocol ospf route-map <route-map-name>
```

## ECMP

During SPF computation for an area, if OSPF finds multiple paths with equal cost (metric), all those paths are used for forwarding. For example, in the reference topology diagram, R8 uses both R3 and R4 as next hops to reach a destination attached to R9.

## Topology Changes and OSPF Reconvergence

Topology changes usually occur due to one of four events:

1. Maintenance of a router node
2. Maintenance of a link
3. Failure of a router node
4. Failure of a link



For the maintenance events, operators typically raise the OSPF administrative weight of the link(s) to ensure that all traffic is diverted from the link or the node (referred to as *costing out*). The speed of reconvergence does not matter. Indeed, changing the OSPF cost causes LSAs to be reissued, but the links remain in service during the SPF computation process of all routers in the network.

For the failure events, traffic may be lost during reconvergence; that is, until SPF on all nodes computes an alternative path around the failed link or node to each of the destinations. The reconvergence depends on layer 1 failure detection capabilities and at the worst case *DeadInterval* OSPF timer.

#### Example configuration for event 1, using vtysh:

```
cumulus@switch:~$ sudo vtysh
switch# configure terminal
switch(config)# router ospf
switch(config-router)# max-metric router-lsa administrative
switch(config-router)# exit
switch(config)# exit
switch# write mem
switch# exit
cumulus@switch:~$
```

#### Example configuration for event 2:

```
cumulus@switch:~$ net add interface swp1 ospf cost 65535
```

## Troubleshooting

- To debug neighbor states, run the `net show ospf neighbor` command.
- To capture OSPF packets, run the `sudo tcpdump -v -i swp1 ip proto ospf` command.
- To verify that the LSDB is synchronized across all routers in the network, run the `net show ospf database` command.
- To debug why an OSPF route is not being forwarded correctly, run the `net show route ospf` command. This command shows the outcome of the SPF computation downloaded to the forwarding table.

[Debugging-OSPF](#) lists all of the OSPF debug options.

## Related Information

- Bidirectional forwarding detection (see page 821) (BFD) and OSPF
- [en.wikipedia.org/wiki/Open\\_Shortest\\_Path\\_First](https://en.wikipedia.org/wiki/Open_Shortest_Path_First)
- [FRR OSPFv2](#)
- Perlman, Radia (1999). Interconnections: Bridges, Routers, Switches, and Internetworking Protocols (2 ed.). Addison-Wesley.
- Moy, John T. OSPF: Anatomy of an Internet Routing Protocol. Addison-Wesley.
- [RFC 2328 OSPFv2](#)
- [RFC 3101 OSPFv2 Not-So-Stubby Area \(NSSA\)](#)

## Open Shortest Path First v3 - OSPFv3

OSPFv3 is a revised version of OSPFv2 to support the IPv6 address family. Refer to [Open Shortest Path First \(OSPF\) Protocol \(see page 756\)](#) for a discussion on the basic concepts, which remain the same between the two versions.

OSPFv3 has changed the formatting in some of the packets and LSAs either as a necessity to support IPv6 or to improve the protocol behavior based on OSPFv2 experience. Most notably, v3 defines a new LSA, called intra-area prefix LSA to separate out the advertisement of stub networks attached to a router from the router LSA. It is a clear separation of node topology from prefix reachability and lends itself well to an optimized SPF computation.



IETF has defined extensions to OSPFv3 to support multiple address families (that is, both IPv6 and IPv4). [FRR \(see page 731\)](#) does not support it yet.

## Contents

This topic describes ...

- Configure OSPFv3 ([see page 770](#))
- Configure the OSPFv3 Area ([see page 771](#))
- Configure the OSPFv3 Distance ([see page 771](#))
- Configure OSPFv3 Interfaces ([see page 772](#))
- Troubleshooting ([see page 773](#))
- Related Information ([see page 773](#))

## Configure OSPFv3

Configuring OSPFv3 involves the following tasks:

1. Enabling the `zebra` and `ospf6` daemons, as described in [Configuring FRRouting \(see page 737\)](#) then start the FRRouting service:

```
cumulus@switch:~$ sudo systemctl enable frr.service
cumulus@switch:~$ sudo systemctl start frr.service
```

2. Enabling OSPFv3 and map interfaces to areas:

```
cumulus@switch:~$ net add ospf6 router-id 0.0.0.1
cumulus@switch:~$ net add ospf6 interface swp1 area 0.0.0.0
cumulus@switch:~$ net add ospf6 interface swp2 area 0.0.0.1
```

3. Defining (custom) OSPFv3 parameters on the interfaces, such as:

- a. Network type (such as point-to-point, broadcast)



- b. Timer tuning (for example, hello interval)

```
cumulus@switch:~$ net add interface swp1 ospf6 network point-to-point
cumulus@switch:~$ net add interface swp1 ospf6 hello-interval 5
```

The OSPFv3 configuration is saved in `/etc/frr/frr.conf`.



Unlike OSPFv2, OSPFv3 intrinsically supports unnumbered interfaces. Forwarding to the next hop router is done entirely using IPv6 link local addresses. Therefore, you are not required to configure any global IPv6 address to interfaces between routers.

## Configure the OSPFv3 Area

Different areas can be used to control routing. You can:

- Limit an OSPFv3 area from reaching another area
- Manage the size of the routing table by creating a summary route for all the routes in a particular address range.

The following example command removes the `3:3::/64` route from the routing table. Without a route in the table, any destinations in that network are not reachable.

```
cumulus@switch:~$ net add ospf6 area 0.0.0.0 range 3:3::/64 not-advertise
```

The following example command creates a summary route for all the routes in the range `2001::/64`:

```
cumulus@switch:~$ net add ospf6 area 0.0.0.0 range 2001::/64 advertise
```

You can also configure the cost for a summary route, which is used to determine the shortest paths to the destination. For example:

```
cumulus@switch:~$ net add ospf6 area 0.0.0.0 range 11.1.1.1/24 cost 16
0
```

The value for cost must be between 0 and 16777215.

## Configure the OSPFv3 Distance

Cumulus Linux provides several commands to change the administrative distance for OSPF routes.

This example command sets the distance for an entire group of routes, rather than a specific route.

```
cumulus@switch:~$ net add ospf6 distance 254
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

This example command changes the OSPF administrative distance to 150 for internal routes and 220 for external routes:

```
cumulus@switch:~$ net add ospf6 distance ospf6 intra-area 150 inter-
area 150 external 220
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

This example command changes the OSPF administrative distance to 150 for internal routes:

```
cumulus@switch:~$ net add ospf6 distance ospf6 intra-area 150 inter-
area 150
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

This example command changes the OSPF administrative distance to 220 for external routes:

```
cumulus@switch:~$ net add ospf6 distance ospf6 external 220
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

This example command changes the OSPF administrative distance to 150 for internal routes to a subnet or network inside the same area as the router:

```
cumulus@switch:~$ net add ospf6 distance ospf6 intra-area 150
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

This example command changes the OSPF administrative distance to 150 for internal routes to a subnet in an area of which the router is *not* a part:

```
cumulus@switch:~$ net add ospf6 distance ospf6 inter-area 150
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

## Configure OSPFv3 Interfaces

You can configure an interface, a bond interface, or a VLAN with an advertise prefix list.

The following example command configures interface swp3s1 with the IPv6 OSPF6 advertise prefix-list 192.168.0.0/24:



```
cumulus@switch:~$ net add interface swp3s1 ospf6 advertise prefix-list 192.168.0.0/24
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

You can also configure the cost for a particular interface, bond interface, or VLAN. The following example command configures the cost for the bond interface swp2.

```
cumulus@switch:~$ net add bond swp2 ospf6 cost 1
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

## Troubleshooting

See [Debugging OSPF \(see page 769\)](#) for OSPFv2 for the troubleshooting discussion. The equivalent commands are:

```
cumulus@switch:~$ net show ospf6 neighbor [detail|drchoice]
cumulus@switch:~$ net show ospf6 database [adv-router|detail|dump|internal|linkstate-id|self-originated]
cumulus@switch:~$ net show route ospf6
```

Another helpful command is `net show ospf6 spf tree`. It dumps the node topology as computed by SPF to help visualize the network view.

## Related Information

- Bidirectional forwarding detection ([see page 821](#)) (BFD) and OSPF
- [en.wikipedia.org/wiki/Open\\_Shortest\\_Path\\_First](https://en.wikipedia.org/wiki/Open_Shortest_Path_First)
- FRR OSPFv3
- RFC 2740 OSPFv3 OSPF for IPv6
- Auto-cost reference bandwidth ([see page 766](#)) (OSPFv2 chapter)

## Border Gateway Protocol - BGP

BGP is the routing protocol that runs the Internet. It is an increasingly popular protocol for use in the data center as it lends itself well to the rich interconnections in a Clos topology. Specifically, BGP:

- Does not require the routing state to be periodically refreshed, unlike OSPF.
- Is less chatty than its link-state siblings. For example, a link or node transition can result in a bestpath change, causing BGP to send updates.
- Is multi-protocol and extensible.
- Has many robust vendor implementations.
- Is very mature as a protocol and comes with many years of operational experience.



RFC 7938 provides further details of the use of BGP within the data center.

## Contents

This topic describes ...

- Autonomous System Number (ASN) (see page 775)
- eBGP and iBGP (see page 775)
- Route Reflectors (see page 775)
- ECMP with BGP (see page 777)
  - Maximum Paths (see page 777)
  - BGP for Both IPv4 and IPv6 (see page 777)
- Configure BGP (see page 777)
- BGP Unnumbered Interfaces (see page 779)
  - BGP and Extended Next Hop Encoding (see page 779)
  - Configure BGP Unnumbered Interfaces (see page 779)
  - Manage Unnumbered Interfaces (see page 780)
  - How traceroute Interacts with BGP Unnumbered Interfaces (see page 782)
  - Advanced: How Next Hop Fields Are Set (see page 782)
  - Limitations (see page 784)
- RFC 5549 Support with Global IPv6 Peers (Cumulus Linux 3.7.2 and later) (see page 784)
  - Configure RFC 5549 Support with Global IPv6 Peers (see page 784)
  - Show IPv4 Prefixes Learned with IPv6 Next Hops (see page 785)
- BGP add-path (see page 789)
  - BGP add-path RX (see page 789)
  - BGP add-path TX (see page 791)
- Fast Convergence Design Considerations (see page 793)
- Peer Groups to Simplify Configuration (see page 794)
- Configure BGP Dynamic Neighbors (see page 794)
- Configure BGP Peering Relationships across Switches (see page 795)
- Configure MD5-enabled BGP Neighbors (see page 797)
- Configure eBGP Multihop (see page 800)
- Configure BGP TTL Security (see page 801)
- Configure Graceful BGP Shutdown (see page 803)
- Configuration Tips (see page 804)
  - BGP Advertisement Best Practices (see page 804)
  - Multiple Routing Tables and Forwarding (see page 804)
  - BGP Community Lists (see page 805)
  - Additional Default Settings (see page 805)
  - Configure BGP Neighbor maximum-prefixes (see page 805)



- Troubleshooting (see page 806)
  - Log Neighbor State Changes (see page 808)
  - Troubleshoot Link-local Addresses (see page 809)
- Enable Read-only Mode (see page 811)
- Apply a Route Map for Route Updates (see page 812)
  - Filter Routes from BGP into Zebra (see page 812)
  - Filter Routes from Zebra into the Linux Kernel (see page 812)
- Protocol Tuning (see page 812)
  - Converge Quickly On Link Failures (see page 812)
  - Converge Quickly On Soft Failures (see page 813)
  - Reconnect Quickly (see page 813)
  - Advertisement Interval (see page 814)
- Caveats and Errata (see page 815)
  - ttl-security Issue (see page 815)
  - BGP Dynamic Capabilities not Supported (see page 815)
  - Related Information (see page 815)

## Autonomous System Number (ASN)

One of the key concepts in BGP is an *autonomous system number* or ASN. An [autonomous system](#) is defined as a set of routers under a common administration. Because BGP was originally designed to peer between independently managed enterprises and/or service providers, each such enterprise is treated as an autonomous system, responsible for a set of network addresses. Each such autonomous system is given a unique number called its ASN. ASNs are handed out by a central authority (ICANN). However, ASNs between 64512 and 65535 are reserved for private use. Using BGP within the data center relies on either using this number space or using the single ASN you own.

The ASN is central to how BGP builds a forwarding topology. A BGP route advertisement carries with it not only the originator's ASN, but also the list of ASNs that this route advertisement has passed through. When forwarding a route advertisement, a BGP speaker adds itself to this list. This list of ASNs is called the *AS path*. BGP uses the AS path to detect and avoid loops.

ASNs were originally 16-bit numbers, but were later modified to be 32-bit. FRRouting supports both 16-bit and 32-bit ASNs, but most implementations still run with 16-bit ASNs.

## eBGP and iBGP

When BGP is used to peer between autonomous systems, the peering is referred to as *external BGP* or eBGP. When BGP is used within an autonomous system, the peering used is referred to as *internal BGP* or iBGP. eBGP peers have different ASNs while iBGP peers have the same ASN.

The heart of the protocol is the same when used as eBGP or iBGP, however, there is a key difference in the protocol behavior between use as eBGP and iBGP: an iBGP speaker does not forward routing information learned from one iBGP peer to another iBGP peer to prevent loops. eBGP prevents loops using the *AS\_Path* attribute.

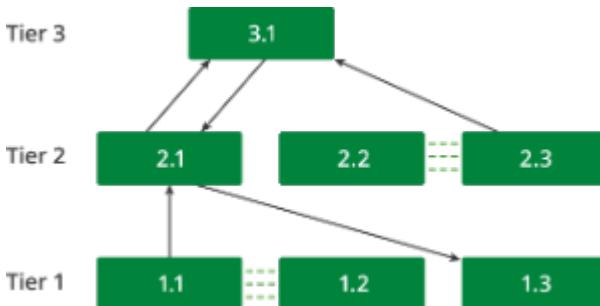
All iBGP speakers need to be peered with each other in a full mesh. In a large network, this requirement can quickly become unscalable. The most popular method to scale iBGP networks is to introduce a *route reflector*.

## Route Reflectors

In a two-tier Clos network, the leaf (or tier 1) switches are the only ones connected to end stations. The spines themselves do not have any routes to announce; they are merely **reflecting** the routes announced by one leaf to the other leaves. Therefore, the spine switches function as route reflectors while the leaf switches serve as route reflector clients.

In a three-tier network, the tier 2 nodes (or mid-tier spines) act as both route reflector servers and route reflector clients. They act as route reflectors because they announce the routes learned from the tier 1 nodes to other tier 1 nodes and to tier 3 nodes. They also act as route reflector clients to the tier 3 nodes, receiving routes learned from other tier 2 nodes. Tier 3 nodes act only as route reflectors.

In the following illustration, tier 2 node 2.1 is acting as a route reflector server, announcing the routes between tier 1 nodes 1.1 and 1.2 to tier 1 node 1.3. It is also a route reflector client, learning the routes between tier 2 nodes 2.2 and 2.3 from the tier 3 node, 3.1.



### Configuring route-reflector-client Requires Specific Order

When configuring a router to be a route reflector client, you must specify the FRRouting configuration in a specific order; otherwise, the router will not be a route reflector client.

You must run the `net add bgp neighbor <IPv4/IPv6> route-reflector-client` command after the `net add bgp neighbor <IPv4/IPv6> activate` command; otherwise, the `route-reflector-client` command is ignored. For example:

```

cumulus@switch:~$ net add bgp ipv4 unicast neighbor 14.0.0.9
activate
cumulus@switch:~$ net add bgp neighbor 14.0.0.9 next-hop-self
cumulus@switch:~$ net add bgp neighbor 14.0.0.9 route-
reflector-client >>> Must be after activate
cumulus@switch:~$ net add bgp neighbor 2001:ded:beef:2::1
remote-as 65000
cumulus@switch:~$ net add bgp ipv6 unicast redistribute
connected
cumulus@switch:~$ net add bgp maximum-paths ibgp 4
cumulus@switch:~$ net add bgp neighbor 2001:ded:beef:2::1
activate
cumulus@switch:~$ net add bgp neighbor 2001:ded:beef:2::1 next-
hop-self
cumulus@switch:~$ net add bgp neighbor 2001:ded:beef:2::1
route-reflector-client >>> Must be after activate

```



A **cluster consists of route reflectors (RRs) and their clients** and is used in iBGP environments where multiple sets of route reflectors and their clients are configured. Configuring a unique ID per cluster (on the route reflector server and clients) prevents looping as a route reflector does not accept routes from another that has the same cluster ID. Additionally, because all route reflectors in the cluster recognize updates from peers in the same cluster, they do not install routes from a route reflector in the same cluster; this reduces the number of updates that need to be stored in BGP routing tables.

To configure a cluster ID on a route reflector, run the `net add bgp cluster-id (<ipv4>|<1-4294967295>)` command. You can enter the cluster ID as an IP address or as a 32-bit quantity.

The following example configures a cluster ID on a route reflector in IP address format:

```
cumulus@switch:~$ net add bgp cluster-id 14.0.0.9
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

The following example configures a cluster ID on a route reflector as a 32-bit quantity:

```
cumulus@switch:~$ net add bgp cluster-id 321
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

## ECMPwith BGP

If a BGP node hears a prefix **p** from multiple peers, it has all the information necessary to program the routing table to forward traffic for that prefix **p** through all of these peers; BGP supports equal-cost multipathing (ECMP).

To perform ECMP in BGP, you may need to configure `net add bgp bestpath as-path multipath-relax` (if you are using eBGP).

### Maximum Paths

In Cumulus Linux, the BGP `maximum-paths` setting is enabled by default, so multiple routes are already installed. The default setting is 64 paths.

### BGP for Both IPv4 and IPv6

Unlike OSPF, which has separate versions of the protocol to announce IPv4 and IPv6 routes, BGP is a multi-protocol routing engine, capable of announcing both IPv4 and IPv6 prefixes. It supports announcing IPv4 prefixes over an IPv4 session and IPv6 prefixes over an IPv6 session. It also supports announcing prefixes of both these address families over a single IPv4 session or over a single IPv6 session.

## Configure BGP

The following example shows a basic BGP configuration. The rest of this chapter discusses how to configure other BGP features, such as unnumbered interfaces to route maps.

1. Enable the BGP and Zebra daemons (`zebra` and `bgpd`), then enable the FRRouting service and start it, as described in [Configuring FRRouting \(see page 737\)](#).



2. Identify the BGP node by assigning an ASN and `router-id`:

```
cumulus@switch:~$ net add bgp autonomous-system 65000
cumulus@switch:~$ net add bgp router-id 10.0.0.1
```

3. Specify where to disseminate routing information:

```
cumulus@switch:~$ net add bgp neighbor 10.0.0.2 remote-as
external
```

For an iBGP session, the `remote-as` is the same as the local AS:

```
cumulus@switch:~$ net add bgp neighbor 10.0.0.2 remote-as
internal
```

Specifying the IP address of the peer allows BGP to set up a TCP socket with this peer, but it does not distribute any prefixes to it, unless it is explicitly told that it must with the `activate` command. You must specify the `activate` command for each address family that is being announced by the BGP session.

```
cumulus@switch:~$ net add bgp ipv4 unicast neighbor 10.0.0.2
activate
cumulus@switch:~$ net add bgp ipv6 unicast neighbor 2001:db8:
0002::0a00:0002 activate
```

4. Specify BGP session properties:

```
cumulus@switch:~$ net add bgp neighbor 10.0.0.2 next-hop-self
```

If this is a route reflector client, it can be specified as follows:

```
cumulus@switchRR:~$ net add bgp neighbor 10.0.0.1 route-
reflector-client
```



It is node `switchRR`, the route reflector, on which the peer is specified as a client.

5. Specify which prefixes to originate:

```
cumulus@switch:~$ net add bgp ipv4 unicast network 192.0.2.0/24
cumulus@switch:~$ net add bgp ipv4 unicast network 203.0.113.1/24
```



```
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

## BGP Unnumbered Interfaces

Unnumbered interfaces are interfaces without unique IP addresses. In BGP, you configure unnumbered interfaces using *extended next hop encoding* (ENHE), which is defined by [RFC 5549](#). BGP unnumbered interfaces provide a means of advertising an IPv4 route with an IPv6 next hop. Prior to RFC 5549, an IPv4 route could be advertised only with an IPv4 next hop.

BGP unnumbered interfaces are particularly useful in deployments where IPv4 prefixes are advertised through BGP over a section without any IPv4 address configuration on links. As a result, the routing entries are also IPv4 for destination lookup and have IPv6 next hops for forwarding purposes.

### *BGP and Extended Next Hop Encoding*

When enabled and active, BGP makes use of the available IPv6 next hops for advertising any IPv4 prefixes. BGP learns the prefixes, calculates the routes and installs them in IPv4 AFI to IPv6 AFI format. However, ENHE in Cumulus Linux does not install routes into the kernel in IPv4 prefix to IPv6 next hop format. For link-local peerings enabled by dynamically learning the other end's link-local address using IPv6 neighbor discovery router advertisements, an IPv6 next hop is converted into an IPv4 link-local address and a static neighbor entry is installed for this IPv4 link-local address with the MAC address derived from the link-local address of the other end.



It is assumed that the IPv6 implementation on the peering device uses the MAC address as the interface ID when assigning the IPv6 link-local address, as suggested by RFC 4291.



Cumulus Linux 3.7.2 and later also supports advertising IPv4 prefixes with IPv6 next hop addresses while peering over IPv6 global unicast addresses. See [RFC 5549 Support with Global IPv6 Peers \(see page 784\)](#) below.

### *Configure BGP Unnumbered Interfaces*

To configure a BGP unnumbered interface, you must enable IPv6 neighbor discovery router advertisements. The `interval` you specify is measured in seconds and defaults to 10 seconds.

In Cumulus Linux 3.7.1 and earlier, extended next hop encoding is sent only for the link-local address peerings (as shown below). In Cumulus Linux 3.7.2 and later, extended next hop encoding can be sent for the both link-local and global unicast address peerings (see [RFC 5549 Support with Global IPv6 Peers \(see page 784\)](#)).

```
cumulus@switch:~$ net add bgp autonomous-system 65020
cumulus@switch:~$ net add bgp router-id 10.0.0.21
cumulus@switch:~$ net add bgp bestpath as-path multipath-relax
cumulus@switch:~$ net add bgp bestpath compare-routerid
cumulus@switch:~$ net add bgp neighbor fabric peer-group
cumulus@switch:~$ net add bgp neighbor fabric remote-as external
```

```
cumulus@switch:~$ net add bgp neighbor fabric description Internal
Fabric Network
cumulus@switch:~$ net add bgp neighbor fabric capability extended-
nexthop
cumulus@switch:~$ net add bgp neighbor swp1 interface peer-group
fabric
cumulus@switch:~$ net add bgp neighbor swp2 interface peer-group
fabric
cumulus@switch:~$ net add bgp neighbor swp3 interface peer-group
fabric
cumulus@switch:~$ net add bgp neighbor swp4 interface peer-group
fabric
cumulus@switch:~$ net add bgp neighbor swp29 interface peer-group
fabric
cumulus@switch:~$ net add bgp neighbor swp30 interface peer-group
fabric
```

These commands create the following configuration in the `/etc/frr/frr.conf` file:

```
router bgp 65020
bgp router-id 10.0.0.21
bgp bestpath as-path multipath-relax
bgp bestpath compare-routerid
neighbor fabric peer-group
neighbor fabric remote-as external
neighbor fabric description Internal Fabric Network
neighbor fabric capability extended-nexthop
neighbor swp1 interface peer-group fabric
neighbor swp2 interface peer-group fabric
neighbor swp3 interface peer-group fabric
neighbor swp4 interface peer-group fabric
neighbor swp29 interface peer-group fabric
neighbor swp30 interface peer-group fabric
!
```

For an unnumbered configuration, you can use a single command to configure a neighbor and attach it to a [peer group](#) (see page 794) (making sure to substitute for the interface and peer group below):

```
cumulus@switch:~$ net add bgp neighbor <swpX> interface peer-group
<group name>
```

### *Manage Unnumbered Interfaces*

All the relevant BGP commands show IPv6 next hops and/or the interface name for any IPv4 prefix:

```
cumulus@switch:~$ net show bgp
```



```
show bgp ipv4 unicast
=====
BGP table version is 6, local router ID is 10.0.0.11
Status codes: s suppressed, d damped, h history, * valid, > best, =
multipath,
          i internal, r RIB-failure, S Stale, R Removed
Origin codes: i - IGP, e - EGP, ? - incomplete
      Network          Next Hop            Metric LocPrf Weight Path
* > 10.0.0.11/32      0.0.0.0                  0        32768 ?
* > 10.0.0.12/32      swp51                   0    65020 65012 ?
*=               swp52                   0    65020 65012 ?
* > 10.0.0.21/32      swp51                   0    65020 ?
* > 10.0.0.22/32      swp52                   0    65020 ?
* > 172.16.1.0/24     0.0.0.0                  0        32768 i
* > 172.16.2.0/24     swp51                   0    65020 65012 i
*=               swp52                   0    65020 65012 i
Total number of prefixes 6

show bgp ipv6 unicast
=====
No BGP network exists
```

FRRouting RIB commands are also modified:

```
cumulus@switch:~$ net show route
RIB entry for route
=====
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, P - PIM, T - Table,
       > - selected route, * - FIB route
K>* 0.0.0.0/0 via 192.168.0.254, eth0
C>* 10.0.0.11/32 is directly connected, lo
B>* 10.0.0.12/32 [20/0] via fe80::4638:39ff:fe00:5c, swp51, 1d01h04m
   *           via fe80::4638:39ff:fe00:2b, swp52, 1d01h04m
B>* 10.0.0.21/32 [20/0] via fe80::4638:39ff:fe00:5c, swp51, 1d01h04m
B>* 10.0.0.22/32 [20/0] via fe80::4638:39ff:fe00:2b, swp52, 1d01h04m
C>* 172.16.1.0/24 is directly connected, br0
B>* 172.16.2.0/24 [20/0] via fe80::4638:39ff:fe00:5c, swp51, 1d01h04m
   *           via fe80::4638:39ff:fe00:2b, swp52, 1d01h04m
C>* 192.168.0.0/24 is directly connected, eth0
```

The following commands show how the IPv4 link-local address 169.254.0.1 is used to install the route and static neighbor entry to facilitate proper forwarding without having to install an IPv4 prefix with IPv6 next hop in the kernel:

```
cumulus@switch:~$ net show route 10.0.0.12
RIB entry for 10.0.0.12
=====
Routing entry for 10.0.0.12/32
```

```

Known via "bgp", distance 20, metric 0, best
Last update 1d01h06m ago
* fe80::4638:39ff:fe00:5c, via swp51
* fe80::4638:39ff:fe00:2b, via swp52

FIB entry for 10.0.0.12
=====
10.0.0.12 proto zebra metric 20
    nexthop via 169.254.0.1 dev swp51 weight 1 onlink
    nexthop via 169.254.0.1 dev swp52 weight 1 onlink

```

You can use the following command to display more neighbor information:

```

cumulus@switch:~$ ip neighbor
192.168.0.254 dev eth0 lladdr 44:38:39:00:00:5f REACHABLE
169.254.0.1 dev swp52 lladdr 44:38:39:00:00:2b PERMANENT
169.254.0.1 dev swp51 lladdr 44:38:39:00:00:5c PERMANENT
fe80::4638:39ff:fe00:2b dev swp52 lladdr 44:38:39:00:00:2b router
REACHABLE
fe80::4638:39ff:fe00:5c dev swp51 lladdr 44:38:39:00:00:5c router
REACHABLE

```

### *How traceroute Interacts with BGP Unnumbered Interfaces*

Every router or end host must have an IPv4 address to complete a `traceroute` of IPv4 addresses. In this case, the IPv4 address used is that of the loopback device.

Even if ENHE is not used in the data center, link addresses are not typically advertised. This is because:

- Link addresses take up valuable FIB resources. In a large Clos environment, the number of such addresses can be quite large.
- Link addresses expose an additional attack vector for intruders to use to either break in or engage in DDOS attacks.

Assigning an IP address to the loopback device is essential.

### *Advanced: How Next Hop Fields Are Set*

This section describes how the IPv6 next hops are set in the MP\_REACH\_NLRI ([multiprotocol reachable NLRI](#)) initiated by the system, which applies whether IPv6 prefixes or IPv4 prefixes are exchanged with ENHE. There are two main aspects to determine — how many IPv6 next hops are included in the MP\_REACH\_NLRI (since the RFC allows either one or two next hops) and the values of the nexthop(s). This section also describes how a received MP\_REACH\_NLRI is handled as far as processing IPv6 next hops.

- Whether peering to a global IPv6 address or link-local IPv6 address, the determination whether to send one or two next hops is as follows:
  1. If reflecting the route, two next hops are sent only if the peer has `nexthop-local unchanged` configured and the attribute of the received route has an IPv6 link-local next hop; otherwise, only one next hop is sent.



2. Otherwise (if it is not reflecting the route), two next hops are sent if explicitly configured (`nexthop-local unchanged`) or the peer is directly connected (that is, either peering is on link-local address or the global IPv4 or IPv6 address is *directly connected*) and the route is either a local/self-originated route or the peer is an eBGP peer.
  3. In all other cases, only one next hop gets sent, unless an outbound route map adds another next hop.
- `route-map` can impose two next hops in scenarios where Cumulus Linux only sends one next hop — by specifying `set ipv6 nexthop link-local`.
  - For all routes to eBGP peers and self-originated routes to iBGP peers, the global next hop (first value) is the peering address of the local system. If the peering is on the link-local address, this is the global IPv6 address on the peering interface, if present; otherwise, it is the link-local IPv6 address on the peering interface.
  - For other routes to iBGP peers (eBGP to iBGP or reflected), the global next hop will be the global next hop in the received attribute.



If this address is a link-local IPv6 address, it is reset so that the link-local IPv6 address of the eBGP peer is not passed along to an iBGP peer, which most likely is on a different link.

- `route-map` and/or the peer configuration can change the above behavior. For example, `route-map` can set the global IPv6 next hop or the peer configuration can set it to `self` — which is relevant for *iBGP* peers. The route map or peer configuration can also set the next hop to `unchanged`, which ensures the source IPv6 global next hop is passed around — which is relevant for *eBGP* peers.
- Whenever two next hops are being sent, the link-local next hop (the second value of the two) is the link-local IPv6 address on the peering interface unless it is due to `nh-local-unchanged` or `route-map` has set the link-local next hop.
- Network administrators cannot set **martian values** for IPv6 next hops in `route-map`. Also, global and link-local next hops are validated to ensure they match the respective address types.
- In a received update, a martian check is imposed for the IPv6 global next hop. If the check fails, it gets treated as an implicit withdraw.
- If two next hops are received in an update and the second next hop is not a link-local address, it gets ignored and the update is treated as if only one next hop was received.
- Whenever two next hops are received in an update, the second next hop is used to install the route into `zebra`. As per the previous point, it is already assured that this is a link-local IPv6 address. Currently, this is assumed to be reachable and is not registered with NHT.
- When `route-map` specifies the next hop as `peer-address`, the global IPv6 next hop as well as the link-local IPv6 next hop (if it's being sent) is set to the *peering address*. If the peering is on a link-local address, the former could be the link-local address on the peering interface, unless there is a global IPv6 address present on this interface.
- When using iBGP unnumbered with IPv6 Link Local Addresses (the default), FRR rewrites the BGP next hop to be the adjacent link. This is similar behavior to eBGP next hops. However, iBGP route advertisement rules do not change and a full mesh or route reflectors is still required.



The above rules imply that there are scenarios where a generated update has two IPv6 next hops, and both of them are the IPv6 link-local address of the peering interface on the local system. If you are peering with a switch or router that is not running Cumulus Linux and expects the first next hop to be a global IPv6 address, a route map can be used on the sender to specify a global IPv6 address. This conforms with the recommendations in the Internet draft [draft-kato-bgp-ipv6-link-local-00.txt](#), "BGP4+ Peering Using IPv6 Link-local Address".

## Limitations

- Interface-based peering with separate IPv4 and IPv6 sessions is not supported.
- In Cumulus Linux 3.7.1 and earlier, ENHE is sent for IPv6 link-local peerings only. In Cumulus Linux 3.7.2 and later, ENHE can also be sent for IPv6 GUA peerings (see below).
- If an IPv4 /30 or /31 IP address is assigned to the interface, IPv4 peering is used over IPv6 link-local peering.
- If the default router lifetime in the generated IPv6 route advertisements (RA) is set to 0, the receiving FRRouting instance drops the RA if it is on a Cumulus Linux **2.5.z** switch. To work around this issue, either:
  - Explicitly configure the switch to advertise a router lifetime of 0, unless a value is specifically set by the operator — with the assumption that the host is running Cumulus Linux 3.y.z version of FRRouting. When hosts see an IPv6 RA with a router lifetime of 0, they do not make that router a default router.
  - Use the `sysctl` on the host — `net.ipv6.conf.all.accept_ra_defrtr`. However, this requires applying this setting on all hosts, which might mean many hosts, especially if FRRouting is run on the hosts.

## RFC 5549 Support with Global IPv6 Peers (Cumulus Linux 3.7.2 and later)

[RFC 5549](#) defines the method used for BGP to advertise IPv4 prefixes with IPv6 next hops. The RFC does not make a distinction between whether the IPv6 peering and next hop values should be global unicast addresses (GUA) or link-local addresses. Cumulus Linux 3.7.1 and earlier only supports advertising IPv4 prefixes using link-local IPv6 next hop addresses via BGP *unnumbered* peering. Cumulus Linux 3.7.2 supports advertising IPv4 prefixes with IPv6 global unicast and link-local next hop addresses, with either *unnumbered* or *numbered* BGP.

When BGP peering uses IPv6 global addresses and IPv4 prefixes are being advertised and installed, IPv6 route advertisements are used to derive the MAC address of the peer so that FRR can create an IPv4 route with a link-local IPv4 next hop address (defined by RFC 3927). This is required to install the route into the kernel. These route advertisement settings are configured automatically when FRR receives an update from a BGP peer using IPv6 global addresses that contain an IPv4 prefix with an IPv6 nexthop, and the enhanced-nexthop capability has been negotiated.

### Configure RFC 5549 Support with Global IPv6 Peers

To enable advertisement of IPv4 prefixes with IPv6 next hops over global IPv6 peerings, add the `extended-nexthop` capability to the global IPv6 neighbor statements on each end of the BGP sessions.

```
cumulus@switch:~$ net add bgp neighbor 2001:1:1::3 capability extended-nexthop
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```



The above commands create the following configuration in the `/etc/frr/frr.conf` file:

```
router bgp 1
bgp router-id 10.0.0.11
neighbor 2001:1:1::3 remote-as external
neighbor 2001:1:1::3 capability extended-nexthop
!
```

Ensure that the IPv6 peers are activated under the IPv4 unicast address family; otherwise, all peers are activated in the IPv4 unicast address family by default.

If no `bgp default ipv4-unicast` is configured, you need to explicitly activate the IPv6 neighbor under the IPv4 unicast address family as shown below:

```
cumulus@switch:~$ net add bgp neighbor 2001:1:1::3 capability
extended-nexthop
cumulus@switch:~$ net add bgp ipv4 unicast neighbor 2001:1:1::3
activate
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

The above commands create the following configuration in the `/etc/frr/frr.conf` file:

```
router bgp 1
router-id 10.0.0.11
no bgp default ipv4-unicast
neighbor 2001:1:1::3 remote-as external
neighbor 2001:1:1::3 capability extended-nexthop
!
address-family ipv4 unicast
  neighbor 2001:1:1::3 activate
exit-address-family
```

### Show IPv4 Prefixes Learned with IPv6 Next Hops

To show IPv4 prefixes learned with IPv6 next hops, you can run `net show bgp ipv4 unicast` commands.

The following examples show an IPv4 prefix learned from a BGP peer over an IPv6 session using IPv6 global addresses, but where the next hop installed by BGP is a link-local IPv6 address. This occurs when the session is directly between peers and both link-local and global IPv6 addresses are included as next hops in the BGP update for the prefix. If both global and link-local next hops exist, BGP prefers the link-local address for route installation.

```
root@Spine01:~# net show bgp ipv4 unicast summary
```

```
BGP router identifier 10.0.0.11, local AS number 1 vrf-id 0
BGP table version 3
RIB entries 1, using 152 bytes of memory
Peers 1, using 19 KiB of memory

Neighbor           V AS MsgRcvd MsgSent TblVer InQ OutQ Up/Down
State/PfxRcd
Leaf01(2001:1:1::3) 4 3     6432      6431      0       0     0   05:21:
25                  1

Total number of neighbors 1

root@Spine01:~# net show bgp ipv4 unicast
BGP table version is 3,
local router ID is 10.0.0.11
Status codes: s suppressed, d damped, h history, * valid, > best,
= multipath,
          i internal, r RIB-failure, S Stale, R Removed
Origin codes: i - IGP, e - EGP, ? - incomplete

Network          Next Hop            Metric LocPrf Weight
Path
*> 172.16.3.0/24 fe80::a00:27ff:fea6:b9fe  0        0       3
i

Displayed 1 routes and 1 total paths

root@Spine01:~# net show bgp ipv4 unicast 172.16.3.0/24
BGP routing table entry for 172.16.3.0/24
Paths: (1 available, best #1, table default)
  Advertised to non peer-group peers:
    Leaf01(2001:1:1::3)
    3
      2001:1:1::3 from Leaf01(2001:1:1::3) (10.0.0.13)
      (fe80::a00:27ff:fea6:b9fe) (used)
        Origin IGP, metric 0, valid, external, bestpath-from-AS 3,
        best
        AddPath ID: RX 0, TX 3
        Last update: Mon Oct 22 08:09:22 2018
```

The example output below shows the results of installing the route in the FRR RIB as well as the kernel FIB. Note that the next hop used for installation in the FRR RIB is the link-local IPv6 address, but then it is converted into an IPv4 link-local address as required for installation into the kernel FIB.

```
root@Spine01:~# net show route 172.16.3.0/24
RIB entry for 172.16.3.0/24
=====
Routing entry for 172.16.3.0/24
```



```
Known via "bgp", distance 20, metric 0, best
Last update 2d17h05m ago
* fe80::a00:27ff:fea6:b9fe, via swp1

FIB entry for 172.16.3.0/24
=====
172.16.3.0/24 via 169.254.0.1 dev swp1 proto bgp metric 20 onlink
```

If an IPv4 prefix is learned with only an IPv6 global next hop address (for example, when the route is learned through a route reflector), the command output shows the IPv6 global address as the next hop value and shows that it is learned recursively through the link-local address of the route reflector. Note that when a global IPv6 address is used as a next hop for route installation in the FRR RIB, it is still converted into an IPv4 link-local address for installation into the kernel.

```
root@Leaf01:~# net show bgp ipv4 unicast summary
BGP router identifier 10.0.0.13, local AS number 1 vrf-id 0
BGP table version 1
RIB entries 1, using 152 bytes of memory
Peers 1, using 19 KiB of memory

Neighbor          V AS MsgRcvd  MsgSent  TblVer  InQ  OutQ  Up
/Down  State/PfxRcd
Spine01(2001:1:1::1) 4 1    74        68        0      0      0
00:00:45           1

Total number of neighbors 1

root@Leaf01:~# net show bgp ipv4 unicast
BGP table version is 1, local router ID is 10.0.0.13
Status codes: s suppressed, d damped, h history, * valid, > best,
= multipath,
          i internal, r RIB-failure, S Stale, R Removed
Origin codes: i - IGP, e - EGP, ? - incomplete

Network Next Hop Metric LocPrf Weight Path
*>i172.16.4.0/24 2001:2:2::4 0 100 0 i

Displayed 1 routes and 1 total paths

root@Leaf01:~# net show bgp ipv4 unicast 172.16.4.0/24
BGP routing table entry for 172.16.4.0/24
Paths: (1 available, best #1, table default)
  Not advertised to any peer
  Local
    2001:2:2::4 from Spine01(2001:1:1::1) (10.0.0.14)
      Origin IGP, metric 0, localpref 100, valid, internal, bestpath-
from-AS Local, best
      Originator: 10.0.0.14, Cluster list: 10.0.0.11
```

```
AddPath ID: RX 0, TX 5
Last update: Mon Oct 22 14:25:30 2018

root@Leaf01:~# net show route 172.16.4.0/24
RIB entry for 172.16.4.0/24
=====
Routing entry for 172.16.4.0/24
  Known via "bgp", distance 200, metric 0, best
  Last update 00:01:13 ago
    2001:2:2::4 (recursive)
* fe80::a00:27ff:fe5a:84ae, via swp1

FIB entry for 172.16.4.0/24
=====
172.16.4.0/24 via 169.254.0.1 dev swp1 proto bgp metric 20 onlink
```

To have only IPv6 global addresses used for route installation into the FRR RIB, you must add an additional route map to the neighbor or peer group statement in the appropriate address family. When the route map command `set ipv6 next-hop prefer-global` is applied to a neighbor, if both a link-local and global IPv6 address are in the BGP update for a prefix, the IPv6 global address is preferred for route installation.

With this additional configuration, the output in the FRR RIB changes in the direct neighbor case, as shown below:

```
router bgp 1
  bgp router-id 10.0.0.11
  neighbor 2001:2:2::4 remote-as internal
  neighbor 2001:2:2::4 capability extended-nexthop
!
  address-family ipv4 unicast
    neighbor 2001:2:2::4 route-map GLOBAL in
  exit-address-family
!
route-map GLOBAL permit 20
  set ipv6 next-hop prefer-global
!
```

The resulting FRR RIB output is as follows:

```
Spine01# sh ip route
Codes: K - kernel route, C - connected, S - static, R - RIP,
      O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
      T - Table, v - VNC, V - VNC-Direct, A - Babel, D - SHARP,
      F - PBR,
      > - selected route, * - FIB route
```



```
B 0.0.0.0/0 [200/0] via 2001:2:2::4, swp2, 00:01:00
K 0.0.0.0/0 [0/0] via 10.0.2.2, eth0, 1d02h29m
C>* 10.0.0.9/32 is directly connected, lo, 5d18h32m
C>* 10.0.2.0/24 is directly connected, eth0, 03:51:31
B>* 172.16.4.0/24 [200/0] via 2001:2:2::4, swp2, 00:01:00
C>* 172.16.10.0/24 is directly connected, swp3, 5d18h32m
```

When the route is learned through a route reflector, it appears like this:

```
router bgp 1
bgp router-id 10.0.0.13
neighbor 2001:1:1::1 remote-as internal
neighbor 2001:1:1::1 capability extended-nexthop
!
address-family ipv6 unicast
neighbor 2001:1:1::1 activate
neighbor 2001:1:1::1 route-map GLOBAL in
exit-address-family
!
route-map GLOBAL permit 10
set ipv6 next-hop prefer-global

Leaf01# sh ip route
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, D - SHARP,
       F - PBR,
       > - selected route, * - FIB route

B    0.0.0.0/0 [200/0] via 2001:2:2::4, 00:00:01
K    0.0.0.0/0 [0/0] via 10.0.2.2, eth0, 3d00h26m
C>* 10.0.0.8/32 is directly connected, lo, 3d00h26m
C>* 10.0.2.0/24 is directly connected, eth0, 03:39:18
C>* 172.16.3.0/24 is directly connected, swp2, 3d00h26m
B>  172.16.4.0/24 [200/0] via 2001:2:2::4 (recursive), 00:00:01
     *                      via 2001:1:1::1, swp1, 00:00:01
C>* 172.16.10.0/24 is directly connected, swp3, 3d00h26m
```

## BGP add-path

Cumulus Linux supports both BGP add-path RX and BGP add-path TX.

### *BGP add-path RX*

*BGP add-path RX* allows BGP to receive multiple paths for the same prefix. A path identifier is used so that additional paths do not override previously advertised paths. No additional configuration is required for BGP add-path RX.



BGP advertises the add-path RX capability by default. Add-Path TX requires an administrator to enable it. Enabling TX resets the session.

To view the existing capabilities, run `net show bgp neighbor`. The existing capabilities are listed in the subsection *Add Path*, below *Neighbor capabilities*:

```
cumulus@leaf01:~$ net show bgp neighbor
BGP neighbor on swp51: fe80::4638:39ff:fe00:5c, remote AS 65020,
local AS 65011, external link
Hostname: spine01
Member of peer-group fabric for session parameters
  BGP version 4, remote router ID 10.0.0.21
  BGP state = Established, up for 1d01h15m
  Last read 00:00:00, Last write 1d01h15m
  Hold time is 3, keepalive interval is 1 seconds
  Configured hold time is 3, keepalive interval is 1 seconds
Neighbor capabilities:
  4 Byte AS: advertised and received
  AddPath:
    IPv4 Unicast: RX advertised IPv4 Unicast and received
    Extended nexthop: advertised and received
    Address families by peer:
      IPv4 Unicast
      Route refresh: advertised and received(old & new)
      Address family IPv4 Unicast: advertised and received
      Hostname Capability: advertised and received
      Graceful Restart Capabilty: advertised and received
      Remote Restart timer is 120 seconds
    Address families by peer:
      none
...
...
```

The example output above shows that additional BGP paths can be sent and received (TX and RX are advertised). It also shows that the BGP neighbor, fe80::4638:39ff:fe00:5c, supports both.

To view the current additional paths, run `net show bgp <network>`. The example output shows an additional path that has been added by the TX node for receiving. Each path has a unique AddPath ID.

```
cumulus@leaf01:~$ net show bgp 10.0.0.12
BGP routing table entry for 10.0.0.12/32
Paths: (2 available, best #1, table Default-IP-Routing-Table)
  Advertised to non peer-group peers:
    spine01(swp51) spine02(swp52)
    65020 65012
      fe80::4638:39ff:fe00:5c from spine01(swp51) (10.0.0.21)
        (fe80::4638:39ff:fe00:5c) (used)
          Origin incomplete, localpref 100, valid, external, multipath,
          bestpath-from-AS 65020, best
```

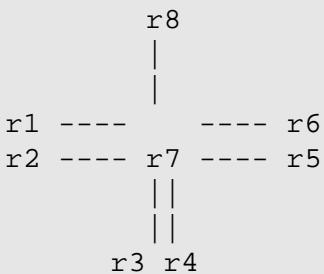
```

AddPath ID: RX 0 , TX 6
Last update: Wed Nov 16 22:47:00 2016
65020 65012
fe80::4638:39ff:fe00:2b from spine02(swp52) (10.0.0.22)
(fe80::4638:39ff:fe00:2b) (used)
Origin incomplete, localpref 100, valid, external, multipath
AddPath ID: RX 0 , TX 3
Last update: Wed Nov 16 22:47:00 2016

```

### *BCP add-path TX*

AddPath TX allows BGP to advertise more than just the bestpath for a prefix. Consider the following topology:



In this topology:

- r1 and r2 are in AS 100
- r3 and r4 are in AS 300
- r5 and r6 are in AS 500
- r7 is in AS 700
- r8 is in AS 800
- r7 learns 1.1.1.1/32 from r1, r2, r3, r4, r5, and r6. Among these r7 picks the path from r1 as the bestpath for 1.1.1.1/32

The example below configures the r7 session to advertise the bestpath learned from each AS. In this case, this means a path from AS 100, a path from AS 300, and a path from AS 500. The `net show bgp 1.1.1.1/32` from r7 has "bestpath-from-AS 100" so the user can see what the bestpath is from each AS:

```

cumulus@r7:~$ net add bgp autonomous-system 700
cumulus@r7:~$ net add bgp neighbor 192.0.2.2 addpath-tx-bestpath-per-
AS

```

The output below shows the result on r8:

```

cumulus@r8:~$ net show bgp 1.1.1.1/32
BGP routing table entry for 1.1.1.1/32
Paths: (3 available, best #3, table Default-IP-Routing-Table)

```

```

Advertised to non peer-group peers:
r7(10.7.8.1)
700 100
  10.7.8.1 from r7(10.7.8.1) (10.0.0.7)
    Origin IGP, localpref 100, valid, external
    Community: 1:1
    AddPath ID: RX 2, TX 4
    Last update: Thu Jun 2 00:57:14 2016

700 300
  10.7.8.1 from r7(10.7.8.1) (10.0.0.7)
    Origin IGP, localpref 100, valid, external
    Community: 3:3
    AddPath ID: RX 4, TX 3
    Last update: Thu Jun 2 00:57:14 2016

700 500
  10.7.8.1 from r7(10.7.8.1) (10.0.0.7)
    Origin IGP, localpref 100, valid, external, bestpath-from-AS
700, best
  Community: 5:5
  AddPath ID: RX 6, TX 2
  Last update: Thu Jun 2 00:57:14 2016

```

The example below shows the results if r7 is configured to advertise all paths to r8:

```

cumulus@r7:~$ net add bgp autonomous-system 700
cumulus@r7:~$ net add bgp neighbor 192.0.2.2 addpath-tx-all-paths

```

The output below shows the result on r8:

```

cumulus@r8:~$ net show bgp 1.1.1.1/32
BGP routing table entry for 1.1.1.1/32
Paths: (3 available, best #3, table Default-IP-Routing-Table)
  Advertised to non peer-group peers:
    r7(10.7.8.1)
    700 100
      10.7.8.1 from r7(10.7.8.1) (10.0.0.7)
        Origin IGP, localpref 100, valid, external
        Community: 1:1
        AddPath ID: RX 2, TX 4
        Last update: Thu Jun 2 00:57:14 2016

    700 300
      10.7.8.1 from r7(10.7.8.1) (10.0.0.7)
        Origin IGP, localpref 100, valid, external
        Community: 3:3
        AddPath ID: RX 4, TX 3
        Last update: Thu Jun 2 00:57:14 2016

```



```
700 500
 10.7.8.1 from r7(10.7.8.1) (10.0.0.7)
    Origin IGP, localpref 100, valid, external, bestpath-from-AS
700, best
  Community: 5:5
  AddPath ID: RX 6, TX 2
  Last update: Thu Jun 2 00:57:14 2016
```

## Fast Convergence Design Considerations

Cumulus Networks strongly recommends the following use of addresses in the design of a BGP-based data center network:

- Set up BGP sessions only using interface-scoped addresses. This allows BGP to react quickly to link failures.
- Use of next hop-self: Every BGP node says that it knows how to forward traffic to the prefixes it is announcing. This reduces the requirement to announce interface-specific addresses and thereby reduces the size of the forwarding table.

When you configure BGP for the neighbors of a given interface, you can specify the interface name instead of its IP address. All the other `neighbor` command options remain the same.

This is equivalent to BGP peering to the link-local IPv6 address of the neighbor on the given interface. The link-local address is learned via IPv6 neighbor discovery router advertisements.

Consider the following example configuration in the `/etc/frr/frr.conf` file:

```
router bgp 65000
  bgp router-id 10.0.0.1
  neighbor swp1 interface
  neighbor swp1 remote-as internal
  neighbor swp1 next-hop-self
!
  address-family ipv6
  neighbor swp1 activate
  exit-address-family
```

You create the above configuration with the following NCLU commands:

```
cumulus@switch:~$ net add bgp autonomous-system 65000
cumulus@switch:~$ net add bgp router-id 10.0.0.1
cumulus@switch:~$ net add bgp neighbor swp1 interface
cumulus@switch:~$ net add bgp neighbor swp1 remote-as internal
cumulus@switch:~$ net add bgp neighbor swp1 next-hop-self
cumulus@switch:~$ net add bgp ipv6 unicast neighbor swp1 activate
```



By default, Cumulus Linux sends IPv6 neighbor discovery router advertisements. Cumulus Networks recommends you adjust the interval of the router advertisement to a shorter value (`net add interface <interface> ipv6 nd ra-interval <interval>`) to address scenarios when nodes come up and miss router advertisement processing to relay the neighbor's link-local address to BGP. The `interval` is measured in seconds and defaults to 10 seconds.

## Peer Groups to Simplify Configuration

When a switch has many peers to connect to, the amount of redundant configuration becomes overwhelming. For example, repeating the `activate` and `next-hop-self` commands for even 60 neighbors makes for a very long configuration file. To address this problem, you can use `peer-group`.

Instead of specifying properties of each individual peer, FRouting allows you to define one or more peer groups and associate all the attributes common to that peer session to a peer group. A peer needs to be attached to a peer group only once, when it then inherits all address families activated for that peer group.

After you attach a peer to a peer group, you need to associate an IP address with the peer group. The following example shows how to define and use peer groups:

```
cumulus@switch:~$ net add bgp neighbor tier-2 peer-group
cumulus@switch:~$ net add bgp ipv4 unicast
cumulus@switch:~$ net add bgp neighbor tier-2 activate
cumulus@switch:~$ net add bgp neighbor tier-2 next-hop-self
cumulus@switch:~$ net add bgp neighbor 10.0.0.2 peer-group tier-2
cumulus@switch:~$ net add bgp neighbor 192.0.2.2 peer-group tier-2
```



BGP peer-group restrictions have been replaced with update-groups, which dynamically examine all peers and group them if they have the same outbound policy.

## Configure BGP Dynamic Neighbors

*BGP dynamic neighbor* provides BGP peering to a group of remote neighbors within a specified range of IPv4 or IPv6 addresses for a BGP peer group. You can configure each range as a subnet IP address.

You configure dynamic neighbors using the `bgp listen range <IP address> peer-group <GROUP>` command. After you configure the dynamic neighbors, a BGP speaker can listen for, and form peer relationships with, any neighbor in the IP address range and mapped to a peer group.

```
cumulus@switch:~$ net add bgp autonomous-system 65001
cumulus@switch:~$ net add bgp listen range 10.1.1.0/24 peer-group
SPINE
```

To limit the number of dynamic peers, specify the limit in the `bgp listen limit` command (the default value is 100):

```
cumulus@switch:~$ net add bgp listen limit 5
```



Collectively, a sample configuration for IPv4 looks like this:

```
cumulus@switch:~$ net add bgp autonomous-system 65001
cumulus@switch:~$ net add bgp neighbor SPINE peer-group
cumulus@switch:~$ net add bgp neighbor SPINE remote-as 65000
cumulus@switch:~$ net add bgp listen limit 5
cumulus@switch:~$ net add bgp listen range 10.1.1.0/24 peer-group
SPINE
```

These commands produce an IPv4 configuration that looks like this:

```
router bgp 65001
neighbor SPINE peer-group
neighbor SPINE remote-as 65000
bgp listen limit 5
bgp listen range 10.1.1.0/24 peer-group SPINE
```

## Configure BGP Peering Relationships across Switches

A BGP peering relationship is typically initiated with the `neighbor <x.x.x.x> remote-as [internal|external]` command.

Specifying *internal* signifies an iBGP peering; that is, the neighbor only creates or accepts a connection with the specified neighbor if the remote peer AS number matches this BGP AS number.

Specifying *external* signifies an eBGP peering; that is, the neighbor will only create a connection with the neighbor if the remote peer AS number does **not** match this BGP AS number.

You can make this distinction using the `neighbor` command or the `peer-group` command.

In general, use the following syntax with the `neighbor` command:

```
cumulus@switch:~$ net add bgp neighbor [<IP address>|<BGP
peer>|<interface>] remote-as [<value>|internal|external]
```

Some example configurations follow.

To connect to **the same AS** using the `neighbor` command, modify your configuration similar to the following:

```
cumulus@switch:~$ net add bgp autonomous-system 500
cumulus@switch:~$ net add bgp neighbor 192.168.1.2 remote-as
internal
```

These commands create the following configuration snippet:



```
router bgp 500
neighbor 192.168.1.2 remote-as internal
```

To connect to a **different AS** using the `neighbor` command, modify your configuration similar to the following:

```
cumulus@switch:~$ net add bgp autonomous-system 500
cumulus@switch:~$ net add bgp neighbor 192.168.1.2 remote-as
external
```

These commands create the following configuration snippet:

```
router bgp 500
neighbor 192.168.1.2 remote-as external
```

To connect to **the same AS** using the `peer-group` command, modify your configuration similar to the following:

```
cumulus@switch:~$ net add bgp autonomous-system 500
cumulus@switch:~$ net add bgp neighbor swp1 interface
cumulus@switch:~$ net add bgp neighbor IBGP peer-group
cumulus@switch:~$ net add bgp neighbor IBGP remote-as internal
cumulus@switch:~$ net add bgp neighbor swp1 interface peer-group
IBGP
cumulus@switch:~$ net add bgp neighbor 192.0.2.3 peer-group IBGP
cumulus@switch:~$ net add bgp neighbor 192.0.2.4 peer-group IBGP
```

These commands create the following configuration snippet:

```
router bgp 500
neighbor swp1 interface
neighbor IBGP peer-group
neighbor IBGP remote-as internal
neighbor swp1 peer-group IBGP
neighbor 192.0.2.3 peer-group IBGP
neighbor 192.0.2.4 peer-group IBGP
```



To connect to a **different AS** using the `peer-group` command, modify your configuration similar to the following:

```
cumulus@switch:~$ net add bgp autonomous-system 500
cumulus@switch:~$ net add bgp neighbor swp2 interface
cumulus@switch:~$ net add bgp neighbor EBGP peer-group
cumulus@switch:~$ net add bgp neighbor EBGP remote-as external
cumulus@switch:~$ net add bgp neighbor 192.0.2.2 peer-group EBGP
cumulus@switch:~$ net add bgp neighbor swp2 interface peer-group
EBGP
cumulus@switch:~$ net add bgp neighbor 192.0.2.4 peer-group EBGP
```

These commands create the following configuration snippet:

```
router bgp 500
neighbor swp2 interface
neighbor EBGP peer-group
neighbor EBGP remote-as external
neighbor 192.0.2.2 peer-group EBGP
neighbor swp2 peer-group EBGP
neighbor 192.0.2.4 peer-group EBGP
```

## Configure MD5-enabled BGP Neighbors

The following sections outline how to configure an MD5-enabled BGP neighbor. Each process assumes that FRRouting is used as the routing platform, and consists of two switches (AS 65011 and AS 65020), connected by the link 10.0.0.100/30, with the following configurations:

### switch1

```
cumulus@leaf01:~$ net show bgp summary
show bgp ipv4 unicast summary
=====
BGP router identifier 10.0.0.11, local AS number 65011 vrf-id 0
BGP table version 6
RIB entries 11, using 1320 bytes of memory
Peers 2, using 36 KiB of memory
Peer groups 1, using 56 bytes of memory
Neighbor          V        AS MsgRcvd MsgSent   TblVer  InQ OutQ Up
/Down  State/PfxRcd
spine01(swp51)   4 65020    93587    93587      0      0      0
1d02h00m          3
spine02(swp52)   4 65020    93587    93587      0      0      0
1d02h00m          3
Total number of neighbors 2
```

```
show bgp ipv6 unicast summary
=====
No IPv6 neighbor is configured
```

**switch2**

```
cumulus@spine01:~$ net show bgp summary
show bgp ipv4 unicast summary
=====
BGP router identifier 10.0.0.21, local AS number 65020 vrf-id 0
BGP table version 5
RIB entries 9, using 1080 bytes of memory
Peers 4, using 73 KiB of memory
Peer groups 1, using 56 bytes of memory
Neighbor          V          AS MsgRcvd MsgSent   TblVer  InQ OutQ Up
/Down  State/PfxRcd
leaf01(swp1)    4 65011      782      782       0     0     0 00:12:54
2
leaf02(swp2)    4 65012      781      781       0     0     0 00:12:53
2
swp3            4     0        0        0       0     0     0 never
Idle
swp4            4     0        0        0       0     0     0 never
Idle
Total number of neighbors 4

show bgp ipv6 unicast summary
=====
No IPv6 neighbor is configured
```

**To manually configure an MD5-enabled BGP neighbor:**

1. SSH into leaf01.
2. Configure the password for the neighbor:

```
cumulus@leaf01:~$ net add bgp neighbor 10.0.0.102 password
mypassword
```

3. Confirm the configuration has been implemented with the `net show bgp summary` command:

```
cumulus@leaf01:~$ net show bgp summary
show bgp ipv4 unicast summary
=====
BGP router identifier 10.0.0.11, local AS number 65011 vrf-id 0
BGP table version 18
RIB entries 11, using 1320 bytes of memory
```



```
Peers 2, using 36 KiB of memory
Peer groups 1, using 56 bytes of memory
Neighbor          V          AS MsgRcvd MsgSent      TblVer  InQ OutQ
Up/Down State/PfxRcd
spine01(swp51)   4 65020    96144   96146        0       0     0 00:30:
29              3
spine02(swp52)   4 65020    96209   96217        0       0     0
1d02h44m        3
Total number of neighbors 2

show bgp ipv6 unicast summary
=====
No IPv6 neighbor is configured
```

4. SSH into spine01.
5. Configure the password for the neighbor:

```
cumulus@spine01:~$ net add bgp neighbor 10.0.0.101 password
mypassword
```

6. Confirm the configuration has been implemented with the `net show bgp summary` command:

```
cumulus@spine01:~$ net show bgp summary
show bgp ipv4 unicast summary
=====
BGP router identifier 10.0.0.21, local AS number 65020 vrf-id 0
BGP table version 5
RIB entries 9, using 1080 bytes of memory
Peers 4, using 73 KiB of memory
Peer groups 1, using 56 bytes of memory
Neighbor          V          AS MsgRcvd MsgSent      TblVer  InQ OutQ
Up/Down State/PfxRcd
leaf01(swp1)   4 65011    782     782        0       0     0 00:12:
54              2
leaf02(swp2)   4 65012    781     781        0       0     0 00:12:
53              2
swp3            4     0      0      0        0       0     0
never           Idle
swp4            4     0      0      0        0       0     0
never           Idle
Total number of neighbors 4

show bgp ipv6 unicast summary
=====
No IPv6 neighbor is configured
```



In Cumulus Linux 3.7.5 and earlier, the MD5 password configured against a BGP listen-range peer-group (used to accept and create dynamic BGP neighbors) is not enforced. This means that connections are accepted from peers that do not specify a password.

## Configure eBGP Multihop

The eBGP Multihop option lets you use BGP to exchange routes with an external peer that is more than one hop away.

1. To establish a connection between two eBGP peers that are not directly connected:

```
cumulus@leaf02:mgmt-vrf:~$ net add bgp neighbor <ip> remote-as
external
cumulus@leaf02:mgmt-vrf:~$ net add bgp neighbor <ip> ebgp-
multihop
```

2. Confirm the configuration with the `net show bgp neighbor <ip>` command:

```
cumulus@leaf02:mgmt-vrf:~$ net show bgp neighbor 10.0.0.11
BGP neighbor is 10.0.0.11, remote AS 65011, local AS 65012, external
link
Hostname: leaf01
BGP version 4, remote router ID 10.0.0.11
BGP state = Established, up for 00:02:54
Last read 00:00:00, Last write 00:00:00
Hold time is 9, keepalive interval is 3 seconds
Neighbor capabilities:
    4 Byte AS: advertised and received
    AddPath:
        IPv4 Unicast: RX advertised IPv4 Unicast and received
        Route refresh: advertised and received(old & new)
        Address Family IPv4 Unicast: advertised and received
        Hostname Capability: advertised (name: leaf02, domain name: n/a)
received (name: leaf01, domain name: n/a)
    Graceful Restart Capability: advertised and received
        Remote Restart timer is 120 seconds
        Address families by peer:
            none
    Graceful restart informations:
        End-of-RIB send: IPv4 Unicast
        End-of-RIB received: IPv4 Unicast
    Message statistics:
        Inq depth is 0
        Outq depth is 0
```



	Sent	Rcvd
Opens:	1	1
Notifications:	0	0
Updates:	2868	2872
Keepalives:	60	60
Route Refresh:	0	0
Capability:	0	0
Total:	2929	2933

Minimum time between advertisement runs is 0 seconds  
For address family: IPv4 Unicast  
    Update group 2, subgroup 4  
    Packet Queue length 0  
    Community attribute sent to this neighbor(all)  
    9 accepted prefixes  
    Connections established 1; dropped 0  
    Last reset never  
**External BGP neighbor may be up to 255 hops away.**  
Local host: 10.0.0.12, Local port: 40135  
Foreign host: 10.0.0.11, Foreign port: 179  
Nexthop: 10.0.0.12  
Nexthop global: ::  
Nexthop local: ::  
BGP connection: non shared network  
BGP Connect Retry Timer in Seconds: 10  
Estimated round trip time: 1 ms  
Read thread: on Write thread: on

## Configure BGP TTL Security

The steps below show how to configure BGP TTL security on Cumulus Linux using a leaf (leaf01) and spine (spine01) for the example output:

1. SSH into leaf01 and configure it for TTL security:

```
cumulus@leaf01:~$ net add bgp autonomous-system 65000
cumulus@leaf01:~$ net add bgp neighbor [spine01-IP] ttl-security
          hops [value]
```

2. SSH into spine01 and configure it for TTL security:

```
cumulus@spine01:~$ net add bgp autonomous-system 65001
cumulus@spine01:~$ net add bgp neighbor [leaf01-IP] ttl-security
          hops [value]
```



3. Confirm the configuration with the `show ip bgp neighbor` command:

```
cumulus@spine01:mgmt-vrf:~$ net show bgp neighbor swp1
BGP neighbor on swp1: fe80::4638:39ff:fe00:5b, remote AS 65011, local
AS 65020, external link
Hostname: leaf01
    BGP version 4, remote router ID 10.0.0.11
    BGP state = Established, up for 00:10:45
    Last read 00:00:03, Last write 00:00:03
    Hold time is 9, keepalive interval is 3 seconds
    Neighbor capabilities:
        4 Byte AS: advertised and received
    AddPath:
        IPv4 Unicast: RX advertised IPv4 Unicast and received
        Extended nexthop: advertised and received
        Address families by peer:
            IPv4 Unicast
            Route refresh: advertised and received(old & new)
            Address Family IPv4 Unicast: advertised and received
            Hostname Capability: advertised (name: spine01, domain name: n/a)
            received (name: leaf01, domain name: n/a)
        Graceful Restart Capabilty: advertised and received
        Remote Restart timer is 120 seconds
        Address families by peer:
            none
    Graceful restart informations:
        End-of-RIB send: IPv4 Unicast
        End-of-RIB received: IPv4 Unicast
    Message statistics:
        Inq depth is 0
        Outq depth is 0
              Sent          Rcvd
        Opens:           46            2
        Notifications:  41            0
        Updates:        38            34
        Keepalives:     49334         49331
        Route Refresh:   0            0
        Capability:     0            0
        Total:          49459         49367
    Minimum time between advertisement runs is 0 seconds

    For address family: IPv4 Unicast
        Update group 1, subgroup 1
        Packet Queue length 0
```



```
Community attribute sent to this neighbor(all)
3 accepted prefixes

Connections established 2; dropped 1
Last reset 00:17:37, due to NOTIFICATION sent (Hold Timer
Expired)
External BGP neighbor may be up to 1 hops away.
Local host: fe80::4638:39ff:fe00:5c, Local port: 35564
Foreign host: fe80::4638:39ff:fe00:5b, Foreign port: 179
Nexthop: 10.0.0.21
Nexthop global: fe80::4638:39ff:fe00:5c
Nexthop local: fe80::4638:39ff:fe00:5c
BGP connection: shared network
BGP Connect Retry Timer in Seconds: 10
Read thread: on Write thread: on
```

## Configure Graceful BGP Shutdown

To reduce packet loss during planned maintenance of a router or link, you can configure graceful BGP shutdown, which forces traffic to route around the node.

To configure graceful BGP shutdown for the current node, run the `net add bgp graceful-shutdown` command:

```
cumulus@spine01:~$ net add bgp graceful-shutdown
cumulus@spine01:~$ net pending
cumulus@spine01:~$ net commit
```

When configured, the `graceful-shutdown` community is added to all paths from eBGP peers and the `local-pref` for that route is set to 0. An example configuration is shown below:

```
cumulus@switch:~$ show ip bgp 10.1.3.0/24
BGP routing table entry for 10.1.3.0/24
Paths: (2 available, best #1, table Default-IP-Routing-Table)
  Advertised to non peer-group peers:
    bottom0(10.1.2.2)
      30 20
        10.1.1.2 (metric 10) from top1(10.1.1.2) (10.1.1.2)
          Origin IGP, localpref 100, valid, internal, bestpath-from-AS
      30, best
        Community: 99:1
        AddPath ID: RX 0, TX 52
        Last update: Mon Sep 18 17:01:18 2017
      20
        10.1.2.2 from bottom0(10.1.2.2) (10.1.1.1)
```

```
Origin IGP, metric 0, localpref 0, valid, external, bestpath-
from-AS 20
Community: 99:1 graceful-shutdown
AddPath ID: RX 0, TX 2
Last update: Mon Sep 18 17:01:18 2017
```

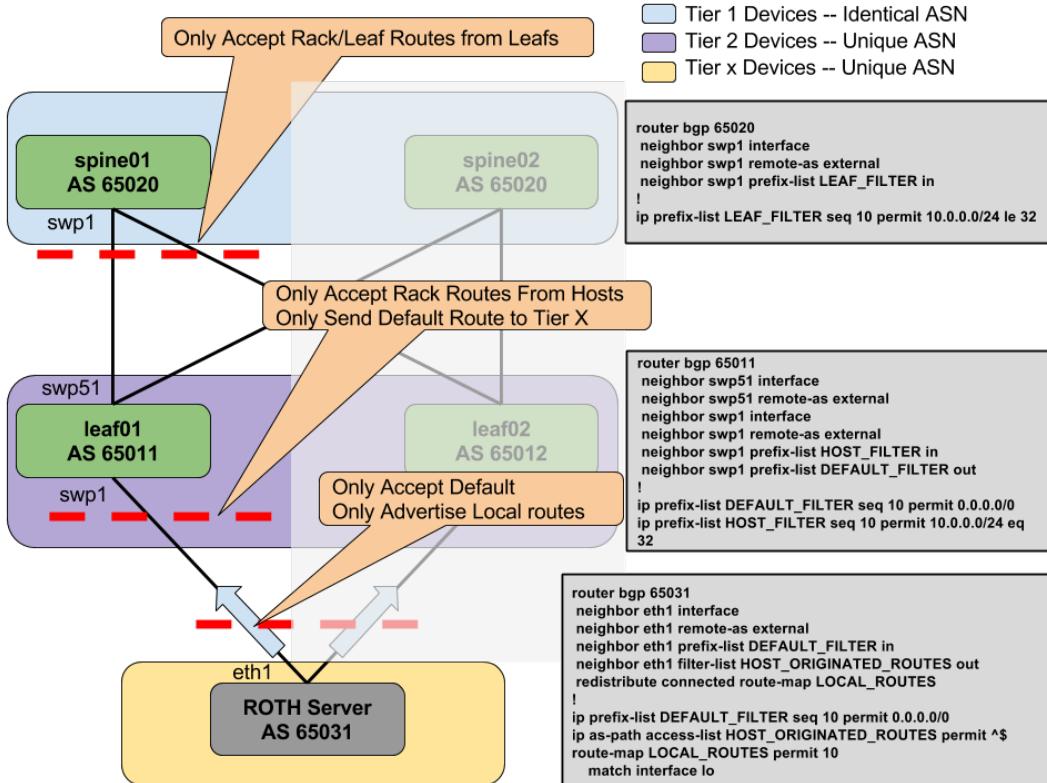
To disable graceful shutdown for the current node, run the `net del bgp graceful-shutdown` command:

```
cumulus@spine01:~$ net del bgp graceful-shutdown
cumulus@spine01:~$ net pending
cumulus@spine01:~$ net commit
```

## Configuration Tips

### BGP Advertisement Best Practices

Limiting the exchange of routing information at various parts in the network is a best practice you should follow. The following image illustrates one way you can do so in a typical Clos architecture:



### Multiple Routing Tables and Forwarding

You can run multiple routing tables (one for in-band/data plane traffic and one for out-of-band /management plane traffic) on the same switch using [management VRF](#) (see page 877) (multiple routing tables and forwarding).



BGP and static routing (IPv4 and IPv6) are supported within a VRF context. For more information, refer to [Virtual Routing and Forwarding - VRF \(see page 847\)](#).

## BGP Community Lists

You can use [community lists](#) to define a BGP community to tag one or more routes. You can then use the communities to apply route policy on either egress or ingress.

The BGP community list can be either *standard* or *expanded*. The standard BGP community list is a pair of values (such as 100:100) that can be tagged on a specific prefix and advertised to other neighbors or applied on route ingress. Alternately, it can be one of four BGP default communities:

- *internet*: a BGP community that matches all routes
- *local-AS*: a BGP community that restrict routes to your confederation's sub-AS
- *no-advertise*: a BGP community that isn't advertised to anyone
- *no-export*: a BGP community that isn't advertised to the eBGP peer

An expanded BGP community list takes a regular expression of communities matches the listed communities.

When the neighbor receives the prefix, it examines the community value and takes action accordingly, such as permitting or denying the community member in the routing policy.

Here is an example of a standard community list filter:

```
cumulus@switch:~$ net add routing community-list standard COMMUNITY1
permit 100:100
```

You can apply the community list to a route map to define the routing policy:

```
cumulus@switch:~$ net add bgp table-map ROUTE-MAP1
```

## Additional Default Settings

Other settings not discussed in detail in this chapter that are enabled by default, include the following:

- `bgp deterministic-med`, which ensures path ordering no longer impacts bestpath selection.
- `bgp show-hostname`, which displays the hostname in show command output.
- `bgp network import-check`, which enables the advertising of the BGP network in IGP.

## Configure BGP Neighbor maximum-prefixes

The maximum number of route announcements, or prefixes, allowed by a BGP neighbor can be configured using the FRR `maximum-prefixes` command:

```
frr(config)# neighbor <peer> maximum-prefix <number>
```

## Troubleshooting

To troubleshoot BGP, you can view the summary of neighbors to which the switch is connected and see information about these connections. The following example shows sample command output:

```
cumulus@switch:~$ net show bgp summary
show bgp ipv4 unicast summary
=====
BGP router identifier 10.0.0.11, local AS number 65011 vrf-id 0
BGP table version 8
RIB entries 11, using 1320 bytes of memory
Peers 2, using 36 KiB of memory
Peer groups 1, using 56 bytes of memory
Neighbor          V          AS MsgRcvd MsgSent      TblVer  InQ OutQ Up
/Down  State/PfxRcd
spine01(swp51)   4 65020      549      551          0     0     0 00:09:
03              3
spine02(swp52)   4 65020      548      550          0     0     0 00:09:
02              3
Total number of neighbors 2

show bgp ipv6 unicast summary
=====
No IPv6 neighbor is configured
```



To determine if the sessions above are iBGP or eBGP sessions, look at the ASNs.

It is also useful to view the routing table as defined by BGP:

```
cumulus@switch:~$ net show bgp ipv4
ERROR: Command not found
Use 'net help KEYWORD(s)' to list all options that use KEYWORD(s)
cumulus@leaf01:~$ net show bgp ipv4
    unicast : add help text
cumulus@leaf01:~$ net show bgp ipv4 unicast
BGP table version is 8, local router ID is 10.0.0.11
Status codes: s suppressed, d damped, h history, * valid, > best, =
multipath,
                i internal, r RIB-failure, S Stale, R Removed
Origin codes: i - IGP, e - EGP, ? - incomplete
      Network          Next Hop            Metric LocPrf Weight Path
*> 10.0.0.11/32      0.0.0.0                  0          32768 ?
*= 10.0.0.12/32      swp52                    0 65020 65012 ?
*>
*> 10.0.0.21/32      swp51                    0 65020 ?
*> 10.0.0.22/32      swp52                    0 65020 ?
```



```
*> 172.16.1.0/24      0.0.0.0          0      32768 i
*= 172.16.2.0/24      swp52           0 65020 65012 i
*>                   swp51           0 65020 65012 i
Total number of prefixes 6
```

To show a more detailed breakdown of a specific neighbor, run the `net show bgp neighbor <neighbor>` command:

```
cumulus@switch:~$ net show bgp neighbor swp51
BGP neighbor on swp51: fe80::4638:39ff:fe00:5c, remote AS 65020,
local AS 65011, external link
Hostname: spine01
Member of peer-group fabric for session parameters
  BGP version 4, remote router ID 10.0.0.21
  BGP state = Established, up for 00:11:30
  Last read 00:00:00, Last write 00:11:26
  Hold time is 3, keepalive interval is 1 seconds
  Configured hold time is 3, keepalive interval is 1 seconds
Neighbor capabilities:
  4 Byte AS: advertised and received
  AddPath:
    IPv4 Unicast: RX advertised IPv4 Unicast and received
    Extended nexthop: advertised and received
    Address families by peer:
      IPv4 Unicast
    Route refresh: advertised and received(old & new)
    Address family IPv4 Unicast: advertised and received
    Hostname Capability: advertised and received
    Graceful Restart Capabilty: advertised and received
    Remote Restart timer is 120 seconds
    Address families by peer:
      none
Graceful restart informations:
  End-of-RIB send: IPv4 Unicast
  End-of-RIB received: IPv4 Unicast
Message statistics:
  Inq depth is 0
  Outq depth is 0
              Sent        Rcvd
  Opens:            1            1
  Notifications:   0            0
  Updates:          7            6
  Keepalives:       690          689
  Route Refresh:    0            0
  Capability:       0            0
  Total:            698          696
Minimum time between advertisement runs is 0 seconds
For address family: IPv4 Unicast
  fabric peer-group member
  Update group 1, subgroup 1
```

```

Packet Queue length 0
Community attribute sent to this neighbor(both)
Inbound path policy configured
Outbound path policy configured
Incoming update prefix filter list is *dc-leaf-in
Outgoing update prefix filter list is *dc-leaf-out
3 accepted prefixes
Connections established 1; dropped 0
Last reset never
Local host: fe80::4638:39ff:fe00:5b, Local port: 48424
Foreign host: fe80::4638:39ff:fe00:5c, Foreign port: 179
Nexthop: 10.0.0.11
Nexthop global: fe80::4638:39ff:fe00:5b
Nexthop local: fe80::4638:39ff:fe00:5b
BGP connection: shared network
BGP Connect Retry Timer in Seconds: 3
Estimated round trip time: 3 ms
Read thread: on Write thread: off

```

To see details of a specific route, such as from where it is received and where it is sent, run the `net show bgp <ip address/prefix>` command:

```

cumulus@leaf01:~$ net show bgp 10.0.0.11/32
BGP routing table entry for 10.0.0.11/32
Paths: (1 available, best #1, table Default-IP-Routing-Table)
  Advertised to non peer-group peers:
    spine01(swp51) spine02(swp52)
  Local
    0.0.0.0 from 0.0.0.0 (10.0.0.11)
      Origin incomplete, metric 0, localpref 100, weight 32768,
      valid, sourced, bestpath-from-AS Local, best
      AddPath ID: RX 0, TX 9
      Last update: Fri Nov 18 01:48:17 2016

```

The above example shows that the routing table prefix seen by BGP is 10.0.0.11/32, that this route is advertised to two neighbors, and that it is not heard by any neighbors.

### *Log Neighbor State Changes*

To log the changes that a neighbor goes through so that you can troubleshoot issues associated with that neighbor, run the `log-neighbor-changes` command, which is enabled by default.

The output is sent to the specified log file, usually `/var/log/frr/bgpd.log`, and looks like this:

```

2016/07/08 10:12:06.572827 BGP: %NOTIFICATION: sent to neighbor
10.0.0.2 6/3 (Cease/Peer Unconfigured) 0 bytes
2016/07/08 10:12:06.572954 BGP: Notification sent to neighbor
10.0.0.2: type 6/3
2016/07/08 10:12:16.682071 BGP: %ADJCHANGE: neighbor 192.0.2.2 Up

```



```
2016/07/08 10:12:16.682660 BGP: %ADJCHANGE: neighbor 10.0.0.2 Up
```

## Troubleshoot Link-local Addresses

To verify that `frr` learned the neighboring link-local IPv6 address via the IPv6 neighbor discovery router advertisements on a given interface, run the `show interface <if-name>` command. If `ipv6 nd suppress-ra` is not enabled on both ends of the interface, then `Neighbor address(s)` has the other end's link-local address. That is the address that BGP uses when BGP is enabled on that interface.



IPv6 route advertisements (RAs) are automatically enabled on an interface with IPv6 addresses; the `no ipv6 nd suppress-ra` command is not needed for BGP unnumbered.

Use `vtysh` to verify the configuration:

```
cumulus@switch:~$ sudo vtysh

Hello, this is FRRouting (version 4.0+cl3u8).
Copyright 1996-2005 Kunihiro Ishiguro, et al.

R7# show interface swp1
Interface swp1 is up, line protocol is up
  Link ups:      0    last: (never)
  Link downs:   0    last: (never)
  PTM status: disabled
  vrf: Default-IP-Routing-Table
  index 4 metric 0 mtu 1500
  flags: <UP,BROADCAST,RUNNING,MULTICAST>
  HWaddr: 44:38:39:00:00:5c
  inet6 fe80::4638:39ff:fe00:5c/64
    ND advertised reachable time is 0 milliseconds
    ND advertised retransmit interval is 0 milliseconds
    ND router advertisements are sent every 10 seconds
    ND router advertisements lifetime tracks ra-interval
    ND router advertisement default router preference is medium
    Hosts use stateless autoconfig for addresses.
  Neighbor address(s):
    inet6 fe80::4638:39ff:fe00:5b/128
```

Instead of the IPv6 address, the peering interface name is displayed in the `show ip bgp summary` command and wherever else applicable:

```
cumulus@switch:~$ net show bgp summary
BGP router identifier 10.0.0.21, local AS number 65020 vrf-id 0
BGP table version 15
RIB entries 17, using 2040 bytes of memory
Peers 6, using 97 KiB of memory
Peer groups 1, using 56 bytes of memory
```

Neighbor State/PfxRcd	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down
leaf01(swp1) 35 2	4	65011	2834	2843	0	0	0	02:21:
leaf02(swp2) 36 2	4	65012	2834	2844	0	0	0	02:21:
leaf03(swp3) 35 2	4	65013	2834	2843	0	0	0	02:21:
leaf04(swp4) 36 2	4	65014	2834	2844	0	0	0	02:21:
edge01(swp29) 37 3	4	65051	8509	8505	0	0	0	02:21:
edge01(swp30) 35 3	4	65051	8506	8503	0	0	0	02:21:

Total number of neighbors 6

Most of the `net show` commands can take the interface name instead of the IP address.

```
cumulus@leaf01:~$ net show bgp neighbor
      fabric : BGP neighbor or peer-group
      swp51   : BGP neighbor or peer-group
      swp52   : BGP neighbor or peer-group
<ENTER>
```

```
cumulus@leaf01:~$ net show bgp neighbor swp51
BGP neighbor on swp51: fe80::4638:39ff:fe00:5c, remote AS 65020,
local AS 65011, external link
Hostname: spine01
Member of peer-group fabric for session parameters
  BGP version 4, remote router ID 0.0.0.0
  BGP state = Connect
  Last read 20:16:21, Last write 20:55:51
  Hold time is 30, keepalive interval is 10 seconds
  Configured hold time is 30, keepalive interval is 10 seconds
Message statistics:
  Inq depth is 0
  Outq depth is 0
          Sent        Rcvd
  Opens:          1          1
  Notifications: 1          0
  Updates:        7          6
  Keepalives:    2374       2373
  Route Refresh: 0          0
  Capability:    0          0
  Total:         2383       2380
Minimum time between advertisement runs is 5 seconds
```

```

For address family: IPv4 Unicast
  fabric peer-group member
  Not part of any update group
  Community attribute sent to this neighbor(both)
  Inbound path policy configured
  Outbound path policy configured
  Incoming update prefix filter list is *dc-leaf-in
  Outgoing update prefix filter list is *dc-leaf-out
  0 accepted prefixes
  Connections established 1; dropped 1
  Last reset 20:16:20, due to NOTIFICATION sent (Cease/Other
Configuration Change)
BGP Connect Retry Timer in Seconds: 3
Next connect timer due in 1 seconds
Read thread: on Write thread: on

```

## Enable Read-only Mode

As BGP peers are established and updates are received, prefixes might be installed in the RIB and advertised to BGP peers even though the information from all peers has not yet been received and processed. Depending on the timing of the updates, prefixes might be installed and propagated through BGP, and then immediately withdrawn and replaced with new routing information. Read-only mode minimizes this BGP route churn in both the local RIB and with BGP peers.

Enable read-only mode to reduce CPU and network usage when you restart the BGP process, or when you issue the `clear ip bgp` command. Because intermediate best paths are possible for the same prefix as peers get established and start receiving updates at different times, read-only mode is particularly useful in topologies where BGP learns a prefix from many peers and the network has a high number of prefixes.

To enable read-only mode, run the `net add bgp update-delay <max-delay in 0-3600 seconds> [<establish-wait in 1-3600 seconds>]` command.

The following example command enables read-only mode, sets the `max-delay` timer to 300 seconds and the `establish-wait` timer to 90 seconds.

```
cumulus@switch:$ net add bgp update-delay 300 90
```



The default value for `max-delay` is 0, which disables read-only mode. The `establish-wait` option is optional; however, if specified, the `establish-wait` option must be shorter than the `max-delay`.

Read-only mode begins as soon as the first peer reaches its established state and the `max-delay` timer starts, and continues until either of the following two conditions are met:

- All the configured peers (except the shutdown peers) have sent an explicit EOR (End-Of-RIB) or an implicit EOR. The first keep-alive after BGP has reached the established state is considered an implicit EOR.  
If you specify the `establish-wait` option, BGP only considers peers that have reached the established state from the moment the `max-delay` timer starts until the `establish-wait` period ends.



The minimum set of established peers for which EOR is expected are the peers that are established during the `establish-wait window`, not necessarily all the configured neighbors.

- The timer reaches the configured `max-delay`.

While in read-only mode, BGP does not run best-path or generate any updates to its peers.

To show information about the state of the update delay, run the `show bgp summary` command.

## Apply a Route Map for Route Updates

There are two ways you can apply [route maps](#) for BGP:

- By filtering routes from BGP into Zebra
- By filtering routes from Zebra into the Linux kernel

### *Filter Routes from BGP into Zebra*

You can apply a route map on route updates from BGP to Zebra. All the applicable match operations are allowed, such as match on prefix, next hop, communities, and so on. Set operations for this attach-point are limited to metric and next hop only. Any operation of this feature does not affect BGPs internal RIB.

Both IPv4 and IPv6 address families are supported. Route maps work on multi-paths; however, the metric setting is based on the best path only.

To apply a route map to filter route updates from BGP into Zebra, run the following command:

```
cumulus@switch:$ net add bgp table-map <route-map-name>
```

### *Filter Routes from Zebra into the Linux Kernel*

To apply a route map to filter route updates from Zebra into the Linux kernel, run the following command:

```
cumulus@switch:$ net add routing protocol bgp route-map <route-map-name>
```

## Protocol Tuning

### *Converge Quickly On Link Failures*

In the Clos topology, we recommend that you only use interface addresses to set up peering sessions. This means that when the link fails, the BGP session is torn down immediately, triggering route updates to propagate through the network quickly. This requires the following commands be enabled for all links: `link-detect` and `ttl-security hops <hops>`. `ttl-security hops` specifies how many hops away the neighbor is. For example, in a Clos topology, every peer is at most 1 hop away.





See Caveats and Errata below for information regarding `ttl-security hops`.

Here is an example:

```
cumulus@switch:~$ net add bgp neighbor 10.0.0.2 ttl-security hops 1
```

### *Converge Quickly On Soft Failures*

It is possible that the link is up but the neighboring BGP process is hung or has crashed. If a BGP process hangs or crashes, the FRRouting `watchfrr` daemon, which monitors the various FRRouting daemons, attempts to restart it. BGP itself has a keepalive interval that is exchanged between neighbors. By default, this keepalive interval is set to 3 seconds. You can increase the interval to a higher number, which decreases CPU load, especially in the presence of a lot of neighbors. The keepalive interval is the periodicity with which the keepalive message is sent. The hold time specifies how many keepalive messages can be lost before the connection is considered invalid. It is usually set to three times the keepalive time and defaults to 9 seconds. The following example shows how to change these timers:

```
cumulus@switch:~$ net add bgp neighbor swp51 timers 10 30
```

The following snippet shows that the default values have been modified for this neighbor:

```
cumulus@switch:~$ net show bgp neighbor swp51
BGP neighbor on swp51: fe80::4638:39ff:fe00:5c, remote AS 65020,
local AS 65011, external link
Hostname: spine01
Member of peer-group fabric for session parameters
  BGP version 4, remote router ID 0.0.0.0
  BGP state = Connect
  Last read 00:00:13, Last write 00:39:43
  Hold time is 30, keepalive interval is 10 seconds
  Configured hold time is 30, keepalive interval is 10 seconds
...
```

### *Reconnect Quickly*

A BGP process attempts to connect to a peer after a failure (or on startup) every `connect-time` seconds. By default, this is 10 seconds. To modify this value, run the following command:

```
cumulus@switch:~$ net add bgp neighbor swp51 timers connect 30
```

You must specify this command for each neighbor.

## Advertisement Interval

BGP by default chooses stability over fast convergence. This is very useful when routing for the Internet. For example, unlike link-state protocols, BGP typically waits for a duration of `advertisement-interval` seconds between sending consecutive updates to a neighbor. This ensures that an unstable neighbor flapping routes are not propagated throughout the network. By default, this is set to zero seconds for both eBGP and iBGP sessions, which allows for very fast convergence. You can modify this as follows:

```
cumulus@switch:~$ net add bgp neighbor swp51 advertisement-interval 5
```

The following output shows the modified value:

```
cumulus@switch:~$ net show bgp neighbor swp51
BGP neighbor on swp51: fe80::4638:39ff:fe00:5c, remote AS 65020,
local AS 65011, external link
Hostname: spine01
Member of peer-group fabric for session parameters
BGP version 4, remote router ID 0.0.0.0
BGP state = Connect
Last read 00:04:37, Last write 00:44:07
Hold time is 30, keepalive interval is 10 seconds
Configured hold time is 30, keepalive interval is 10 seconds
Message statistics:
  Inq depth is 0
  Outq depth is 0
          Sent      Rcvd
Opens:            1          1
Notifications:    1          0
Updates:          7          6
Keepalives:       2374      2373
Route Refresh:    0          0
Capability:       0          0
Total:            2383      2380
Minimum time between advertisement runs is 5 seconds
...
```



This command is not supported with peer-groups.

See this [IETF draft](#) for more details on the use of this value.



## Caveats and Errata

### *ttl-security Issue*

Enabling `ttl-security` does not cause the hardware to be programmed with the relevant information. This means that frames will come up to the CPU and be dropped there. It is recommended that you use the `net add acl` command to explicitly add the relevant entry to hardware.

For example, you can configure a file, such as `/etc/cumulus/acl/policy.d/01control_plane_bgp.rules`, with a rule like this for TTL:

```
INGRESS_INTF = swp1
INGRESS_CHAIN = INPUT, FORWARD

[iptables]
-A $INGRESS_CHAIN --in-interface $INGRESS_INTF -p tcp --dport bgp
-m ttl --ttl 255 POLICE --set-mode pkt --set-rate 2000 --set-burst
1000
-A $INGRESS_CHAIN --in-interface $INGRESS_INTF -p tcp --dport bgp DROP
```



For more information about ACLs, see [Netfilter \(ACLs\)](#) (see page 142).

### *BGP Dynamic Capabilities not Supported*

Dynamic capabilities, which enable BGP to renegotiate a new feature for an already established peer, are not supported in Cumulus Linux.

### *Related Information*

- Bidirectional forwarding detection (see page 821) (BFD) and BGP
- Wikipedia entry for BGP (includes list of useful RFCs)
- FRR BGP documentation
- IETF draft discussing BGP use within data centers
- RFC 1657, Definitions of Managed Objects for the Fourth Version of the Border Gateway Protocol (BGP-4) using SMIv2
- RFC 1997, BGP Communities Attribute
- RFC 2385, Protection of BGP Sessions via the TCP MD5 Signature Option
- RFC 2439, BGP Route Flap Damping
- RFC 2545, Use of BGP-4 Multiprotocol Extensions for IPv6 Inter-Domain Routing
- RFC 2918, Route Refresh Capability for BGP-4
- RFC 4271, A Border Gateway Protocol 4 (BGP-4)
- RFC 4360, BGP Extended Communities Attribute



- RFC 4456, BGP Route Reflection – An Alternative to Full Mesh Internal BGP (iBGP)
- RFC 4760, Multiprotocol Extensions for BGP-4
- RFC 5004, Avoid BGP Best Path Transitions from One External to Another
- RFC 5065, Autonomous System Confederations for BGP
- RFC 5291, Outbound Route Filtering Capability for BGP-4
- RFC 5492, Capabilities Advertisement with BGP-4
- RFC 5549, Advertising IPv4 Network Layer Reachability Information with an IPv6 Next Hop
- RFC 6793, BGP Support for Four-Octet Autonomous System (AS) Number Space
- RFC 7911, Advertisement of Multiple Paths in BGP
- draft-walton-bgp-hostname-capability-02, Hostname Capability for BGP

## Policy-based Routing

Typical routing systems and protocols forward traffic based on the destination address in the packet, which is used to look up an entry in a routing table. However, sometimes the traffic on your network requires a more hands-on approach. You might need to forward a packet based on the source address, the packet size, or other information in the packet header.

Policy-based routing (PBR) lets you make routing decisions based on filters that change the routing behavior of specific traffic so that you can override the routing table and influence where the traffic goes. For example, you can use PBR to help you reach the best bandwidth utilization for business-critical applications, isolate traffic for inspection or analysis, or manually load balance outbound traffic.

Policy-based routing is applied to incoming packets. All packets received on a PBR-enabled interface pass through enhanced packet filters that determine rules and specify where to forward the packets.



- You can create a *maximum* of 255 PBR match rules and 256 nexthop groups (this is the ECMP limit).
- You can apply only one PBR policy per input interface.
- You can match on source and *destination* IP address only.
- PBR is not supported for GRE or VXLAN tunneling.
- PBR is not supported on ethernet interfaces.
- A PBR rule cannot contain both IPv4 and IPv6 addresses.

## Contents

### This topic describes ...

- Configure PBR (see page 817)
- Configuration Example (see page 818)
- Review Your Configuration (see page 819)
- Delete PBR Rules and Policies (see page 820)



## Configure PBR

A PBR policy contains one or more policy maps. Each policy map:

- Is identified with a unique map name and sequence number. The sequence number is used to determine the relative order of the map within the policy.
- Contains a match source IP rule or a match destination IP rule, and a set rule.
  - To match on a source and destination address, a policy map can contain both match source and match destination IP rules.
  - A set rule determines the PBR nexthop for the policy. The set rule can contain a single nexthop IP address or it can contain a nexthop group. A nexthop group has more than one nexthop IP address so that you can use multiple interfaces to forward traffic. To use ECMP, you configure a nexthop group.

To use PBR in Cumulus linux, you define a PBR policy and apply it to the ingress interface (the interface must already have an IP address assigned). Traffic is matched against the match rules in sequential order and forwarded according to the set rule in the first match. Traffic that does not match any rule is passed onto the normal destination based routing mechanism.



For Tomahawk and Tomahawk+ platforms, you must configure the switch to operate in non-atomic mode, which offers better scaling as all TCAM resources are used to actively impact traffic. Add the line `acl.non_atomic_update_mode = TRUE` to the `/etc/cumulus/switchd.conf` file. For more information, see [Nonatomic Update Mode vs. Atomic Update Mode \(see page 150\)](#).

To configure a PBR policy:

1. Configure the policy map with the `net add pbr-map <name> seq <1-700> match dst-ip|src-ip <ip/prefixlen>` command.  
The example commands below configure a policy map called `map1` with sequence number 1, that matches on destination address `10.1.2.0/24` and source address `10.1.4.1/24`.

```
cumulus@switch:~$ net add pbr-map map1 seq 1 match dst-ip  
10.1.2.0/24  
cumulus@switch:~$ net add pbr-map map1 seq 1 match src-ip  
10.1.4.1/24
```



If the IP address in the rule is `0.0.0.0/0` or `::/0`, any IP address is a match. You cannot mix IPv4 and IPv6 addresses in a rule.

2. Either apply a *nexthop* or a *nexthop* group to the policy map:
  - To apply a nexthop to the policy map, use the `net add pbr-map <name> seq <1-700> set nexthop <ipaddress> [<interface>] [nexthop-vrf <vrfname>]` command. The output interface and VRF are optional, however, you *must* specify the VRF you want to use for resolution if the nexthop is *not* in the default VRF.  
The example command below applies the nexthop `192.168.0.31` on the output interface `swp2` and VRF `rocket` to the `map1` policy map:

```
cumulus@switch:~$ net add pbr-map map1 seq 1 set nexthop
192.168.0.31 swp2 nexthop-vrf rocket
```

- To apply a nexthop group (for ECMP) to the policy map, first create the nexthop group, then apply the group to the policy map:

a. Create the nexthop group with the `net add nexthop-group <groupname> nexthop <ipaddress> [<interface>] [nexthop-vrf <vrfname>]` command.

The output interface and VRF are optional. However, you must specify the VRF if the nexthop is not in the default VRF.

The example commands below create a nexthop group called `group1` that contains the nexthop 192.168.0.21 on output interface `swp1` and VRF `rocket`, and the nexthop 192.168.0.22.

```
cumulus@switch:~$ net add nexthop-group group1 nexthop
192.168.0.21 swp1 nexthop-vrf rocket
cumulus@switch:~$ net add nexthop-group group1 nexthop
192.168.0.22
```

- b. Apply the nexthop group to the policy map with the `net add pbr-map <name> seq <1-700> set nexthop-group <groupname>` command.
- The example command below applies the nexthop group `group1` to the `map1` policy map:

```
cumulus@switch:~$ net add pbr-map map1 seq 1 set
nexthop-group group1
```

3. Assign the PBR policy to an ingress interface with the `net add interface <interface> pbr-policy <name>` command.

The example command below assigns the PBR policy `map1` to interface `swp51`:

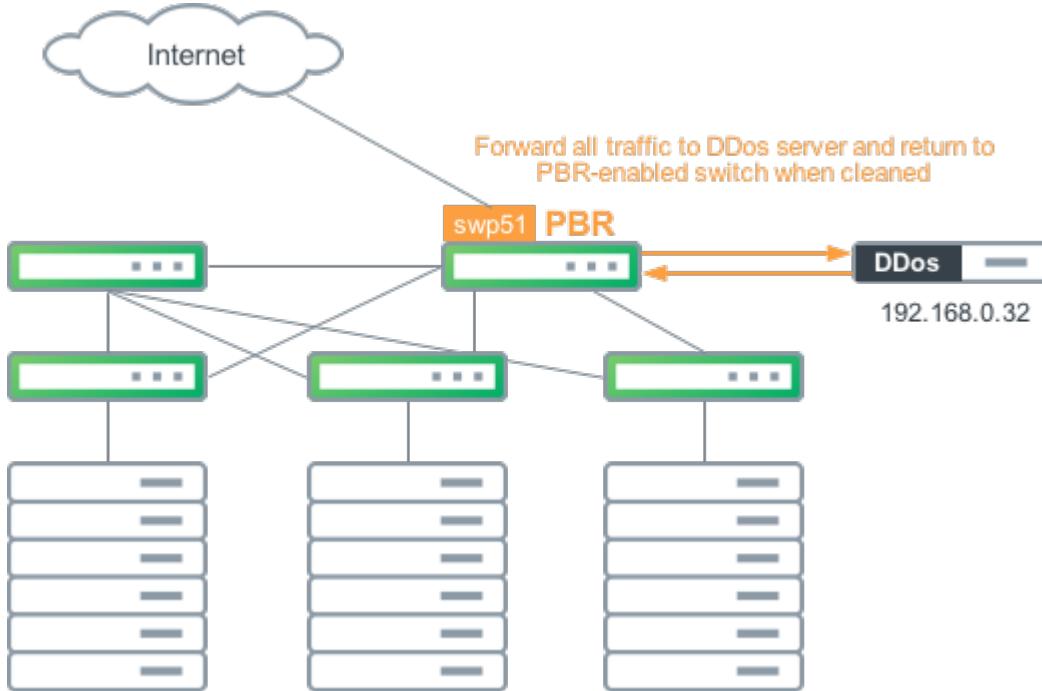
```
cumulus@switch:~$ net add interface swp51 pbr-policy map1
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```



You can only set one policy per interface.

## Configuration Example

In the following example, the PBR-enabled switch has a PBR policy to route all traffic from the Internet to a server that performs anti-DDOS. The traffic returns to the PBR-enabled switch after being cleaned and is then passed onto the regular destination based routing mechanism.



The configuration for the example above is:

```
cumulus@switch:~$ net add pbr-map map1 seq 1 match src-ip 0.0.0.0/0
cumulus@switch:~$ net add pbr-map map1 seq 1 set nexthop 192.168.0.32
cumulus@switch:~$ net add interface swp51 pbr-policy map1
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands produce the following snippet in the `/etc/frr/frr.conf` file.

```
interface swp51
pbr-policy map1
pbr-map map1 seq 1
match src-ip 0.0.0.0/0
set nexthop 192.168.0.32
```

## Review Your Configuration

Use the following commands to see the configured PBR policies.

To see the policies applied to all interfaces on the switch, use the `net show pbr interface` command. For example:

```
cumulus@switch:~$ net show pbr interface
swp55s3(67) with pbr-policy map1
```

To see the policies applied to a specific interface on the switch, add the interface name at the end of the command; for example, `net show pbr interface swp51`.

To see information about all policies, including mapped table and rule numbers, use the `net show pbr map` command. If the rule is not set, you see a reason why.

```
cumulus@switch:~$ net show pbr map
pbr-map map1 valid: 1
Seq: 700 rule: 999 Installed: 1(1) Reason: Valid
SRC Match: 10.0.0.1/32
nexthop 192.168.0.32
Installed: 1(1) Tableid: 10003
Seq: 701 rule: 1000 Installed: 1(2) Reason: Valid
SRC Match: 90.70.0.1/32
nexthop 192.168.0.32
Installed: 1(1) Tableid: 10004
```

To see information about a specific policy, what it matches, and with which interface it is associated, add the map name at the end of the command; for example, `net show pbr map map1`.

To see information about all nexthop groups, run the `net show pbr nexthop-group` command:

```
cumulus@switch:~$ net show pbr nexthop-group
Nexthop-Group: map1701 Table: 10004 Valid: 1 Installed: 1
Valid: 1 nexthop 10.1.1.2
Nexthop-Group: map1700 Table: 10003 Valid: 1 Installed: 1
Valid: 1 nexthop 10.1.1.2
Nexthop-Group: group1 Table: 10000 Valid: 1 Installed: 1
Valid: 1 nexthop 192.168.10.0 bond1
Valid: 1 nexthop 192.168.10.2
Valid: 1 nexthop 192.168.10.3 vlan70
Nexthop-Group: group2 Table: 10001 Valid: 1 Installed: 1
Valid: 1 nexthop 192.168.8.1
Valid: 1 nexthop 192.168.8.2
Valid: 1 nexthop 192.168.8.3
```

To see information about a specific nexthop group, add the group name at the end of the command; for example, `net show pbr nexthop-group group1`.



A new Linux routing table ID is used for each nexthop and nexthop group.

## Delete PBR Rules and Policies

You can delete a PBR rule, a nexthop group, or a policy with the `net del` command. The following commands provide examples.





Use caution when deleting PBR rules and nexthop groups, as you might create an incorrect configuration for the PBR policy.

The following example shows how to delete a PBR rule:

```
cumulus@switch:~$ net del pbr-map map1  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

The following example shows how to delete a PBR rule match:

```
cumulus@switch:~$ net del pbr-map map1 seq 1 match dst-ip 10.1.2.0/24  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

The following example shows how to delete a nexthop group:

```
cumulus@switch:~$ net del nexthop-group group1  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

The following example shows how to delete a nexthop from a group:

```
cumulus@switch:~$ net del nexthop-group group1 nexthop 192.168.0.32  
swp1 nexthop-vrf rocket  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

The following example shows how to delete a PBR policy so that the PBR interface is no longer receiving PBR traffic:

```
cumulus@switch:~$ net del interface swp3 pbr-policy map1  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

## Bidirectional Forwarding Detection - BFD

*Bidirectional Forwarding Detection* (BFD) provides low overhead and rapid detection of failures in the paths between two network devices. It provides a unified mechanism for link detection over all media and protocol layers. Use BFD to detect failures for IPv4 and IPv6 single or multihop paths between any two network devices, including unidirectional path failure detection.





Cumulus Linux does not support demand mode in BFD.

## Contents

This topic describes ...

- BFD Multihop Routed Paths (see page 822)
- BFD Parameters (see page 822)
- Configure BFD (see page 822)
- BFD in BGP (see page 823)
- BFD in OSPF (see page 824)
- OSPF Show Commands (see page 825)
- Scripts (see page 826)
- Echo Function (see page 827)
  - About the Echo Packet (see page 827)
  - Transmit and Receive Echo Packets (see page 827)
  - Echo Function Parameters (see page 827)
- Troubleshooting (see page 828)
- Related Information (see page 829)

## BFD Multihop Routed Paths

BFD multihop sessions are built over arbitrary paths between two systems, which results in some complexity that does not exist for single hop sessions. Here are some best practices for using multihop paths:

- **Spoofing:** To avoid spoofing with multihop paths, configure `max_hop_cnt` (maximum hop count) for each peer, which limits the number of hops for a BFD session. All BFD packets exceeding the max hop count will be dropped.
- **Demultiplexing:** Since multihop BFD sessions can take arbitrary paths, demultiplex the initial BFD packet based on the source/destination IP address pair. Use FRRouting, which monitors connectivity to the peer, to determine the source/destination IP address pairs.

Multihop BFD sessions are supported for both IPv4 and IPv6 peers. See below for more details.

## BFD Parameters

You can configure the following BFD parameters for both IPv4 and IPv6 sessions:

- The required minimum interval between the received BFD control packets.
- The minimum interval for transmitting BFD control packets.
- The detection time multiplier.

## Configure BFD

You configure BFD one of two ways: by specifying the configuration in the `PTM topology.dot` file (see page 360), or using `FRRouting` (see page 731). However, the topology file has some limitations:



- The `topology.dot` file supports creating BFD IPv4 and IPv6 single hop sessions only; you cannot specify IPv4 or IPv6 multihop sessions in the topology file.
- The topology file supports BFD sessions for only link-local IPv6 peers; BFD sessions for global IPv6 peers discovered on the link will not be created.



You cannot specify BFD multihop sessions in the `topology.dot` file since you cannot specify the source and destination IP address pairs in that file. Use [FRRouting \(see page 737\)](#) to configure multihop sessions.

The FRRouting CLI can track IPv4 and IPv6 peer connectivity — both single hop and multihop, and both link-local IPv6 peers and global IPv6 peers — using BFD sessions without needing the `topology.dot` file. Use FRRouting to register multihop peers with PTM and BFD as well as for monitoring the connectivity to the remote BGP multihop peer. FRRouting can dynamically register and unregister both IPv4 and IPv6 peers with BFD when the BFD-enabled peer connectivity is established or de-established, respectively. Also, you can configure BFD parameters for each BGP or OSPF peer using FRRouting.



The BFD parameter configured in the topology file is given higher precedence over the client-configured BFD parameters for a BFD session that has been created by both topology file and client (FRRouting).



BFD requires an IP address for any interface on which it is configured. The neighbor IP address for a single hop BFD session must be in the ARP table before BFD can start sending control packets.

## BFD in BGP

For FRRouting when using **BGP**, neighbors are registered and de-registered with [PTM \(see page 360\)](#) dynamically when you enable BFD in BGP using `net add bgp neighbor <neighbor|IP|interface> bfd`. For example:

Configuration of BFD for a peergroup or individual neighbors is performed in the same way.

```
cumulus@switch:~$ net add bgp neighbor swp1 bfd
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands add the `neighbor SPINE bfd` line below the last address family configuration in the `/etc/frr/frr.conf` file:

```
...
router bgp 65000
    neighbor swp1 bfd
```



...

The configuration above configures the default BFD values of intervals: 3, minimum RX interval: 300ms, minimum TX interval: 300ms.

To see neighbor information in BGP, including BFD status, run `net show bgp neighbor <interface>`.

```
cumulus@spine01:~$ net show bgp neighbor swp1
...
BFD: Type: single hop
    Detect Mul: 3, Min Rx interval: 300, Min Tx interval: 300
    Status: Down, Last update: 0:00:00:08
...
```

To change the BFD values to something other than the defaults, BFD parameters can be configured for each BGP neighbor. For example:

#### BFD in BGP

```
cumulus@switch:~$ net add bgp neighbor swp1 bfd 4 400 400
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

#### BFD in OSPF

For FRRouting using **OSFP**, neighbors are registered and de-registered dynamically with [PTM \(see page 360\)](#) when you enable or disable BFD in OSPF. A neighbor is registered with BFD when two-way adjacency is established and deregistered when adjacency goes down if the BFD is enabled on the interface. The BFD configuration is per interface and any IPv4 and IPv6 neighbors discovered on that interface inherit the configuration.

#### BFD in OSPF

```
cumulus@switch:~$ net add interface swp1 ospf6 bfd 5 500 500
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands create the following configuration snippet in the `/etc/frr/frr.conf` file:

```
interface swp1
  ipv6 ospf6 bfd 5 500 500
end
```



## OSPF Show Commands

The BFD lines at the end of each code block shows the corresponding IPv6 or IPv4 OSPF interface or neighbor information.

### Show IPv6 OSPF Interface

```
cumulus@switch:~$ net show ospf6 interface swp2s0
swp2s0 is up, type BROADCAST
  Interface ID: 4
  Internet Address:
    inet : 11.0.0.21/30
    inet6: fe80::4638:39ff:fe00:6c8e/64
  Instance ID 0, Interface MTU 1500 (autodetect: 1500)
  MTU mismatch detection: enabled
  Area ID 0.0.0.0, Cost 10
  State PointToPoint, Transmit Delay 1 sec, Priority 1
  Timer intervals configured:
    Hello 10, Dead 40, Retransmit 5
  DR: 0.0.0.0 BDR: 0.0.0.0
  Number of I/F scoped LSAs is 2
    0 Pending LSAs for LSUpdate in Time 00:00:00 [thread off]
    0 Pending LSAs for LSAck in Time 00:00:00 [thread off]
  BFD: Detect Mul: 3, Min Rx interval: 300, Min Tx interval: 300
```

### Show IPv6 OSPF Neighbor

```
cumulus@switch:~$ net show ospf6 neighbor detail
Neighbor 0.0.0.4%swp2s0
  Area 0.0.0.0 via interface swp2s0 (ifindex 4)
  His IfIndex: 3 Link-local address: fe80::202:ff:fe00:a
  State Full for a duration of 02:32:33
  His choice of DR/BDR 0.0.0.0/0.0.0.0, Priority 1
  DbDesc status: Slave SeqNum: 0x76000000
  Summary-List: 0 LSAs
  Request-List: 0 LSAs
  Retrans-List: 0 LSAs
    0 Pending LSAs for DbDesc in Time 00:00:00 [thread off]
    0 Pending LSAs for LSReq in Time 00:00:00 [thread off]
    0 Pending LSAs for LSUpdate in Time 00:00:00 [thread off]
    0 Pending LSAs for LSAck in Time 00:00:00 [thread off]
  BFD: Type: single hop
    Detect Mul: 3, Min Rx interval: 300, Min Tx interval: 300
    Status: Up, Last update: 0:00:00:20
```

### Show IPv4 OSPF Interface

```
cumulus@switch:~$ net show ospf interface swp2s0
swp2s0 is up
    ifindex 4, MTU 1500 bytes, BW 0 Kbit <UP,BROADCAST,RUNNING,
MULTICAST>
        Internet Address 11.0.0.21/30, Area 0.0.0.0
        MTU mismatch detection:enabled
        Router ID 0.0.0.3, Network Type POINTOPOINT, Cost: 10
        Transmit Delay is 1 sec, State Point-To-Point, Priority 1
        No designated router on this network
        No backup designated router on this network
        Multicast group memberships: OSPFAllRouters
        Timer intervals configured, Hello 10s, Dead 40s, Wait 40s,
Retransmit 5
            Hello due in 7.056s
        Neighbor Count is 1, Adjacent neighbor count is 1
        BFD: Detect Mul: 5, Min Rx interval: 500, Min Tx interval: 500
```

### Show IPv4 OSPF Neighbor

```
cumulus@switch:~$ net show ospf neighbor detail
Neighbor 0.0.0.4, interface address 11.0.0.22
    In the area 0.0.0.0 via interface swp2s0
    Neighbor priority is 1, State is Full, 5 state changes
    Most recent state change statistics:
        Progressive change 3h59m04s ago
    DR is 0.0.0.0, BDR is 0.0.0.0
    Options 2 *|-|-|E|*
    Dead timer due in 38.501s
    Database Summary List 0
    Link State Request List 0
    Link State Retransmission List 0
    Thread Inactivity Timer on
    Thread Database Description Retransmission off
    Thread Link State Request Retransmission on
    Thread Link State Update Retransmission on
    BFD: Type: single hop
        Detect Mul: 5, Min Rx interval: 500, Min Tx interval: 500
        Status: Down, Last update: 0:00:01:29
```

## Scripts

`ptmd` executes scripts at `/etc/ptm.d/bfd-sess-down` and `/etc/ptm.d/bfd-sess-up` for when BFD sessions go down or up, running `bfd-sess-down` when a BFD session goes down and running `bfd-sess-up` when a BFD session goes up.

You should modify these default scripts as needed.



## Echo Function

Cumulus Linux supports the *echo function* for IPv4 single hops only, and with the asynchronous operating mode only (Cumulus Linux does not support demand mode).

You use the echo function primarily to test the forwarding path on a remote system. To enable the echo function, set `echoSupport` to 1 in the topology file.

Once the echo packets are looped by the remote system, the BFD control packets can be sent at a much lower rate. You configure this lower rate by setting the `slowMinTx` parameter in the topology file to a non-zero value of milliseconds.

You can use more aggressive detection times for echo packets since the round-trip time is reduced because they are accessing the forwarding path. You configure the detection interval by setting the `echoMinRx` parameter in the topology file to a non-zero value of milliseconds; the minimum setting is 50 milliseconds. Once configured, BFD control packets are sent out at this required minimum echo Rx interval. This indicates to the peer that the local system can loop back the echo packets. Echo packets are transmitted if the peer supports receiving echo packets.

### About the Echo Packet

BFD echo packets are encapsulated into UDP packets over destination and source UDP port number 3785. The BFD echo packet format is vendor-specific and has not been defined in the RFC. BFD echo packets that originate from Cumulus Linux are 8 bytes long and have the following format:

0	1	2	3
Version	Length	Reserved	
My Discriminator			

Where:

- **Version** is the version of the BFD echo packet.
- **Length** is the length of the BFD echo packet.
- **My Discriminator** is a non-zero value that uniquely identifies a BFD session on the transmitting side. When the originating node receives the packet after being looped back by the receiving system, this value uniquely identifies the BFD session.

### Transmit and Receive Echo Packets

BFD echo packets are transmitted for a BFD session only when the peer has advertised a non-zero value for the required minimum echo Rx interval (the `echoMinRx` setting) in the BFD control packet when the BFD session starts. The transmit rate of the echo packets is based on the peer advertised echo receive value in the control packet.

BFD echo packets are looped back to the originating node for a BFD session only if locally the `echoMinRx` and `echoSupport` are configured to a non-zero values.

### Echo Function Parameters

You configure the echo function by setting the following parameters in the topology file at the global, template and port level:

- **echoSupport:** Enables and disables echo mode. Set to 1 to enable the echo function. It defaults to 0 (disable).
- **echoMinRx:** The minimum interval between echo packets the local system is capable of receiving. This is advertised in the BFD control packet. When the echo function is enabled, it defaults to 50. If you disable the echo function, this parameter is automatically set to 0, which indicates the port or the node cannot process or receive echo packets.
- **slowMinTx:** The minimum interval between transmitting BFD control packets when the echo packets are being exchanged.

## Troubleshooting

You can use the following commands to view information about active BFD sessions.

To return information on active BFD sessions, use the `net show bfd sessions` command:

```
cumulus@switch:~$ net show bfd sessions

-----
port  peer          state  local          type      diag
-----
swp1  11.0.0.2     Up     N/A           singlehop  N/A
N/A   12.12.12.1   Up     12.12.12.4   multihop   N/A
```

To return more **detailed** information on active BFD sessions, use the `net show bfd sessions detail` command (results are for an IPv6-connected peer):

```
cumulus@switch:~$ net show bfd sessions detail

-----
port  peer          state  local          type      diag  det
tx_timeout rx_timeout
-----
mult
-----
swp1  fe80::202:ff:fe00:1  Up     N/A           singlehop  N/A   3
300      900
swp1  3101:abc:bcad::2    Up     N/A           singlehop  N/A   3
300      900

#continuation of output
-----
echo      echo      max      rx_ctrl  tx_ctrl  rx_echo  tx_echo
tx_timeout rx_timeout hop_cnt
-----
0         0        N/A      187172  185986  0        0
0         0        N/A      501     533     0        0
```



## Related Information

- RFC 5880 - Bidirectional Forwarding Detection
- RFC 5881 - BFD for IPv4 and IPv6 (Single Hop)
- RFC 5882 - Generic Application of BFD
- RFC 5883 - Bidirectional Forwarding Detection (BFD) for Multihop Paths

## Equal Cost Multipath Load Sharing - Hardware ECMP

Cumulus Linux supports hardware-based [equal cost multipath](#) (ECMP) load sharing. ECMP is enabled by default in Cumulus Linux. Load sharing occurs automatically for all routes with multiple next hops installed. ECMP load sharing supports both IPv4 and IPv6 routes.

## Contents

This topic describes ...

- Equal Cost Routing (see page 829)
- ECMP Hashing (see page 830)
  - Use cl-ecmpcalc to Determine the Hash Result (see page 830)
  - cl-ecmpcalc Limitations (see page 831)
  - ECMP Hash Buckets (see page 831)
  - Configure a Hash Seed to Avoid Hash Polarization (see page 833)
- Resilient Hashing (see page 834)
  - Resilient Hash Buckets (see page 834)
  - Remove Next Hops (see page 835)
  - Add Next Hops (see page 836)
  - Configure Resilient Hashing (see page 837)

## Equal Cost Routing

ECMP operates only on equal cost routes in the Linux routing table.

In this example, the 10.1.1.0/24 route has two possible next hops that have been installed in the routing table:

```
$ ip route show 10.1.1.0/24
10.1.1.0/24 proto zebra metric 20
nexthop via 192.168.1.1 dev swp1 weight 1 onlink
nexthop via 192.168.2.1 dev swp2 weight 1 onlink
```

For routes to be considered equal they must:

- Originate from the same routing protocol. Routes from different sources are not considered equal. For example, a static route and an OSPF route are not considered for ECMP load sharing.

- Have equal cost. If two routes from the same protocol are unequal, only the best route is installed in the routing table.



The BGP `maximum-paths` setting is enabled, so multiple routes are installed by default. See the [ECMP section \(see page 777\)](#) of the BGP chapter for more information.

## ECMP Hashing

Once multiple routes are installed in the routing table, a hash is used to determine which path a packet follows.

Cumulus Linux hashes on the following fields:

- IP protocol
- Ingress interface
- Source IPv4 or IPv6 address
- Destination IPv4 or IPv6 address

For TCP/UDP frames, Cumulus Linux also hashes on:

- Source port
- Destination port

ECMP Hash Fields					
Source IP	Destination IP	Layer 4 Protocol	Source Port	Destination Port	Payload

To prevent out of order packets, ECMP hashing is done on a per-flow basis, which means that all packets with the same source and destination IP addresses and the same source and destination ports always hash to the same next hop. ECMP hashing does not keep a record of flow states.

ECMP hashing does not keep a record of packets that have hashed to each next hop and does not guarantee that traffic sent to each next hop is equal.

### Use `cl-ecmpcalc` to Determine the Hash Result

Since the hash is deterministic and always provides the same result for the same input, you can query the hardware and determine the hash result of a given input. This is useful when determining exactly which path a flow takes through a network.

On Cumulus Linux, use the `cl-ecmpcalc` command to determine a hardware hash result.

In order to use `cl-ecmpcalc`, all fields that are used in the hash must be provided. This includes ingress interface, layer 3 source IP, layer 3 destination IP, layer 4 source port and layer 4 destination port.

```
$ sudo cl-ecmpcalc -i swp1 -s 10.0.0.1 -d 10.0.0.1 -p tcp --sport 2000
0 --dport 80
ecmpcalc: will query hardware
swp3
```

If any field is omitted, `cl-ecmpcalc` fails.

```
$ sudo cl-ecmpcalc -i swp1 -s 10.0.0.1 -d 10.0.0.1 -p tcp
ecmpcalc: will query hardware
usage: cl-ecmpcalc [-h] [-v] [-p PROTOCOL] [-s SRC] [--sport SPORT] [-
d DST]
                [--dport DPORT] [--vid VID] [-i IN_INTERFACE]
                [--sportid SPORTID] [--smoid SMODID] [-o
OUT_INTERFACE]
                [--dportid DPORTID] [--dmodid DMODID] [--hardware]
                [--nohardware] [-hs HASHSEED]
                [-hf HASHFIELDS [HASHFIELDS ...]]
                [--hashfunction {crc16-ccitt,crc16-bisync}] [-e
EGRESS]
                [-c MCOUNT]
cl-ecmpcalc: error: --sport and --dport required for TCP and UDP
frames
```

### *cl-ecmpcalc Limitations*

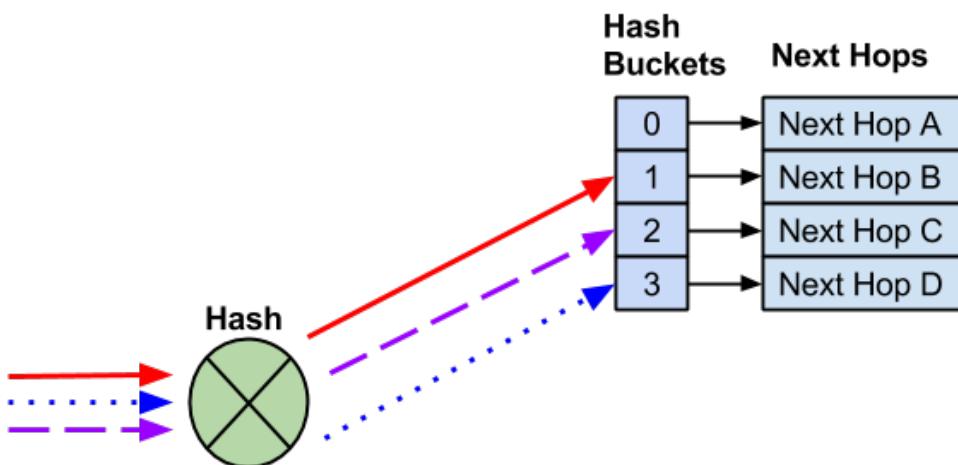
`cl-ecmpcalc` can only take input interfaces that can be converted to a single physical port in the port tab file, like the physical switch ports (swp). Virtual interfaces like bridges, bonds, and subinterfaces are not supported.

`cl-ecmpcalc` is supported only on switches with the [Mellanox Spectrum](#) and the [Broadcom Maverick](#), [Tomahawk](#), [Trident II](#), [Trident II+](#) and [Trident3](#) chipsets.

### *ECMP Hash Buckets*

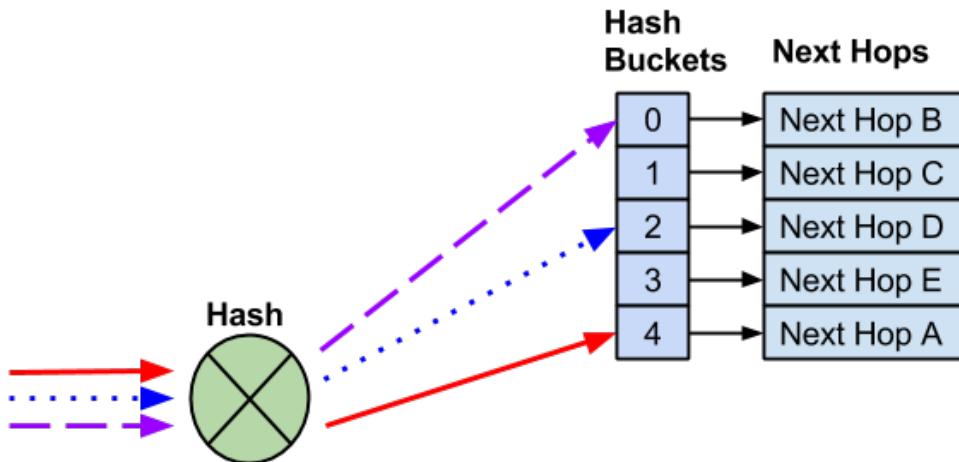
When multiple routes are installed in the routing table, each route is assigned to an ECMP *bucket*. When the ECMP hash is executed the result of the hash determines which bucket gets used.

In the following example, 4 next hops exist. Three different flows are hashed to different hash buckets. Each next hop is assigned to a unique hash bucket.



## Add a Next Hop

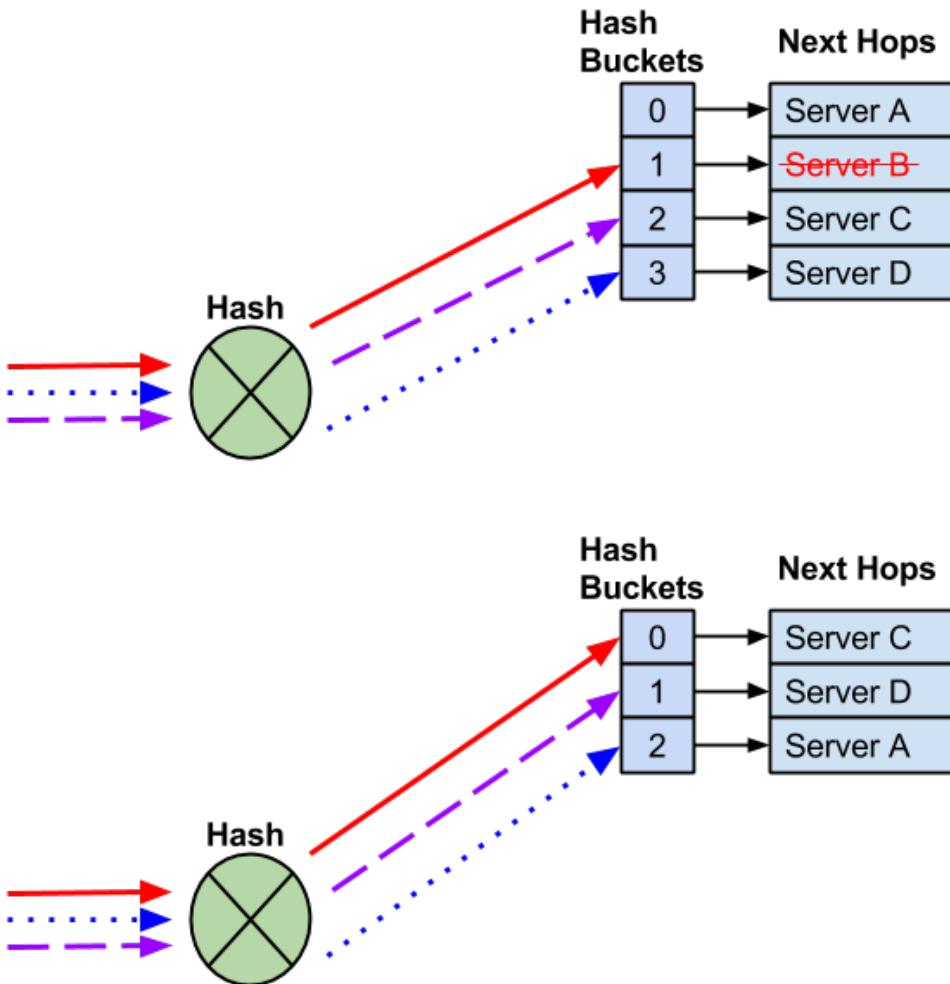
When a next hop is added, a new hash bucket is created. The assignment of next hops to hash buckets, as well as the hash result, may change when additional next hops are added.



A new next hop is added and a new hash bucket is created. As a result, the hash and hash bucket assignment changed, causing the existing flows to be sent to different next hops.

## Remove a Next Hop

When a next hop is removed, the remaining hash bucket assignments may change, again, potentially changing the next hop selected for an existing flow.



A next hop fails and the next hop and hash bucket are removed. The remaining next hops may be reassigned.

In most cases, the modification of hash buckets has no impact on traffic flows as traffic is being forward to a single end host. In deployments where multiple end hosts are using the same IP address (anycast), *resilient hashing* must be used.

### Configure a Hash Seed to Avoid Hash Polarization

It is useful to have a unique hash seed for each switch. This helps avoid *hash polarization*, a type of network congestion that occurs when multiple data flows try to reach a switch using the same switch ports.



Starting in Cumulus Linux 3.5.4, if the `ecmp_hash_seed` value is not set in `/etc/cumulus/datapath/traffic.conf` (the default as shipped), `switchd` will use a randomly generated seed, which is stable across `switchd` restarts and reboots.

The hash seed is set by the `ecmp_hash_seed` parameter in the `/etc/cumulus/datapath/traffic.conf` file. It is an integer with a value from 0 to 4294967295. If you don't specify a value for it, `switchd` creates a randomly generated seed instead.

To set the hash seed to 50 for example, run the following commands:



```
cumulus@switch:~$ net add forwarding ecmp hash-seed 50  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

These commands create the following configuration in the `/etc/cumulus/datapath/traffic.conf` file:

```
cumulus@leaf01:~$ cat /etc/cumulus/datapath/traffic.conf  
...  
#Specify the hash seed for Equal cost multipath entries  
ecmp_hash_seed = 50  
...  
cumulus@leaf01:~$
```

## Resilient Hashing

In Cumulus Linux, when a next hop fails or is removed from an ECMP pool, the hashing or hash bucket assignment can change. For deployments where there is a need for flows to always use the same next hop, like TCP anycast deployments, this can create session failures.

The ECMP hash performed with resilient hashing is exactly the same as the default hashing mode. Only the method in which next hops are assigned to hash buckets differs.

Resilient hashing supports both IPv4 and IPv6 routes.

Resilient hashing is not enabled by default. See below for steps on configuring it.



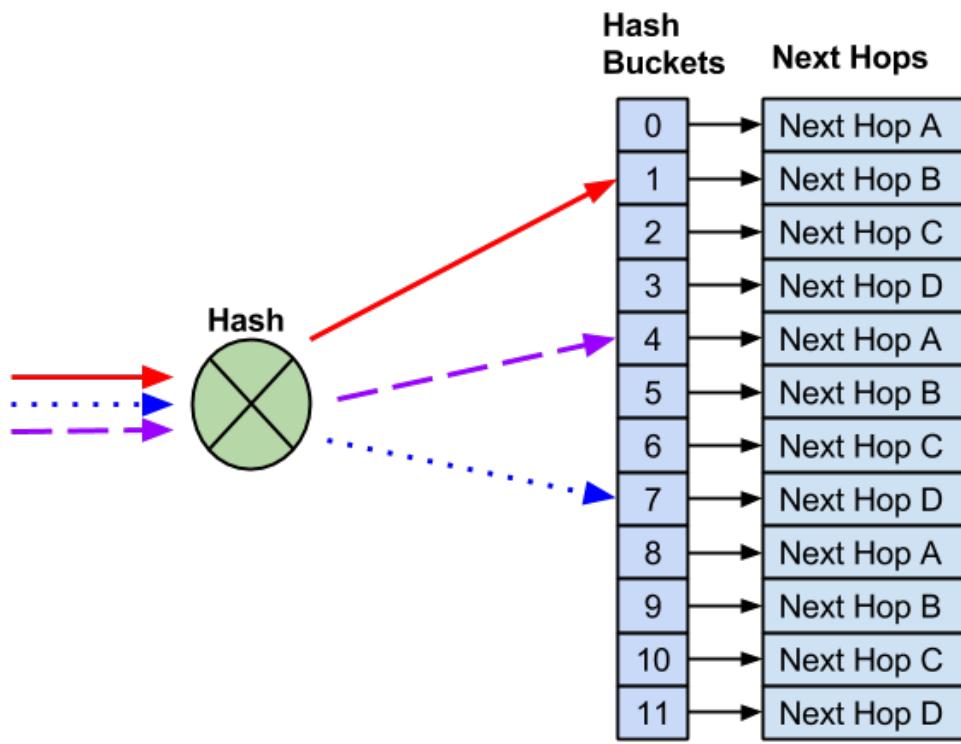
Resilient hashing prevents disruptions when next hops are removed. It does not prevent disruption when next hops are added.



Resilient hashing is supported only on switches with the [Broadcom Tomahawk](#), [Trident II](#), [Trident II+](#), and [Trident3](#) as well as [Mellanox Spectrum](#) chipsets. You can run `net show system` to determine the chipset.

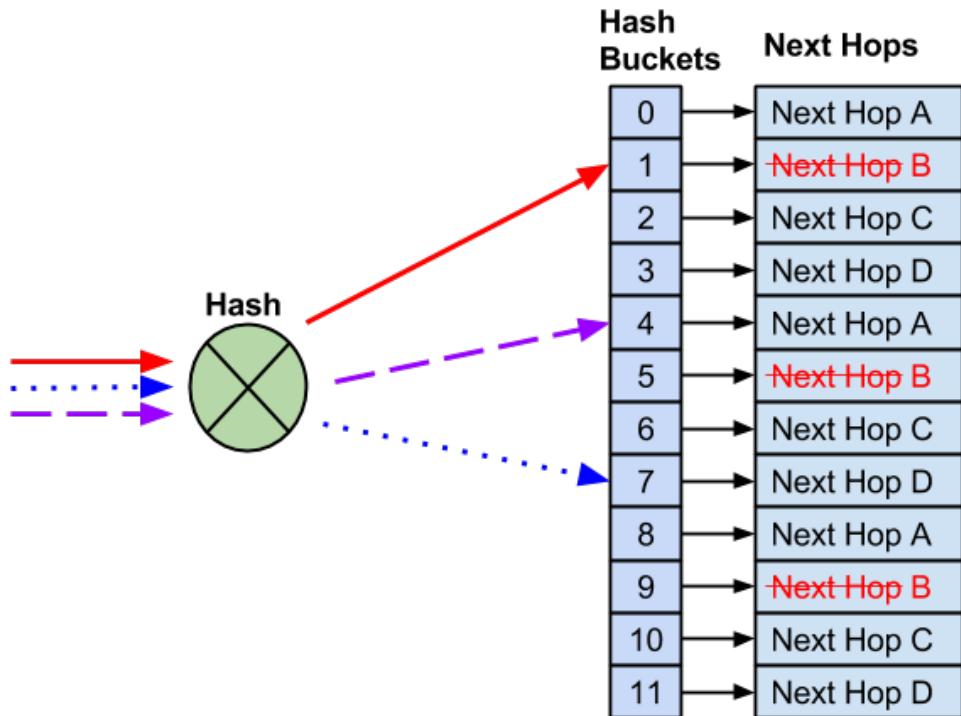
### Resilient Hash Buckets

When resilient hashing is configured, a fixed number of buckets are defined. Next hops are then assigned in round robin fashion to each of those buckets. In this example, 12 buckets are created and four next hops are assigned.

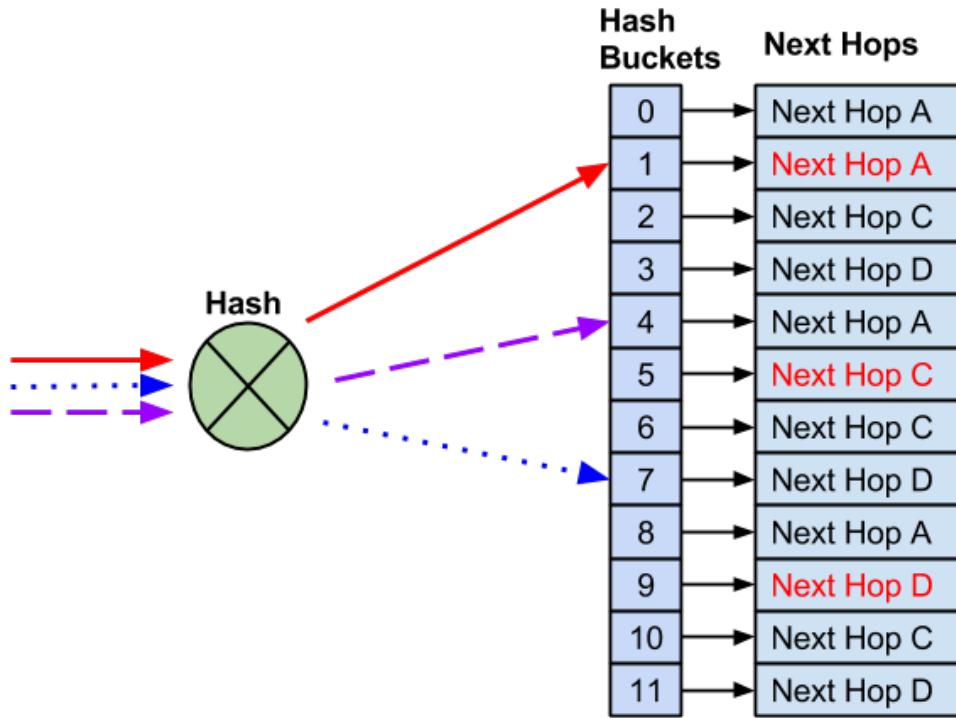


### Remove Next Hops

Unlike default ECMP hashing, when a next hop needs to be removed, the number of hash buckets does not change.



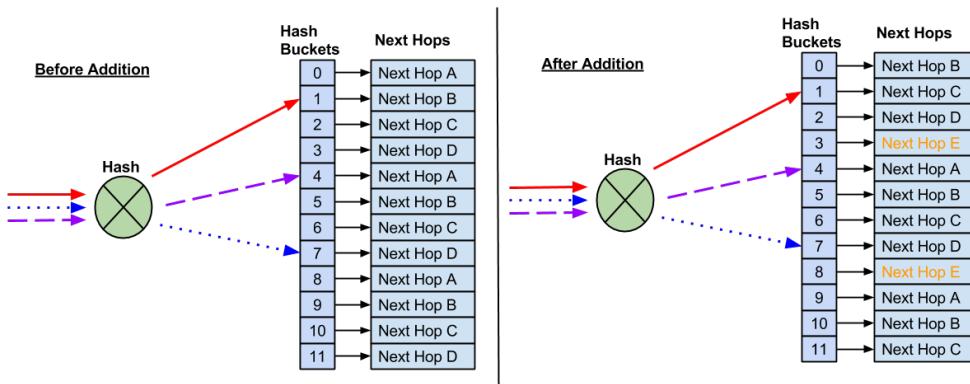
With 12 buckets assigned and four next hops, instead of reducing the number of buckets — which would impact flows to known good hosts — the remaining next hops replace the failed next hop.



After the failed next hop is removed, the remaining next hops are installed as replacements. This prevents impact to any flows that hash to working next hops.

### Add Next Hops

Resilient hashing does not prevent possible impact to existing flows when new next hops are added. Due to the fact there are a fixed number of buckets, a new next hop requires reassigning next hops to buckets.



As a result, some flows may hash to new next hops, which can impact anycast deployments.

## Configure Resilient Hashing

Resilient hashing is not enabled by default. When resilient hashing is enabled, 65,536 buckets are created to be shared among all ECMP groups. An ECMP group is a list of unique next hops that are referenced by multiple ECMP routes.



An ECMP route counts as a single route with multiple next hops. The following example is considered to be a single ECMP route:

```
$ ip route show 10.1.1.0/24
10.1.1.0/24 proto zebra metric 20
nexthop via 192.168.1.1 dev swp1 weight 1 onlink
nexthop via 192.168.2.1 dev swp2 weight 1 onlink
```

All ECMP routes must use the same number of buckets (the number of buckets cannot be configured per ECMP route).

The number of buckets can be configured as 64, 128, 256, 512 or 1024; the default is 128:

Number of Hash Buckets	Number of Supported ECMP Groups
64	1024
<b>128</b>	<b>512</b>
256	256
512	128
1024	64

A larger number of ECMP buckets reduces the impact on adding new next hops to an ECMP route. However, the system supports fewer ECMP routes. If the maximum number of ECMP routes have been installed, new ECMP routes log an error and are not installed.

To enable resilient hashing, edit `/etc/cumulus/datapath/traffic.conf`:

1. Enable resilient hashing:

```
# Enable resilient hashing
resilient_hash_enable = TRUE
```

2. **(Optional)** Edit the number of hash buckets:

```
# Resilient hashing flowset entries per ECMP group
```



```
# Valid values - 64, 128, 256, 512, 1024
resilient_hash_entries_ecmp = 256
```

3. Restart (see page 207) the `switchd` service:

```
cumulus@switch:~$ sudo systemctl restart switchd.service
```

## Redistribute Neighbor

*Redistribute neighbor* provides a mechanism for IP subnets to span racks without forcing the end hosts to run a routing protocol.

The fundamental premise behind redistribute neighbor is to announce individual host /32 routes in the routed fabric. Other hosts on the fabric can then use this new path to access the hosts in the fabric. If multiple equal-cost paths (ECMP) are available, traffic can load balance across the available paths natively.

The challenge is to accurately compile and update this list of reachable hosts or neighbors. Luckily, existing commonly-deployed protocols are available to solve this problem. Hosts use [ARP](#) to resolve MAC addresses when sending to an IPv4 address. A host then builds an ARP cache table of known MAC addresses: IPv4 tuples as they receive or respond to ARP requests.

In the case of a leaf switch, where the default gateway is deployed for hosts within the rack, the ARP cache table contains a list of all hosts that have ARP'd for their default gateway. In many scenarios, this table contains all the layer 3 information that's needed. This is where redistribute neighbor comes in, as it is a mechanism of formatting and syncing this table into the routing protocol.

## Contents

### This topic describes ...

- Availability (see page 839)
- Target Use Cases and Best Practices (see page 839)
- How It Works (see page 839)
- Example Configuration (see page 839)
  - Configure the Leaf(s) (see page 840)
  - Configure the Host(s) (see page 842)
- Known Limitations (see page 844)
  - TCAM Route Scale (see page 844)
  - Possible Uneven Traffic Distribution (see page 844)
  - Silent Hosts Never Receive Traffic (see page 844)
  - Support for IPv4 Only (see page 844)
  - VRFs Are not Supported (see page 844)
  - Only 1024 Interfaces Supported (see page 844)
- Troubleshooting (see page 844)
  - How do I determine if rdnbrd (the redistribute neighbor daemon) is running? (see page 844)
  - How do I change rdnbrd's default configuration? (see page 845)



- What is table 10? Why was table 10 chosen? (see page 845)
- How do I determine that the /32 redistribute neighbor routes are being advertised to my neighbor? (see page 846)
- How do I verify that the kernel routing table is being correctly populated? (see page 846)

## Availability

Redistribute neighbor is distributed as `python-rdnbrd`.

## Target Use Cases and Best Practices

Redistribute neighbor was created with these use cases in mind:

- Virtualized clusters
- Hosts with service IP addresses that migrate between racks
- Hosts that are dual connected to two leaf nodes without using proprietary protocols such as [MLAG \(see page 440\)](#)
- Anycast services needing dynamic advertisement from multiple hosts

Cumulus Networks recommends following these guidelines with redistribute neighbor:

- Use a single logical connection from each host to each leaf.
- A host can connect to one or more leafs. Each leaf advertises the /32 it sees in its neighbor table.
- A host-bound bridge/VLAN should be local to each switch only.
- Leaf switches with redistribute neighbor enabled should be directly connected to the hosts.
- IP addressing must be non-overlapping, as the host IPs are directly advertised into the routed fabric.
- Run redistribute neighbor on Linux-based hosts primarily; other host operating systems may work, but Cumulus Networks has not actively tested any at this stage.

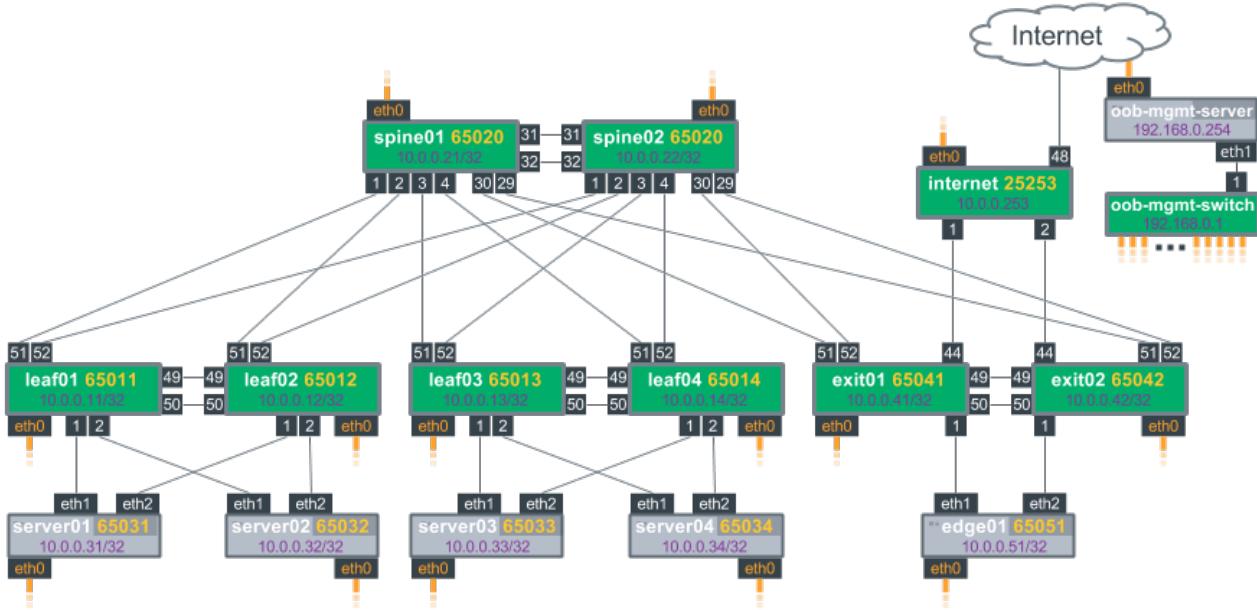
## How It Works

Redistribute neighbor works as follows:

1. The leaf/ToR switches learn about connected hosts when the host sends an ARP request or ARP reply.
2. An entry for the host is added to the kernel neighbor table of each leaf switch.
3. The redistribute neighbor daemon, `rdnbrd`, monitors the kernel neighbor table and creates a /32 route for each neighbor entry. This /32 route is created in kernel table 10.
4. FRRouting is configured to import routes from kernel table 10.
5. A route-map is used to control which routes from table 10 are imported.
6. In FRRouting these routes are imported as *table* routes.
7. BGP, OSPF and so forth are then configured to redistribute the table 10 routes.

## Example Configuration

The following example configuration is based on the [reference topology](#) created by Cumulus Networks. Other configurations are possible, based on the use cases outlined above. Here is a diagram of the topology:



## Configure the Leaf(s)

The following steps demonstrate how to configure leaf01, but the same steps can be applied to any of the leafs.

1. Configure the host facing ports, using the same IP address on both host-facing interfaces as well as a /32 prefix. In this case, swp1 and swp2 are configured as they are the ports facing server01 and server02:

```
cumulus@leaf01:~$ net add loopback lo ip address 10.0.0.11/32
cumulus@leaf01:~$ net add interface swp1-2 ip address 10.0.0.11/32
cumulus@leaf01:~$ net pending
cumulus@leaf01:~$ net commit
```

The commands produce the following configuration in the `/etc/network/interfaces` file:

```
auto lo
iface lo inet loopback
    address 10.0.0.11/32

auto swp1
iface swp1
    address 10.0.0.11/32

auto swp2
iface swp2
    address 10.0.0.11/32
```

2. Enable the daemon so it starts at bootup:



```
cumulus@leaf01:~$ sudo systemctl enable rdnbrd.service
```

3. Start the daemon:

```
cumulus@leaf01:~$ sudo systemctl restart rdnbrd.service
```

4. Configure routing:

- a. Define a route-map that matches on the host-facing interfaces:

```
cumulus@leaf01:~$ net add routing route-map REDIST_NEIGHBOR
permit 10 match interface swp1
cumulus@leaf01:~$ net add routing route-map REDIST_NEIGHBOR
permit 20 match interface swp2
```

- b. Import routing table 10 and apply the route-map:

```
cumulus@leaf01:~$ net add routing import-table 10 route-map
REDIST_NEIGHBOR
```

- c. Redistribute the imported *table* routes in into the appropriate routing protocol.

**BGP:**

```
cumulus@leaf01:~$ net add bgp autonomous-system 65001
cumulus@leaf01:~$ net add bgp ipv4 unicast redistribute
table 10
```

**OSPF:**

```
cumulus@leaf01:~$ net add ospf redistribute table 10
```

- d. Save the configuration by committing your changes.

```
cumulus@leaf01:~$ net pending
cumulus@leaf01:~$ net commit
```

[Click here to expand the contents of /etc/frr/frr.conf](#)

This configuration uses OSPF as the routing protocol.

```
cumulus@leaf01$ cat /etc/frr/frr.conf
```



```
frr version 3.1+cl3u1
frr defaults datacenter
ip import-table 10 route-map REDIST_NEIGHBOR
username cumulus nopassword
!
service integrated-vtysh-config
!
log syslog informational
!
router bgp 65001
!
address-family ipv4 unicast
  redistribute table 10
exit-address-family
!
route-map REDIST_NEIGHBOR permit 10
  match interface swp1
!
route-map REDIST_NEIGHBOR permit 20
  match interface swp2
!
router ospf
  redistribute table 10
!
line vty
!
```

## Configure the Host(s)

There are a few possible host configurations that range in complexity. This document only covers the basic use case: dual-connected Linux hosts with static IP addresses assigned.

Additional host configurations will be covered in future separate knowledge base articles.

## Configure a Dual-connected Host

Configure a host with the same /32 IP address on its loopback (lo) and uplinks (in this example, eth1 and eth2). This is done so both leaf switches advertise the same /32 regardless of the interface. Cumulus Linux relies on [ECMP \(see page 829\)](#) to load balance across the interfaces southbound, and an equal cost static route (see the configuration below) for load balancing northbound.

The loopback hosts the primary service IP address(es) and to which you can bind services.

Configure the loopback and physical interfaces. Referring back to the topology diagram, server01 is connected to leaf01 via eth1 and to leaf02 via eth2. You should note:

- The loopback IP is assigned to lo, eth1 and eth2.
- The post-up ARPing is used to force the host to ARP as soon as its interface comes up. This allows the leaf to learn about the host as soon as possible.
- The post-up ip route replace is used to install a default route via one or both leaf nodes if both swp1 and swp2 are up.



```
user@server01:$ cat /etc/network/interfaces
# The loopback network interface
auto lo
iface lo inet loopback

auto lo:1
iface lo:1
    address 10.1.0.101/32

auto eth1
iface eth1
    address 10.1.0.101/32
    post-up for i in {1..3}; do arping -q -c 1 -w 0 -i eth1
10.0.0.11; sleep 1; done
    post-up ip route add 0.0.0.0/0 nexthop via 10.0.0.11 dev eth1
onlink nexthop via 10.0.0.12 dev eth2 onlink || true

auto eth2
iface eth2
    address 10.1.0.101/32
    post-up for i in {1..3}; do arping -q -c 1 -w 0 -i eth2
10.0.0.12; sleep 1; done
    post-up ip route add 0.0.0.0/0 nexthop via 10.0.0.11 dev eth1
onlink nexthop via 10.0.0.12 dev eth2 onlink || true
```

### *Install ifplugd*

Additionally, install and use [ifplugd](#) (see page 273). `ifplugd` modifies the behavior of the Linux routing table when an interface undergoes a link transition (carrier up/down). The Linux kernel by default leaves routes up even when the physical interface is unavailable (NO-CARRIER).

After you install `ifplugd`, edit `/etc/default/ifplugd` as follows, where `eth1` and `eth2` are the interface names that your host uses to connect to the leaves.

```
user@server01:$ cat /etc/default/ifplugd
INTERFACES="eth1 eth2"
HOTPLUG_INTERFACES=""
ARGS="-q -f -u10 -d10 -w -I"
SUSPEND_ACTION="stop"
```

For full instructions on installing `ifplugd` on Ubuntu, [follow this guide](#).



## Known Limitations

### *TCAM Route Scale*

This feature adds each ARP entry as a /32 host route into the routing table of all switches within a summarization domain. Take care to keep the number of hosts minus fabric routes under the TCAM size of the switch. Review the [Cumulus Networks datasheets](#) for up to date scalability limits of your chosen hardware platforms. If in doubt, contact Cumulus Networks support or your Cumulus Networks CSE; they will be happy to help.

### *Possible Uneven Traffic Distribution*

Linux uses source L3 addresses only to do load balancing on most older distributions.

### *Silent Hosts Never Receive Traffic*

Freshly provisioned hosts that have never sent traffic may not ARP for their default gateways. The post-up ARPing in `/etc/network/interfaces` on the host should take care of this. If the host does not ARP, then `rdnbrd` on the leaf cannot learn about the host.

### *Support for IPv4 Only*

This release of redistribute neighbor supports IPv4 only.

### *VRFs Are not Supported*

This release of redistribute neighbor does not support [VRFs \(see page 847\)](#).

### *Only 1024 Interfaces Supported*

Redistribute neighbor does not work with more than 1024 interfaces. Doing so can cause the `rdnbrd` service to crash.

## Troubleshooting

### *How do I determine if rdnbrd (the redistribute neighbor daemon) is running?*

Use `systemctl` to check:

```
cumulus@leaf01$ systemctl status rdnbrd.service
* rdnbrd.service - Cumulus Linux Redistribute Neighbor Service
  Loaded: loaded (/lib/systemd/system/rdnbrd.service; enabled)
  Loaded: loaded (/lib/systemd/system/rdnbrd.service; enabled)
  Active: active (running) since Wed 2016-05-04 18:29:03 UTC; 1h 13min
            ago
    Main PID: 1501 (python)
   CGroup: /system.slice/rdnbrd.service
           `--1501 /usr/bin/python /usr/sbin/rdnbrd -d
```



## How do I change rdnbrd's default configuration?

Editing the /etc/rdnbrd.conf file, then run systemctl restart rdnbrd.service:

```
cumulus@leaf01$ cat /etc/rdnbrd.conf
# syslog logging level CRITICAL, ERROR, WARNING, INFO, or DEBUG
loglevel = INFO

# TX an ARP request to known hosts every keepalive seconds
keepalive = 1

# If a host does not send an ARP reply for holdtime consider the host
down
holdtime = 3

# Install /32 routes for each host into this table
route_table = 10

# Uncomment to enable ARP debugs on specific interfaces.
# Note that ARP debugs can be very chatty.
# debug_arp = swp1 swp2 swp3 br1
# If we already know the MAC for a host, unicast the ARP request.
# This is
# unusual for ARP (why ARP if you know the destination MAC) but we
will be
# using ARP as a keepalive mechanism and do not want to broadcast so
many ARPs
# if we do not have to. If a host cannot handle a unicasted ARP
request, set
# the following option to False.
#
# Unicasting ARP requests is common practice (in some scenarios) for
other
# networking operating systems so it is unlikely that you will need
to set
# this to False.
unicast_arp_requests = True
cumulus@leaf01:~$ sudo systemctl restart rdnbrd.service
```

## What is table 10? Why was table 10 chosen?

The Linux kernel supports multiple routing tables and can utilize 0 through 255 as table IDs. However, tables 0, 253, 254 and 255 are reserved, and 1 is usually the first one utilized. Therefore, rdnbrd only allows you to specify 2-252. The number 10 was chosen for no particular reason. Feel free to set it to any value between 2-252. You can see all the tables specified here:

```
cumulus@switch$ cat /etc/iproute2/rt_tables
```



```
#  
# reserved values  
#  
255 local  
254 main  
253 default  
0 unspec  
#  
# local  
#  
#1 inr.ruhep
```

Read more information on [Linux route tables](#), or you can read the [Ubuntu man pages for ip route](#).

*How do I determine that the /32 redistribute neighbor routes are being advertised to my neighbor?*

For BGP, check the advertised routes to the neighbor.

```
cumulus@leaf01:~$ sudo vtysh  
Hello, this is Quagga (version 0.99.23.1+cl3u2).  
Copyright 1996-2005 Kunihiro Ishiguro, et al.  
leaf01# show ip bgp neighbor swp51 advertised-routes  
BGP table version is 5, local router ID is 10.0.0.11  
Status codes: s suppressed, d damped, h history, * valid, > best, =  
multipath,  
          i internal, r RIB-failure, S Stale, R Removed  
Origin codes: i - IGP, e - EGP, ? - incomplete  
  
      Network          Next Hop            Metric LocPrf Weight Path  
*> 10.0.0.11/32    0.0.0.0                  0        32768  i  
*> 10.0.0.12/32    ::                      0       65020  
65012 i  
*> 10.0.0.21/32    ::                      0       65020  i  
*> 10.0.0.22/32    ::                      0       65020  i  
  
Total number of prefixes 4
```

*How do I verify that the kernel routing table is being correctly populated?*

Use the following workflow to verify that the kernel routing table is being populated correctly and that routes are being correctly imported/advertised:

1. Verify that ARP neighbor entries are being populated into the Kernel routing table 10.

```
cumulus@switch:~$ ip route show table 10  
10.0.1.101 dev swp1 scope link
```



If these routes are not being generated, verify the following:

- That the `rdnbrd` daemon is running
  - Check `/etc/rdnbrd.conf` to verify the correct table number is used
2. Verify that routes are being imported into FRRouting from the kernel routing table 10.

```
cumulus@switch:~$ sudo vtysh
Hello, this is Quagga (version 0.99.23.1+cl3u2).
Copyright 1996-2005 Kunihiro Ishiguro, et al.

switch# show ip route table
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, A - Babel, T - Table,
       > - selected route, * - FIB route
T[10]>* 10.0.1.101/32 [19/0] is directly connected, swp1, 01:25:
29
```

Both the `>` and `*` should be present so that table 10 routes are installed as preferred into the routing table. If the routes are not being installed, verify the following:

- The imported distance of the locally imported kernel routes using the `ip import 10 distance X` command, where X is **not** less than the administrative distance of the routing protocol. If the distance is too low, routes learned from the protocol may overwrite the locally imported routes.
  - The routes are in the kernel routing table.
3. Confirm that routes are in the BGP/OSPF database and are being advertised.

```
switch# show ip bgp
```

## Virtual Routing and Forwarding - VRF

Cumulus Linux provides *virtual routing and forwarding* (VRF) to allow for the presence of multiple independent routing tables working simultaneously on the same router or switch. This permits multiple network paths without the need for multiple switches. Think of this feature as VLAN for layer 3, but unlike VLANs, there is no field in the IP header carrying it. Other implementations call this feature *VRF-Lite*.

The primary use cases for VRF in a data center are similar to VLANs at layer 2: using common physical infrastructure to carry multiple isolated traffic streams for multi-tenant environments, where these streams are allowed to cross over only at configured boundary points, typically firewalls or IDS. You can also use it to burst traffic from private clouds to enterprise networks where the burst point is at layer 3. Or you can use it in an OpenStack deployment.

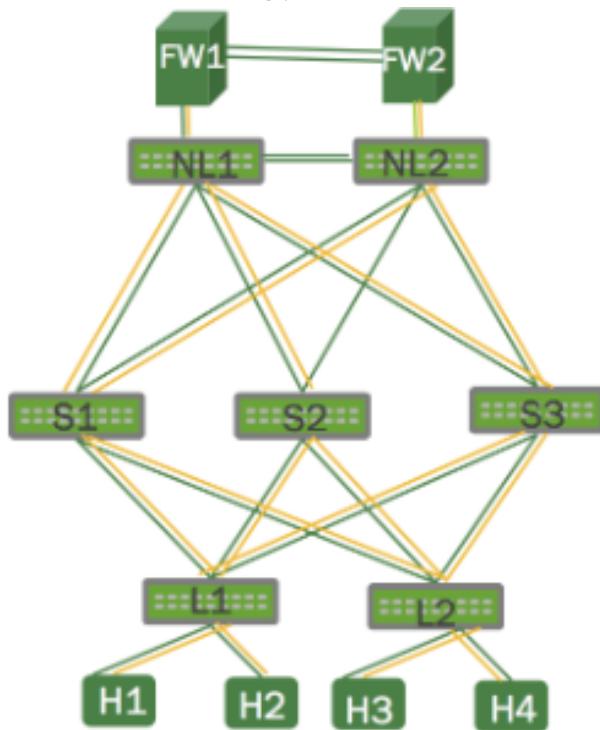
VRF is fully supported in the Linux kernel, so it has the following characteristics:

- The VRF is presented as a layer 3 master network device with its own associated routing table.
- The layer 3 interfaces (VLAN interfaces, bonds, switch virtual interfaces/SVIs) associated with the VRF are enslaved to that VRF; IP rules direct FIB (forwarding information base) lookups to the routing table for the VRF device.
- The VRF device can have its own IP address, known as a *VRF-local loopback*.

- Applications can use existing interfaces to operate in a VRF context — by binding sockets to the VRF device or passing the `ifindex` using `cmsg`. By default, applications on the switch run against the default VRF. Services started by `systemd` run in the default VRF unless the VRF instance is used. If [management VRF \(see page 877\)](#) is enabled, logins to the switch default to the management VRF. This is a convenience for users to not have to specify management VRF for each command.
- Listen sockets used by services are VRF-global by default unless the application is configured to use a more limited scope — for example, read about [services in the management VRF \(see page 879\)](#). Connected sockets (like TCP) are then bound to the VRF domain in which the connection originates. The kernel provides a sysctl that allows a single instance to accept connections over all VRFs. For TCP, connected sockets are bound to the VRF the first packet was received. This sysctl is enabled for Cumulus Linux.
- Connected and local routes are placed in appropriate VRF tables.
- Neighbor entries continue to be per-interface, and you can view all entries associated with the VRF device.
- A VRF does not map to its own network namespace; however, you can nest VRFs in a network namespace.
- You can use existing Linux tools to interact with it, such as `tcpdump`.

Cumulus Linux supports up to 255 VRFs on a switch.

You configure VRF by associating each subset of interfaces to a VRF routing table, and configuring an instance of the routing protocol — BGP or OSPFv2 — for each routing table.



## Contents

This topic describes ...

- Configure VRF (see page 849)
  - Specify a Table ID (see page 850)
  - Bring a VRF Up after Downing It with `ifdown` (see page 850)



- [vrf Command \(see page 850\)](#)
- [Services in VRFs \(see page 851\)](#)
- [VRF Route Leaking \(see page 852\)](#)
  - [Configure Static Route Leaking \(see page 853\)](#)
  - [Configure Static Route Leaking with EVPN \(see page 854\)](#)
  - [Configure Dynamic Route Leaking \(see page 855\)](#)
  - [Dynamic Route Leaking Between VRFs where Subnets Extend across Racks \(see page 856\)](#)
  - [Verify Dynamic Route Leaking Configuration \(see page 856\)](#)
  - [Delete Dynamic Route Leaking Configuration \(see page 857\)](#)
- [FRRouting Operation in a VRF \(see page 858\)](#)
- [Example Commands to Show VRF Data \(see page 860\)](#)
  - [Show VRF Data Using NCLU Commands \(see page 860\)](#)
  - [Show VRF Data Using FRRouting Commands \(see page 864\)](#)
  - [Show VRF Data Using ip Commands \(see page 866\)](#)
- [BGP Unnumbered Interfaces with VRF \(see page 870\)](#)
- [DHCP with VRF \(see page 872\)](#)
  - [Caveats for DHCP with VRF \(see page 873\)](#)
  - [Example Configuration \(see page 873\)](#)
- [ping or traceroute on a VRF \(see page 876\)](#)
- [Caveats and Errata \(see page 877\)](#)

## Configure VRF

Each routing table is called a *VRF table*, and has its own table ID. You configure VRF using [NCLU \(see page 88\)](#), then place the layer 3 interface in the VRF. You can have a maximum of 255 VRFs on a switch.

When you configure a VRF, you follow a similar process to other network interfaces. Keep in mind the following for a VRF table:

- It can have an IP address, a loopback interface for the VRF.
- Associated rules are added automatically.
- You can also add a default route to avoid skipping across tables when the kernel forwards the packet.
- Names for VRF tables can be up to 15 characters. However, you **cannot** use the name *mgmt*, as this name can **only** be used for [management VRF \(see page 877\)](#).

To configure a VRF, run:

```
cumulus@switch:~$ net add vrf rocket vrf-table auto
cumulus@switch:~$ net add interface swp1 vrf rocket
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands result in the following VRF configuration in the `/etc/network/interfaces` file:



```
auto swp1
iface swp1
    vrf rocket

auto rocket
iface rocket
    vrf-table auto
```

### Specify a Table ID

Instead of having Cumulus Linux assign a table ID for the VRF table, you can specify your own table ID in the configuration. The table ID to name mapping is saved in `/etc/iproute2/rt_tables.d/` for name-based references. So instead of using the `auto` option above, specify the table ID like this:

```
cumulus@switch:~$ net add vrf rocket vrf-table 1016
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```



If you do specify a table ID, it **must** be in the range of 1001 to 1255 which is reserved in Cumulus Linux for VRF table IDs.

### Bring a VRF Up after Downing It with ifdown

If you take down a VRF using `ifdown`, to bring it back up you need to do one of two things:

- Use `ifup --with-dependents <vrf>`
- Use `ifreload -a`

For example:

```
cumulus@switch:~$ sudo ifdown rocket
cumulus@switch:~$ sudo ifup --with-dependents rocket
```

### vrf Command

The `vrf` command returns information about VRF tables that is otherwise not available in other Linux commands, such as `iproute`. You can also use it to execute non-VRF-specific commands and perform other tasks related to VRF tables.

To get a list of VRF tables, run:

```
cumulus@switch:~$ vrf list
```



VRF	Table
rocket	1016

To return a list of processes and PIDs associated with a specific VRF table, run `vrf task list <vrf-name>`. For example:

```
cumulus@switch:~$ vrf task list rocket

VRF: rocket
-----
dhclient      2508
sshd          2659
bash          2681
su            2702
bash          2720
vrf           2829
```

To determine which VRF table is associated with a particular PID, run `vrf task identify <pid>`. For example:

```
cumulus@switch:~$ vrf task identify 2829

rocket
```

### *IPv4 and IPv6 Commands in a VRF Context*

You can execute non-VRF-specific Linux commands and perform other tasks against a given VRF table. This typically applies to single-use commands started from a login shell, as they affect only AF\_INET and AF\_INET6 sockets opened by the command that gets executed; it has no impact on netlink sockets, associated with the `ip` command.

To execute such a command against a VRF table, run `vrf task exec <vrf-name> <command>`. For example, to SSH from the switch to a device accessible through VRF `rocket`:

```
cumulus@switch:~$ sudo vrf task exec rocket ssh user@host
```

You should manage long-running services with `systemd` using the `service@vrf` notation; for example, `systemctl start ntp@mgmt`. `systemd`-based services are stopped when a VRF is deleted and started when the VRF is created. For example, restarting networking or running an `ifdown/ifup` sequence.

### *Services in VRFs*

For services that need to run against a specific VRF, Cumulus Linux uses `systemd` instances, where the instance is the VRF. In general, you start a service within a VRF like this:



```
cumulus@switch:~$ sudo systemctl start <service>@<vrf>
```

For example, you can run the NTP service in the turtle VRF using:

```
cumulus@switch:~$ sudo systemctl start ntp@turtle
```

In most cases, the instance running in the default VRF needs to be stopped before a VRF instance can start. This is because the instance running in the default VRF owns the port across all VRFs — that is, it is VRF global. `systemd`-based services are stopped when the VRF is deleted and started when the VRF is created. For example, when you restart networking or run an `ifdown/ifup` sequence — as mentioned above. The [management VRF chapter \(see page 879\)](#) details how to do this.

In Cumulus Linux, the following services work with VRF instances:

- chef-client
- collectd
- dhcpcd
- dhcrelay
- hsflowd
- netq-agent
- ntp
- puppet
- snmpd
- snmptrapd
- ssh
- zabbix-agent



There are cases where `systemd` instances do not work; you must use a service-specific configuration option instead. For example, you can configure `rsyslogd` to send messages to remote systems over a VRF:

```
action(type="omfwd" Target="hostname or ip here" Device="mgmt"
Port=514
Protocol="udp")
```

## VRF Route Leaking

The most common use case for VRF is to use multiple independent routing and forwarding tables; however, there are situations where destinations in one VRF must be reachable (leaked) from another VRF. For example, to make a service (such as a firewall) available to multiple VRFs or to enable routing to external networks (or the Internet) for multiple VRFs, where the external network itself is reachable through a specific VRF.



Cumulus Linux provides two options for route leaking across VRFs: *static route leaking* and *dynamic route leaking*.



- An interface is always assigned to only one VRF; any packets received on that interface are routed using the associated VRF routing table.
- Route leaking is typically used for non-overlapping addresses.
- Route leaking is supported for both IPv4 and IPv6 routes.
- Do not mix static and dynamic route leaking in a fabric.
- VRF route leaking is not supported between the tenant VRF and the default VRF with onlink next hops (BGP unnumbered).

### Configure Static Route Leaking

For *static route leaking*, you configure routes manually in a VRF whose next hops are reachable over an interface that is part of another VRF. This is useful where one or more specific destinations in a different VRF need to be reachable from another VRF. You can use static route leaking to reach remote destinations (through a next hop router) or directly-connected destinations in another VRF.



Cumulus Networks recommends that you use *dynamic route leaking* instead of static route leaking. Dynamic route leaking is easier to configure, easier to maintain (static route leaking configuration requires changes when you want to leak new routes), and supports route maps for better control. See [Configure Dynamic Route Leaking \(see page 855\)](#).

To configure static route leaking in a non-EVPN configuration, follow the steps below. To configure static route leaking with EVPN, see [Configure Static Route Leaking with EVPN \(see page \)](#).

1. In the `/etc/cumulus/switchd.conf` file, change the `vrf_route_leak_enable` option to `TRUE` and uncomment the line. Then, restart `switchd` for the change to take effect.

```
cumulus@switch:~$ sudo nano /etc/cumulus/switchd.conf
...
#static vrf route leak enable
vrf_route_leak_enable = TRUE
```

```
cumulus@switch:~$ sudo systemctl restart switchd.service
```



Only set the `vrf_route_leak_enable` option to `TRUE` for *static* VRF route leaking. This option must be set to `false` for *dynamic* route leaking.



2. Use the keyword `nexthop-vrf` to specify the VRF through which the next hop router is reachable. The example command below adds a static route (10.1.0.0/24) to a VRF named `turtle`, which is reachable through a next-hop router (192.168.200.1) over a different VRF, `rocket`.

```
cumulus@switch:~$ net add routing route 10.1.0.0/24  
192.168.200.1 vrf turtle nexthop-vrf rocket  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

### Configure Static Route Leaking with EVPN

Static route leaking is supported with EVPN symmetric routing only.



You cannot leak the default route.

To configure static route leaking with EVPN symmetric routing:

1. Enable VRF route leaking, as shown in step 1 of [configure-static-routing \(see page \)](#) above.
2. Configure static route leaking for EVPN. The following commands provide examples.

To configure static route leaking between VRF1 and VRF2, where VRF1 contains subnets 10.50.1.0/24, 10.50.2.0/24, 10.50.3.0/24, and 10.50.4.0/24 and VRF2 contains subnets 10.60.1.0/24, 10.60.2.0/24, 10.60.3.0/24, and 10.60.4.0/24, run these commands:

```
cumulus@switch:~$ net add routing route 10.60.0.0/21 vrf2 vrf  
vrf1 nexthop-vrf vrf2  
cumulus@switch:~$ net add routing route 10.50.0.0/21 vrf1 vrf  
vrf2 nexthop-vrf vrf1  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

To configure static route leaking between the default VRF and VRF1, where `swp1s0` is the egress port for subnets under 10.10.0.0/16 in the default VRF, run these commands:

```
cumulus@switch:~$ net add routing route 10.10.0.0/16 swp1s0 vrf  
vrf1 nexthop-vrf default-IP-Routing-Table  
cumulus@switch:~$ net add routing route 10.50.0.0/21 vrf1  
nexthop-vrf vrf1  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```



## Configure Dynamic Route Leaking

For dynamic route leaking, a destination VRF is interested in the routes of a source VRF. As routes come and go in the source VRF, they are dynamically leaked to the destination VRF through BGP. If the routes in the source VRF are learned through BGP, no additional configuration is necessary. If the routes in the source VRF are learned through OSPF, or if they are statically configured or directly-connected networks have to be reached, the routes need to be first *redistributed* into BGP (in the source VRF) for them to be leaked.

You can also use dynamic route leaking to reach remote destinations as well as directly connected destinations in another VRF. Multiple VRFs can import routes from a single source VRF and a VRF can import routes from multiple source VRFs. This is typically used when a single VRF provides connectivity to external networks or a shared service for many other VRFs.

You can control the routes that are leaked dynamically across VRFs with a route-map.

Because dynamic route leaking happens through BGP, the underlying mechanism relies on the BGP constructs of the Route Distinguisher (RD) and Route Targets (RTs). However, you do not need to configure these parameters; they are automatically derived when you enable route leaking between a pair of VRFs.



- Dynamic route leaking with EVPN is supported in Cumulus Linux 3.7.4 and later.
- You cannot reach the loopback address of a VRF (the address assigned to the VRF device) from another VRF.
- When using dynamic route leaking, you must use the `redistribute` command in BGP to leak non-BGP routes (connected or static routes); you cannot use the `network` command.
- Routes in the management VRF with the next-hop as eth0 or the management interface are *not* leaked.
- Routes learned with iBGP or multi-hop eBGP in a VRF can be leaked even if their next hops become unreachable. Therefore, route leaking for BGP-learned routes is recommended only when they are learned through single-hop eBGP.
- Cumulus Networks recommends that you do not use the default VRF as a shared service VRF. Create another VRF for shared services.
- Broadcom switches have certain limitations when leaking routes between the default VRF and non-default VRFs.
- On Mellanox switches, only leak the specific routes you need from the default VRF; do not include the VTEP routes or filter out the VTEP routes with a route filter.

In the following example commands, routes in the BGP routing table of VRF `rocket` are dynamically leaked into VRF `turtle`.

```
cumulus@switch:~$ net add bgp vrf turtle ipv4 unicast import vrf
rocket
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

The NCLU commands save the configuration in the `/etc/frr/frr.conf` file. For example:

```
cumulus@switch:~$ sudo cat /etc/frr/frr.conf
```



```
...
router bgp 65001 vrf turtle
!
address-family ipv4 unicast
  import vrf rocket
...
...
```

## Exclude Certain Prefixes

To exclude certain prefixes from being imported, you can use a route map.

The following example configures a route map to match the source protocol BGP and imports the routes from VRF `turtle` to VRF `rocket`. For the imported routes, the community is set to 11:11 in VRF `rocket`.

```
cumulus@switch:~$ net add bgp vrf rocket ipv4 unicast import vrf
turtle
cumulus@switch:~$ net add routing route-map turtle-to-rocket-IPV4
permit 10
cumulus@switch:~$ net add routing route-map turtle-to-rocket-IPV4
permit 10 match source-protocol bgp
cumulus@switch:~$ net add routing route-map turtle-to-rocket-IPV4
permit 10 set community 11:11
cumulus@switch:~$ net add bgp vrf rocket ipv4 unicast import vrf
route-map turtle-to-rocket-IPV4
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

## Dynamic Route Leaking Between VRFs where Subnets Extend across Racks

When you configure dynamic VRF route leaking to leak routes between VRFs, especially in an EVPN deployment where subnets are extended across racks, be aware of the following considerations:

- If end systems (hosts or VMs) are present in one VRF at the router where route leaking is configured that need to be reached from another VRF, you must configure the router to announce a subnet route for the corresponding subnet. Either redistribute the connected subnets into BGP or inject the specific subnet into BGP in the source VRF. This step is necessary because VRF route leaking only leaks routes in the BGP VRF routing table from one VRF into another, which includes only subnet routes and remote host routes, but not routes to local hosts.
- If the leaked routes are being aggregated in the target VRF for route announcement, and if the aggregate matches with a subnet being leaked, you need to configure static routes for the local hosts either in the source VRF or in the destination VRF. Without this configuration, when the aggregate becomes active in the target VRF due to the presence of more-specific contributing leaked routes, a blackhole/discard route is installed in the target VRF, and because this matches one of the leaked subnets, connectivity to any local hosts in that subnet is lost from the target VRF.

## Verify Dynamic Route Leaking Configuration

To check the status of dynamic VRF route leaking, run the NCLU `net show bgp vrf <vrf-name> ipv4|ipv6 unicast route-leak` command. For example:



```
cumulus@switch:~$ net show bgp vrf turtle ipv4 unicast route-leak
This VRF is importing IPv4 Unicast routes from the following VRFs:
    rocket
Import RT(s): 0.0.0.0:3
This VRF is exporting IPv4 Unicast routes to the following VRFs:
    rocket
RD: 10.1.1.1:2
Export RT: 10.1.1.1:2
```

- To view the BGP routing table, run the NCLU `net show bgp vrf <vrf-name> ipv4|ipv6 unicast` command.
- To view the FRR IP routing table, run the NCLU `net show route vrf <vrf-name>` command. This command shows all routes, including routes leaked from other VRFs.

The following example command shows all routes in VRF `turtle`, including routes leaked from VRF `rocket`:

```
cumulus@switch:~$ net show route vrf turtle
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, P - PIM, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, D - SHARP,
       F - PBR,
       > - selected route, * - FIB route

VRF turtle:
K * 0.0.0.0/0 [255/8192] unreachable (ICMP unreachable), 6d07h01m
C>* 10.1.1.1/32 is directly connected, turtle, 6d07h01m
B>* 10.0.100.1/32 [200/0] is directly connected, rocket(vrf rocket),
  6d05h10m
B>* 10.0.200.0/24 [20/0] via 10.10.2.2, swp1.11, 5d05h10m
B>* 10.0.300.0/24 [200/0] via 10.20.2.2, swp1.21(vrf rocket), 5d05h10m
C>* 10.10.2.0/30 is directly connected, swp1.11, 6d07h01m
C>* 10.10.3.0/30 is directly connected, swp2.11, 6d07h01m
C>* 10.10.4.0/30 is directly connected, swp3.11, 6d07h01m
B>* 10.20.2.0/30 [200/0] is directly connected, swp1.21(vrf rocket),
  6d05h10m
```

## Delete Dynamic Route Leaking Configuration

To remove dynamic route leaking configuration, run the following commands. These commands ensure that all leaked routes are removed and routes are no longer leaked from the specified source VRF.

The following example commands delete leaked routes from VRF `rocket` to VRF `turtle`:

```
cumulus@switch:~$ net del bgp vrf turtle ipv4 unicast import vrf
rocket
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```



Do not use the kernel commands; they are no longer supported and might cause issues when used with VRF route leaking in FRR.

## FRRouting Operation in a VRF

In Cumulus Linux 3.5 and later, [BGP \(see page 773\)](#), [OSPFv2 \(see page 756\)](#) and [static routing \(see page 720\)](#) (IPv4 and IPv6) are supported within a VRF context. Various FRRouting routing constructs, such as routing tables, nexthops, router-id, and related processing are also VRF-aware.

[FRRouting \(see page 731\)](#) learns of VRFs provisioned on the system as well as interface attachment to a VRF through notifications from the kernel.

You can assign switch ports to each VRF table with an interface-level configuration, and BGP instances can be assigned to the table with a BGP router-level command.

Because BGP is VRF-aware, they support per-VRF neighbors, both iBGP and eBGP as well as numbered and unnumbered interfaces. Non-interface-based VRF neighbors are bound to the VRF, which is how you can have overlapping address spaces in different VRFs. Each VRF can have its own parameters, such as address families and redistribution. Incoming connections rely on the Linux kernel for VRF-global sockets. BGP neighbors can be tracked using [BFD \(see page 821\)](#), both for single and multiple hops. You can configure multiple BGP instances, associating each with a VRF.

A VRF-aware OSPFv2 configuration also supports numbered and unnumbered interfaces. Supported layer 3 interfaces include SVIs, sub-interfaces and physical interfaces. The VRF supports types 1 through 5 (ABR /ASBR – external LSAs) and types 9 through 11 (opaque LSAs) link state advertisements, redistributing other routing protocols, connected and static routes, and route maps. As with BGP, you can track OSPF neighbors with [BFD \(see page 821\)](#).



Cumulus Linux does not support multiple VRFs in multi-instance OSPF.

VRFs are provisioned using NCLU. VRFs can be pre-provisioned in FRRouting too, but they become active only when configured with NCLU.

- You pre-provision a VRF in FRRouting by running the command `vrf vrf-name`.
- A BGP instance corresponding to a VRF can be pre-provisioned by configuring `net add bgp <VRF> autonomous-system <ASN>`. Under this context, all existing BGP parameters can be configured: neighbors, peer-groups, address-family configuration, redistribution, and so forth.
- An OSPFv2 instance can be configured using the `net add ospf vrf <VRF>` command; as with BGP, all OSPFv2 parameters can be configured.
- Static routes (IPv4 and IPv6) can be provisioned in a VRF by specifying the VRF along with the static route configuration. For example, `ip route prefix dev vrf vrf-name`. The VRF has to exist for this configuration to be accepted — either already defined through `/etc/network/interfaces` or pre-provisioned in FRRouting. If you want to leak a static route in a VRF, see the [note above \(see page \)](#).

### *Example BGP and OSPF Configurations*

Here's an example VRF configuration in BGP:



```
cumulus@switch:~$ net add bgp vrf vrf1012 autonomous-system 64900
cumulus@switch:~$ net add bgp vrf vrf1012 router-id 6.0.2.7
cumulus@switch:~$ net add bgp vrf vrf1012 neighbor ISL peer-group
cumulus@switch:~$ net add bgp vrf vrf1012 neighbor ISLv6 peer-group
cumulus@switch:~$ net add bgp vrf vrf1012 neighbor swp1.2 interface
v6only peer-group ISLv6
cumulus@switch:~$ net add bgp vrf vrf1012 neighbor swp1.2 remote-as
external
cumulus@switch:~$ net add bgp vrf vrf1012 neighbor swp3.2 interface
v6only peer-group ISLv6
cumulus@switch:~$ net add bgp vrf vrf1012 neighbor swp3.2 remote-as
external
cumulus@switch:~$ net add bgp vrf vrf1012 neighbor 169.254.2.18
remote-as external
cumulus@switch:~$ net add bgp vrf vrf1012 neighbor 169.254.2.18 peer-
group ISL
cumulus@switch:~$ net add bgp vrf vrf1012 ipv4 unicast network
20.7.2.0/24
cumulus@switch:~$ net add bgp vrf vrf1012 ipv4 unicast neighbor ISL
activate
cumulus@switch:~$ net add bgp vrf vrf1012 neighbor ISL route-map
ALLOW_BR2 out
cumulus@switch:~$ net add bgp vrf vrf1012 ipv6 unicast network 2003:7:2::/125
cumulus@switch:~$ net add bgp vrf vrf1012 ipv6 unicast neighbor ISLv6
activate
cumulus@switch:~$ net add bgp vrf vrf1012 neighbor ISLv6 route-map
ALLOW_BR2_v6 out
```

These commands produce the following configuration in the `/etc/frr/frr.conf` file.

```
router bgp 64900 vrf vrf1012
  bgp router-id 6.0.2.7
  no bgp default ipv4-unicast
  neighbor ISL peer-group
  neighbor ISLv6 peer-group
  neighbor swp1.2 interface v6only peer-group ISLv6
  neighbor swp1.2 remote-as external
  neighbor swp3.2 interface v6only peer-group ISLv6
  neighbor swp3.2 remote-as external
  neighbor 169.254.2.18 remote-as external
  neighbor 169.254.2.18 peer-group ISL
!
address-family ipv4 unicast
  network 20.7.2.0/24
  neighbor ISL activate
  neighbor ISL route-map ALLOW_BR2 out
exit-address-family
!
address-family ipv6 unicast
```

```

network 2003:7:2::/125
neighbor ISLv6 activate
neighbor ISLv6 route-map ALLOW_BR2_v6 out
exit-address-family
!
```

Here is the FRRouting OSPF configuration:

```

cumulus@switch:~$ net add ospf vrf vrf1
cumulus@switch:~$ net add ospf vrf vrf1 router-id 4.4.4.4
cumulus@switch:~$ net add ospf vrf vrf1 log-adjacency-changes detail
cumulus@switch:~$ net add ospf vrf vrf1 network 10.0.0.0/24 area
0.0.0.1
cumulus@switch:~$ net add ospf vrf vrf1 network 9.9.0.0/16 area
0.0.0.0
cumulus@switch:~$ net add ospf vrf vrf1 redistribute connected
cumulus@switch:~$ net add ospf vrf vrf1 redistribute bgp
cumulus@switch:~$ net add interface swp1 ospf network point-to-point
cumulus@switch:~$ net add interface swp2 ospf network point-to-point
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands create the following configuration in the `/etc/frr/frr.conf` file:

```

!
interface swp1
  ip ospf network point-to-point
!
interface swp2
  ip ospf network point-to-point
!
router ospf vrf vrf1
  ospf router-id 4.4.4.4
  log-adjacency-changes detail
  redistribute connected
  redistribute bgp
  network 9.9.0.0/16 area 0.0.0.0
  network 10.0.0.0/24 area 0.0.0.1
!
```

## Example Commands to Show VRF Data

There are a number of ways to interact with VRFs, including NCLU, `vtysession` (the FRRouting CLI) and `iproute2`.

### Show VRF Data Using NCLU Commands

To show the routes in the VRF:



```
cumulus@switch:~$ net show route vrf rocket
RIB entry for rocket
=====
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, T - Table,
       > - selected route, * - FIB route

C>* 169.254.2.8/30 is directly connected, swp1.2
C>* 169.254.2.12/30 is directly connected, swp2.2
C>* 169.254.2.16/30 is directly connected, swp3.2
```

To show the BGP summary for the VRF:

```
cumulus@switch:~$ net show bgp vrf rocket summary
BGP router identifier 6.0.2.7, local AS number 64900 vrf-id 14
BGP table version 0
RIB entries 1, using 120 bytes of memory
Peers 6, using 97 Kib of memory
Peer groups 2, using 112 bytes of memory

Neighbor          V     AS MsgRcvd MsgSent      TblVer  InQ OutQ Up/Down
State/PfxRcd
s3(169.254.2.18)
                  4 65000  102039  102040      0      0      0
3d13h03m         0
s1(169.254.2.10)
                  4 65000  102039  102040      0      0      0
3d13h03m         0
s2(169.254.2.14)
                  4 65000  102039  102040      0      0      0
3d13h03m         0

Total number of neighbors 3
```

To show BGP (IPv4) routes in the VRF:

```
cumulus@switch:~$ net show bgp vrf vrf1012
BGP table version is 0, local router ID is 6.0.2.7
Status codes: s suppressed, d damped, h history, * valid, > best, =
multipath,
               i internal, r RIB-failure, S Stale, R Removed
Origin codes: i - IGP, e - EGP, ? - incomplete

Network          Next Hop            Metric LocPrf Weight Path
20.7.2.0/24      0.0.0.0                      0          32768 i

Total number of prefixes 1
```

However, to show BGP IPv6 routes in the VRF, you need to use vtysh, the FRRouting CLI:

```
cumulus@switch:~$ sudo vtysh
switch# show bgp vrf vrf1012
BGP table version is 0, local router ID is 6.0.0.2.7
Status codes: s suppressed, d damped, h history, * valid, > best, =
multipath,
                  i internal, r RIB-failure, S Stale, R Removed
Origin codes: i - IGP, e - EGP, ? - incomplete

      Network          Next Hop           Metric LocPrf Weight Path
  2003:7:2::/125    ::                           0          32768 i

Total number of prefixes 1
switch# exit
cumulus@switch:~$
```

To show the OSPF VRFs:

```
cumulus@switch:~$ net show ospf vrf all
Name                      Id       RouterId
Default-IP-Routing-Table 0        6.0.0.7
vrf1012                   45      9.9.12.7
vrf1013                   52      9.9.13.7
vrf1014                   59      9.9.14.7
vrf1015                   65535   0.0.0.0      <- OSPF
instance not active, pre-provisioned config.
vrf1016                   65535   0.0.0.0

Total number of OSPF VRFs: 6
```

To show all the OSPF routes in a VRF:

```
cumulus@switch:~$ net show ospf vrf vrf1012 route
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, P - PIM, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel,
       > - selected route, * - FIB route

VRF vrf1012:
O>* 6.0.0.1/32 [110/210] via 200.254.2.10, swp2s0.2, 00:13:30
  *
  *
  *
O>* 6.0.0.2/32 [110/210] via 200.254.2.10, swp2s0.2, 00:13:30
  *
  *
  *
O>* 9.9.12.5/32 [110/20] via 200.254.2.10, swp2s0.2, 00:13:29
```



```
*          via 200.254.2.14, swp2s1.2, 00:13:29
*          via 200.254.2.18, swp2s2.2, 00:13:29
```

To show which interfaces are in a VRF (either BGP or OSPF), run the `net show vrf list` command. The following command shows which interfaces are in the VRFs configured on the switch:

```
cumulus@switch:~$ net show vrf list
VRF: mgmt
-----
eth0           UP      a0:00:00:00:00:11 <BROADCAST,MULTICAST,UP,
LOWER_UP>

VRF: turtle
-----
vlan13@bridge    UP      44:38:39:00:00:03 <BROADCAST,MULTICAST,UP,
LOWER_UP>
vlan13-v0@vlan13  UP      44:39:39:ff:00:13 <BROADCAST,MULTICAST,UP,
LOWER_UP>
vlan24@bridge    UP      44:38:39:00:00:03 <BROADCAST,MULTICAST,UP,
LOWER_UP>
vlan24-v0@vlan24  UP      44:39:39:ff:00:24 <BROADCAST,MULTICAST,UP,
LOWER_UP>
vlan4001@bridge   UP      44:39:39:ff:40:94 <BROADCAST,MULTICAST,UP,
LOWER_UP>
```

To show the interfaces for a specific VRF, run the `net show vrf list <vrf_name>` command. The following command shows which interfaces are in VRF `turtle`:

```
cumulus@switch:~$ net show vrf list turtle
VRF: turtle
-----
vlan13@bridge    UP      44:38:39:00:00:03 <BROADCAST,MULTICAST,UP,
LOWER_UP>
vlan13-v0@vlan13  UP      44:39:39:ff:00:13 <BROADCAST,MULTICAST,UP,
LOWER_UP>
vlan24@bridge    UP      44:38:39:00:00:03 <BROADCAST,MULTICAST,UP,
LOWER_UP>
vlan24-v0@vlan24  UP      44:39:39:ff:00:24 <BROADCAST,MULTICAST,UP,
LOWER_UP>
vlan4001@bridge   UP      44:39:39:ff:40:94 <BROADCAST,MULTICAST,UP,
LOWER_UP>
```



You can only specify one VRF with the `net show vrf list <vrf_name>` command. For example, `net show vrf list mgmt turtle` is an invalid command.

To show the VNIs for the interfaces in a VRF, run the `net show vrf vni` command. For example:

```
cumulus@switch:~$ net show vrf vni
VRF          VNI      VxLAN IF     L3-SVI      State   Rmac
turtle       104001  vxlan4001  vlan4001    Up      44:39:39:ff:40:94
```

To see the VNIs for the interfaces in a VRF in JSON format, run the `net show vrf vni json` command. For example:

```
cumulus@switch:~$ net show vrf vni json
{
  "vrfs": [
    {
      "vrf": "turtle",
      "vni": 104001,
      "vxlanIntf": "vxlan4001",
      "sviIntf": "vlan4001",
      "state": "Up",
      "routerMac": "44:39:39:ff:40:94"
    }
  ]
}
```

### *Show VRF Data Using FRRouting Commands*

Show all VRFs learned by FRRouting from the kernel. The table ID shows the corresponding routing table in the kernel either automatically assigned or manually defined:

```
cumulus@switch:~$ sudo vtysh
switch# show vrf
vrf vrf1012 id 14 table 1012
vrf vrf1013 id 21 table 1013
vrf vrf1014 id 28 table 1014
switch# exit
cumulus@switch:~$
```

Show VRFs configured in BGP, including the default. A non-zero ID is a VRF that has also been actually provisioned — that is, defined in `/etc/network/interfaces`:

```
cumulus@switch:~$ sudo vtysh
switch# show bgp vrfs
Type  Id      RouterId           #PeersCfg  #PeersEstb  Name
DFLT  0       6.0.0.7            0          0          Default
VRF   14      6.0.2.7            6          6          vrf1012
VRF   21      6.0.3.7            6          6          vrf1013
VRF   28      6.0.4.7            6          6          vrf1014

Total number of VRFs (including default): 4
```



```
switch# exit  
cumulus@switch:~$
```

Display interfaces known to FRRouting and attached to this VRF:

```
cumulus@switch:~$ sudo vtysh  
switch# show interface vrf vrf1012  
Interface br2 is up, line protocol is down  
  PTM status: disabled  
  vrf: vrf1012  
    index 13 metric 0 mtu 1500  
    flags: <UP,BROADCAST,MULTICAST>  
    inet 20.7.2.1/24  
  
      inet6 fe80::202:ff:fe00:a/64  
        ND advertised reachable time is 0 milliseconds  
        ND advertised retransmit interval is 0 milliseconds  
        ND router advertisements are sent every 600 seconds  
        ND router advertisements lifetime tracks ra-interval  
        ND router advertisement default router preference is medium  
        Hosts use stateless autoconfig for addresses.  
switch# exit  
cumulus@switch:~$
```

To show VRFs configured in OSPF:

```
cumulus@switch:~$ sudo vtysh  
switch# show ip ospf vrf  
Name           Id     RouterId  
Default-IP-Routing-Table   0     0.0.0.0  
rocket          57    0.0.0.10  
turtle          58    0.0.0.20  
Total number of OSPF VRFs (including default): 3  
switch# exit  
cumulus@switch:~$
```

To show all OSPF routes in a VRF:

```
cumulus@switch:~$ sudo vtysh  
switch# show ip ospf vrf all route  
===== OSPF network routing table =====  
N    7.0.0.0/24          [10] area: 0.0.0.0  
                                directly attached to swp2  
  
===== OSPF router routing table =====  
  
===== OSPF external routing table =====
```

```
===== OSPF network routing table =====
N    8.0.0.0/24          [10] area: 0.0.0.0
                                directly attached to swp1

===== OSPF router routing table =====

===== OSPF external routing table =====

switch# exit
cumulus@switch:~$
```

To see the routing table for each VRF, use the `show ip route vrf all` command. The OSPF route is denoted in the row that starts with O:

```
cumulus@switch:~$ sudo vtysh
switch# show ip route vrf all
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, P - PIM, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel,
       > - selected route, * - FIB route
VRF turtle:
K>* 0.0.0.0/0 [0/8192] unreachable (ICMP unreachable)
O  7.0.0.0/24 [110/10] is directly connected, swp2, 00:28:35
C>* 7.0.0.0/24 is directly connected, swp2
C>* 7.0.0.5/32 is directly connected, turtle
C>* 7.0.0.100/32 is directly connected, turtle
C>* 50.1.1.0/24 is directly connected, swp3ls1
VRF rocket:
K>* 0.0.0.0/0 [0/8192] unreachable (ICMP unreachable)
O
8.0.0.0/24 [110/10]
is directly connected, swp1, 00:23:26
C>* 8.0.0.0/24 is directly connected, swp1
C>* 8.0.0.5/32 is directly connected, rocket
C>* 8.0.0.100/32 is directly connected, rocket
C>* 50.0.1.0/24 is directly connected, swp3ls0
switch# exit
cumulus@switch:~$
```

## Show VRF Data Using ip Commands

To list all VRFs provisioned, showing the VRF ID (vrf1012, vrf1013 and vrf1014 below) as well as the table ID:

```
cumulus@switch:~$ ip -d link show type vrf
14: vrf1012: <NOARP,MASTER,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast
state UNKNOWN mode DEFAULT group default qlen 1000
    link/ether 46:96:c7:64:4d:fa brd ff:ff:ff:ff:ff:ff promiscuity 0
    vrf table 1012 addrgenmode eui64
```



```
21: vrf1013: <NOARP,MASTER,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast
    state UNKNOWN mode DEFAULT group default qlen 1000
        link/ether 7a:8a:29:0f:5e:52 brd ff:ff:ff:ff:ff:ff promiscuity 0
        vrf table 1013 addrgenmode eui64
28: vrf1014: <NOARP,MASTER,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast
    state UNKNOWN mode DEFAULT group default qlen 1000
        link/ether e6:8c:4d:fc:eb:b1 brd ff:ff:ff:ff:ff:ff promiscuity 0
        vrf table 1014 addrgenmode eui64
```

To list the interfaces attached to a specific VRF:

```
cumulus@switch:~$ ip -d link show vrf vrf1012
8: swp1.2@swp1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc
noqueue master vrf1012 state UP mode DEFAULT group default
    link/ether 00:02:00:00:00:07 brd ff:ff:ff:ff:ff:ff promiscuity 0
    vlan protocol 802.1Q id 2 <REORDER_HDR>
    vrf_slave addrgenmode eui64
9: swp2.2@swp2: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc
noqueue master vrf1012 state UP mode DEFAULT group default
    link/ether 00:02:00:00:00:08 brd ff:ff:ff:ff:ff:ff promiscuity 0
    vlan protocol 802.1Q id 2 <REORDER_HDR>
    vrf_slave addrgenmode eui64
10: swp3.2@swp3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc
noqueue master vrf1012 state UP mode DEFAULT group default
    link/ether 00:02:00:00:00:09 brd ff:ff:ff:ff:ff:ff promiscuity 0
    vlan protocol 802.1Q id 2 <REORDER_HDR>
    vrf_slave addrgenmode eui64
11: swp4.2@swp4: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc
noqueue master vrf1012 state UP mode DEFAULT group default
    link/ether 00:02:00:00:00:0a brd ff:ff:ff:ff:ff:ff promiscuity 0
    vlan protocol 802.1Q id 2 <REORDER_HDR>
    vrf_slave addrgenmode eui64
12: swp5.2@swp5: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc
noqueue master vrf1012 state UP mode DEFAULT group default
    link/ether 00:02:00:00:00:0b brd ff:ff:ff:ff:ff:ff promiscuity 0
    vlan protocol 802.1Q id 2 <REORDER_HDR>
    vrf_slave addrgenmode eui64
13: br2: <NO-CARRIER,BROADCAST,MULTICAST,UP> mtu 1500 qdisc noqueue
master vrf1012 state DOWN mode DEFAULT group default
    link/ether 00:00:00:00:00:00 brd ff:ff:ff:ff:ff:ff promiscuity 0
    bridge forward_delay 100 hello_time 200 max_age 2000 ageing_time
30000 stp_state 0 priority 32768
    vlan_filtering 0 vlan_protocol 802.1Q bridge_id 8000.0:0:0:0:0:0
designated_root 8000.0:0:0:0:0:0
    root_port 0 root_path_cost 0 topology_change 0
topology_change_detected 0 hello_timer 0.00
    tcn_timer 0.00 topology_change_timer 0.00 gc_timer 202.23
vlan_default_pvid 1 group_fwd_mask 0
    group_address 01:80:c2:00:00:00 mcast_snooping 1 mcast_router 1
mcast_query_use_ifaddr 0 mcast_querier 0
```

```
mcast_hash_elasticity 4096 mcast_hash_max 4096
mcast_last_member_count 2 mcast_startup_query_count 2
    mcast_last_member_interval 100 mcast_membership_interval 26000
mcast_querier_interval 25500
    mcast_query_interval 12500 mcast_query_response_interval 1000
mcast_startup_query_interval 3125
    nf_call_iptables 0 nf_call_ip6tables 0 nf_call_arptables 0
    vrf_slave addrgenmode eui64
```

To show IPv4 routes in a VRF:

```
cumulus@switch:~$ ip route show table vrf1012
unreachable default metric 240
broadcast 20.7.2.0 dev br2 proto kernel scope link src 20.7.2.1
dead linkdown
20.7.2.0/24 dev br2 proto kernel scope link src 20.7.2.1 dead
linkdown
local 20.7.2.1 dev br2 proto kernel scope host src 20.7.2.1
broadcast 20.7.2.255 dev br2 proto kernel scope link src 20.7.2.1
dead linkdown
broadcast 169.254.2.8 dev swp1.2 proto kernel scope link src
169.254.2.9
169.254.2.8/30 dev swp1.2 proto kernel scope link src 169.254.2.9
local 169.254.2.9 dev swp1.2 proto kernel scope host src
169.254.2.9
broadcast 169.254.2.11 dev swp1.2 proto kernel scope link src
169.254.2.9
broadcast 169.254.2.12 dev swp2.2 proto kernel scope link src
169.254.2.13
169.254.2.12/30 dev swp2.2 proto kernel scope link src
169.254.2.13
local 169.254.2.13 dev swp2.2 proto kernel scope host src
169.254.2.13
broadcast 169.254.2.15 dev swp2.2 proto kernel scope link src
169.254.2.13
broadcast 169.254.2.16 dev swp3.2 proto kernel scope link src
169.254.2.17
169.254.2.16/30 dev swp3.2 proto kernel scope link src
169.254.2.17
local 169.254.2.17 dev swp3.2 proto kernel scope host src
169.254.2.17
broadcast 169.254.2.19 dev swp3.2 proto kernel scope link src
169.254.2.17
```

To show IPv6 routes in a VRF:

```
cumulus@switch:~$ ip -6 route show table vrf1012
local fe80:: dev lo proto none metric 0 pref medium
local fe80:: dev lo proto none metric 0 pref medium
```



```
local fe80:: dev lo proto none metric 0 pref medium
local fe80:: dev lo proto none metric 0 pref medium
local fe80::202:ff:fe00:7 dev lo proto none metric 0 pref medium
local fe80::202:ff:fe00:8 dev lo proto none metric 0 pref medium
local fe80::202:ff:fe00:9 dev lo proto none metric 0 pref medium
local fe80::202:ff:fe00:a dev lo proto none metric 0 pref medium
fe80::/64 dev br2 proto kernel metric 256 dead linkdown pref medium
fe80::/64 dev swp1.2 proto kernel metric 256 pref medium
fe80::/64 dev swp2.2 proto kernel metric 256 pref medium
fe80::/64 dev swp3.2 proto kernel metric 256 pref medium
ff00::/8 dev br2 metric 256 dead linkdown pref medium
ff00::/8 dev swp1.2 metric 256 pref medium
ff00::/8 dev swp2.2 metric 256 pref medium
ff00::/8 dev swp3.2 metric 256 pref medium
unreachable default dev lo metric 240 error -101 pref medium
```

To see a list of links associated with a particular VRF table, run `ip link list <vrf-name>`. For example:

```
cumulus@switch:~$ ip link list rocket

VRF: rocket
-----
swp1.10@swp1      UP            6c:64:1a:00:5a:0c <BROADCAST,
MULTICAST,UP,LOWER_UP>
swp2.10@swp2      UP            6c:64:1a:00:5a:0d <BROADCAST,
MULTICAST,UP,LOWER_UP>
```

To see a list of routes associated with a particular VRF table, run `ip route list <vrf-name>`. For example:

```
cumulus@switch:~$ ip route list rocket

VRF: rocket
-----
unreachable default metric 8192
10.1.1.0/24 via 10.10.1.2 dev swp2.10
10.1.2.0/24 via 10.99.1.2 dev swp1.10
broadcast 10.10.1.0 dev swp2.10 proto kernel scope link src
10.10.1.1
10.10.1.0/28 dev swp2.10 proto kernel scope link src 10.10.1.1
local 10.10.1.1 dev swp2.10 proto kernel scope host src 10.10.1.1
broadcast 10.10.1.15 dev swp2.10 proto kernel scope link src
10.10.1.1
broadcast 10.99.1.0 dev swp1.10 proto kernel scope link src
10.99.1.1
10.99.1.0/30 dev swp1.10 proto kernel scope link src 10.99.1.1
local 10.99.1.1 dev swp1.10 proto kernel scope host src 10.99.1.1
```

```
broadcast 10.99.1.3 dev swp1.10 proto kernel scope link src
10.99.1.1

local fe80:: dev lo proto none metric 0 pref medium
local fe80:: dev lo proto none metric 0 pref medium
local fe80::6e64:1aff:fe00:5a0c dev lo proto none metric 0 pref
medium
local fe80::6e64:1aff:fe00:5a0d dev lo proto none metric 0 pref
medium
fe80::/64 dev swp1.10 proto kernel metric 256 pref medium
fe80::/64 dev swp2.10 proto kernel metric 256 pref medium
ff00::/8 dev swp1.10 metric 256 pref medium
ff00::/8 dev swp2.10 metric 256 pref medium
unreachable default dev lo metric 8192 error -101 pref medium
```



You can also show routes in a VRF using `ip [-6] route show vrf <name>`. This command omits local and broadcast routes, which can clutter the output.

## BGP Unnumbered Interfaces with VRF

BGP unnumbered interface configurations (see page 773) are supported with VRF. In BGP unnumbered, there are no addresses on any interface. However, debugging tools like `traceroute` need at least a single IP address per node as the node's source IP address. Typically, this address was assigned to the loopback device. With VRF, you need a loopback device for each VRF table since VRF is based on interfaces, not IP addresses. While Linux does not support multiple loopback devices, it does support the concept of a dummy interface, which is used to achieve the same goal.

An IP address can be associated with the VRF device, which will then act as the dummy (loopback-like) interface for that VRF.

Configure the BGP unnumbered configuration. The BGP unnumbered configuration is the same for a non-VRF, applied under the VRF context (`router bgp asn vrf <vrf-name>`).

```
cumulus@switch:~$ net add vrf vrf1 vrf-table auto
cumulus@switch:~$ net add vrf vrf1 ip address 6.1.0.6/32
cumulus@switch:~$ net add vrf vrf1 ipv6 address 2001:6:1::6/128
cumulus@switch:~$ net add interface swp1 link speed 10000
cumulus@switch:~$ net add interface swp1 link autoneg on
cumulus@switch:~$ net add vlan 101 vrf vrf1
cumulus@switch:~$ net add vlan 101 ip address 20.1.6.1/24
cumulus@switch:~$ net add vlan 101 ipv6 address 2001:20:1:6::1/80
cumulus@switch:~$ net add bridge bridge ports swp1
```

These commands create the following configuration in the `/etc/network/interfaces` file:

```
...
auto swp1
```



```
iface swp1
    link-autoneg on
    link-speed 10000

auto bridge
iface bridge
    bridge-ports swp1
    bridge-vids 101
    bridge-vlan-aware yes

auto vlan101
iface vlan101
    address 20.1.6.1/24
    address 2001:20:1:6::1/80
    vlan-id 101
    vlan-raw-device bridge
    vrf vrf1

auto vrf1
iface vrf1
    address 6.1.0.6/32
    address 2001:6:1::6/128
    vrf-table auto
```

Here is the FRRouting BGP configuration:

```
cumulus@switch:~$ net add bgp vrf vrf1 autonomous-system 65001
cumulus@switch:~$ net add bgp vrf vrf1 bestpath as-path multipath-relax
cumulus@switch:~$ net add bgp vrf vrf1 bestpath compare-routerid
cumulus@switch:~$ net add bgp vrf vrf1 neighbor LEAF peer-group
cumulus@switch:~$ net add bgp vrf vrf1 neighbor LEAF remote-as external
cumulus@switch:~$ net add bgp vrf vrf1 neighbor LEAF capability extended-nexthop
cumulus@switch:~$ net add bgp vrf vrf1 neighbor swp1.101 interface peer-group LEAF
cumulus@switch:~$ net add bgp vrf vrf1 neighbor swp2.101 interface peer-group LEAF
cumulus@switch:~$ net add bgp vrf vrf1 ipv4 unicast redistribute connected
cumulus@switch:~$ net add bgp vrf vrf1 ipv4 unicast neighbor LEAF activate
cumulus@switch:~$ net add bgp vrf vrf1 ipv6 unicast redistribute connected
cumulus@switch:~$ net add bgp vrf vrf1 ipv6 unicast neighbor LEAF activate
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```



These commands create the following configuration in the `/etc/frr/frr.conf` file:

```
!
router bgp 65001 vrf vrf1
  no bgp default ipv4-unicast
  bgp bestpath as-path multipath-relax
  bgp bestpath compare-routerid
  neighbor LEAF peer-group
  neighbor LEAF remote-as external
  neighbor LEAF capability extended-nexthop
  neighbor swp1.101 interface peer-group LEAF
  neighbor swp2.101 interface peer-group LEAF
!
address-family ipv4 unicast
  redistribute connected
  neighbor LEAF activate
exit-address-family
!
address-family ipv6 unicast
  redistribute connected
  neighbor LEAF activate
exit-address-family
!
```

## DHCP with VRF

Because you can use VRF to bind IPv4 and IPv6 sockets to non-default VRF tables, you have the ability to start DHCP servers and relays in any non-default VRF table using the `dhcpd` and `dhcrelay` services, respectively. These services must be managed by `systemd` in order to run in a VRF context; in addition, the services must be listed in `/etc/vrf/systemd.conf`. By default, this file already lists these two services, as well as others like `ntp` and `snmpd`. You can add more services as needed, such as `dhcpd6` and `dhcrelay6` for IPv6.

If you edit `/etc/vrf/systemd.conf`, run `sudo systemctl daemon-reload` to generate the `systemd` instance files for the newly added service(s). Then you can start the service in the VRF using `systemctl start <service>@<vrf-name>.service`, where `<service>` is the name of the service — such as `dhcpd` or `dhcrelay` — and `<vrf-name>` is the name of the VRF.

For example, to start the `dhcrelay` service after you configured a VRF named *turtle*, run:

```
cumulus@switch:~$ sudo systemctl start dhcrelay@turtle.service
```

To enable the service at boot time you should also run `systemctl enable <service>@<vrf-name>`. To continue with the previous example:

```
cumulus@switch:~$ sudo systemctl enable dhcrelay@turtle.service
```

In addition, you need to create a separate default file in `/etc/default` for every instance of a DHCP server and/or relay in a non-default VRF; this is where you set the server and relay options. To run multiple instances of any of these services, you need a separate file for each instance. The files must be named as follows:

- `isc-dhcp-server-<vrf-name>`
- `isc-dhcp-server6-<vrf-name>`
- `isc-dhcp-relay-<vrf-name>`
- `isc-dhcp-relay6-<vrf-name>`

See the example configuration below for more details.

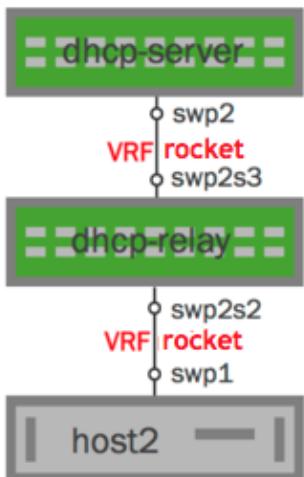
### Caveats for DHCP with VRF

- Cumulus Linux does **not** support DHCP server and relay across VRFs, so the server and host cannot be in different VRF tables. In addition, the server and relay cannot be in different VRF tables.
- Typically a service running in the default VRF owns a port across all VRFs. If the VRF local instance is preferred, the global one may need to be disabled and stopped first.
- VRF is a layer 3 routing feature. It only makes sense to run programs that use AF\_INET and AF\_INET6 sockets in a VRF. VRF context does not affect any other aspects of the operation of a program.
- This method only works with `systemd`-based services.

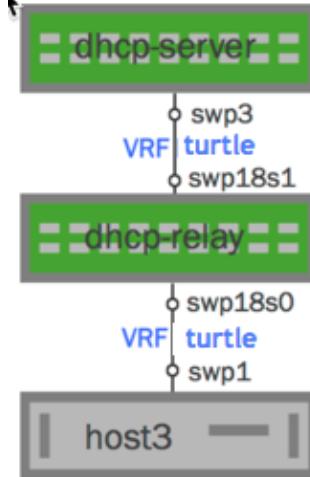
### Example Configuration

In the following example, there is one IPv4 network with a VRF named *rocket* and one IPv6 network with a VRF named *turtle*.

The IPv4 DHCP server/relay network looks like this:



The IPv6 DHCP server/relay network looks like this:



Configure each DHCP server and relay as follows:

#### Sample DHCP Server Configuration

#### Sample DHCP6 Server Configuration

1. Create the file `isc-dhcp-server6-turtle` in `/etc/default/`. Here is sample content:

1. Create the file `isc-dhcp-server-rocket` in `/etc/default/`. Here is sample content:

```
# Defaults for isc-dhcp-
server initscript
# sourced by /etc/init.d
/etc/dhcp-server
# installed at /etc/default
/etc/dhcp-server by the
maintainer scripts
#
# This is a POSIX shell
fragment
#
# Path to dhcpcd's config
file (default: /etc/dhcp
/dhcpcd.conf).
DHCPD_CONF="-cf /etc/dhcp
/dhcpcd-rocket.conf"
# Path to dhcpcd's PID file
(default: /var/run/dhcpcd.
pid).
DHCPD_PID="-pf /var/run
/dhcpcd-rocket.pid"
# Additional options to
start dhcpcd with.
# Don't use options -cf or
-pf here; use DHCPD_CONF/
DHCPD_PID instead
#OPTIONS=""
# On what interfaces
should the DHCP server
(dhcpcd) serve DHCP
requests?
# Separate multiple
interfaces with spaces, e.
g. "eth0 eth1".
INTERFACES="swp2"
```

2. Enable the DHCP server:

```
cumulus@switch:~$ sudo systemctl
enable dhcpd@rocket.service
```

3. Start the DHCP server:

```
cumulus@switch:~$ sudo systemctl
start dhcpd@rocket.service
or
cumulus@switch:~$ sudo systemctl
restart dhcpd@rocket.service
```

```
# Defaults for isc-dhcp-
server initscript
# sourced by /etc/init.d
/etc/dhcp-server
# installed at /etc/default
/etc/dhcp-server by the
maintainer scripts
#
# This is a POSIX shell
fragment
#
# Path to dhcpcd's config
file (default: /etc/dhcp
/dhcpcd.conf).
DHCPD_CONF="-cf /etc/dhcp
/dhcpcd-turtle.conf"
# Path to dhcpcd's PID file
(default: /var/run/dhcpcd.
pid).
DHCPD_PID="-pf /var/run
/dhcpcd-turtle.pid"
# Additional options to
start dhcpcd with.
# Don't use options -cf or
-pf here; use DHCPD_CONF/
DHCPD_PID instead
#OPTIONS=""
# On what interfaces
should the DHCP server
(dhcpcd) serve DHCP
requests?
# Separate multiple
interfaces with spaces, e.
g. "eth0 eth1".
INTERFACES="swp3"
```

2. Enable the DHCP server:

```
cumulus@switch:~$ sudo systemctl
enable dhcpd6@turtle.service
```

3. Start the DHCP server:

```
cumulus@switch:~$ sudo systemctl
start dhcpd6@turtle.service
or
```

```
cumulus@switch:~$ sudo systemctl
restart dhcpd6@turtle.service
```

4. Check status:

```
cumulus@switch:~$ sudo systemctl
status dhcpd6@turtle.service
```



## 4. Check status:

```
cumulus@switch:~$ sudo systemctl  
status dhcpcd@rocket.service
```



You can create this configuration using the `vrf` command ([see above \(see page 851\)](#) for more details):

```
cumulus@switch:~$ sudo  
vrf task exec rocket /usr  
/sbin/dhcpcd -f -q -cf /  
/etc/dhcp/dhcpcd-  
rocket.conf -pf /var/run  
/dhcpcd-rocket.pid swp2
```



You can create this configuration using the `vrf` command ([see above \(see page 851\)](#) for more details):

```
cumulus@switch:~$ sudo  
vrf task exec turtle  
dhcpcd -6 -q -cf /  
/etc/dhcp/dhcpd6-  
turtle.conf -pf /var/run  
/dhcpd6-turtle.pid swp3
```

## Sample DHCP Relay Configuration

1. Create the file `isc-dhcp-relay-rocket` in `/etc/default/`. Here is sample content:

```
# Defaults for isc-dhcp-  
relay initscript  
# sourced by /etc/init.d  
/isc-dhcp-relay  
# installed at /etc/default  
/isc-dhcp-relay by the  
maintainer scripts  
#  
# This is a POSIX shell  
fragment  
#  
# What servers should the  
DHCP relay forward  
requests to?  
SERVERS="102.0.0.2"  
# On what interfaces  
should the DHCP relay  
(dhrelay) serve DHCP  
requests?  
# Always include the  
interface towards the DHCP  
server.
```

## Sample DHCP6 Relay Configuration

1. Create the file `isc-dhcp-relay6-turtle` in `/etc/default/`. Here is sample content:

```
# Defaults for isc-dhcp-  
relay initscript  
# sourced by /etc/init.d  
/isc-dhcp-relay  
# installed at /etc/default  
/isc-dhcp-relay by the  
maintainer scripts  
#  
# This is a POSIX shell  
fragment  
#  
# What servers should the  
DHCP relay forward  
requests to?  
#SERVERS="103.0.0.2"  
# On what interfaces  
should the DHCP relay  
(dhrelay) serve DHCP  
requests?  
# Always include the  
interface towards the DHCP  
server.  
# This variable requires a  
-i for each interface  
configured above.
```

```
# This variable requires a
-i for each interface
configured above.
# This will be used in the
actual dhcrelay command
# For example, "-i eth0 -i
eth1"
INTF_CMD="-i swp2s2 -i
swp2s3"
# Additional options that
are passed to the DHCP
relay daemon?
OPTIONS=""
```

2. Enable the DHCP relay:

```
cumulus@switch:~$ sudo systemctl
enable dhcrelay@rocket.service
```

3. Start the DHCP relay:

```
cumulus@switch:~$ sudo systemctl
start dhcrelay@rocket.service
or
cumulus@switch:~$ sudo systemctl
restart dhcrelay@rocket.service
```

4. Check status:

```
cumulus@switch:~$ sudo systemctl
status dhcrelay@rocket.service
```



You can create this configuration using the `vrf` command ([see above \(see page 851\)](#) for more details):

```
cumulus@switch:~$ sudo
vrf task exec rocket /usr
/sbin/dhcrelay -d -q -i /
swp2s2 -i swp2s3
102.0.0.2
```

```
# This will be used in the
actual dhcrelay command
# For example, "-i eth0 -i
eth1"
INTF_CMD="-l swp18s0 -u
swp18s1"
# Additional options that
are passed to the DHCP
relay daemon?
OPTIONS="-pf /var/run
/dhcrelay6@turtle.pid"
```

2. Enable the DHCP relay:

```
cumulus@switch:~$ sudo systemctl
enable dhcrelay6@turtle.service
```

3. Start the DHCP relay:

```
cumulus@switch:~$ sudo systemctl
start dhcrelay6@turtle.service
or
cumulus@switch:~$ sudo systemctl
restart dhcrelay6@turtle.service
```

4. Check status:

```
cumulus@switch:~$ sudo systemctl
status dhcrelay6@turtle.service
```



You can create this configuration using the `vrf` command ([see above \(see page 851\)](#) for more details):

```
cumulus@switch:~$ sudo
vrf task exec turtle /usr
/sbin/dhcrelay -d -q -6 -
l /
swp18s0 -u swp18s1 -
pf /var/run
/dhcrelay6@turtle.pid
```

## ping or traceroute on a VRF

You can run `ping` or `traceroute` on a VRF from the default VRF.

To ping a VRF from the default VRF, run the `ping -I <vrf-name>` command. For example:

```
cumulus@switch:~$ ping -I turtle
```



To run `traceroute` on a VRF from the default VRF, run the `traceroute -i <vrf-name>` command. For example:

```
cumulus@switch:~$ sudo traceroute -i turtle
```

## Caveats and Errata

- Switches using the Hurricane2 ASIC (such as the Penguin Computing Arctica 4804IP) do not support VRFs.
- Table selection based on the incoming interface only; currently, packet attributes or output-interface-based selection are not available.
- Setting the router ID outside of BGP via the `router-id` option causes all BGP instances to get the same router ID. If you want each BGP instance to have its own router ID, specify the `router-id` under the BGP instance using `bgp router-id`. If both are specified, the one under the BGP instance overrides the one provided outside BGP.
- You cannot configure [EVPN address families \(see page 501\)](#) within a VRF.

## Management VRF

*Management VRF* is a subset of [VRF \(see page 847\)](#) (virtual routing tables and forwarding) and provides a separation between the out-of-band management network and the in-band data plane network. For all VRFs, the *main* routing table is the default table for all of the data plane switch ports. With management VRF, a second table, *mgmt*, is used for routing through the Ethernet ports of the switch. The *mgmt* name is special cased to identify the management VRF from a data plane VRF. FIB rules are installed for DNS servers because this is the typical deployment case.

Cumulus Linux only supports `eth0` as the management interface, or `eth1`, depending on the switch platform. The Ethernet ports are software-only parts that are not hardware accelerated by `switchd`. VLAN subinterfaces, bonds, bridges, and the front panel switch ports are not supported as management interfaces.

When management VRF is enabled, logins to the switch are set into the management VRF context. IPv4 and IPv6 networking applications (for example, Ansible, Chef, and `apt-get`) run by an administrator communicate out the management network by default. This default context does not impact services run through `systemd` and the `systemctl` command, and does not impact commands examining the state of the switch, such as the `ip` command to list links, neighbors, or routes.



The management VRF configurations in this chapter contain a localhost loopback IP address (127.0.0.1/8). Adding the loopback address to the L3 domain of the management VRF prevents issues with applications that expect the loopback IP address to exist in the VRF, such as NTP.

## Contents

### This topic describes ...

- [Enable Management VRF \(see page 878\)](#)
- [Run Services within the Management VRF \(see page 879\)](#)



- Enable Polling with snmpd in a Management VRF (see page 881)
- ping or traceroute on the Management VRF (see page 881)
- Run Services as a Non-root User (see page 881)
- OSPF and BGP (see page 883)
- SSH within a Management VRF Context (see page 883)
- View the Routing Tables (see page 884)
- mgmt Interface Class (see page 884)
- Management VRF and DNS (see page 885)
- Incompatibility with cl-ns-mgmt (see page 886)

## Enable Management VRF

To enable management VRF on eth0, complete the following steps:

### Example Management VRF Configuration

The example NCLU commands below create a VRF called *mgmt*:



The management VRF must be named `mgmt` to differentiate from a data plane VRF.

```
cumulus@switch:~$ net add vrf mgmt
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

The NCLU commands above create the following snippets in the `/etc/network/interfaces` file:

```
...
auto eth0
iface eth0 inet dhcp
    vrf mgmt

...
auto mgmt
iface mgmt
    address 127.0.0.1/8
    vrf-table auto

...
```





When you commit the change to add the management VRF, all connections over eth0 are dropped. This can impact any automation that might be running, such as Ansible or Puppet scripts.

If you take down the management VRF using `ifdown`, to bring it back up you need to do one of two things:

- Use `ifup --with-dependents <vrf>`
- Use `ifreload -a`

For example:

```
cumulus@switch:~$ sudo ifdown mgmt
cumulus@switch:~$ sudo ifup --with-dependents mgmt
```



Running `ifreload -a` disconnects the session for any interface configured as *auto*.

## Run Services within the Management VRF

You can run a variety of services within the management VRF instead of the default VRF. In most cases, you must stop and disable the instance running in the default VRF before you can start the service in the management VRF. This is because the instance running in the default VRF owns the port across all VRFs. The list of services that must be disabled in the default VRF are:

- chef-client
- collectd
- dhcpcd
- dhcrelay
- hsflowd
- netq-agent
- netq-notifier
- netqd
- ntp
- puppet
- snmpd
- snmptrapd
- ssh
- zabbix-agent

When you run a service inside the management VRF, that service runs **only** on eth0; it no longer runs on any switch port. However, you can keep the service running in the default VRF with a wildcard for [agentAddress \(see page\)](#). This enables the service to run on **all** interfaces no matter which VRF, so you don't have to run a different process for each VRF.



Some applications can work across all VRFs. The kernel provides a `sysctl` that allows a single instance to accept connections over all VRFs. For TCP, connected sockets are bound to the VRF on which the first packet is received. This `sysctl` is enabled for Cumulus Linux.

To enable a service to run in the management VRF, do the following. These steps use the NTP service, but you can use any of the services listed above, except for `dhcrelay`, which is discussed [here](#) (see page 295).

1. Configure the management VRF as described in [the Enabling Management VRF section above \(see page 878\)](#).
2. If NTP is running, stop the service:

```
cumulus@switch:~$ sudo systemctl stop ntp.service
```

3. Disable NTP from starting automatically in the default VRF:

```
cumulus@switch:~$ sudo systemctl disable ntp.service
```

4. Run the `daemon-reload` command:

```
cumulus@switch:~$ sudo systemctl daemon-reload
```

5. Start NTP in the management VRF:

```
cumulus@switch:~$ sudo systemctl start ntp@mgmt.service
```

6. Enable `ntp@mgmt` so that it starts when the switch boots:

```
cumulus@switch:~$ sudo systemctl enable ntp@mgmt.service
```

7. Verify that the `ntpd` service is running in the management VRF:

```
cumulus@switch:~$ ps aux | grep ntp
ntp      7294  0.0  0.4  81320  2108 ?          Ssl   22:22   0:00
/usr/sbin/ntpd -n -u ntp:ntp -g
cumulus  7906  0.0  0.4  12728  2056 ttys1      S+    22:34   0:00
grep ntp
cumulus@switch:~$ vrf task identify 7294
mgmt
```

After you enable `ntp@mgmt`, you can verify that NTP peers are active:

```
cumulus@switch:~$ ntpq -pn
```

remote offset	jitter	refid	st	t	when	poll	reach	delay
<hr/>								
<hr/>								
*38.229.71.1 -0.625	3.105	204.9.54.119	2	u	42	64	377	31.275
-104.131.53.252 -5.251	0.681	209.51.161.238	2	u	47	64	377	16.381
+45.79.10.228 0.115	0.585	200.98.196.212	2	u	44	64	377	42.998
+74.207.240.206 -1.623	0.320	127.67.113.92	2	u	43	64	377	73.240

### Enable Polling with `snmpd` in a Management VRF

When you enable `snmpd` to run in the management VRF, you need to specify that VRF with NCLU so that `snmpd` listens on eth0 in the management VRF; you can also configure `snmpd` to listen on other ports with the NCLU `listening-address vrf` command. As of Cumulus Linux 3.6, SNMP configuration is VRF aware so `snmpd` can bind to multiple IP addresses each configured with a particular VRFs (routing table). The `snmpd` daemon responds to polling requests on the interfaces of the VRF on which the request came in. SNMP version 1, 2c and 3 Traps and (v3) Inform messages can be configured with NCLU. See the chapter on SNMP management with NCLU for detailed instructions on how to configure SNMP with VRFs.



The message `Duplicate IPv4 address detected, some interfaces may not be visible in IP-MIB` displays after starting `snmpd` in the mgmt VRF. This is because the IP-MIB assumes the same IP address cannot be used twice on the same device; the IP-MIB is not VRF aware. This message is a warning that the SNMP IP-MIB detects overlapping IP addresses on the system; it does *not* indicate a problem and is non-impacting to the operation of the switch.

### ping or traceroute on the Management VRF

By default, when you issue a `ping` or `traceroute`, the packet is sent to the dataplane network (the main routing table). To use `ping` or `traceroute` on the management network, use `ping -I mgmt` or `traceroute -i mgmt`. To select a source address within the management VRF, use the `-s` flag for `traceroute`.

```
cumulus@switch:~$ ping -I <destination-ip>
```

Or:

```
cumulus@switch:~$ traceroute -s <source-ip> <destination-ip>
```

For additional information on using `ping` and `traceroute`, see the [Network Troubleshooting chapter \(see page 1003\)](#).



## Run Services as a Non-root User

Sometimes you may want to run services in the management VRF as a non-root user. To do so, you need to create a custom service based on the original service file.

1. Copy the original service file to its new name and store the file in `/etc/systemd/system`.

```
cumulus@switch:~$ sudo cp /lib/systemd/system/myservice.service  
/etc/systemd/system/myservice.service
```

2. If there is a `User` directive, comment it out. If it exists, you can find it under `[Service]`.

```
cumulus@switch:~$ sudo nano /etc/systemd/system/myservice.  
service
```

```
[Unit]  
Description=Example  
Documentation=https://www.example.io/  
  
[Service]  
#User=username  
ExecStart=/usr/local/bin/myservice agent -data-dir=/tmp  
/myservice -bind=192.168.0.11  
  
[Install]  
WantedBy=multi-user.target
```

3. Modify the `ExecStart` line to `/usr/bin/vrf exec mgmt /sbin/runuser -u USER -- COMMAND`. For example, to have the `cumulus` user run the `foocommand`:

```
[Unit]  
Description=Example  
Documentation=https://www.example.io/  
  
[Service]  
#User=username  
ExecStart=/usr/bin/vrf task exec mgmt /sbin/runuser -u cumulus  
-- foocommand  
  
[Install]  
WantedBy=multi-user.target
```

4. Save and exit the file.

```
^O  
^X  
cumulus@switch:~$
```



5. Reload the service so the changes take effect:

```
cumulus@switch:~$ sudo systemctl daemon-reload
```

## OSPF and BGP

In general, no changes are required for either BGP or OSPF. FRRouting is VRF-aware and automatically sends packets based on the switch port routing table. This includes BGP peering via loopback interfaces. BGP does routing lookups in the default table. However, depending on how your routes are redistributed, you might want to perform the following modification.

Management VRF uses the mgmt table, including local routes. It does not affect how the routes are redistributed when using routing protocols such as OSPF and BGP.

To redistribute the routes in your network, use the `redistribute connected` command under BGP or OSPF. This enables the directly-connected network out of eth0 to be advertised to its neighbor.



This also creates a route on the neighbor device to the management network through the data plane, which might not be desired.

Cumulus Networks recommends you always use route maps to control the advertised networks redistributed by the `redistribute connected` command. For example, you can specify a route map to redistribute routes in this way (for both BGP and OSPF):

```
cumulus@leaf01:~$ net add routing route-map REDISTRIBUTE-CONNECTED
deny 100 match interface eth0
cumulus@leaf01:~$ net add routing route-map REDISTRIBUTE-CONNECTED
permit 1000
```

These commands produce the following configuration snippet in the `/etc/frr/frr.conf` file:

```
<routing protocol>
redistribute connected route-map REDISTRIBUTE-CONNECTED

route-map REDISTRIBUTE-CONNECTED deny 100
match interface eth0
!
route-map REDISTRIBUTE-CONNECTED permit 1000
```

## SSH within a Management VRF Context

If you SSH to the switch through a switch port, SSH works as expected. If you need to SSH from the device out of a switch port, use `vrf exec default ssh <ip_address_of_swport>`. For example:



```
cumulus@switch:~$ sudo vrf exec default ssh 10.23.23.2 10.3.3.3
```

## View the Routing Tables

When you look at the routing table with `ip route show`, you are looking at the switch port (*main*) table. You can also see the dataplane routing table with `net show route vrf main`.

To look at information about eth0 (the management routing table), use `net show route vrf mgmt`.

```
cumulus@switch:~$ net show route vrf mgmt
default via 192.168.0.1 dev eth0

cumulus@switch:~$ net show route
default via 10.23.23.3 dev swp17 proto zebra metric 20
10.3.3.3 via 10.23.23.3 dev swp17
10.23.23.0/24 dev swp17 proto kernel scope link src 10.23.23.2
192.168.0.0/24 dev eth0 proto kernel scope link src 192.168.0.11
```

If you use `ip route get` to return information about a single route, the command resolves over the *mgmt* table by default. To obtain information about the route in the switching silicon, use:

```
cumulus@switch:~$ net show route <addr>
```

To get the route for any VRF, run the following command:

```
cumulus@switch:~$ net show route vrf mgmt <addr>
```

## mgmt Interface Class

In `ifupdown2`, [interface classes](#) (see page 222) are used to create a user-defined grouping for interfaces. The special class *mgmt* is available to separate the management interfaces of the switch from the data interfaces. This allows you to manage the data interfaces by default using `ifupdown2` commands. Performing operations on the *mgmt* interfaces requires specifying the `--allow-mgmt` option, which prevents inadvertent outages on the management interfaces. Cumulus Linux by default brings up all interfaces in both the *auto* (default) class and the *mgmt* interface class when the switch boots.



The management VRF interface class is not supported if you are configuring Cumulus Linux using [NCLU](#) (see page 88).

You configure the management interface in the `/etc/network/interfaces` file. In the example below, the management interface, eth0 and the management VRF stanzas are added to the *mgmt* interface class:

```
auto lo
iface lo inet loopback
```



```
allow-mgmt eth0
iface eth0 inet dhcp
    vrf mgmt

allow-mgmt mgmt
iface mgmt
    address 127.0.0.1/8
    vrf-table auto
```

When you run `ifupdown2` commands against the interfaces in the `mgmt` class, include `--allow=mgmt` with the commands. For example, to see which interfaces are in the `mgmt` interface class, run:

```
cumulus@switch:~$ ifquery l --allow=mgmt
eth0
mgmt
```

To reload the configurations for interfaces in the `mgmt` class, run:

```
cumulus@switch:~$ sudo ifreload --allow=mgmt
```

You can still bring the management interface up and down using `ifup eth0` and `ifdown eth0`.

## Management VRF and DNS

Cumulus Linux supports both DHCP and static DNS entries over management VRF through IP FIB rules. These rules are added to direct lookups to the DNS addresses out of the management VRF.

For DNS to use the management VRF, the static DNS entries must reference the management VRF in the `/etc/resolv.conf` file. You cannot specify the same DNS server address twice to associate it with different VRFs.

For example, to specify DNS servers and associate some of them with the management VRF, run the following commands:

```
cumulus@switch:~$ net add dns nameserver ipv4 192.0.2.1
cumulus@switch:~$ net add dns nameserver ipv4 198.51.100.31 vrf mgmt
cumulus@switch:~$ net add dns nameserver ipv4 203.0.113.13 vrf mgmt
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

These commands create the following configuration in the `/etc/resolv.conf` file:

```
cumulus@switch:~$ cat /etc/resolv.conf
nameserver 192.0.2.1
nameserver 198.51.100.31 # vrf mgmt
nameserver 203.0.113.13 # vrf mgmt
```



Nameservers configured through DHCP are updated automatically. Statically configured nameservers (configured in the `/etc/resolv.conf` file) only get updated when you run `ifreload -a`.



Because DNS lookups are forced out of the management interface using FIB rules, this might affect data plane ports if overlapping addresses are used. For example, when the DNS server IP address is learned over the management VRF, a FIB rule is created for that IP address. When DHCP relay is configured for the same IP address, a DHCP discover packet received on the front panel port is forwarded out of the management interface (`eth0`) even though a route is present out the front-panel port.



If you don't specify a DNS server and you lose in band connectivity, DNS will not work through the management VRF. Cumulus Linux does not assume all DNS servers are reachable through the management VRF.

## Incompatibility with `cl-ns-mgmt`



Management VRF has replaced the management namespace functionality in Cumulus Linux. The management namespace feature (used with the `cl-ns-mgmt` utility) has been deprecated, and the `cl-ns-mgmt` command has been removed.

## GRE Tunneling



### Early Access Feature

GRE Tunneling is an [early access feature](#).

Generic Routing Encapsulation (GRE) is a tunneling protocol that encapsulates network layer protocols inside virtual point-to-point links over an Internet Protocol network. The two endpoints are identified by the tunnel source and tunnel destination addresses at each endpoint.

GRE packets travel directly between the two endpoints through a virtual tunnel. As a packet comes across other routers, there is no interaction with its payload; the routers only parse the outer IP packet. When the packet reaches the endpoint of the GRE tunnel, the outer packet is de-encapsulated, the payload is parsed, then forwarded to its ultimate destination.

GRE uses multiple protocols over a single-protocol backbone and is less demanding than some of the alternative solutions, such as VPN. You can use GRE to transport protocols that the underlying network does not support, work around networks with limited hops, connect non-contiguous subnets, and allow VPNs across wide area networks.

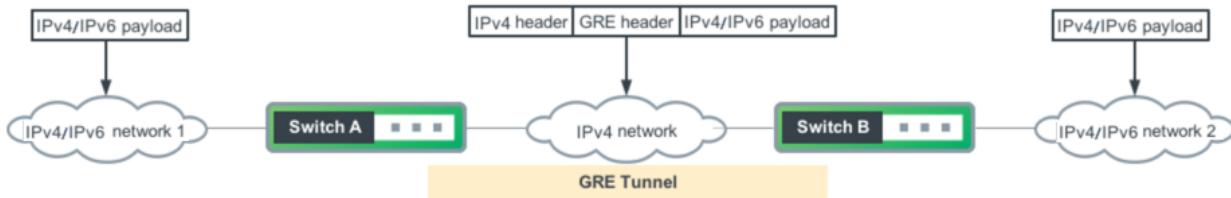


### Notes

- GRE Tunneling is supported for Mellanox (Spectrum ASIC) switches only.
- Only static routes are supported as a destination for the tunnel interface.

- IPv6 endpoints are not supported.

The following example shows two sites that use IPv4 addresses. Using GRE tunneling, the two end points can encapsulate an IPv4 or IPv6 payload inside an IPv4 packet. The packet is routed based on the destination in the outer IPv4 header.



## Contents

This topic describes ...

- [Contents \(see page 887\)](#)
- [Configure GRE Tunneling \(see page 887\)](#)
- [Verify GRE Tunnel Settings \(see page 889\)](#)
- [Delete a GRE Tunnel Interface \(see page 889\)](#)
- [Change GRE Tunnel Settings \(see page 890\)](#)

## Configure GRE Tunneling

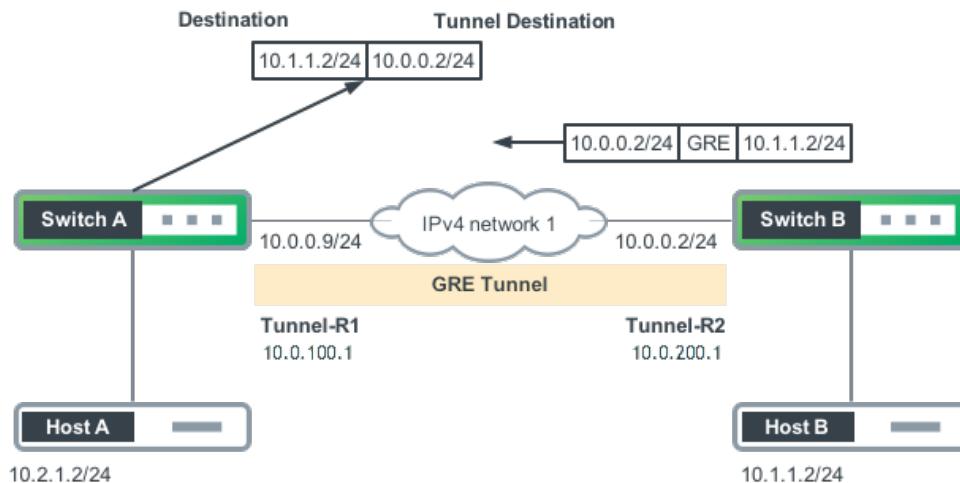
To configure GRE tunneling, you create a GRE tunnel interface with routes for tunneling on both endpoints as follows:

1. Create a tunnel interface by specifying an interface name, the tunnel mode as `gre`, the source (local) and destination (remote) underlay IP address, and the `ttl` (optional).
2. Bring the GRE tunnel interface up.
3. Assign an IP address to the tunnel interface.
4. Add route entries to encapsulate the packets using the tunnel interface.

The following configuration example shows the commands used to set up a bidirectional GRE tunnel between two endpoints: `Tunnel1-R1` and `Tunnel1-R2`.

The local tunnel endpoint for `Tunnel1-R1` is 10.0.0.9 and the remote endpoint is 10.0.0.2.

The local tunnel endpoint for `Tunnel1-R2` is 10.0.0.2 and the remote endpoint is 10.0.0.9.



### Tunnel-R1 commands:

```
cumulus@switch:~$ sudo ip tunnel add Tunnel-R2 mode gre remote
10.0.0.2 local 10.0.0.9 ttl 255
cumulus@switch:~$ sudo ip link set Tunnel-R2 up
cumulus@switch:~$ sudo ip addr add 10.0.100.1 dev Tunnel-R2
cumulus@switch:~$ sudo ip route add 10.0.100.0/24 dev Tunnel-R2
```

### Tunnel-R2 commands:

```
cumulus@switch:~$ sudo ip tunnel add Tunnel-R1 mode gre remote
10.0.0.9 local 10.0.0.2 ttl 255
cumulus@switch:~$ sudo ip link set Tunnel-R1 up
cumulus@switch:~$ sudo ip addr add 10.0.200.1 dev Tunnel-R1
cumulus@switch:~$ sudo ip route add 10.0.200.0/24 dev Tunnel-R1
```

To apply the GRE tunnel configuration automatically at reboot, instead of running the commands from the command line (as above), you can add the following commands directly in the `/etc/network/interfaces` file.

```
cumulus@switch:~$ sudo nano /etc/network/interfaces
# Tunnel-R1 configuration
auto swp1 #underlay interface for tunnel
iface swp1
    link-speed 10000
    link-duplex full
    link-autoneg off
    address 10.0.0.9/24

auto Tunnel-R2 #overlay interface for tunnel
iface Tunnel-R2 inet static
```



```
address 10.0.100.1/24
# Run pre-up command before bringing the interface up. If this
command fails, then ifup aborts, refraining from marking the
interface as configured, prints an error message, and exits with
status 0. This behavior may change in the future.
pre-up ip tunnel add Tunnel-R2 mode gre remote 10.0.0.2 local
10.0.0.9 ttl 255
# Run post-up command after bringing the interface up. If this
command fails then ifup aborts, refraining from marking the interface
as configured (even though it has really been configured), prints an
error message, and exits with status 0. This behavior may change in
the future.
post-up ip route add 10.0.100.0/24 dev Tunnel-R2
# Run post-down command after taking the interface down. If this
command fails then ifdown aborts, marks the interface as
deconfigured, and exits with status 0. This behavior may change in
the future.
post-down ip tunnel del Tunnel-R2

# Tunnel-R2 configuration
auto swp1 #underlay interface for tunnel
iface swp1
    link-speed 10000
    link-duplex full
    link-autoneg off
    address 10.0.0.2/24
auto Tunnel-R1 #overlay interface for tunnel
iface Tunnel-R1 inet static
    address 10.0.200.1/24
    pre-up ip tunnel add Tunnel-R1 mode gre local 10.0.0.2 remote
10.0.0.9 ttl 255
    post-up ip route add 10.0.200.0/24 dev Tunnel-R1
    post-down ip tunnel del Tunnel-R1
```

For more information about the `pre-up`, `post-up`, and `post-down` commands, run the `man interfaces` command.

## Verify GRE Tunnel Settings

Use the `ip tunnel show` command to check GRE tunnel settings:

```
cumulus@switch:~$ ip tunnel show
gre0: gre/ip remote any local any ttl inherit nopmtudisc
Tunnel-R1: gre/ip remote 10.0.0.2 local 10.0.0.9 ttl 255
```

## Delete a GRE Tunnel Interface

Use the `ip tunnel del` command to delete a GRE tunnel, remove the tunnel interface, and remove the routes configured with the tunnel interface. For example:

```
cumulus@switch:~$ sudo ip tunnel del Tunnel-R2 mode gre remote  
10.0.0.2 local 10.0.0.9 ttl 255
```



You can delete a GRE tunnel directly from the `/etc/network/interfaces` file instead of using the `ip tunnel del` command. Make sure you run the `ifreload -a` command after you update the interfaces file.

## Change GRE Tunnel Settings

Use the `ip tunnel change` command to make changes to the GRE tunnel settings. The following example changes the remote underlay IP address from the original setting to 11.0.0.4:

```
cumulus@switch:~$ sudo ip tunnel change Tunnel-R2 mode gre local  
10.0.0.2 remote 10.0.0.4
```



You can make changes to GRE tunnel settings directly in the `/etc/network/interfaces` file instead of using the `ip tunnel change` command. Make sure you run the `ifreload -a` command after you update the interfaces file.

## Protocol Independent Multicast - PIM

Protocol Independent Multicast (PIM) is a multicast control plane protocol that advertises multicast sources and receivers over a routed layer 3 network. Layer 3 multicast relies on PIM to advertise information about multicast capable routers, and the location of multicast senders and receivers. For this reason, multicast cannot be sent through a routed network without PIM.

PIM has two modes of operation: Sparse Mode (PIM-SM) and Dense Mode (PIM-DM).



Cumulus Linux supports only PIM Sparse Mode.

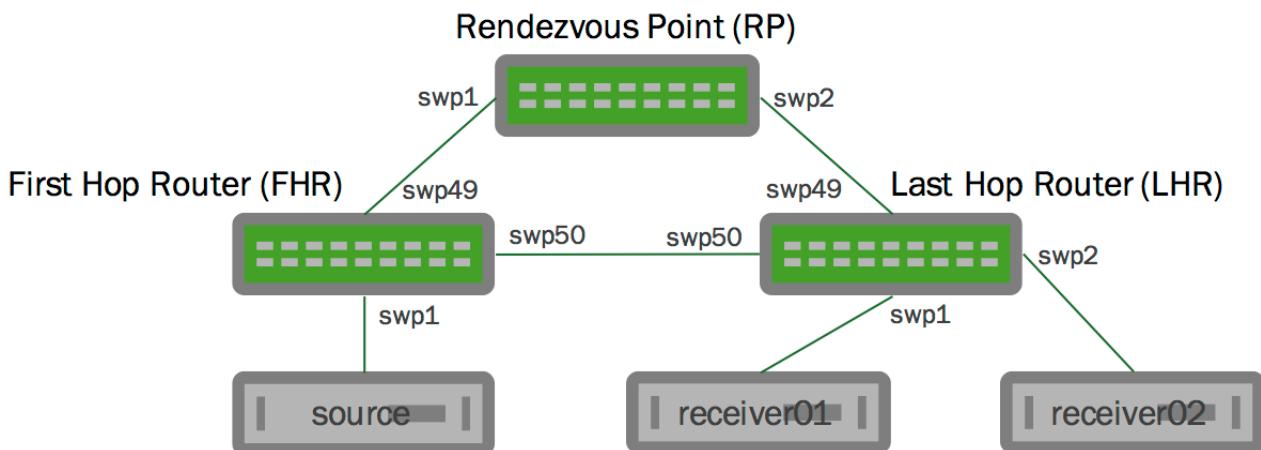
## Contents

This topic describes ...

- PIM Overview (see page 891)
  - PIM Messages (see page 893)
  - PIM Neighbors (see page 895)
- PIM Sparse Mode (PIM-SM) (see page 895)
  - Any-source Multicast Routing (see page 896)

- PIM Null-Register (see page 899)
- PIM and ECMP (see page 900)
- Configure PIM (see page 900)
  - Configure PIM Using FRRouting (see page 901)
  - Example Configurations (see page 903)
- Source Specific Multicast Mode (SSM) (see page 905)
- IP Multicast Boundaries (see page 906)
- Multicast Source Discovery Protocol (MSDP) (see page 907)
- Verify PIM (see page 908)
  - Source Starts First (see page 908)
  - Receiver Joins First (see page 911)
- PIM in a VRF (see page 912)
- BFD for PIM Neighbors (see page 915)
- Troubleshooting (see page 915)
  - FHR Stuck in Registering Process (see page 915)
  - No \*,G Is Built on LHR (see page 916)
  - No mroute Created on FHR (see page 917)
  - No S,G on RP for an Active Group (see page 918)
  - No mroute Entry Present in Hardware (see page 918)
  - Verify MSDP Session State (see page 919)
  - View the Active Sources (see page 919)
- Caveats and Errata (see page 919)

## PIM Overview



Network Element	Description
First Hop Router (FHR)	The FHR is the router attached to the source. The FHR is responsible for the PIM register process.
Last Hop Router (LHR)	The LHR is the last router in the path, attached to an interested multicast receiver. There is a single LHR for each network subnet with an interested receiver, however multicast groups can have multiple LHRs throughout the network.
Rendezvous Point (RP)	<p>The RP allows for the discovery of multicast sources and multicast receivers. The RP is responsible for sending PIM Register Stop messages to FHRs. The PIM RP address must be globally routable.</p> <div style="border: 2px solid red; padding: 10px;"> <p><span style="color: red;">!</span> Do not use a spine switch as an RP. If you are running <a href="#">BGP (see page 773)</a> on a spine switch and it is configured for allow-as in origin, BGP does not accept routes learned through other spines that do not originate on the spine itself. The RP must route to a multicast source. During a single failure scenario, this is not possible if the RP is on the spine. This also applies to Multicast Source Discovery Protocol (MSDP — <a href="#">see below (see page 890)</a>).</p> </div>
PIM Shared Tree (RP Tree) or (*, G) Tree	The Shared Tree is the multicast tree rooted at the RP. When receivers want to join a multicast group, join messages are sent along the shared tree towards the RP.
PIM Shortest Path Tree (SPT) or (S, G) Tree	The SPT is the multicast tree rooted at the multicast source for a given group. Each multicast source has a unique SPT. The SPT can match the RP Tree, but this is not a requirement. The SPT represents the most efficient way to send multicast traffic from a source to the interested receivers.
Outgoing Interface (OIF)	The outgoing interface indicates the interface on which a PIM or multicast packet is be sent out. OIFs are the interfaces towards the multicast receivers.
Incoming Interface (IIF)	The incoming interface indicates the interface on which a multicast packet is received. An IIF can be the interface towards the source or towards the RP.
Reverse Path Forwarding Interface (RPF Interface)	Reverse path forwarding interface is the path used to reach the RP or source. There must be a valid PIM neighbor to determine the RPF unless directly connected to source.



Network Element	Description
Multicast Route (mroute)	A multicast route indicates the multicast source and multicast group as well as associated OIFs, IIFs, and RPF information.
Star-G mroute (*, G)	The (*,G) mroute represents the RP Tree. The * is a wildcard indicating any multicast source. The G is the multicast group. An example (*,G) is (*, 239.1.2.9).
S-G mroute (S,G)	This is the mroute representing the source entry. The S is the multicast source IP. The G is the multicast group. An example (S,G) is (10.1.1.1, 239.1.2.9).

## PIM Messages

PIM Message	Description
PIM Hello	<p>PIM hellos announce the presence of a multicast router on a segment. PIM hellos are sent every 30 seconds by default.</p> <p><b>PIM Hello Example</b></p> <pre>22.1.2.2 &gt; 224.0.0.13: PIMv2, length 34 Hello, cksum 0xfd6b (correct) Hold Time Option (1), length 2, Value: 1m45s 0x0000: 0069 LAN Prune Delay Option (2), length 4, Value: T-bit=0, LAN delay 500ms, Override interval 2500ms 0x0000: 01f4 09c4 DR Priority Option (19), length 4, Value: 1 0x0000: 0000 0001 Generation ID Option (20), length 4, Value: 0x2459b190 0x0000: 2459 b190</pre>
PIM Join /Prune (J/P)	<p>PIM J/P messages indicate the groups that a multicast router would like to receive or no longer receive. Often PIM join/prune messages are described as distinct message types, but are actually a single PIM message with a list of groups to join and a second list of groups to leave. PIM J/P messages can be to join or prune from the SPT or RP trees (also called (*,G) joins or (S,G) joins).</p> <div style="border: 2px solid yellow; padding: 10px;"><p><b>⚠️</b> PIM join/prune messages are sent to PIM neighbors on individual interfaces. Join /prune messages are never unicast.</p></div>

PIM Message	Description
	<ul style="list-style-type: none"> <li>► Internet Protocol Version 4, Src: 10.4.1.1, Dst: 224.0.0.13</li> <li>▼ Protocol Independent Multicast           <ul style="list-style-type: none"> <li>0010 .... = Version: 2</li> <li>.... 0011 = Type: Join/Prune (3)</li> <li>Reserved byte(s): 00</li> <li>Checksum: 0x8dd9 [correct]</li> <li>▼ PIM Options               <ul style="list-style-type: none"> <li>Upstream-neighbor: 10.4.1.2</li> <li>Reserved byte(s): 00</li> <li>Num Groups: 1</li> <li>Holdtime: 210</li> <li>▼ Group 0: 239.1.1.9/32                   <ul style="list-style-type: none"> <li>▼ Num Joins: 1                       <ul style="list-style-type: none"> <li>IP address: 104.255.224.1/32 (SWR)</li> <li>Num Prunes: 0</li> </ul> </li> </ul> </li> </ul> </li> </ul> </li> </ul> <p>This PIM join/prune is for group 239.1.1.9, with 1 join and 0 prunes for the group. Join/prunes for multiple groups can exist in a single packet.</p> <div style="background-color: #f0f0f0; padding: 10px;"> <p><b>S,G Prune Example</b></p> <pre>21:49:59.470885 IP (tos 0x0, ttl 255, id 138, offset 0, flags [none], proto PIM (103), length 54)   22.1.2.2 &gt; 224.0.0.13: PIMv2, length 34     Join / Prune, cksum 0xb9e5 (correct), upstream-neighbor:   22.1.2.1     1 group(s), holdtime: 3m30s     group #1: 225.1.0.0, joined sources: 0, pruned sources: 1     pruned source #1: 33.1.1.1(S)</pre> </div>
PIM Register	PIM register messages are unicast packets sent from an FHR destined to the RP to advertise a multicast group. The FHR fully encapsulates the original multicast packet in PIM register messages. The RP is responsible for decapsulating the PIM register message and forwarding it along the (*,G) tree towards the receivers.
PIM Null Register	PIM null register is a special type of PIM register message where the <i>Null-Register</i> flag is set within the packet. Null register messages are used for an FHR to signal to an RP that a source is still sending multicast traffic. Unlike normal PIM register messages, null register messages do not encapsulate the original data packet.
PIM Register Stop	PIM register stop messages are sent by an RP to the FHR to indicate that PIM register messages must no longer be sent.
	<b>Register Stop Example</b>



PIM Message	Description
	<pre>21:37:00.419379 IP (tos 0x0, ttl 255, id 24, offset 0, flags [none], proto PIM (103), length 38) 100.1.2.1 &gt; 33.1.1.10: PIMv2, length 18 Register Stop, cksum 0xd8db (correct) group=225.1.0.0 source=33.1.1.1</pre>
IGMP Membership Report (IGMP Join)	IGMP membership reports are sent by multicast receivers to tell multicast routers of their interest in a specific multicast group. IGMP join messages trigger PIM *G joins. IGMP version 2 queries are sent to the all hosts multicast address, 224.0.0.1. IGMP version 2 reports (joins) are sent to the group's multicast address. IGMP version 3 messages are sent to an IGMP v3 specific multicast address, 224.0.0.22.
IGMP Leave	IGMP leaves tell a multicast router that a multicast receiver no longer wants the multicast group. IGMP leave messages trigger PIM *,G prunes.

## PIM Neighbors

When PIM is configured on an interface, `PIM Hello` messages are sent to the link local multicast group 224.0.0.13. Any other router configured with PIM on the segment that hears the PIM Hello messages build a PIM neighbor with the sending device.



PIM neighbors are stateless. No confirmation of neighbor relationship is exchanged between PIM endpoints.

## PIM Sparse Mode (PIM-SM)

PIM Sparse Mode (PIM-SM) is a *pull* multicast distribution method; multicast traffic is only sent through the network if receivers explicitly ask for it. When a receiver *pulls* multicast traffic, the network must be periodically notified that the receiver wants to continue the multicast stream.



This behavior is in contrast to PIM Dense Mode (PIM-DM), where traffic is flooded, and the network must be periodically notified that the receiver wants to stop receiving the multicast stream.

PIM-SM has three configuration options: Any-source Multicast (ASM), Bi-directional Multicast (BiDir), and Source Specific Multicast (SSM):

- Any-source Multicast (ASM) is the traditional, and most commonly deployed PIM implementation. ASM relies on rendezvous points to connect multicast senders and receivers that then dynamically determine the shortest path through the network between source and receiver, to efficiently send multicast traffic.
- Bidirectional PIM (BiDir) forwards all traffic through the multicast rendezvous point (RP) instead of tracking multicast source IPs, allowing for greater scale while resulting in inefficient forwarding of network traffic.

- Source Specific Multicast (SSM) requires multicast receivers to know exactly from which source they want to receive multicast traffic instead of relying on multicast rendezvous points. SSM requires the use of IGMPv3 on the multicast clients.



Cumulus Linux only supports ASM and SSM. PIM BiDir is not currently supported.

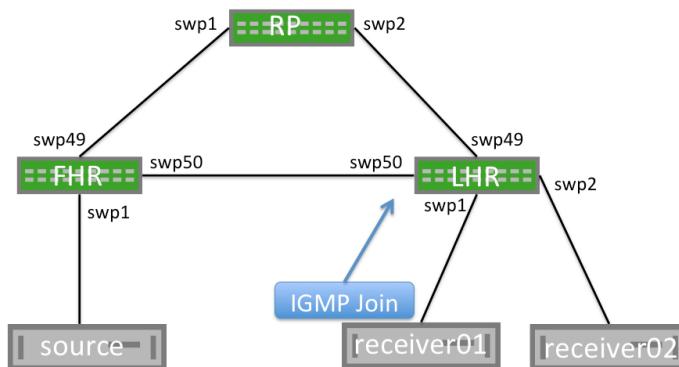
For additional information, see [RFC 7761 - Protocol Independent Multicast - Sparse Mode](#).

### *Any-source Multicast Routing*

Multicast routing behaves differently depending on whether the source is sending before receivers request the multicast stream, or if a receiver tries to join a stream before there are any sources.

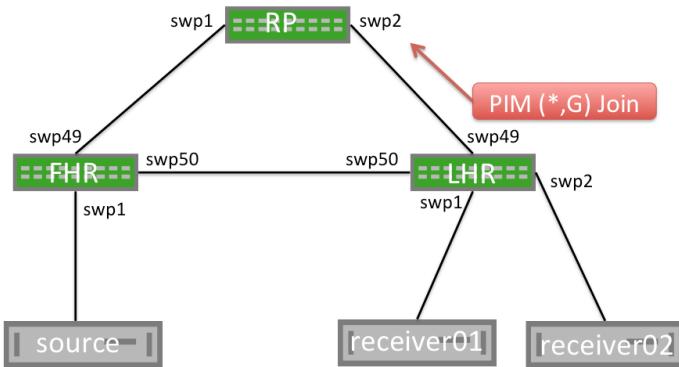
#### *Receiver Joins First*

When a receiver joins a group, an IGMP membership join message is sent to the IGMPv3 multicast group, 224.0.0.22. The PIM multicast router for the segment that is listening to the IGMPv3 group receives the IGMP membership join message and becomes an LHR for this group.



This creates a  $(*,G)$  mroute with an OIF of the interface on which the IGMP Membership Report is received and an IIF of the RPF interface for the RP.

The LHR generates a PIM  $(*,G)$  join message and sends it from the interface towards the RP. Each multicast router between the LHR and the RP builds a  $(*,G)$  mroute with the OIF being the interface on which the PIM join message is received and an Incoming Interface of the reverse path forwarding interface for the RP.



When the RP receives the  $(*,G)$  Join message, it does not send any additional PIM join messages. The RP will maintain a  $(*,G)$  state as long as the receiver wishes to receive the multicast group.



Unlike multicast receivers, multicast sources do not send IGMP (or PIM) messages to the FHR. A multicast source begins sending, and the FHR receives the traffic and builds both a  $(*,G)$  and an  $(S,G)$  mroute. The FHR then begins the PIM register process.

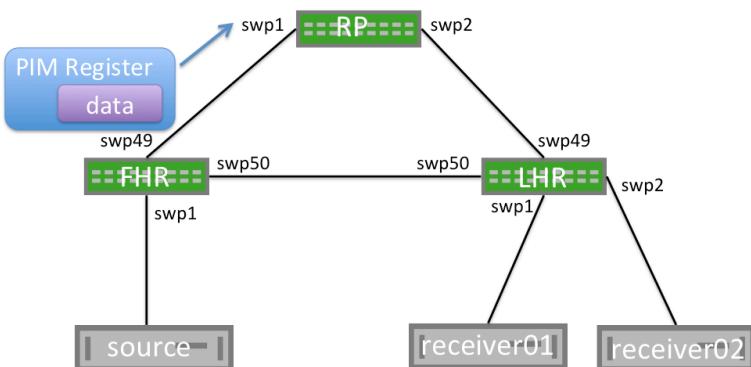
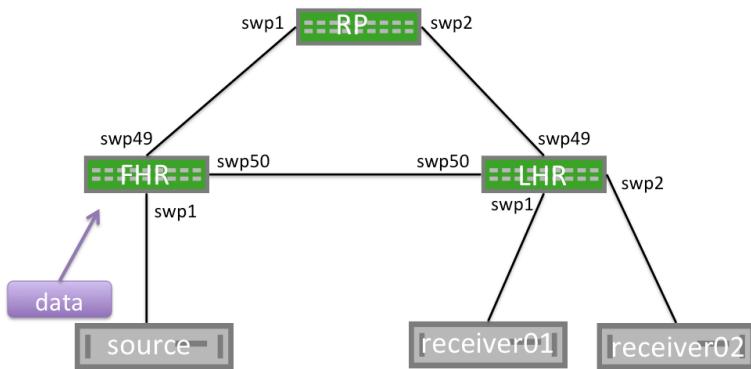
### PIM Register Process

When a first hop router (FHR) receives a multicast data packet from a source, the FHR does not know if there are any interested multicast receivers in the network. The FHR encapsulates the data packet in a unicast PIM register message. This packet is sourced from the FHR and destined to the RP address. The RP builds an  $(S,G)$  mroute, decapsulates the multicast packet, and forwards it along the  $(*,G)$  tree.

As the unencapsulated multicast packet travels down the  $(*,G)$  tree towards the interested receivers, at the same time, the RP sends a PIM  $(S,G)$  join towards the FHR. This builds an  $(S,G)$  state on each multicast router between the RP and FHR.

When the FHR receives a PIM  $(S,G)$  join, it continues encapsulating and sending PIM register messages, but also makes a copy of the packet and sends it along the  $(S,G)$  mroute.

The RP then receives the multicast packet along the  $(S,G)$  tree and sends a PIM register stop to the FHR to end the register process.



## PIM SPT Switchover

When the LHR receives the first multicast packet, it sends a PIM (S,G) join towards the FHR to efficiently forward traffic through the network. This builds the shortest path tree (SPT), or the tree that is the shortest path to the source.

When the traffic arrives over the SPT, a PIM (S,G) RPT prune is sent up the shared tree towards the RP. This removes multicast traffic from the shared tree; multicast data is only sent over the SPT.

SPT switchover can be configured on a per-group basis, allowing for some groups to never switch to a shortest path tree; this is also called *SPT infinity*.

The LHR now sends both (\*,G) joins and (S,G) RPT prune messages towards the RP.

To configure a group to never follow the SPT, complete the following steps:

1. Create the necessary prefix-lists using the FRouting CLI:



```
cumulus@switch:~$ sudo vtysh
switch# configure terminal
switch(config)# ip prefix-list spt-range permit 235.0.0.0/8 ge 32
switch(config)# ip prefix-list spt-range permit 238.0.0.0/8 ge 32
```

2. Configure SPT switchover for the *spt-range* prefix-list:

```
switch(config)# ip pim spt-swtchover infinity prefix-list spt-
range
```

You can view the configured prefix-list with the `net show mroute` command:

```
cumulus@switch:~$ net show mroute
Source          Group        Proto  Input    Output   TTL
Uptime
*              235.0.0.0    IGMP   swp3ls0  pimreg   1      00:
03:3
                    IGMP           br1     1      00:
03:38
*              238.0.0.0    IGMP   swp3ls0  br1      1      00:
02:08
```

In the example above, 235.0.0.0 is configured for SPT switchover, identified by *pimreg*.

### *Sender Starts Before Receivers Join*

A multicast sender can send multicast data without any additional IGMP or PIM signaling. When the FHR receives the multicast traffic, it encapsulates it and sends a PIM register to the rendezvous point (RP).

When the RP receives the PIM register, it builds an (S,G) mroute; however, there is no (\*,G) mroute and no interested receivers.

The RP drops the PIM register message and immediately sends a PIM register stop message to the FHR.

Receiving a PIM register stop without any associated PIM joins leaves the FHR without any outgoing interfaces. The FHR drops this multicast traffic until a PIM join is received.



PIM register messages are sourced from the interface that receives the multicast traffic and are destined to the RP address. The PIM register is not sourced from the interface towards the RP.

### *PIM Null-Register*

To notify the RP that multicast traffic is still flowing when the RP has no receiver, or if the RP is not on the SPT tree, the FHR periodically sends PIM null register messages. The FHR sends a PIM register with the Null-Register flag set, but without any data. This special PIM register notifies the RP that a multicast source is still sending, in case any new receivers come online.

After receiving a PIM Null-Register, the RP immediately sends a PIM register stop to acknowledge the reception of the PIM null register message.

## PIM and ECMP

PIM uses the RPF procedure to choose an upstream interface to build a forwarding state. If equal-cost multipaths (ECMP) are configured, PIM can use choose the RPF based on ECMP using hash algorithms.

The FRR `ip pim ecmp` command enables PIM to use all the available nexthops for the installation of mroutes. For example, if you have four-way ECMP, PIM spreads the S,G and \*,G mroutes across the four different paths.

```
cumulus@switch:~$ sudo vtysh
switch# configure terminal
switch(config)# ip pim ecmp
```

The `ip pim ecmp rebalance` command recalculates all stream paths in the event of a loss of path over one of the ECMP paths. Without this command, only the streams that are using the path that is lost are moved to alternate ECMP paths. Rebalance does not affect existing groups.

```
cumulus@switch:~$ sudo vtysh
switch# configure terminal
switch(config)# ip pim ecmp rebalance
```

 The rebalance command can cause some packet loss.

The `show ip pim nexthop` provides you with a way to review which nexthop is selected for a specific source/group:

```
cumulus@switch:~$ sudo vtysh
switch# show ip pim nexthop
Number of registered addresses: 3
Address           Interface      Nexthop
-----
6.0.0.9           swp31s0       169.254.0.9
6.0.0.9           swp31s1       169.254.0.25
6.0.0.11          lo            0.0.0.0
6.0.0.10          swp31s0       169.254.0.9
6.0.0.10          swp31s1       169.254.0.25
```

## Configure PIM

To configure PIM using NCLU:

1. Configure the PIM interface:

```
cumulus@switch:~$ net add interface swp1 pim sm
```



PIM must be enabled on all interfaces facing multicast sources or multicast receivers, as well as on the interface where the RP address is configured.

2. **Optional:** Run the following command to enable IGMP (either version 2 or 3) on the interfaces with hosts attached. IGMP version 3 is the default, so you only need to specify the version if you want to use IGMP version 2:

```
cumulus@switch:~$ net add interface swp1 igmp version 2
```



You must configure IGMP on all interfaces where multicast receivers exist.

3. Configure a group mapping for a static RP:

```
cumulus@switch:~$ net add pim rp 192.168.0.1
```



Unless you are using PIM SSM, each PIM-SM enabled device must configure a static RP to a group mapping, and all PIM-SM enabled devices must have the same RP to group mapping configuration.

IP PIM RP group ranges can overlap. Cumulus Linux performs a longest prefix match (LPM) to determine the RP. For example:

```
cumulus@switch:~$ net add pim rp 192.168.0.1 224.10.0.0/16
cumulus@switch:~$ net add pim rp 192.168.0.2 224.10.2.0/24
```

In this example, if the group is in 224.10.2.5, the RP that gets selected is 192.168.0.2. If the group is 224.10.15, the RP that gets selected is 192.168.0.1.

4. Review and commit your changes:

```
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

## Configure PIM Using FRRouting

PIM is included in the FRRouting package. For proper PIM operation, PIM depends on Zebra. PIM relies on unicast routing to be configured and operational to do RPF operations. Therefore, you must configure some other routing protocol or static routes.

To configure PIM on a switch using FRR:



1. Open the `/etc/frr/daemons` file in a text editor.
2. Add the following line to the end of the file to enable `pimd`, then save the file:

```
zebra=yes  
pimd=yes
```

3. Run the `sudo systemctl restart frr` command to restart FRRouting:

```
cumulus@switch:~$ sudo systemctl restart frr
```

4. In a terminal, run the `vtysh` command to start the FRRouting CLI on the switch.

```
cumulus@switch:~$ sudo vtysh  
cumulus#
```

5. Run the following commands to configure the PIM interfaces:

```
cumulus# configure terminal  
cumulus(config)# int swp1  
cumulus(config-if)# ip pim sm
```



PIM must be enabled on all interfaces facing multicast sources or multicast receivers, as well as on the interface where the RP address is configured.

6. **Optional:** Run the following commands to enable IGMP (either version 2 or 3) on the interfaces with hosts attached. IGMP version 3 is the default; you only need to specify the version if you want to use IGMP version 2:

```
cumulus# configure terminal  
cumulus(config)# int swp1  
cumulus(config-if)# ip igmp  
cumulus(config-if)# ip igmp version 2 #skip this step if you are  
using version 3
```



You must configure IGMP on all interfaces where multicast receivers exist.

7. Configure a group mapping for a static RP:

```
cumulus# configure terminal
```



```
cumulus(config)# ip pim rp 192.168.0.1
```



Each PIM-SM enabled device must configure a static RP to a group mapping, and all PIM-SM enabled devices must have the same RP to group mapping configuration.

IP PIM RP group ranges can overlap. Cumulus Linux performs a longest prefix match (LPM) to determine the RP. For example:

```
cumulus(config)# ip pim rp 10.0.0.13 224.10.0.0/16
```

## Example Configurations

### Complete Multicast Network Configuration Example

The following is example configuration:

#### RP Configuration

```
RP# show run
Building configuration...
Current configuration:
!
log syslog
ip multicast-routing
ip pim rp 192.168.0.1 224.0.0.0/4
username cumulus nopassword
!
!
interface lo
description RP Address interface
ip ospf area 0.0.0.0
ip pim sm
!
interface swp1
description interface to FHR
ip ospf area 0.0.0.0
ip ospf network point-to-point
ip pim sm
!
interface swp2
description interface to LHR
ip ospf area 0.0.0.0
ip ospf network point-to-point
ip pim sm
!
router ospf
ospf router-id 192.168.0.1
```



```
!
line vty
!
end
```

### FHR Configuration

```
FHR# show run
!
log syslog
ip multicast-routing
ip pim rp 192.168.0.1 224.0.0.0/4
username cumulus nopassword
!
interface bridge10.1
description Interface to multicast source
ip ospf area 0.0.0.0
ip ospf network point-to-point
ip pim sm
!
interface lo
ip ospf area 0.0.0.0
ip pim sm
!
interface swp49
description interface to RP
ip ospf area 0.0.0.0
ip ospf network point-to-point
ip pim sm
!
interface swp50
description interface to LHR
ip ospf area 0.0.0.0
ip ospf network point-to-point
ip pim sm
!
router ospf
ospf router-id 192.168.1.1
!
line vty
!
end
```

### LHR Configuration

```
LHR# show run
!
log syslog
```

```
ip multicast-routing
ip pim rp 192.168.0.1 224.0.0.0/4
username cumulus nopassword
!
interface bridge0.1
description interface to multicast receivers
ip igmp
ip ospf area 0.0.0.0
ip ospf network point-to-point
ip pim sm
!
interface lo
ip ospf area 0.0.0.0
ip pim sm
!
interface swp49
description interface to RP
ip ospf area 0.0.0.0
ip ospf network point-to-point
ip pim sm
!
interface swp50
description interface to FHR
ip ospf area 0.0.0.0
ip ospf network point-to-point
ip pim sm
!
router ospf
ospf router-id 192.168.2.2
!
line vty
!
end
```

## Source Specific Multicast Mode (SSM)

The source-specific multicast method uses prefix-lists to configure a receiver to only allow traffic to a multicast address from a single source. This removes the need for an RP, as the source must be known before traffic can be accepted. The default range is 232.0.0.0/8, and must be further configured by setting a prefix-list.

The example process below configures a prefix-list named `ssm-range`, and prefix-lists permitting traffic from 230.0.0.0/8 and 238.0.0.0/8, for prefixes longer than 32.



PIM considers 232.0.0.0/8 the default range if the ssm range is not configured. If this default is overridden with a prefix-list, **all** ranges that should be considered must be in the prefix-list

```
cumulus@switch:~$ net add pim prefix-list ipv4 ssm range permit
232.0.0.0/8 ge 32
cumulus@switch:~$ net add pim prefix-list ipv4 ssm range permit
238.0.0.0/8 ge 32
cumulus@switch:~$ net add pim prefix-list ipv4 ssm range permit
cumulus@switch:~$ net add pim ssm prefix-list ssm-range
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

You can also perform this configuration with the FRRouting CLI:

```
cumulus@switch:~$ sudo vtysh
switch# conf t
switch(config)# ip prefix-list ssm-range seq 5 permit 232.0.0.0/8 ge
32
switch(config)# ip prefix-list ssm-range seq 10 permit 238.0.0.0/8 ge
32
switch(config)# ip pim ssm prefix-list ssm-range
switch(config)# exit
switch# write mem
```

To view the existing prefix-lists, run the `net show ip` command:

```
cumulus@switch:~$ net show ip prefix-list ssm-range
ZEBRA: ip prefix-list ssm-range: 2 entries
      seq 5 permit 232.0.0.0/8 ge 32
      seq 10 permit 238.0.0.0/8 ge 32
OSPF: ip prefix-list ssm-range: 2 entries
      seq 5 permit 232.0.0.0/8 ge 32
      seq 10 permit 238.0.0.0/8 ge 32
PIM: ip prefix-list ssm-range: 2 entries
      seq 5 permit 232.0.0.0/8 ge 32
      seq 10 permit 238.0.0.0/8 ge 32
```

## IP Multicast Boundaries

Multicast boundaries enable you to limit the distribution of multicast traffic by setting boundaries with the goal of pushing multicast to a subset of the network.

With such boundaries in place, any incoming IGMP or PIM joins are dropped or accepted based upon the prefix-list specified. The boundary is implemented by applying an IP multicast boundary OIL (outgoing interface list) on an interface.

To configure the boundary, use NCLU:

1. Create a prefix-list as above.
2. Configure the IP multicast boundary:



```
cumulus@switch:~$ net add <interface> multicast boundary oil  
<prefix-list>  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

## Multicast Source Discovery Protocol (MSDP)

You can use the Multicast Source Discovery Protocol (MSDP) to connect multiple PIM-SM multicast domains together, using the PIM-SM RPs. By configuring any cast RPs with the same IP address on multiple multicast switches (primarily on the loopback interface), the PIM-SM limitation of only one RP per multicast group is relaxed. This allows for an increase in both failover and load-balancing throughout.

When an RP discovers a new source (typically a PIM-SM register message), a source-active (SA) message is sent to each MSDP peer. The peer then determines if any receivers are interested.



Cumulus Linux MSDP support is primarily for anycast-RP configuration, rather than multiple multicast domains. You must configure each MSDP peer in a full mesh, as SA messages are not received and re-forwarded.



Cumulus Linux currently only supports one MSDP mesh-group.

The following steps demonstrate how to configure a Cumulus switch to use the MSDP:

1. Add an anycast IP address to the loopback interface for each RP in the domain:

```
cumulus@rp01:~$ net add loopback lo ip address 10.1.1.1/32  
cumulus@rp01:~$ net add loopback lo ip address 10.1.1.100/32
```

2. On every multicast switch, configure the group to RP mapping using the anycast address:

```
cumulus@switch:$ net add pim rp 100.1.1.100 224.0.0.0/4  
cumulus@switch:$ net pending  
cumulus@switch:$ net commit
```

3. Configure the MSDP mesh group for all active RPs (the following example uses 3 RPs):

The mesh group must include all RPs in the domain as members, with a unique address as the source. This configuration results in MSDP peerings between all RPs.

```
cumulus@rp01:$ net add msdp mesh-group cumulus member 100.1.1.2  
cumulus@rp01:$ net add msdp mesh-group cumulus member 100.1.1.3
```



```
cumulus@rp02:$ net add msdp mesh-group cumulus member 100.1.1.1  
cumulus@rp02:$ net add msdp mesh-group cumulus member 100.1.1.3
```

```
cumulus@rp03:$ net add msdp mesh-group cumulus member 100.1.1.1  
cumulus@rp03:$ net add msdp mesh-group cumulus member 100.1.1.2
```

4. Pick the local loopback address as the source of the MSDP control packets:

```
cumulus@rp01:$ net add msdp mesh-group cumulus source 100.1.1.1
```

```
cumulus@rp02:$ net add msdp mesh-group cumulus source 100.1.1.2
```

```
cumulus@rp03:$ net add msdp mesh-group cumulus source 100.1.1.3
```

5. Inject the anycast IP address into the IGP of the domain.



If the network is unnumbered and uses unnumbered BGP as the IGP, avoid using the anycast IP address for establishing unicast or multicast peerings. For PIM-SM, ensure that the unique address is used as the PIM hello source by setting the source:

```
cumulus@rp01:$ net add loopback lo pim use-source 100.1.1.1
```

## Verify PIM



The following outputs are based on the [Cumulus Reference Topology](#) with cldemo-pim.

### Source Starts First

On the FHR, an mroute is built, but the upstream state is *Prune*. The FHR flag is set on the interface receiving multicast.

Use the `net show mroute` command (or `show ip mroute` in FRR) to review detailed output for the FHR:

```
cumulus@fhr:~$ net show mroute
```



```
Source          Group          Proto  Input       Output      TTL
Uptime
172.16.5.105   239.1.1.1    none   br0        none       0        --:
--:--
!
cumulus@fhr:~$ net show pim upstream
Iif Source Group State Uptime JoinTimer RSTimer KATimer RefCnt
br0 172.16.5.105 239.1.1.1 Prune 00:07:40 --:---:--- 00:00:36 00:02:50 1
!
cumulus@fhr:~$ net show pim upstream-join-desired
Interface Source          Group          LostAssert Joins PimInclude
JoinDesired EvalJD
!
cumulus@fhr:~$ net show pim interface
Interface  State          Address     PIM Nbrs      PIM DR  FHR
br0        up            172.16.5.1  0           local   1
swp51      up            10.1.0.17  1           local   0
swp52      up            10.1.0.19  0           local   0
!
cumulus@fhr:~$ net show pim state
Source          Group          IIF      OIL
172.16.5.105   239.1.1.1    br0
!
cumulus@fhr:~$ net show pim interface detail
Interface : br0
State     : up
Address   : 172.16.5.1
Designated Router
-----
Address   : 172.16.5.1
Priority  : 1
Uptime    : --:---:---
Elections : 2
Changes   : 0

FHR - First Hop Router
-----
239.1.1.1 : 172.16.5.105 is a source, uptime is 00:27:43
```

On the RP, no mroute state is created, but the `net show pim upstream` output includes the S,G:

```
cumulus@rp01:~$ net show mroute
Source          Group          Proto  Input       Output      TTL
Uptime
!
cumulus@rp01:~$ net show pim upstream
Iif      Source          Group          State      Uptime
JoinTimer RSTimer      KATimer      RefCnt
swp30    172.16.5.105   239.1.1.1   Prune     00:00:19  --:---:--- 00:02:46 1
```

As a receiver joins the group, the mroute output interface on the FHR transitions from *none* to the RPF interface of the RP:

```
cumulus@fhr:~$ net show mroute
Source          Group          Proto  Input       Output      TTL
Uptime
172.16.5.105   239.1.1.1     PIM    br0        swp51      1  00:
05:40
!
cumulus@fhr:~$ net show pim upstream
Iif      Source          Group          State       Uptime
JoinTimer RSTimer      KATimer      RefCnt
br0      172.16.5.105   239.1.1.1   Prune      00:48:23 --:--
-- 00:00:00 00:00:37      2
!
cumulus@fhr:~$ net show pim upstream-join-desired
Interface Source          Group          LostAssert Joins PimInclude
JoinDesired EvalJD
swp51    172.16.5.105   239.1.1.1   no         yes    no
yes      yes
!
cumulus@fhr:~$ net show pim state
Source          Group          IIF      OIL
172.16.5.105   239.1.1.1     br0      swp51
```

```
cumulus@rp01:~$ net show mroute
Source          Group          Proto  Input       Output      TTL
Uptime
*            239.1.1.1     PIM    lo        swp1      1  00:
09:59
172.16.5.105   239.1.1.1     PIM    swp30     swp1      1  00:
09:59
!
cumulus@rp01:~$ net show pim upstream
Iif      Source          Group          State       Uptime
JoinTimer RSTimer      KATimer      RefCnt
lo      *            239.1.1.1   Joined      00:10:01 00:00:
59  --:---:--  --:---:--      1
swp30    172.16.5.105   239.1.1.1   Joined      00:00:01 00:00:
59  --:---:--  00:02:35      1
!
cumulus@rp01:~$ net show pim upstream-join-desired
Interface Source          Group          LostAssert Joins PimInclude
JoinDesired EvalJD
swp1    *            239.1.1.1   no         yes    no
yes      yes
!
cumulus@rp01:~$ net show pim state
```



Source	Group	IIF	OIL
*	239.1.1.1	lo	swp1
172.16.5.105	239.1.1.1	swp30	swp1

### Receiver Joins First

On the LHR attached to the receiver:

```
cumulus@lhr:~$ net show mroute
Source          Group          Proto  Input     Output    TTL
Uptime
*              239.2.2.2      IGMP   swp51    br0       1      00:
01:19
!
cumulus@lhr:~$ net show pim local-membership
Interface Address      Source          Group          Membership
br0      172.16.1.1      *              239.2.2.2      INCLUDE
!
cumulus@lhr:~$ net show pim state
Source          Group          IIF    OIL
*              239.2.2.2      swp51  br0
!
cumulus@lhr:~$ net show pim upstream
Iif      Source          Group          State        Uptime
JoinTimer RSTimer      KATimer      RefCnt
swp51      *              239.2.2.2      Joined      00:02:07 00:00:
53  --::--  --::--      1
!
cumulus@lhr:~$ net show pim upstream-join-desired
Interface Source          Group          LostAssert  Joins  PimInclude
JoinDesired EvalJD
br0      *              239.2.2.2      no          no     yes
yes      yes
!
cumulus@lhr:~$ net show igmp groups
Interface Address          Group          Mode Timer    Srcs V Uptime
br0      172.16.1.1          239.2.2.2      EXCL 00:04:02  1 3 00:04:
12
!
cumulus@lhr:~$ net show igmp sources
Interface Address          Group          Source        Timer Fwd
Uptime
br0      172.16.1.1          239.2.2.2      *           03:54   Y
00:04:21
```

On the RP:

```
cumulus@rp01:~$ net show mroute
```

```

Source          Group          Proto  Input   Output   TTL
Uptime
*              239.2.2.2      PIM    lo      swp1     1      00:
00:03
!
cumulus@rp01:~$ net show pim state
Source          Group          IIF    OIL
*              239.2.2.2      lo      swp1
!
cumulus@rp01:~$ net show pim upstream
Iif      Source          Group          State   Uptime
JoinTimer RSTimer      KATimer      RefCnt
lo       *              239.2.2.2      Joined  00:05:17 00:00:
43   ---:---  ---:---      1
!
cumulus@rp01:~$ net show pim upstream-join-desired
Interface Source          Group          LostAssert Joins PimInclude
JoinDesired EvalJD
swp1      *              239.2.2.2      no        yes    no
yes        yes

```

## PIM in a VRF

VRFs (see page 847) divide the routing table on a per-tenant basis, ultimately providing for separate layer 3 networks over a single layer 3 infrastructure. With a VRF, each tenant has its own virtualized layer 3 network, so IP addresses can overlap between tenants.

PIM in a VRF enables PIM trees and multicast data traffic to run inside a layer 3 virtualized network, with a separate tree per domain or tenant. Each VRF has its own multicast tree with its own RP(s), sources, and so on. Therefore, you can have one tenant per corporate division, client, or product; for example.

VRFs on different switches typically connect or are peered over subinterfaces, where each subinterface is in its own VRF, provided MP-BGP VPN is not enabled or supported.

To configure PIM in a VRF, run the following commands. First, add the VRFs and associate them with switch ports:

```

cumulus@rp01:~$ net add vrf blue
cumulus@rp01:~$ net add vrf purple
cumulus@rp01:~$ net add interface swp1 vrf blue
cumulus@rp01:~$ net add interface swp2 vrf purple

```

Then add the PIM configuration to FRR, review and commit the changes:

```

cumulus@fhr:~$ net add interface swp1 pim sm
cumulus@fhr:~$ net add interface swp2 pim sm
cumulus@fhr:~$ net add bgp vrf blue auto 65001
cumulus@fhr:~$ net add bgp vrf purple auto 65000
cumulus@fhr:~$ net add bgp vrf blue router-id 10.1.1.1
cumulus@fhr:~$ net add bgp vrf purple router-id 10.1.1.2

```



```
cumulus@fhr:~$ net add bgp vrf blue neighbor swp1 interface remote-as
external
cumulus@fhr:~$ net add bgp vrf purple neighbor swp2 interface remote-
as external
cumulus@fhr:~$ net pending
cumulus@fhr:~$ net commit
```

These commands create the following configuration in the /etc/network/interfaces file and the /etc/frr/frr.conf file:

```
auto purple
iface purple
    vrf-table auto

auto blue
iface blue
    vrf-table auto

auto swp1
iface swp1
    vrf purple

auto swp49.1
iface swp49.1
    vrf purple

auto swp2
iface swp2
    vrf blue

auto swp49.2
iface swp49.2
    vrf blue

...
```

```
ip pim rp 192.168.0.1 224.0.0.0/4

vrf purple
    ip pim rp 192.168.0.1 224.0.0.0/4
!
vrf blue
    ip pim rp 192.168.0.1 224.0.0.0/4
!

int swp1 vrf purple
    ip pim sm
    ip igmp version 2
```



```
int swp2 vrf blue
    ip pim sm
    ip igmp version 3

int swp49.1 vrf purple
    ip pim sm

int swp49.2
    ip pim sm

router bgp 65000 vrf purple
    Bgp router-id 10.1.1.1
    Neighbor PURPLE peer-group
    Neighbor PURPLE remote-as external
    neighbor swp49.1 interface peer-group PURPLE

router bgp 65001 vrf blue
    bgp router-id 10.1.1.2
    neighbor BLUE peer-group
    neighbor BLUE remote-as external
    neighbor swp49.2 interface peer-group BLUE
```

In FRR, you can use show commands to display VRF information:

```
cumulus@fhr:~$ net show mroute vrf blue
Source          Group          Proto  Input     Output    TTL
Uptime
11.1.0.1        239.1.1.1    IGMP   swp32s0  swp32s1  1      00:
01:13
                                IGMP   br0.200  1      00:
01:13
*               239.1.1.2    IGMP   mars    pimreg1001 1      00:
01:13
                                IGMP   swp32s1  1      00:
01:12
                                IGMP   br0.200  1      00:
01:13
```

```
cumulus@fhr:~$ net show mroute
Source          Group          Proto  Input     Output    TTL
Uptime
11.1.0.1        239.1.1.1    IGMP   swp31s0  swp31s1  1      00:
01:15
                                IGMP   br0.100  1      00:
01:15
*               239.1.1.2    IGMP   lo      pimreg   1      00:
01:15
```

01:14	IGMP	swp31s1	1	00:
01:15	IGMP	br0.100	1	00:

## BFD for PIM Neighbors

You can use [bidirectional forward detection \(see page 821\)](#) (BFD) for PIM neighbors to quickly detect link failures. When you configure an interface, include the `pim bfd` option:

```
cumulus@switch:~$ net add interface swp31s3 pim bfd
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

## Troubleshooting

### FHR Stuck in Registering Process

When a multicast source starts, the FHR sends unicast PIM register messages from the RPF interface towards the source. After the PIM register is received by the RP, a `PIM register stop` message is sent from the RP to the FHR to end the register process. If an issue occurs with this communication, the FHR becomes stuck in the registering process, which can result in high CPU, as PIM register packets are generated by the FHR CPU and sent to the RP CPU.

To assess this issue:

- Review the FHR. The output interface of `pimreg` can be seen here. If this does not change to an interface within a few seconds, the FHR is likely stuck.

```
cumulus@fhr:~$ net show mroute
Source          Group          Proto  Input    Output
TTL   Uptime
172.16.5.105   239.2.2.3      PIM    br0      pimreg
1    00:03:59
```

To troubleshoot the issue:

- Validate that the FHR can reach the RP. If the RP and FHR can not communicate, the registration process fails:

```
cumulus@fhr:~$ ping 10.0.0.21 -I br0
PING 10.0.0.21 (10.0.0.21) from 172.16.5.1 br0: 56(84) bytes of
data.
^C
--- 10.0.0.21 ping statistics ---
4 packets transmitted, 0 received, 100% packet loss, time 3000ms
```



2. On the RP, use `tcpdump` to see if the PIM register packets are arriving:

```
cumulus@rp01:~$ sudo tcpdump -i swp30
tcpdump: verbose output suppressed, use -v or -vv for full
protocol decode
listening on swp30, link-type EN10MB (Ethernet), capture size
262144 bytes
23:33:17.524982 IP 172.16.5.1 > 10.0.0.21: PIMv2, Register,
length 66
```

3. If PIM registration packets are being received, verify that they are seen by PIM by issuing `debug pim packets` from within FRRouting:

```
cumulus@fhr:~$ sudo vtysh -c "debug pim packets"
PIM Packet debugging is on

cumulus@rp01:~$ sudo tail /var/log/frr/frr.log
2016/10/19 23:46:51 PIM: Recv PIM REGISTER packet from
172.16.5.1 to 10.0.0.21 on swp30: ttl=255 pim_version=2
pim_msg_size=64 checksum=a681
```

4. Repeat the process on the FHR to see if PIM register stop messages are being received on the FHR and passed to the PIM process:

```
cumulus@fhr:~$ sudo tcpdump -i swp51
23:58:59.841625 IP 172.16.5.1 > 10.0.0.21: PIMv2, Register,
length 28
23:58:59.842466 IP 10.0.0.21 > 172.16.5.1: PIMv2, Register Stop,
length 18

cumulus@fhr:~$ sudo vtysh -c "debug pim packets"
PIM Packet debugging is on

cumulus@fhr:~$ sudo tail -f /var/log/frr/frr.log
2016/10/19 23:59:38 PIM: Recv PIM REGSTOP packet from 10.0.0.21
to 172.16.5.1 on swp51: ttl=255 pim_version=2 pim_msg_size=18
checksum=5a39
```

### No \*,G Is Built on LHR

The most common reason for a \*,G to not be built on an LHR is for if both PIM **and** IGMP are not enabled on an interface facing a receiver.

```
lhr# show run
!
interface br0
```



```
ip igmp
ip ospf area 0.0.0.0
ip pim sm
```

To troubleshoot this issue, if both PIM and IGMP are enabled, ensure that IGMPv3 joins are being sent by the receiver:

```
cumulus@lhr:~$ sudo tcpdump -i br0 igmp
tcpdump: verbose output suppressed, use -v or -vv for full protocol
decode
listening on br0, link-type EN10MB (Ethernet), capture size 262144
bytes
00:03:55.789744 IP 172.16.1.101 > igmp.mcast.net: igmp v3 report, 1
group record(s)
```

### No mroute Created on FHR

To troubleshoot this issue:

1. Verify that multicast traffic is being received:

```
cumulus@fhr:~$ sudo tcpdump -i br0
tcpdump: verbose output suppressed, use -v or -vv for full
protocol decode
listening on br0, link-type EN10MB (Ethernet), capture size
262144 bytes
00:11:52.944745 IP 172.16.5.105.51570 > 239.2.2.9.1000: UDP,
length 9
```

2. Verify that PIM is configured on the interface facing the source:

```
fhr# show run
!
interface br0
  ip ospf area 0.0.0.0
  ip pim sm
```

3. If PIM is configured, verify that the RPF interface for the source matches the interface on which the multicast traffic is received:

```
fhr# show ip rpf 172.16.5.105
Routing entry for 172.16.5.0/24 using Multicast RIB
  Known via "connected", distance 0, metric 0, best
    * directly connected, br0
```

4. Verify that an RP is configured for the multicast group:



```
fhr# show ip pim rp-info
RP address          group/prefix-list      OIF           I am RP
  10.0.0.21          224.0.0.0/4            swp51         no
```

### No S,G on RP for an Active Group

An RP does not build an mroute when there are no active receivers for a multicast group, even though the mroute was created on the FHR:

```
cumulus@rp01:~$ net show mroute
Source          Group          Proto  Input        Output       TTL
Uptime
spine01#
```

```
cumulus@rp01:~$ net show mroute
Source          Group          Proto  Input        Output       TTL
Uptime
172.16.5.105   239.2.2.9    none   br0         none        0      --:
--:--
```

This is expected behavior. You can see the active source on the RP with the `show ip pim upstream` command:

```
cumulus@rp01:~$ net show pim upstream
Iif      Source          Group          State        Uptime
JoinTimer RSTimer      KATimer      RefCnt
swp30    172.16.5.105   239.2.2.9    Prune       00:08:03 --:--
--  --:--:-- 00:02:20      1
!
cumulus@rp01:~$ net show mroute
Source          Group          Proto  Input        Output       TTL
Uptime
```

### No mroute Entry Present in Hardware

Use the `cl-resource-query` command to verify that the hardware IP multicast entry is the maximum value:

```
cumulus@switch:~$ cl-resource-query | grep Mcast
Total Mcast Routes:      450,   0% of maximum value     450
```

For Mellanox chipsets, refer to [TCAM Resource Profiles for Mellanox Switches](#) (see page 726).



## Verify MSDP Session State

Run the following commands to verify the state of MSDP sessions:

```
cumulus@switch:~$ net show msdp mesh-group
Mesh group : pod1
  Source : 100.1.1.1
    Member           State
  100.1.1.2       established
  100.1.1.3       established
cumulus@switch:~$
cumulus@switch:~$ net show msdp peer
Peer                  Local          State      Uptime   SaCnt
100.1.1.2            100.1.1.1     established  00:07:21   0
100.1.1.3            100.1.1.1     established  00:07:21   0
```

## View the Active Sources

Review the active sources learned locally (through PIM registers) and from MSDP peers:

```
cumulus@switch:~$ net show msdp sa
Source                Group          RP   Local   SPT
Uptime
44.1.11.2            239.1.1.1    n    n    00:00:
40
44.1.11.2            239.1.1.2    n    n    00:00:
25
```

## Caveats and Errata

- Cumulus Linux only supports *PIM sparse mode* (PIM-SM), *any-source multicast* (PIM-SM ASM), and *source-specific multicast* (SSM). *Dense mode* and *bidirectional multicast* are not supported.
- Non-native forwarding (register decapsulation) is not supported. Initial packet loss is expected while the PIM  $\ast, G$  tree is built from the rendezvous point to the FHR to trigger native forwarding.
- Cumulus Linux does not currently build an S,G mroute when forwarding over an  $\ast, G$  tree.

## Segment Routing

### ⚠ Early Access Feature

Segment routing is an [early access feature](#) in Cumulus Linux and is supported only on [Mellanox switches](#).

Cumulus Linux supports *segment routing*, also known as source routing, which provides the ability for a source node to specify the path a packet should take (traffic engineering). In some more advanced cases, you can use segment routing to have offline multiprotocol label switching (MPLS) controllers program labels into the network for traffic engineering.

Cumulus Linux provides full label-based forwarding, relying on [BGP \(see page 773\)](#) for label exchange. However, Cumulus Linux does not provide LDP interoperability for MPLS and it does not support [VRFs \(see page 847\)](#) for tenant isolation.

## Contents

**This topic describes ...**

- Features ([see page 920](#))
- Example Configuration ([see page 920](#))
- Configure Segment Routing ([see page 927](#))
- View the Configuration ([see page 927](#))

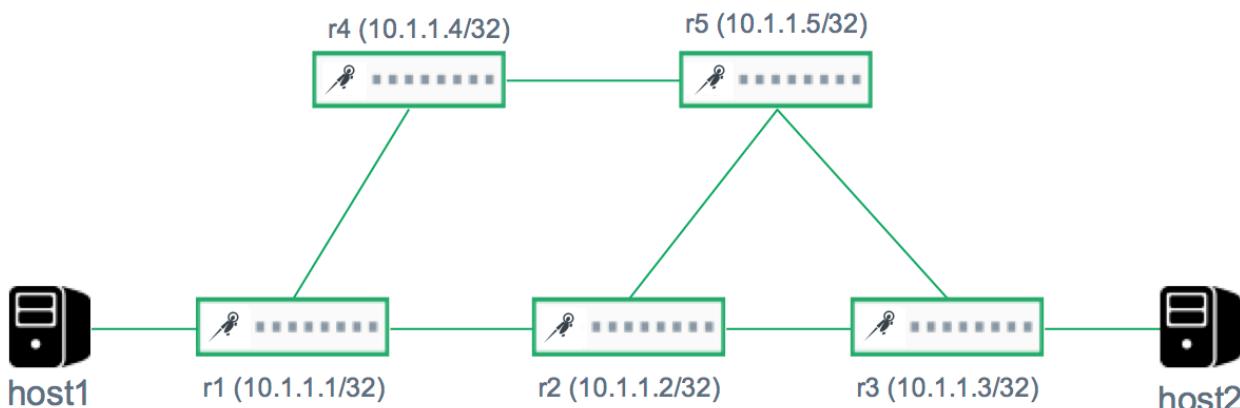
## Features

Segment routing is MPLS for the data plane **only**. In this EA release, Cumulus Linux does not impose the labels, the host does. The MTUs should be large enough to accommodate the MPLS shim header and label stack. Segment routing supports the following features:

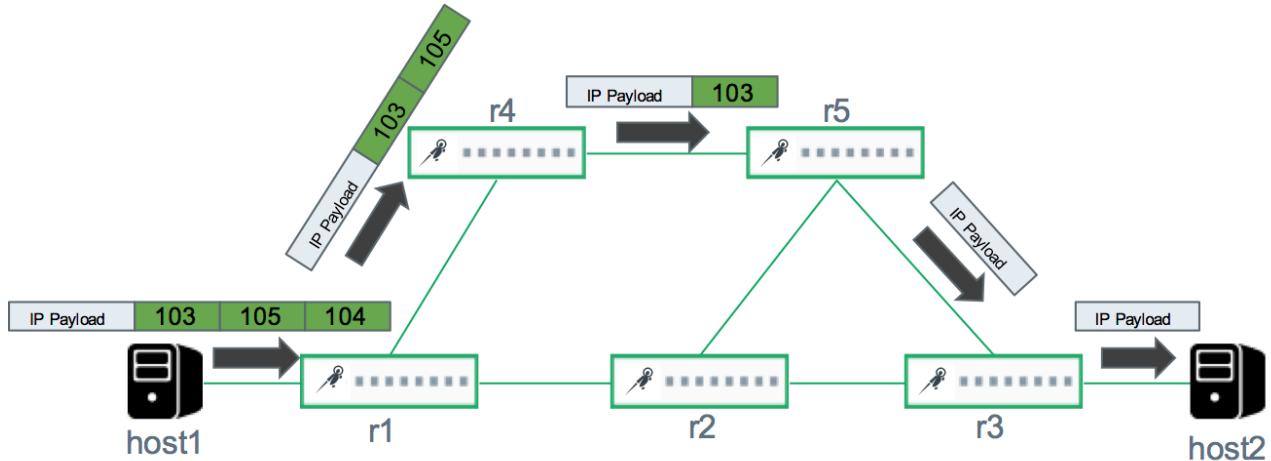
- MPLS label edge router (LER) functionality for IPv4 and IPv6 routing with [ECMP \(see page 829\)](#). An ingress LER first adds an MPLS label to an IP packet. An egress LER removes the outermost MPLS label (also called *popping* the label).
- MPLS label switch router (LSR) functionality with ECMP. The LSR receives a packet with a label and forwards it based on that label.
- [FRRouting \(see page 731\)](#) support for MPLS transit label switched paths (LSPs) and labeled routes (LER), both static routes and routes using BGP labeled-unicast (LU).
- FRR support for BGP/MPLS segment routing based on [draft-ietf-idr-bgp-prefix-sid-06](#).

## Example Configuration

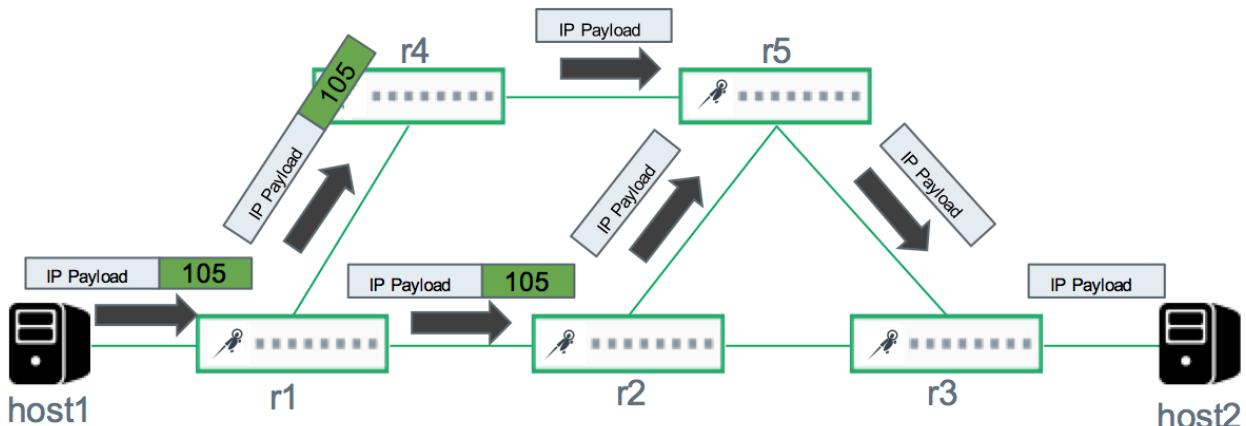
Consider the following topology. Typically, host1 sends traffic to host2 through r1, r2 and r3. However, you can use segment routing to route traffic through a specific path. In the examples below, HTTP traffic is routed from host1 to host2 via r1, r4, r5 then r3. In addition, FTP traffic is routed via r5 without worrying what path it takes to get there.



For HTTP traffic to be routed from host1 to host2 via r1, r4, r5 then r3, the MPLS controller tells host1 to push *label stack* 103,105,104 on all HTTP traffic destined for host2; 104 is the outside label and 103 is the inside label. Switch r1 sees label 104, then pops that outermost label and forwards the payload towards switch r4. Switch r4 sees label 105, then pops that label and forwards the payload towards switch r5. Switch r5 sees label 103, then pops that label and forwards the payload towards switch r3. Switch r3 sees just an IP packet, and routes it as usual.



For FTP traffic to be routed from host1 to host2 through r5, the MPLS controller tells host1 to push label stack 105 on all FTP traffic destined for host2. Switch r1 sees label 105, then uses ECMP using swap with label 105 and forwards the payload towards switches r4 and r2. Switches r2 and r4 see label 105, then they pop the label and forward the payload towards switches r5 and r3. Switches r5 and r3 both see just an IP packet and route it as usual.



Switches r1 through r5 announce their loopbacks (the 10.1.1.\* addresses above) in BGP with a *label-index*. The table below contains the configuration for all five nodes.

Node	/etc/network/interfaces	/etc/frr/frr.conf
r1	<a href="#">Click to see the config ...</a>  <code>/etc/network/interfaces</code>	<a href="#">Click to see the config ...</a>  <code>/etc/frr/frr.conf</code>



Node	/etc/network/interfaces	/etc/frr/frr.conf
	<pre>auto lo iface lo inet loopback     address 10.1.1.1/32 auto swp2 iface swp2     mpls-enable yes auto swp4 iface swp4     mpls-enable yes auto swp10 iface swp10     address 192.168.11.1/24     mpls-enable yes auto vagrant iface vagrant inet dhcp auto eth0 iface eth0 inet dhcp     vrf mgmt auto mgmt iface mgmt     address 127.0.0.1/8     vrf-table auto</pre>	<pre>frr version 4.0+cl3u9 frr defaults datacenter hostname r1 username cumulus nopassword ! service integrated-vtysh-config ! log syslog informational ! router bgp 65111 bgp router-id 10.1.1.1 no bgp default ipv4-unicast neighbor EBGP peer-group neighbor EBGP remote-as external neighbor swp2 interface peer- group EBGP neighbor swp4 interface peer- group EBGP ! address-family ipv4 unicast     network 10.1.1.1/32 label-index 1     network 10.1.1.2/32 label-index 2     network 10.1.1.3/32 label-index 3     network 10.1.1.4/32 label-index 4     network 10.1.1.5/32 label-index 5 exit-address-family ! address-family ipv4 labeled- unicast     neighbor EBGP activate exit-address-family ! mpls label global-block 100 200 ! line vty !</pre>
r2	<a href="#">Click to see the config ...</a>	<a href="#">Click to see the config ...</a>
	/etc/network/interfaces	/etc/frr/frr.conf

Node	/etc/network/interfaces	/etc/frr/frr.conf
	<pre> auto lo iface lo inet loopback     address 10.1.1.2/32 auto swp1 iface swp1     mpls-enable yes auto swp3 iface swp3     mpls-enable yes auto swp5 iface swp5     mpls-enable yes auto vagrant iface vagrant inet dhcp auto eth0 iface eth0 inet dhcp     vrf mgmt auto mgmt iface mgmt     address 127.0.0.1/8     vrf-table auto </pre>	<pre> frr version 4.0+cl3u9 frr defaults datacenter hostname r2 username cumulus nopassword ! service integrated-vtysh-config ! log syslog informational ! router bgp 65222 bgp router-id 10.1.1.2 no bgp default ipv4-unicast neighbor EBGP peer-group neighbor EBGP remote-as external neighbor swp1 interface peer- group EBGP neighbor swp3 interface peer- group EBGP neighbor swp5 interface peer- group EBGP ! address-family ipv4 unicast     network 10.1.1.1/32 label-index 1     network 10.1.1.2/32 label-index 2     network 10.1.1.3/32 label-index 3     network 10.1.1.4/32 label-index 4     network 10.1.1.5/32 label-index 5     exit-address-family ! address-family ipv4 labeled- unicast     neighbor EBGP activate     exit-address-family ! mpls label global-block 100 200 ! line vty !</pre>
r3	<a href="#">Click to see the config ...</a> <div style="background-color: #e0e0e0; padding: 5px; margin-top: 10px;"> <b>/etc/network/interfaces</b> </div>	<a href="#">Click to see the config ...</a> <div style="background-color: #e0e0e0; padding: 5px; margin-top: 10px;"> <b>/etc/frr/frr.conf</b> </div>



Node	/etc/network/interfaces	/etc/frr/frr.conf
	<pre>auto lo iface lo inet loopback     address 10.1.1.3/32 auto swp2 iface swp2     mpls-enable yes auto swp5 iface swp5     mpls-enable yes auto swp10 iface swp10     address 192.168.22.1/24     mpls-enable yes auto vagrant iface vagrant inet dhcp auto eth0 iface eth0 inet dhcp     vrf mgmt auto mgmt iface mgmt     address 127.0.0.1/8     vrf-table auto</pre>	<pre>frr version 4.0+cl3u9 frr defaults datacenter hostname r3 username cumulus nopassword ! service integrated-vtysh-config ! log syslog informational ! router bgp 65333 bgp router-id 10.1.1.3 no bgp default ipv4-unicast neighbor EBGP peer-group neighbor EBGP remote-as external neighbor swp2 interface peer- group EBGP neighbor swp5 interface peer- group EBGP ! address-family ipv4 unicast     network 10.1.1.1/32 label-index 1     network 10.1.1.2/32 label-index 2     network 10.1.1.3/32 label-index 3     network 10.1.1.4/32 label-index 4     network 10.1.1.5/32 label-index 5 exit-address-family ! address-family ipv4 labeled- unicast     neighbor EBGP activate exit-address-family ! mpls label global-block 100 200 ! line vty !</pre>
r4	<a href="#">Click to see the config ...</a>	<a href="#">Click to see the config ...</a>
	<b>/etc/network/interfaces</b>	<b>/etc/frr/frr.conf</b>



Node	/etc/network/interfaces	/etc/frr/frr.conf
	<pre>auto lo iface lo inet loopback     address 10.1.1.4/32 auto swp1 iface swp1     mpls-enable yes auto swp5 iface swp5     mpls-enable yes auto vagrant iface vagrant inet dhcp auto eth0 iface eth0 inet dhcp     vrf mgmt auto mgmt iface mgmt     address 127.0.0.1/8     vrf-table auto</pre>	<pre>frr version 4.0+cl3u9 frr defaults datacenter hostname r4 username cumulus nopassword ! service integrated-vtysh-config ! log syslog informational ! router bgp 65444 bgp router-id 10.1.1.4 no bgp default ipv4-unicast neighbor EBGP peer-group neighbor EBGP remote-as external neighbor swp1 interface peer- group EBGP neighbor swp5 interface peer- group EBGP ! address-family ipv4 unicast     network 10.1.1.1/32 label-index 1     network 10.1.1.2/32 label-index 2     network 10.1.1.3/32 label-index 3     network 10.1.1.4/32 label-index 4     network 10.1.1.5/32 label-index 5 exit-address-family ! address-family ipv4 labeled- unicast     neighbor EBGP activate exit-address-family ! mpls label global-block 100 200 ! line vty !</pre>
r5	<a href="#">Click to see the config ...</a>  <a href="#">/etc/network/interfaces</a>	<a href="#">Click to see the config ...</a>  <a href="#">/etc/frr/frr.conf</a>



Node	/etc/network/interfaces	/etc/frr/frr.conf
	<pre>auto lo iface lo inet loopback     address 10.1.1.5/32 auto swp2 iface swp2     mpls-enable yes auto swp5 iface swp5     mpls-enable yes auto swp10 iface swp10     address 192.168.22.1/24     mpls-enable yes auto vagrant iface vagrant inet dhcp auto eth0 iface eth0 inet dhcp     vrf mgmt auto mgmt iface mgmt     address 127.0.0.1/8     vrf-table auto</pre>	<pre>frr version 4.0+cl3u9 frr defaults datacenter hostname r5 username cumulus nopassword ! service integrated-vtysh-config ! log syslog informational ! router bgp 65555 bgp router-id 10.1.1.5 no bgp default ipv4-unicast neighbor EBGP peer-group neighbor EBGP remote-as external neighbor swp2 interface peer- group EBGP neighbor swp3 interface peer- group EBGP neighbor swp5 interface peer- group EBGP ! address-family ipv4 unicast     network 10.1.1.1/32 label-index 1     network 10.1.1.2/32 label-index 2     network 10.1.1.3/32 label-index 3     network 10.1.1.4/32 label-index 4     network 10.1.1.5/32 label-index 5 exit-address-family ! ! address-family ipv4 labeled- unicast     neighbor EBGP activate exit-address-family ! mpls label global-block 100 200 ! line vty !</pre>



## Configure Segment Routing

To configure the segment routing example above, use the `label-index` option in [NCLU](#) (see page 88). Configure the following on each node:

```
cumulus@switch:~$ net add bgp network 10.1.1.1/32 label-index 1
cumulus@switch:~$ net add bgp network 10.1.1.2/32 label-index 2
cumulus@switch:~$ net add bgp network 10.1.1.3/32 label-index 3
cumulus@switch:~$ net add bgp network 10.1.1.4/32 label-index 4
cumulus@switch:~$ net add bgp network 10.1.1.5/32 label-index 5
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

Then, for each switch in the topology, define the *global-block* of labels to use for segment routing in [FRR](#) (see page 737). The default global-block is 16000-23999. The example configuration uses global-block 100 200. The *local label* is the MPLS label global-block plus the label-index.

```
cumulus@switch:~$ cat /etc/frr/frr.conf
router bgp 400
  bgp router-id 10.1.1.4
  no bgp default ipv4-unicast
  neighbor EBGP peer-group
  neighbor EBGP remote-as external
  neighbor swp1 interface peer-group EBGP
  neighbor swp2 interface peer-group EBGP
!
  address-family ipv4 unicast
    network 10.1.1.4/32 label-index 4
  exit-address-family
!
  address-family ipv4 labeled-unicast
    neighbor EBGP activate
  exit-address-family
!
  mpls label global-block 100 200
```

## View the Configuration

You can see the label-index when you show the BGP configuration on a router.

```
cumulus@r4:~$ net show configuration bgp
...
router bgp 400
  bgp router-id 10.1.1.4
```

```
address-family ipv4 unicast
  network 10.1.1.4/32 label-index 4
```

Or from another node in the network:

```
cumulus@r1:~$ net show bgp 10.1.1.4/32
BGP routing table entry for 10.1.1.4/32
Local label: 104
Paths: (1 available, best #1, table Default-IP-Routing-Table)
  Advertised to non peer-group peers:
    h1(swp1) r2(swp2) r4(swp3)
    400
      fe80::202:ff:fe00:c from r4(swp3) (10.1.1.4)
      (fe80::202:ff:fe00:c) (used)
        Origin IGP, metric 0, localpref 100, valid, external, bestpath-
from-AS 400, best
        Remote label: 3
        Label Index: 4
        AddPath ID: RX 0, TX 14
        Last update: Tue Aug 15 13:57:45 2017
cumulus@r1:~$
```

You can see the FRR MPLS table in the output below, where r1 receives a packet with label 104. Its outbound label is 3, which appears as *implicit-null* below, so it pops then the payload is forwarded out of swp3, the interface to r4:

```
cumulus@r1:~$ net show mpls table

Inbound                                         Outbound
-----   -----   -----   -----
  Label     Type    Nexthop     Label
-----   -----   -----   -----
  102      BGP    fe80::202:ff:fe00:6      3
  103      BGP    fe80::202:ff:fe00:6     103
  104      BGP    fe80::202:ff:fe00:c      3
  105      BGP    fe80::202:ff:fe00:c     105
  106      BGP    fe80::202:ff:fe00:1      3
  107      BGP    fe80::202:ff:fe00:6     107

cumulus@r1:~$
cumulus@r1:~$
cumulus@r1:~$ net show mpls table 104
Local label: 104 (installed)
  type: BGP remote label: implicit-null distance: 150
  via fe80::202:ff:fe00:c dev swp3 (installed)
cumulus@r1:~$
```

You can see the MPLS routing table that is installed in the kernel as well:



```
cumulus@r1:~$ ip -f mpls route show
102 via inet6 fe80::202:ff:fe00:6 dev swp2 proto zebra
103 as to 103 via inet6 fe80::202:ff:fe00:6 dev swp2 proto zebra
104 via inet6 fe80::202:ff:fe00:c dev swp3 proto zebra
105 proto zebra
    nexthop as to 105 via inet6 fe80::202:ff:fe00:6 dev swp2
    nexthop as to 105 via inet6 fe80::202:ff:fe00:c dev swp3
106 via inet6 fe80::202:ff:fe00:1 dev swp1 proto zebra
107 as to 107 via inet6 fe80::202:ff:fe00:6 dev swp2 proto zebra
cumulus@r1:~$
cumulus@r1:~$ ip -f mpls route show 104
104 via inet6 fe80::202:ff:fe00:c dev swp3 proto zebra
cumulus@r1:~$
```



# Monitoring and Troubleshooting

This chapter introduces monitoring and troubleshooting Cumulus Linux.

## Contents

**This topic describes ...**

- Serial Console (see page 930)
  - Configure the Serial Console on ARM Switches (see page 930)
  - Configure the Serial Console on x86 Switches (see page 931)
- Show General System Information (see page 932)
- Diagnostics Using cl-support (see page 932)
- Send Log Files to a syslog Server (see page 933)
  - NCLU (see page 933)
  - Log Technical Details (see page 933)
  - Local Logging (see page 934)
  - Enable Remote syslog (see page 935)
  - Write to syslog with Management VRF Enabled (see page 936)
  - Rate-limit syslog Messages (see page 936)
  - Harmless syslog Error: Failed to reset devices.list (see page 937)
  - Syslog Troubleshooting Tips (see page 937)
- Next Steps (see page 940)

## Serial Console

The serial console can be a useful tool for debugging issues, especially when you find yourself rebooting the switch often or if you don't have a reliable network connection.

The default serial console baud rate is 115200, which is the baud rate ONIE uses.

### Configure the Serial Console on ARM Switches

On ARM switches, the U-Boot environment variable `baudrate` identifies the baud rate of the serial console. To change the `baudrate` variable, use the `fw_setenv` command:

```
cumulus@switch:~$ sudo fw_setenv baudrate 9600
Updating environment variable: `baudrate'
Proceed with update [N/y]? y
```

You must reboot the switch for the `baudrate` change to take effect.



The valid values for `baudrate` are:

- 300
- 600
- 1200
- 2400
- 4800
- 9600
- 19200
- 38400
- 115200

## Configure the Serial Console on x86 Switches

On x86 switches, you configure serial console baud rate by editing `grub`.



Incorrect configuration settings in `grub` can cause the switch to be inaccessible via the console. Grub changes should be carefully reviewed before implementation.

The valid values for the baud rate are:

- 300
- 600
- 1200
- 2400
- 4800
- 9600
- 19200
- 38400
- 115200

To change the serial console baud rate:

1. Edit `/etc/default/grub`. The two relevant lines in `/etc/default/grub` are as follows; replace the `115200` value with a valid value specified above in the `--speed` variable in the first line and in the `console` variable in the second line:

```
GRUB_SERIAL_COMMAND="serial --port=0x2f8 --speed=115200 --word=8  
--parity=no --stop=1"  
GRUB_CMDLINE_LINUX="console=ttyS1,115200n8  
cl_platform=accton_as5712_54x"
```

2. After you save your changes to the grub configuration, type the following at the command prompt:



```
cumulus@switch:~$ update-grub
```

3. If you plan on accessing your switch's BIOS over the serial console, you need to update the baud rate in the switch BIOS. For more information, see [this knowledge base article](#).
4. Reboot the switch.

## Show General System Information

Two commands are helpful for getting general information about the switch and the version of Cumulus Linux you are running. These are helpful with system diagnostics and if you need to submit a support request to Cumulus Networks.

For information about the version of Cumulus Linux running on the switch, run `net show version`, which displays the contents of `/etc/lsb-release`:

```
cumulus@switch:~$ net show version
NCLU_VERSION=1.0
DISTRIB_ID="Cumulus Linux"
DISTRIB_RELEASE=3.4.0
DISTRIB_DESCRIPTION="Cumulus Linux 3.4.0"
```

For general information about the switch, run `net show system`, which gathers information about the switch from a number of files in the system:

```
cumulus@switch:~$ net show system
Hostname..... celRED

Build..... Cumulus Linux 3.7.4~1551312781.35d3264
Uptime..... 8 days, 12:24:01.770000

Model..... Cel REDSTONE
CPU..... x86_64 Intel Atom C2538 2.4 GHz
Memory..... 4GB
Disk..... 14.9GB
ASIC..... Broadcom Trident2 BCM56854
Ports..... 48 x 10G-SFP+ & 6 x 40G-QSFP+
Base MAC Address. a0:00:00:00:00:50
Serial Number.... A1010B2A011212AB000001
```

## Diagnostics Using cl-support

You can use `cl-support` to generate a single export file that contains various details and the configuration from a switch. This is useful for remote debugging and troubleshooting. For more information about `cl-support`, read [Understanding the cl-support Output File \(see page 968\)](#).

You should run `cl-support` before you submit a support request to Cumulus Networks as this file helps in the investigation of issues.



```
cumulus@switch:~$ sudo cl-support -h
Usage: cl-support [-h] [-s] [-t] [-v] [reason]...

Args:
  [reason]: Optional reason to give for invoking cl-support.
            Saved into tarball's cmdline.args file.

Options:
  -h: Print this usage statement
  -s: Security sensitive collection
  -t: User filename tag
  -v: Verbose
  -e MODULES: Enable modules. Comma separated module list (run with -e
             help for module names)
  -d MODULES: Disable modules. Comma separated module list (run with -d
             help for module names)
```

## Send Log Files to a syslog Server

### NCLU

The remote syslog server can be configured on the switch using the following configuration:

```
cumulus@switch:~$ net add syslog host ipv4 192.168.0.254 port udp 514
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

This creates a file called `/etc/rsyslog.d/11-remotesyslog.conf` in the `rsyslog` directory. The file has the following content:

```
cumulus@switch:~$ cat /etc/rsyslog.d/11-remotesyslog.conf
# This file was automatically generated by NCLU.
*.*    @192.168.0.254:514    # UDP
```



NCLU cannot configure a remote syslog if management VRF is enabled on the switch. Refer to [Writing to syslog with Management VRF Enabled \(see page 936\)](#) below.

### Log Technical Details

Logging on Cumulus Linux is done with `rsyslog`. `rsyslog` provides both local logging to the `syslog` file as well as the ability to export logs to an external `syslog` server. High precision timestamps are enabled for all `rsyslog` log files; here's an example:



```
2015-08-14T18:21:43.337804+00:00 cumulus switchd[3629]: switchd.c:  
1409 switchd version 1.0-cl2.5+5
```

There are applications in Cumulus Linux that could write directly to a log file without going through `rsyslog`. These files are typically located in `/var/log/`.



All Cumulus Linux rules are stored in separate files in `/etc/rsyslog.d/`, which are called at the end of the `GLOBAL DIRECTIVES` section of `/etc/rsyslog.conf`. As a result, the `RULES` section at the end of `rsyslog.conf` is ignored because the messages have to be processed by the rules in `/etc/rsyslog.d` and then dropped by the last line in `/etc/rsyslog.d/99-syslog.conf`.

## Local Logging

Most logs within Cumulus Linux are sent through `rsyslog`, which then writes them to files in the `/var/log` directory. There are default rules in the `/etc/rsyslog.d/` directory that define where the logs are written:

Rule	Purpose
10-rules.conf	Sets defaults for log messages, include log format and log rate limits.
15-crit.conf	Logs crit, alert or emerg log messages to <code>/var/log/crit.log</code> to ensure they are not rotated away rapidly.
20-clagd.conf	Logs <code>clagd</code> messages to <code>/var/log/clagd.log</code> for <a href="#">MLAG (see page 440)</a> .
22-linkstate.conf	Logs link state changes for all physical and logical network links to <code>/var/log/linkstate</code>
25-switchd.conf	Logs <code>switchd</code> messages to <code>/var/log/switchd.log</code> .
30-ptmd.conf	Logs <code>ptmd</code> messages to <code>/var/log/ptmd.log</code> for <a href="#">Prescription Topology Manager (see page 360)</a> .
35-rdnbrd.conf	Logs <code>rdnbrd</code> messages to <code>/var/log/rdnbrd.log</code> for <a href="#">redistribute neighbor (see page 838)</a> .
40-netd.conf	Logs <code>netd</code> messages to <code>/var/log/netd.log</code> for <a href="#">NCLU (see page 88)</a> .
45-frr.conf	Logs routing protocol messages to <code>/var/log/frr/frr.log</code> . This includes BGP and OSPF log messages.



Rule	Purpose
99-syslog.conf	All remaining processes that use <code>rsyslog</code> are sent to <code>/var/log/syslog</code> .

Log files that are rotated are compressed into an archive. Processes that do not use `rsyslog` write to their own log files within the `/var/log` directory. For more information on specific log files, see [Troubleshooting Log Files \(see page 969\)](#).

## Enable Remote syslog

If you need to send other log files — such as `switchd` logs — to a `syslog` server, do the following:

1. Create a file in `/etc/rsyslog.d/`. Make sure it starts with a number lower than 99 so that it executes before log messages are dropped in, such as `20-clagd.conf` or `25-switchd.conf`. Our example file is called `/etc/rsyslog.d/11-remotesyslog.conf`. Add content similar to the following:

```
## Logging switchd messages to remote syslog server  
@192.168.1.2:514
```

This configuration sends log messages to a remote `syslog` server for the following processes: `clagd`, `switchd`, `ptmd`, `rdnbrd`, `netd` and `syslog`. It follows the same syntax as the `/var/log/syslog` file, where @ indicates UDP, 192.168.1.2 is the IP address of the `syslog` server, and 514 is the UDP port.



For TCP-based syslog, use two @@ before the IP address: @@192.168.1.2:514.

Running `syslog` over TCP places a burden on the switch to queue packets in the `syslog` buffer. This may cause detrimental effects if the remote `syslog` server becomes unavailable.



The numbering of the files in `/etc/rsyslog.d/` dictates how the rules are installed into `rsyslog.d`. If you want to remotely log only the messages in `/var/syslog`, and not those in `/var/log/clagd.log` or `/var/log/switchd.log`, for instance, then name the file `98-remotesyslog.conf`, since it's lower than the `/var/syslog` file `99-syslog.conf` only.



Do not use the `imfile` module with any file written by `rsyslogd`.

2. Restart `rsyslog`.



```
cumulus@switch:~$ sudo systemctl restart rsyslog.service
```

## Write to syslog with Management VRF Enabled

You can write to syslog with [management VRF \(see page 877\)](#) enabled by applying the following configuration; this configuration is commented out in the `/etc/rsyslog.d/11-remotesyslog.conf` file:

```
cumulus@switch:~$ cat /etc/rsyslog.d/11-remotesyslog.conf
## Copy all messages to the remote syslog server at 192.168.0.254
port 514
action(type="omfwd" Target="192.168.0.254" Device="mgmt" Port="514"
Protocol="udp")
```

For each syslog server, configure a unique `action` line. For example, to configure two syslog servers at 192.168.0.254 and 10.0.0.1:

```
cumulus@switch:~$ cat /etc/rsyslog.d/11-remotesyslog.conf
## Copy all messages to the remote syslog servers at 192.168.0.254
and 10.0.0.1 port 514
action(type="omfwd" Target="192.168.0.254" Device="mgmt" Port="514"
Protocol="udp")
action(type="omfwd" Target="10.0.0.1" Device="mgmt" Port="514"
Protocol="udp")
```

## Rate-limit syslog Messages

If you want to limit the number of `syslog` messages that can be written to the `syslog` file from individual processes, add the following configuration to `/etc/rsyslog.conf`. Adjust the interval and burst values to rate-limit messages to the appropriate levels required by your environment. For more information, read the [rsyslog documentation](#).

```
module(load="imuxsock"
       SysSock.RateLimit.Interval="2" SysSock.RateLimit.Burst="50")
```

**The following test script shows an example of rate-limit output in Cumulus Linux ...**

```
root@leaf1:mgmt-vrf:/home/cumulus# cat ./syslog.py
#!/usr/bin/python
import syslog
message_count=100
print "Sending %s Messages..."%(message_count)
for i in range(0,message_count):
    syslog.syslog("Message Number:%s"%(i))
print "DONE."
```



```
root@leaf1:mgmt-vrf:/home/cumulus# ./syslog.py
Sending 100 Messages...
DONE.
root@leaf1:mgmt-vrf:/home/cumulus# tail -n 60 /var/log/syslog
2017-02-22T19:59:50.043342+00:00 leaf1 syslog.py[22830]: Message
Number:0
2017-02-22T19:59:50.043723+00:00 leaf1 syslog.py[22830]: Message
Number:1
2017-02-22T19:59:50.043941+00:00 leaf1 syslog.py[22830]: Message
Number:2
2017-02-22T19:59:50.044565+00:00 leaf1 syslog.py[22830]: Message
Number:3
2017-02-22T19:59:50.044830+00:00 leaf1 syslog.py[22830]: Message
Number:4
2017-02-22T19:59:50.045680+00:00 leaf1 syslog.py[22830]: Message
Number:5
<...snip...>
2017-02-22T19:59:50.056727+00:00 leaf1 syslog.py[22830]: Message
Number:45
2017-02-22T19:59:50.057599+00:00 leaf1 syslog.py[22830]: Message
Number:46
2017-02-22T19:59:50.057741+00:00 leaf1 syslog.py[22830]: Message
Number:47
2017-02-22T19:59:50.057936+00:00 leaf1 syslog.py[22830]: Message
Number:48
2017-02-22T19:59:50.058125+00:00 leaf1 syslog.py[22830]: Message
Number:49
2017-02-22T19:59:50.058324+00:00 leaf1 rsyslogd-2177: imuxsock[pid
22830]: begin to drop messages due to rate-limiting
```

## Harmless syslog Error: Failed to reset devices.list

The following message gets logged to `/var/log/syslog` when you run `sudo systemctl daemon-reload` and during system boot:

```
systemd[1]: Failed to reset devices.list on /system.slice: Invalid
argument
```

This message is harmless, and can be ignored. It is logged when `systemd` attempts to change cgroup attributes that are read only. The upstream version of `systemd` has been modified to not log this message by default.

The `sudo systemctl daemon-reload` command is often issued when Debian packages are installed, so the message may be seen multiple times when upgrading packages.

## Syslog Troubleshooting Tips

You can use the following commands to troubleshoot `syslog` issues.



## Verifying that rsyslog is Running

To verify that the `rsyslog` service is running, use the `sudo systemctl status rsyslog.service` command:

```
cumulus@leaf01:mgmt-vrf:~$ sudo systemctl status rsyslog.service
rsyslog.service - System Logging Service
   Loaded: loaded (/lib/systemd/system/rsyslog.service; enabled)
   Active: active (running) since Sat 2017-12-09 00:48:58 UTC; 7min
ago
     Docs: man:rsyslogd(8)
           http://www.rsyslog.com/doc/
 Main PID: 11751 (rsyslogd)
    CGroup: /system.slice/rsyslog.service
             11751 /usr/sbin/rsyslogd -n

Dec 09 00:48:58 leaf01 systemd[1]: Started System Logging Service.
```

## Verify your rsyslog Configuration.

After making manual changes to any files in the `/etc/rsyslog.d` directory, use the `sudo rsyslogd -N1` command to identify any errors in the configuration files that might prevent the `rsyslog` service from starting.

In the following example, a closing parenthesis is missing in the `11-remotesyslog.conf` file, which is used to configure `syslog` for management VRF:

```
cumulus@leaf01:mgmt-vrf:~$ cat /etc/rsyslog.d/11-remotesyslog.conf
action(type="omfwd" Target="192.168.0.254" Device="mgmt" Port="514"
Protocol="udp"

cumulus@leaf01:mgmt-vrf:~$ sudo rsyslogd -N1
rsyslogd: version 8.4.2, config validation run (level 1), master
config /etc/rsyslog.conf
rsyslogd: error during parsing file /etc/rsyslog.d/15-crit.conf, on
or before line 3: invalid character '$' in object definition - is
there an invalid escape sequence somewhere? [try http://www.rsyslog.
com/e/2207 ]
rsyslogd: error during parsing file /etc/rsyslog.d/15-crit.conf, on
or before line 3: syntax error on token 'crit_log' [try http://www.
rsyslog.com/e/2207 ]
```

After correcting the invalid syntax, issuing the `sudo rsyslogd -N1` command produces the following output.

```
cumulus@leaf01:mgmt-vrf:~$ cat /etc/rsyslog.d/11-remotesyslog.conf
action(type="omfwd" Target="192.168.0.254" Device="mgmt" Port="514"
Protocol="udp" )
```



```
cumulus@leaf01:mgmt-vrf:~$ sudo rsyslogd -N1
rsyslogd: version 8.4.2, config validation run (level 1), master
config /etc/rsyslog.conf
rsyslogd: End of config validation run. Bye.
```

## *tcpdump*

If a syslog server is not accessible to validate that `syslog` messages are being exported, you can use `tcpdump`.

In the following example, a syslog server has been configured at 192.168.0.254 for UDP syslogs on port 514:

```
cumulus@leaf01:mgmt-vrf:~$ sudo tcpdump -i eth0 host 192.168.0.254
and udp port 514
```

A simple way to generate `syslog` messages is to use `sudo` in another session, such as `sudo date`. Using `sudo` generates an `authpriv` log.

```
cumulus@leaf01:mgmt-vrf:~$ sudo tcpdump -i eth0 host 192.168.0.254
and udp port 514
tcpdump: verbose output suppressed, use -v or -vv for full protocol
decode
listening on eth0, link-type EN10MB (Ethernet), capture size 262144
bytes
00:57:15.356836 IP leaf01.lab.local.33875 > 192.168.0.254.syslog:
SYSLOG authpriv.notice, length: 105
00:57:15.364346 IP leaf01.lab.local.33875 > 192.168.0.254.syslog:
SYSLOG authpriv.info, length: 103
00:57:15.369476 IP leaf01.lab.local.33875 > 192.168.0.254.syslog:
SYSLOG authpriv.info, length: 85
```

To see the contents of the `syslog` file, use the `tcpdump -X` option:

```
cumulus@leaf01:mgmt-vrf:~$ sudo tcpdump -i eth0 host 192.168.0.254
and udp port 514 -X -c 3
tcpdump: verbose output suppressed, use -v or -vv for full protocol
decode
listening on eth0, link-type EN10MB (Ethernet), capture size 262144
bytes
00:59:15.980048 IP leaf01.lab.local.33875 > 192.168.0.254.syslog:
SYSLOG authpriv.notice, length: 105
0x0000: 4500 0085 33ee 4000 4011 8420 c0a8 000b E...3.@.@@.....
0x0010: c0a8 00fe 8453 0202 0071 9d18 3c38 353e .....S...q..<85>
0x0020: 4465 6320 2039 2030 303a 3539 3a31 3520 Dec..9.00:59:15.
0x0030: 6c65 6166 3031 2073 7564 6f3a 2020 6375 leaf01.sudo:..cu
0x0040: 6d75 6c75 7320 3a20 5454 593d 7074 732f mulus.:TTY=pts/
```



```
0x0050: 3120 3b20 5057 443d 2f68 6f6d 652f 6375 1.;.PWD=/home/cu
0x0060: 6d75 6c75 7320 3b20 5553 4552 3d72 6f6f mulus.;.USER=roo
0x0070: 7420 3b20 434f 4d4d 414e 443d 2f62 696e t.;.COMMAND=/bin
0x0080: 2f64 6174 65 /date
```

## Next Steps

The links below discuss more specific monitoring topics.

## Single User Mode - Boot Recovery

Use single user mode to assist in troubleshooting system boot issues or for password recovery. To enter single user mode, follow the steps below.

1. Boot the switch as soon as you see the GRUB menu.

```
GNU GRUB version 2.02-cl3u3

+-----+
-----+
| *Cumulus Linux GNU
/Linux
| Advanced options for Cumulus Linux GNU
/Linux
|
ONIE
|
|
+-----+
-----+
```

2. Use the ^ and v arrow keys to select **Advanced options for Cumulus Linux GNU/Linux**. A menu similar to the following should appear:

```
GNU GRUB version 2.02-cl3u3

+-----+
-----+
| Cumulus Linux GNU/Linux, with Linux 4.1.0-cl-7-
amd64
| *Cumulus Linux GNU/Linux, with Linux 4.1.0-cl-7-amd64
(recovery mode) |
```



3. Select **Cumulus Linux GNU/Linux, with Linux 4.1.0-cl-7-amd64 (recovery mode)**.
4. Press **ctrl-x** to reboot.
5. After the system reboots, set a new **root** password. This is useful since the root user provides complete control over the switch, and providing a new password now helps in case the current password has been forgotten, which is a common problem.

```
root@switch:~# passwd
Enter new UNIX password:
Retype new UNIX password:
passwd: password updated successfully
```



You may want to take this opportunity to reset the password for the *cumulus* account as well.

```
root@switch:~# passwd cumulus
Enter new UNIX password:
Retype new UNIX password:
passwd: password updated successfully
```

6. Sync the `/etc` directory using `btrfs`, then reboot the system:

```
root@switch:~# btrfs filesystem sync /etc
root@switch:~# reboot -f
Restarting the system.
```

## Resource Diagnostics Using `cl-resource-query`

You can use the `cl-resource-query` command to retrieve information about host entries, MAC entries, layer 2 and layer 3 routes, and ECMP (see page 731) routes that are in use. Because Cumulus Linux synchronizes routes between the kernel and the switching silicon, if the required resource pools in hardware fill up, new kernel routes can cause existing routes to move from being fully allocated to being partially allocated. To avoid this, monitor the routes in the hardware to keep them below the ASIC limits. For example, on a Broadcom Tomahawk switch, the limits are as follows:



```
routes: 8192 <<< if all routes are IPv6, or 65536 if all routes are IPv4
route mask limit 64
host_routes: 73728
ecmp_nhs: 16327
ecmp_nhs_per_route: 52
```

This translates to about 314 routes with ECMP nexthops, if every route has the maximum ECMP nexthops.

To monitor the routes in Cumulus Linux hardware, use the `cl-resource-query` command. The results vary between switches running on different chipsets.

The example below shows `cl-resource-query` results for a Broadcom Tomahawk switch:

```
cumulus@switch:~$ sudo cl-resource-query
IPv4/IPv6 host entries: 0, 0% of maximum value 4096
IPv4 neighbors: 0
IPv6 neighbors: 0
IPv4 route entries: 4, 0% of maximum value 6553
IPv6 route entries: 8, 0% of maximum value 819
IPv4 Routes: 4
IPv6 Routes: 8
Total Routes: 12, 0% of maximum value 6553
ECMP nexthops: 0, 0% of maximum value 1632
MAC entries: 1, 0% of maximum value 4096
Total Mcast Routes: 0, 0% of maximum value 2048
Ingress ACL entries: 195, 12% of maximum value 153
Ingress ACL counters: 195, 12% of maximum value 153
Ingress ACL meters: 21, 1% of maximum value 204
Ingress ACL slices: 6, 100% of maximum value
Egress ACL entries: 58, 11% of maximum value 51
Egress ACL counters: 58, 5% of maximum value 102
Egress ACL meters: 29, 5% of maximum value 51
Egress ACL slices: 2, 100% of maximum value
Ingress ACL ipv4_mac filter table: 36, 14% of maximum value 25
6 (allocated: 256)
```



Ingress ACL ipv6 filter table:	29	11% of maximum value	25
6 (allocated: 256)			
Ingress ACL mirror table:	0	0% of maximum value	
0 (allocated: 0)			
Ingress ACL 8021x filter table:	0	0% of maximum value	
0 (allocated: 0)			
Ingress PBR ipv4_mac filter table:	0	0% of maximum value	
0 (allocated: 0)			
Ingress PBR ipv6 filter table:	0	0% of maximum value	
0 (allocated: 0)			
Ingress ACL ipv4_mac mangle table:	0	0% of maximum value	
0 (allocated: 0)			
Ingress ACL ipv6 mangle table:	0	0% of maximum value	
0 (allocated: 0)			
Egress ACL ipv4_mac filter table:	29	11% of maximum value	25
6 (allocated: 256)			
Egress ACL ipv6 filter table:	0	0% of maximum value	
0 (allocated: 0)			
ACL L4 port range checkers:	2	6% of maximum value	3
2			

The example below shows `cl-resource-query` results for a Broadcom Trident II switch:

cumulus@switch:~\$ sudo cl-resource-query			
IPv4/IPv6 host entries:	0	0% of maximum value	1638
4			
IPv4 neighbors:	0		
IPv6 neighbors:	0		
IPv4 route entries:	0	0% of maximum value	13107
2			
IPv6 route entries:	1	0% of maximum value	2048
0			
IPv4 Routes:	0		
IPv6 Routes:	1		
Total Routes:	1	0% of maximum value	13107
2			
ECMP nexthops:	0	0% of maximum value	1634
6			
MAC entries:	0	0% of maximum value	3276
8			
Total Mcast Routes:	0	0% of maximum value	819
2			
Ingress ACL entries:	130	6% of maximum value	204
8			
Ingress ACL counters:	86	4% of maximum value	204
8			
Ingress ACL meters:	21	0% of maximum value	409
6			
Ingress ACL slices:	4	66% of maximum value	
6			

Egress ACL entries:	58,	11% of maximum value	51
2			
Egress ACL counters:	58,	5% of maximum value	102
4			
Egress ACL meters:	29,	5% of maximum value	51
2			
Egress ACL slices:	2,	100% of maximum value	
2			
Ingress ACL ipv4_mac filter table:	36,	7% of maximum value	51
2 (allocated: 256)			
Ingress ACL ipv6 filter table:	29,	3% of maximum value	76
8 (allocated: 512)			
Ingress ACL mirror table:	0,	0% of maximum value	
0 (allocated: 0)			
Ingress ACL 8021x filter table:	0,	0% of maximum value	
0 (allocated: 0)			
Ingress PBR ipv4_mac filter table:	0,	0% of maximum value	
0 (allocated: 0)			
Ingress PBR ipv6 filter table:	0,	0% of maximum value	
0 (allocated: 0)			
Ingress ACL ipv4_mac mangle table:	0,	0% of maximum value	
0 (allocated: 0)			
Ingress ACL ipv6 mangle table:	0,	0% of maximum value	
0 (allocated: 0)			
Egress ACL ipv4_mac filter table:	29,	11% of maximum value	25
6 (allocated: 256)			
Egress ACL ipv6 filter table:	0,	0% of maximum value	
0 (allocated: 0)			
ACL L4 port range checkers:	2,	8% of maximum value	2
4			



Ingress ACL and Egress ACL entries show the counts in single wide (*not double-wide*). For information about ACL entries, see [Estimate the Number of ACL Rules \(see page 154\)](#).



On a Mellanox switch in Cumulus Linux 3.7.4, the `c1-resource-query` command shows the number of TCAM entries used by the different types of ACL resources.

## Monitoring System Hardware

You monitor system hardware in these ways, using:

- `decode-syseeprom`
- `smond`
- `sensors`
- Net-SNMP (see page 1024)



- watchdog

## Contents

This topic describes ...

- Retrieve Hardware Information Using decode-syseeprom (see page 945)
  - Command Options (see page 945)
  - Related Commands (see page 946)
- Monitor System Units Using smond (see page 946)
- Monitor Hardware Health Using sensors (see page 948)
- Monitor Switch Hardware Using SNMP (see page 949)
- Keep the Switch Alive Using the Hardware Watchdog (see page 949)
- Related Information (see page 950)

## Retrieve Hardware Information Using decode-syseeprom

The `decode-syseeprom` command enables you to retrieve information about the switch's EEPROM. If the EEPROM is writable, you can set values on the EEPROM.

For example:

```
cumulus@switch:~$ decode-syseeprom
TlvInfo Header:
  Id String:      TlvInfo
  Version:        1
  Total Length:  114
TLV Name           Code Len Value
-----
Product Name       0x21   4 4804
Part Number        0x22   14 R0596-F0009-00
Device Version     0x26   1 2
Serial Number      0x23   19 D1012023918PE000012
Manufacture Date   0x25   19 10/09/2013 20:39:02
Base MAC Address   0x24   6 00:E0:EC:25:7B:D0
MAC Addresses      0x2A   2 53
Vendor Name         0x2D   17 Penguin Computing
Label Revision     0x27   4 4804
Manufacture Country 0x2C   2 CN
CRC-32             0xFE   4 0x96543BC5
(checksum valid)
```

### Command Options

Usage: /usr/cumulus/bin/decode-syseeprom [-a][-r][-s [args]][-t]



Option	Description
-h, --help	Displays the help message and exits.
-a	Prints the base MAC address for switch interfaces.
-r	Prints the number of MACs allocated for switch interfaces.
-s	Sets the EEPROM content if the EEPROM is writable. <code>args</code> can be supplied in command line in a comma separated list of the form ' <code>&lt;field&gt;=&lt;value&gt;</code> , ...'. ' ' and '=' are illegal characters in field names and values. Fields that are not specified will default to their current values. If <code>args</code> are supplied in the command line, they will be written without confirmation. If <code>args</code> is empty, the values will be prompted interactively.
-t TARGET	Selects the target EEPROM ( <code>board</code> , <code>psu2</code> , <code>psu1</code> ) for the read or write operation; default is <code>board</code> .
-e, --serial	Prints the device serial number.

### Related Commands

You can also use the `dmidecode` command to retrieve hardware configuration information that's been populated in the BIOS.

You can use `apt-get` to install the `lshw` program on the switch, which also retrieves hardware configuration information.

## Monitor System Units Using smond

The `smond` daemon monitors system units like power supply and fan, updates their corresponding LEDs, and logs the change in the state. Changes in system unit state are detected via the `cp1d` registers. `smond` utilizes these registers to read all sources, which impacts the health of the system unit, determines the unit's health, and updates the system LEDs.

Use `smonctl` to display sensor information for the various system units:

```
cumulus@switch:~$ sudo smonctl
Board : OK
Fan   : OK
PSU1  : OK
PSU2  : BAD
Temp1 (Networking ASIC Die Temp Sensor ) : OK
Temp10 (Right side of the board ) : OK
Temp2 (Near the CPU (Right) ) : OK
Temp3 (Top right corner ) : OK
Temp4 (Right side of Networking ASIC ) : OK
```

Temp5	(Middle of the board	) : OK
Temp6	(P2020 CPU die sensor	) : OK
Temp7	(Left side of the board	) : OK
Temp8	(Left side of the board	) : OK
Temp9	(Right side of the board	) : OK



When the switch is not powered on, `smonctl` shows the PSU status as *BAD* instead of *POWERED OFF* or *NOT DETECTED*. This is a known limitation.



On the Dell S4148 switch, `smonctl` shows PSU1 and PSU2; however in the sensors output, both PSUs are listed as PSU1.



Some switch models lack the sensor for reading voltage information, so this data is not output from the `smonctl` command.

For example, the Dell S4048 series has this sensor and displays power and voltage information:

```
cumulus@dell-s4048-ON:~$ sudo smonctl -v -s PSU2
PSU2:  OK
power:8.5 W    (voltages = ['11.98', '11.87'] V currents =
['0.72'] A)
```

Whereas the Penguin Arctica 3200C (Celestica Seastone) does not:

```
cumulus@cel-sea:~/tmp$ sudo smonctl -v -s PSU1
PSU1:  OK
```

The following table shows the `smonctl` command options.

Usage: `smonctl [OPTION]... [CHIP]...`

Option	Description
<code>-s SENSOR, --sensor SENSOR</code>	Displays data for the specified sensor.
<code>-v, --verbose</code>	Displays detailed hardware sensors data.

For more information, read `man smond` and `man smonctl`.

## Monitor Hardware Health Using `sensors`

The `sensors` command provides a method for monitoring the health of your switch hardware, such as power, temperature and fan speeds. This command executes `lm-sensors`.



Even though you can use the `sensors` command to monitor the health of your switch hardware, the `smond` daemon is the recommended method for monitoring hardware health. See [Monitor System Units Using smond \(see page \)](#) above.

For example:

```
cumulus@switch:~$ sensors
tmp75-i2c-6-48
Adapter: i2c-1-mux (chan_id 0)
temp1:      +39.0  C  (high = +75.0  C, hyst = +25.0  C)

tmp75-i2c-6-49
Adapter: i2c-1-mux (chan_id 0)
temp1:      +35.5  C  (high = +75.0  C, hyst = +25.0  C)

ltc4215-i2c-7-40
Adapter: i2c-1-mux (chan_id 1)
in1:      +11.87  V
in2:      +11.98  V
power1:    12.98  W
curr1:    +1.09  A

max6651-i2c-8-48
Adapter: i2c-1-mux (chan_id 2)
fan1:     13320  RPM  (div = 1)
fan2:     13560  RPM
```



Output from the `sensors` command varies depending upon the switch hardware you use, as each platform ships with a different type and number of sensors.

The following table shows the `sensors` command options.

Usage: `sensors [OPTION]... [CHIP]...`

Option	Description
<code>-c, --config-file</code>	Specify a config file; use <code>-</code> after <code>-c</code> to read the config file from <code>stdin</code> ; by default, <code>sensors</code> references the configuration file in <code>/etc/sensors.d/</code> .
<code>-s, --set</code>	



Option	Description
	Executes set statements in the config file (root only); <code>sensors -s</code> is run once at boot time and applies all the settings to the boot drivers.
<code>-f, --fahrenheit</code>	Show temperatures in degrees Fahrenheit.
<code>-A, --no-adapter</code>	Do not show the adapter for each chip.
<code>--bus-list</code>	Generate bus statements for <code>sensors.conf</code> .

If [CHIP] is not specified in the command, all chip info will be printed. Example chip names include:

- lm78-i2c-0-2d \*-i2c-0-2d
- lm78-i2c-0-\* \*-i2c-0-\*
- lm78-i2c-\* -2d \*-i2c-\* -2d
- lm78-i2c-\* -\* \*-i2c-\* -\*
- lm78-isa-0290 \*-isa-0290
- lm78-isa-\* \*-isa-\*
- lm78-\*

## Monitor Switch Hardware Using SNMP

The Net-SNMP documentation is discussed [here \(see page 1024\)](#).

## Keep the Switch Alive Using the Hardware Watchdog

Cumulus Linux includes a simplified version of the `wd_keepalive(8)` daemon from the standard `watchdog` Debian package. `wd_keepalive` writes to a file called `/dev/watchdog` periodically to keep the switch from resetting, at least once per minute. Each write delays the reboot time by another minute. After one minute of inactivity where `wd_keepalive` doesn't write to `/dev/watchdog`, the switch resets itself. The watchdog is enabled by default on all supported switches, and starts when you boot the switch, before `switchd` starts.

To enable the hardware watchdog, edit the `/etc/watchdog.d/<your_platform>` file and set `run_watchdog` to 1:

```
run_watchdog=1
```

To disable the watchdog, edit the `/etc/watchdog.d/<your_platform>` file and set `run_watchdog` to 0 :

```
run_watchdog=0
```



Then stop the daemon:

```
cumulus@switch:~$ sudo systemctl stop wd_keepalive.service
```

You can modify the settings for the watchdog — like the timeout setting and scheduler priority — in its configuration file, `/etc/watchdog.conf`.

## Related Information

- [packages.debian.org/search?keywords=lshw](http://packages.debian.org/search?keywords=lshw)
- [lm-sensors.org](http://lm-sensors.org)
- Net-SNMP tutorials

## Network Switch Port LED and Status LED Guidelines

Data centers today have a large number of network switches manufactured by different hardware vendors running NOSes (network operating system) from different providers. This chapter provides a set of guidelines for how network port and status LEDs should appear on the front panel of a network switch. This provides a network operator with a standard way to identify the state of a switch and its ports by looking at its front panel, irrespective of the hardware vendor or NOS.

### Contents

#### This topic describes ...

- Network Port LEDs (see page 950)
- Status LEDs (see page 951)
- Locate a Switch (see page 952)

### Network Port LEDs

A network port LED indicates the state of the link, e.g. link UP, Tx/Rx activity etc.. Here are the requirements for these LEDs

- **Number of LEDs per port** — Ports that cannot be split; for example, 1G ports must have 1 LED per port. Ports that can be split should have 1 LED per split port. So a 40G port that can be split into 4 10G ports has 4 LEDs, one per split port.
- **Location** — A port LED should be placed right above the port. This prevents the LEDs from being hidden by drooping cables. If the port can be split, the LED for each split port should also be placed above the port. The LEDs should be evenly spaced and be inside the edges of the ports to prevent confusion.
- **Port Number Label** — The port number must be printed in white on the switch front panel directly under the corresponding LED.
- **Colors** — As network port technology improves with smaller ports and higher speeds, having different colors for different types of ports or speeds is confusing. The focus should be on giving a network operator a simple set of indications that provide the operator with basic information about the port. Hence, green and amber colors must be used on the LED to differentiate between good and bad states. These colors are commonly found on network port LEDs and should be easy to implement on future switches.



- **Signaling** — The table below indicates the information that can be conveyed via port LEDs and how it should be done.
  - **Max Speed** indicates the maximum speed at which the port can be run. For a 10G port, if the port speed is 10G, then it is running at its maximum speed. If the 10G port is running at 1G speed, then it's running at a *lower speed*.
  - **Physical Link Up/Down** displays layer 2 link status.
  - **Beaconing** provides a way for a network operator to identify a particular link. The administrator can *beacon* that port from a remote location so the network operator has visual indication for that port.
  - **Fault** can also be considered a form of beaconing or vice versa. Both try to draw attention of the network operator towards the port, thus they are signaled the same way.
  - **Blinking amber** implies a blink rate of 33ms. *Slow blinking amber* indicates a blink rate of 500 ms, with a 50% on/off duty cycle. In other words, a slow blinking amber LED is amber for 500 ms and then off for 500ms.

Activity	Max Speed indication	Lower Speed Indication
Physical Link Down	Off	Off
Physical Link UP	Solid Green	Solid Amber
Link Tx/Rx Activity	Blinking Green	Blinking Amber
Beaconing	Slow Blinking Amber	Slow Blinking Amber
Fault	Slow Blinking Amber	Slow Blinking Amber

## Status LEDs

A set of status LEDs are typically located on one side of a network switch. The status LEDs provide a visual indication on what is physically wrong with the network switch. Typical LEDs on the front panel are for PSU (Power Supply Units), fans and system. Locator LEDs are also found on the front panel of a switch. Let's call the different components for which the LEDs are there as just units for now.

- **Number of LEDs per unit** — Each unit should have only 1 LED.
- **Location** — All units should have their LEDs on the righthand side of the switch after the physical ports.
- **Unit label** — The label should be printed on the front panel directly above the LED.
- **Colors** — The focus should be on giving a network operator a simple set of indications that provide basic information about the unit. The following section has more information about the indications, but colors are standardized on green and amber. These colors are universally found on all status LEDs and should be easy to implement on future switches.
- **Defined LED** — Every network switch must have LEDs for the following:
  - PSU
  - Fans
  - System LED



- **Locator LED**
- **PSU LEDs** — Each PSU must have its own LED. PSU faults are difficult to debug. If a network operator knows which PSU is faulty, he or she can quickly check if it is powered up correctly and if that fault persists, replace the PSU.

Unit Activity	Indication
Installed and power OK	Solid Green
Installed, but no power	Slow Blinking Amber
Installed, powered, but has faults.	Slow Blinking Amber

- **Fan LED** — A network switch may have multiple fan trays (3 - 6). It is difficult to put an LED for each fan tray on the front panel, given the limited real estate. Hence, the recommendation is one LED for all fans.

Unit Activity	Indication
All fans running OK	Solid Green
Fault on any one of the fans.	Slow Blinking Amber

- **System LED** — A network switch must have a system LED that indicates the general state of a switch. This state could be of hardware, software, or both. It is up to the individual switch NOS to decide what this LED indicates. But the LED can have only the following indications:

Unit Activity	Indication
All OK	Solid Green
Not OK	Slow Blinking Amber

- **Locator LED** — The locator LED helps locate a particular switch in a data center full of switches. Thus, it should have a different color and predefined location. It must be located at the top right corner on the front panel of the switch and its color must be blue.

Unit Activity	Indication
Locate enabled	Blinking Blue
Locate disabled	Off

## Locate a Switch

Cumulus Linux 3.3 and newer versions support the locator LED functionality for identifying a switch, by blinking a single LED on a specified network port, on the following switches:



- Celestica Seastone, Dell Z9100-ON, Edgecore AS7712-32X, Penguin Arctica 3200C, Quanta QuantaMesh BMS T4048-IX2, Supermicro SSE-C3632S

To use the locator LED functionality, run:

```
cumulus@switch:~$ ethtool -p --identify PORT_NAME TIME
```

In the example above, `INTERFACE_NAME` should be replaced with the name of the port, and `TIME` should be replaced with the length of time, in seconds, that the port LED should blink.



This functionality is only supported on `swp*` ports, not `eth*` management interfaces.

## Monitoring Virtual Device Counters

Cumulus Linux gathers statistics for VXLANS and VLANs using virtual device counters. These counters are supported on Tomahawk, Trident II+ and Trident II-based platforms only; see the [Cumulus Networks HCL](#) for a list of supported platforms.

You can retrieve the data from these counters using tools like `ip -s link show`, `ifconfig`, `/proc/net/dev`, or `netstat -i`.

## Contents

### This topic describes ...

- Sample VXLAN Statistics (see page 953)
- Sample VLAN Statistics (see page 955)
  - For VLANs Using the VLAN-aware Bridge Mode Driver (see page 955)
  - For VLANs Using the Traditional Bridge Mode Driver (see page 955)
- Configure the Counters in switchd (see page 956)
  - Configure the Poll Interval (see page 956)
  - Configure Internal VLAN Statistics (see page 956)
  - Clear Statistics (see page 956)
- Caveats and Errata (see page 957)

## Sample VXLAN Statistics

VXLAN statistics are available as follows:

- Aggregate statistics are available per VNI; this includes access and network statistics.
- Network statistics are available for each VNI and displayed against the VXLAN device. This is independent of the VTEP used, so this is a summary of the VNI statistics across all tunnels.
- Access statistics are available per VLAN subinterface.

First, get interface information regarding the VXLAN bridge:

```
cumulus@switch:~$ brctl show br-vxln16757104
bridge name          bridge id      STP enabled    interfaces
-vxln16757104        8000.443839006988    no           swp2s0.6
                                         swp2s1.6
                                         swp2s2.6
                                         swp2s3.6
                                         vxln16757104
```

To get VNI statistics, run:

```
cumulus@switch:~$ ip -s link show br-vxln16757104
62: br-vxln16757104: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc
noqueue state UP mode DEFAULT
    link/ether 44:38:39:00:69:88 brd ff:ff:ff:ff:ff:ff
    RX: bytes   packets   errors   dropped overrun mcast
      10848       158        0        0        0        0
    TX: bytes   packets   errors   dropped carrier collsns
      27816       541        0        0        0        0
```

To get access statistics, run:

```
cumulus@switch:~$ ip -s link show swp2s0.6
63: swp2s0.6@swp2s0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc
noqueue master br-vxln16757104 state UP mode DEFAULT
    link/ether 44:38:39:00:69:88 brd ff:ff:ff:ff:ff:ff
    RX: bytes   packets   errors   dropped overrun mcast
      2680        39        0        0        0        0
    TX: bytes   packets   errors   dropped carrier collsns
      7558       140        0        0        0        0
```

To get network statistics, run:

```
cumulus@switch:~$ ip -s link show vxln16757104
61: vxln16757104: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc
noqueue master br-vxln16757104 state UNKNOWN mode DEFAULT
    link/ether e2:37:47:db:f1:94 brd ff:ff:ff:ff:ff:ff
    RX: bytes   packets   errors   dropped overrun mcast
      0         0         0         0         0         0
    TX: bytes   packets   errors   dropped carrier collsns
      0         0         0         9         0         0
```



## Sample VLAN Statistics

### For VLANs Using the VLAN-aware Bridge Mode Driver

For a bridge using the [VLAN-aware bridge mode \(see page 415\)](#) driver, the bridge is a just a container and each VLAN (VID/PVID) in the bridge is an independent L2 broadcast domain. As there is no netdev available to display these VLAN statistics, the `switchd` nodes are used instead:

```
cumulus@switch:~$ ifquery bridge
auto bridge
iface bridge inet static
    bridge-vlan-aware yes
    bridge-ports swp2s0 swp2s1
    bridge-stp on
    bridge-vids 2000-2002 4094
cumulus@switch:~$ ls /cumulus/switchd/run/stats/vlan/
2 2000 2001 2002 all
cumulus@switch:~$ cat /cumulus/switchd/run/stats/vlan/2000/aggregate
Vlan id                      : 2000
L3 Routed In Octets           : -
L3 Routed In Packets          : -
L3 Routed Out Octets          : -
L3 Routed Out Packets         : -
Total In Octets               : 375
Total In Packets              : 3
Total Out Octets              : 387
Total Out Packets             : 3
```

### For VLANs Using the Traditional Bridge Mode Driver

For a bridge using the [traditional bridge mode \(see page 427\)](#) driver, each bridge is a single L2 broadcast domain and is associated with an internal VLAN. This internal VLAN's counters are displayed as bridge netdev stats.

```
cumulus@switch:~$ brctl show br0
bridge name      bridge id      STP enabled      interfaces
br0              8000.443839006989    yes            bond0.100
                                         swp2s2.100
cumulus@switch:~$ ip -s link show br0
42: br0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue
state UP mode DEFAULT
    link/ether 44:38:39:00:69:89 brd ff:ff:ff:ff:ff:ff
    RX: bytes   packets   errors   dropped overrun mcast
        23201498   227514     0       0       0       0
    TX: bytes   packets   errors   dropped carrier collsns
        18198262   178443     0       0       0       0
```



## Configure the Counters in switchd

These counters are enabled by default. To configure them, use `cl-cfg` and configure them as you would any other `switchd` parameter (see page 204). The `switchd` parameters are as follows:

- `stats.vlan.aggregate`, which controls the statistics available for each VLAN. Its value defaults to *BRIEF*.
- `stats.vxlan.aggregate`, which controls the statistics available for each VNI (access and network). Its value defaults to *DETAIL*.
- `stats.vxlan.member`, which controls the statistics available for each local/access port in a VXLAN bridge. Its value defaults to *BRIEF*.

The values for each parameter can be one of the following:

- `NONE`: This disables the counter.
- `BRIEF`: This provides tx/rx packet/byte counters for the associated parameter.
- `DETAIL`: This provides additional feature-specific counters. In the case of `stats.vxlan.aggregate`, `DETAIL` provides access vs. network statistics. For the other types, `DETAIL` has the same effect as `BRIEF`.



If you change one of these settings on the fly, the new configuration applies only to those VNIs or VLANs set up after the configuration changed; previously allocated counters remain as is.

## Configure the Poll Interval

The virtual device counters are polled periodically. This can be CPU intensive, so the interval is configurable in `switchd`, with a default of 2 seconds.

```
# Virtual devices hw-stat poll interval (in seconds)
#stats.vdev_hw_poll_interval = 2
```

## Configure Internal VLAN Statistics

For debugging purposes, you may need to access packet statistics associated with internal VLAN IDs. These statistics are hidden by default, but can be configured in `switchd`:

```
#stats.vlan.show_internal_vlans = FALSE
```

## Clear Statistics

Since `ethtool` is not supported for virtual devices, you cannot clear the statistics cache maintained by the kernel. You can clear the hardware statistics via `switchd`:



```
cumulus@switch:~$ sudo echo 1 > /cumulus/switchd/clear/stats/vlan  
cumulus@switch:~$ sudo echo 1 > /cumulus/switchd/clear/stats/vxlan  
cumulus@switch:~$
```

## Caveats and Errata

- Currently the CPU port is internally added as a member of all VLANs. Because of this, packets sent to the CPU are counted against the corresponding VLAN's tx packets/bytes. There is no workaround.
- When checking the virtual counters for the bridge, the TX count is the number of packets destined to the CPU before any hardware policers take effect. For example, if 500 broadcast packets are sent into the bridge, the CPU is also sent 500 packets. These 500 packets are policed by the default ACLs in Cumulus Linux, so the CPU might receive fewer than the 500 packets if the incoming packet rate is too high. The TX counter for the bridge should be equal to  $500 * (\text{number of ports in the bridge} - \text{incoming port} + \text{CPU port})$  or just  $500 * \text{number of ports in the bridge}$ .
- You cannot use `ethtool -S` for virtual devices. This is because the counters available via `netdev` are sufficient to display the vlan/vxlan counters currently supported in the hardware (only rx/tx packets/bytes are supported currently).

## ASIC Monitoring

Cumulus Linux provides an ASIC monitoring tool that collects and distributes data about the state of the ASIC. The monitoring tool polls for data at specific intervals and takes certain actions so that you can quickly identify and respond to problems, such as:

- Microbursts that result in longer packet latency
- Packet buffer congestion that might lead to packet drops
- Network problems with a particular switch, port, or traffic class



ASIC monitoring is currently supported on Mellanox switches only.

### Contents

#### This topic describes ...

- [What Type of Statistics Can You Collect? \(see page 957\)](#)
- [Collecting Queue Lengths in Histograms \(see page 958\)](#)
- [Configure ASIC Monitoring \(see page 959\)](#)
- [Configuration Examples \(see page 962\)
  - \[Queue Length Histograms \\(see page 962\\)\]\(#\)
  - \[Packet Drops Due to Errors \\(see page 962\\)\]\(#\)
  - \[Queue Length \\(Histogram\\) with Collect Actions \\(see page 963\\)\]\(#\)](#)
- [Example Snapshot File \(see page 964\)](#)
- [Example Log Message \(see page 964\)](#)
- [ASIC Monitoring Settings \(see page 964\)](#)



## What Type of Statistics Can You Collect?

You can collect the following type of statistics with the ASIC monitoring tool:

- A fine-grained history of queue lengths using histograms maintained by the ASIC
- Packet counts per port, priority and size
- Dropped packet, pause frame, and ECN-marked packet counts
- Buffer congestion occupancy per port, priority and buffer pool, and at input and output ports

## Collecting Queue Lengths in Histograms

The Mellanox Spectrum ASIC provides a mechanism to measure and report egress queue lengths in histograms (a graphical representation of data, which is divided into intervals or bins). You can configure the ASIC to measure up to 64 egress queues. Each queue is reported through a histogram with 10 bins, where each bin represents a range of queue lengths.

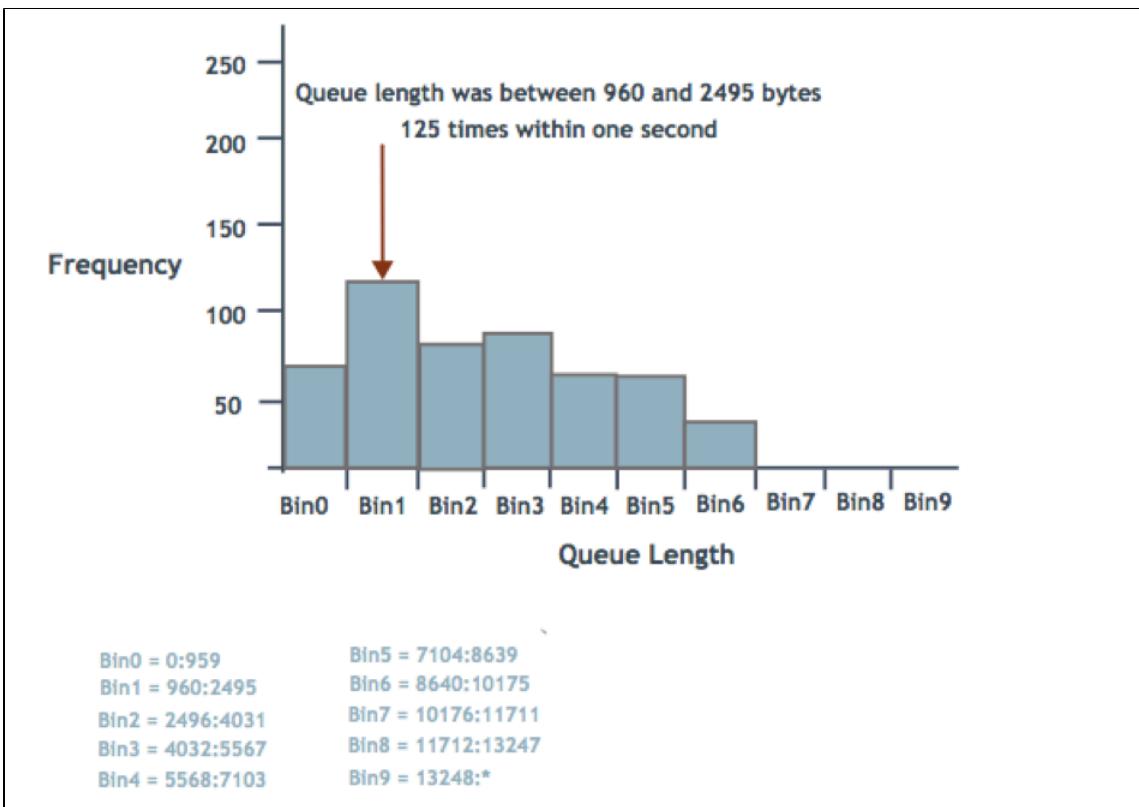
You configure the histogram with a minimum size boundary (Min) and a histogram size. You then derive the maximum size boundary (Max) by adding the minimum size boundary and the histogram size.

The 10 bins are numbered 0 through 9. Bin 0 represents queue lengths up to the Min specified, including queue length 0. Bin 9 represents queue lengths of Max and above. Bins 1 through 8 represent equal-sized ranges between the Min and Max, which is determined by dividing the histogram size by 8.

For example, consider the following histogram queue length ranges, in bytes:

- Min = 960
- Histogram size = 12288
- Max = 13248
- Range size = 1536
- Bin 0: 0:959
- Bin 1: 960:2495
- Bin 2: 2496:4031
- Bin 3: 4032:5567
- Bin 4: 5568:7103
- Bin 5: 7104:8639
- Bin 6: 8640:10175
- Bin 7: 10176:11711
- Bin 8: 11712:13247
- Bin 9: 13248:\*

The following illustration demonstrates a histogram showing how many times the queue length for a port was in the ranges specified by each bin. The example shows that the queue length was between 960 and 2495 bytes 125 times within one second.



## Configure ASIC Monitoring

The ASIC monitoring tool is managed by the `asic-monitor` service, (which is managed by `systemd`). The `asic-monitor` service reads the `/etc/cumulus/datapath/monitor.conf` configuration file to determine what statistics to collect and when to trigger. The service always starts; however, if the configuration file is empty, the service exits.

The `monitor.conf` configuration file provides information about the type of data to collect, the switch ports to monitor, how and when to start reading the ASIC (such as when a specific queue length or number of packets dropped is reached), and what actions to take (create a snapshot file, send a message to the `/var/log/syslog` file, or collect more data).

To configure ASIC monitoring, edit the `/etc/cumulus/datapath/monitor.conf` file and restart the `asic-monitor` service. The `asic-monitor` service reads the new configuration file and then runs until it is stopped.

The following procedure describes how to monitor queue lengths using a histogram. The settings are configured to collect data every second and write the results to a snapshot file. When the size of the queue reaches 500 bytes, the system sends a message to the `/var/log/syslog` file.

To monitor queue lengths using a histogram:

1. Open the `/etc/cumulus/datapath/monitor.conf` file in a text editor.

```
cumulus@switch:~$ sudo nano /etc/cumulus/datapath/monitor.conf
```

2. At the end of the file, add the following line to specify the name of the histogram monitor (port group). The example uses `histogram_pg`; however, you can use any name you choose. You must use the same name with all histogram settings.



```
monitor.port_group_list = [histogram_pg]
```

3. Add the following line to specify the ports you want to monitor. The following example sets swp1 through swp50.

```
monitor.histogram_pg.port_set = swp1-swp50
```

4. Add the following line to set the data type to `histogram`. This is the data type for histogram monitoring.

```
monitor.histogram_pg.stat_type = histogram
```

5. Add the following line to set the trigger type to `timer`. Currently, the only trigger type available is `timer`.

```
monitor.histogram_pg.trigger_type = timer
```

6. Add the following line to set the frequency at which data collection starts. In the following example, the frequency is set to one second.

```
monitor.histogram_pg.timer = 1s
```

7. Add the following line to set the actions you want to take when data is collected. In the following example, the system writes the results of data collection to a snapshot file and sends a message to the `/var/log/syslog` file .

```
monitor.histogram_pg.action_list = [snapshot,log]
```

8. Add the following line to specify a name and location for the snapshot file. In the following example, the system writes the snapshot to a file called `histogram_stats` in the `/var/lib/cumulus` directory and adds a suffix to the file name with the snapshot file count (see the following step).

```
monitor.histogram_pg.snapshot.file = /var/lib/cumulus  
/histogram_stats
```

9. Add the following line to set the number of snapshots that are taken before the system starts overwriting the earliest snapshot files.

In the following example, because the snapshot file count is set to 64, the first snapshot file is named `histogram_stats_0` and the 64th snapshot is named `histogram_stats_63`. When the 65th snapshot is taken, the original snapshot file (`histogram_stats_0`) is overwritten and the sequence continues until `histogram_stats_63` is written. Then, the sequence restarts.



```
monitor.histogram_pg.snapshot.file_count = 64
```

10. Add the following line to include a threshold, which determines how to collect data. Setting a threshold is optional. In the following example, when the size of the queue reaches 500 bytes, the system sends a message to the `/var/log/syslog` file .

```
monitor.histogram_pg.log.queue_bytes = 500
```

11. Add the following lines to set the size, minimum boundary, and sampling time of the histogram. Adding the histogram size and the minimum boundary size together produces the maximum boundary size. These settings are used to represent the range of queue lengths per bin.

```
monitor.histogram_pg.histogram.minimum_bytes_boundary = 960  
monitor.histogram_pg.histogram.histogram_size_bytes = 12288  
monitor.histogram_pg.histogram.sample_time_ns = 1024
```

12. Save the file, then restart the `asic-monitor` service with the following command.

```
cumulus@switch:~$ systemctl restart asic-monitor.service
```

**⚠️** Restarting the `asic-monitor` service does not disrupt traffic or require you to restart `switchd`. The service is enabled by default when you boot the switch and restarts when you restart `switchd`.

### **⚠️ Important**

Overhead is involved in collecting the data, which uses both the CPU and SDK process and can affect execution of `switchd`. Snapshots and logs can occupy a lot of disk space if you do not limit their number.

To collect other data, such as all packets per port, buffer congestion, or packet drops due to error, follow the procedure above but change the port group list setting to include the port group name you want to use. For example, to monitor packet drops due to buffer congestion:

```
monitor.port_group_list = [buffers_pg]  
monitor.buffers_pg.port_set = swp1-swp50  
monitor.buffers_pg.stat_type = buffer  
...
```

Certain settings in the procedure above (such as the histogram size, boundary size, and sampling time) only apply to the histogram monitor. All ASIC monitor settings are described in [ASIC Monitoring Settings \(see page 964\)](#).

## Configuration Examples

Several configuration examples are provided below.

### *Queue Length Histograms*

In the following example:

- Queue length histograms are collected every second for swp1 through swp50.
- The results are written to the `/var/lib/cumulus/histogram_stats` snapshot file.
- The size of the histogram is set to 12288 bytes, the minimum boundary to 960 bytes, and the sampling time to 1024 nanoseconds.
- A threshold is set so that when the size of the queue reaches 500 bytes, the system sends a message to the `/var/log/syslog` file.

```

monitor.port_group_list          = [histogram_pg]
monitor.histogram_pg.port_set    = swp1-swp50
monitor.histogram_pg.stat_type   = histogram
monitor.histogram_pg.cos_list    = [0]
monitor.histogram_pg.trigger_type= timer
monitor.histogram_pg.timer       = 1s
monitor.histogram_pg.action_list = [snapshot,log]
monitor.histogram_pg.snapshot.file= /var/lib
/cumulus/histogram_stats
monitor.histogram_pg.snapshot.file_count = 64
monitor.histogram_pg.log.queue_bytes = 500
monitor.histogram_pg.histogram.minimum_bytes_boundary = 960
monitor.histogram_pg.histogram.histogram_size_bytes = 12288
monitor.histogram_pg.histogram.sample_time_ns = 1024

```

### *Packet Drops Due to Errors*

In the following example:

- Packet drops on swp1 through swp50 are collected every two seconds.
- If the number of packet drops is greater than 100, the results are written to the `/var/lib/cumulus/discard_stats` snapshot file and the system sends a message to the `/var/log/syslog` file.

```

monitor.port_group_list          = [discards_pg]
monitor.discards_pg.port_set     = swp1-swp50
monitor.discards_pg.stat_type    = packet
monitor.discards_pg.action_list  = [snapshot,log]
monitor.discards_pg.trigger_type= timer
monitor.discards_pg.timer        = 2s
monitor.discards_pg.log.packet_error_drops = 100
monitor.discards_pg.snapshot.packet_error_drops = 100

```

```

monitor.discards_pg.snapshot.file          = /var/lib/cumulus
/discard_stats
monitor.discards_pg.snapshot.file_count   = 16

```

## Queue Length (Histogram) with Collect Actions

A collect action triggers the collection of additional information. You can daisy chain multiple monitors (port groups) into a single collect action.

In the following example:

- Queue length histograms are collected for swp1 through swp50 every second.
- The results are written to the `/var/lib/cumulus/histogram_stats` snapshot file.
- When the queue length reaches 500 bytes, the system sends a message to the `/var/log/syslog` file and collects additional data; buffer occupancy and all packets per port.
- Buffer occupancy data is written to the `/var/lib/cumulus/buffer_stats` snapshot file and all packets per port data is written to the `/var/lib/cumulus/all_packet_stats` snapshot file.
- In addition, packet drops on swp1 through swp50 are collected every two seconds. If the number of packet drops is greater than 100, the results are written to the `/var/lib/cumulus/discard_stats` snapshot file and a message is sent to the `/var/log/syslog` file.

```

monitor.port_group_list                  = [histogram_pg,
discards_pg]

monitor.histogram_pg.port_set            = swp1-swp50
monitor.histogram_pg.stat_type          = buffer
monitor.histogram_pg.cos_list           = [0]
monitor.histogram_pg.trigger_type       = timer
monitor.histogram_pg.timer              = 1s
monitor.histogram_pg.action_list        = [snapshot,
collect,log]
monitor.histogram_pg.snapshot.file      = /var/lib
/cumulus/histogram_stats
monitor.histogram_pg.snapshot.file_count = 64
monitor.histogram_pg.histogram.minimum_bytes_boundary = 960
monitor.histogram_pg.histogram.histogram_size_bytes = 12288
monitor.histogram_pg.histogram.sample_time_ns = 1024
monitor.histogram_pg.log.queue_bytes    = 500
monitor.histogram_pg.collect.queue_bytes = 500
monitor.histogram_pg.collect.port_group_list = [buffers_pg,
all_packet_pg]

monitor.buffers_pg.port_set             = swp1-swp50
monitor.buffers_pg.stat_type            = buffer
monitor.buffers_pg.action_list          = [snapshot]
monitor.buffers_pg.snapshot.file        = /var/lib
/cumulus/buffer_stats
monitor.buffers_pg.snapshot.file_count  = 8

```



```
monitor.all_packet_pg.port_set          = swp1-swp50
monitor.all_packet_pg.stat_type         = packet_all
monitor.all_packet_pg.action_list       = [snapshot]
monitor.all_packet_pg.snapshot.file     = /var/lib
/cumulus/all_packet_stats
monitor.all_packet_pg.snapshot.file_count = 8

monitor.discard_pg.port_set            = swp1-swp50
monitor.discard_pg.stat_type          = packet
monitor.discard_pg.action_list        = [snapshot,log]
monitor.discard_pg.trigger_type       = timer
monitor.discard_pg.timer              = 2s
monitor.discard_pg.log.packet_error_drops = 100
monitor.discard_pg.snapshot.packet_error_drops = 100
monitor.discard_pg.snapshot.file      = /var/lib
/cumulus/discard_stats
monitor.discard_pg.snapshot.file_count = 16
```



Certain actions require additional settings. For example, if the `snapshot` action is specified, a snapshot file is also required. If the `log` action is specified, a log threshold is also required. See [action\\_list \(see page 966\)](#) for additional settings required for each *action*.

## Example Snapshot File

A snapshot action writes a snapshot of the current state of the ASIC to a file. Because parsing the file and finding the information can be tedious, you can use a third-party analysis tool to analyze the data in the file. The following example shows a snapshot of queue lengths.

```
{"timestamp_info": {"start_datetime": "2017-03-16 21:36:40.775026", "end_datetime": "2017-03-16 21:36:40.775848"}, "buffer_info": null, "packet_info": null, "histogram_info": {"swp2": {"0": 55531}, "swp32": {"0": 48668}, "swp1": {"0": 64578}}}
```

## Example Log Message

A log action writes out the ASIC state to the `/var/log/syslog` file. In the following example, when the size of the queue reaches 500 bytes, the system sends this message to the `/var/log/syslog` file:

```
2018-02-26T20:14:41.560840+00:00 cumulus asic-monitor-module INFO:
2018-02-26 20:14:41.559967: Egress queue(s) greater than 500 bytes in
monitor port group histogram_pg.
```



## ASIC Monitoring Settings

The following table provides descriptions of the ASIC monitor settings.

Setting	Description
port_group_list	<p>Specifies the names of the monitors (port groups) you want to use to collect data, such as <code>discards_pg</code>, <code>histogram_pg</code>, <code>all_packet_pg</code>, <code>buffers_pg</code>. You can provide any name you want for the port group; the names above are just examples. You must use the same name for all the settings of a particular port group.</p> <p>Example:</p> <pre>monitor.port_group_list = [histogram_pg, discards_pg, buffers_pg, all_packets_pg]</pre> <div style="border: 2px solid #f0a; padding: 10px; margin-top: 10px;"><p><span style="color: yellow;">⚠</span> You must specify at least one port group. If the port group list is empty, systemd shuts down the asic-monitor service.</p></div>
<port_group_name>.port_set	<p>Specifies the range of ports monitored. You can specify GLOBs and comma-separated lists; for example, <code>swp1-swp4,swp8,swp10-swp50</code>.</p> <p>Example:</p> <pre>monitor.histogram_pg.port_set = swp1-swp50</pre>
<port_group_name>.stat_type	<p>Specifies the type of data that the port group collects.</p> <ul style="list-style-type: none"><li>For histograms, specify <code>histogram</code>. For example: <code>monitor.histogram_pg.stat_type = histogram</code></li><li>For packet drops due to errors, specify <code>packet</code>. For example: <code>monitor.discards_pg.stat_type = packet</code></li><li>For packet occupancy statistics, specify <code>buffer</code>. For example: <code>monitor.buffers_pg.stat_type = buffer</code></li><li>For all packets per port, specify <code>packet_all</code>. For example: <code>monitor.all_packet_pg.stat_type = packet_all</code></li></ul>
<port_group_name>.cos_list	<p>For histogram monitoring, each CoS (Class of Service) value in the list has its own histogram on each port. The global limit on the number of histograms is an average of one histogram per port.</p> <p>Example:</p> <pre>monitor.histogram_pg.cos_list = [0]</pre>
<port_group_name>.trigger_type	<p>Specifies the type of trigger that initiates data collection. Currently, the only option is <code>timer</code>. At least one port group must have a timer configured, otherwise no data is ever collected.</p> <p>Example:</p> <pre>monitor.histogram_pg.trigger_type = timer</pre>



<port_group_name>.timer	<p>Specifies the frequency at which data is collected; for example, a setting of 1s indicates that data is collected once per second. You can set the timer to the following:</p> <ul style="list-style-type: none"><li>• 1 to 60 seconds: 1s, 2s, and so on up to 60s</li><li>• 1 to 60 minutes: 1m, 2m, and so on up to 60m</li><li>• 1 to 24 hours: 1h, 2h, and so on up to 24h</li><li>• 1 to 7 days: 1d, 2d and so on up to 7d</li></ul> <p>Example:</p> <pre>monitor.histogram_pg.timer = 4s</pre>
<port_group_name>.action_list	<p>Specifies one or more actions that occur when data is collected:</p> <ul style="list-style-type: none"><li>• <code>snapshot</code> writes a snapshot of the data collection results to a file. If you specify this action, you must also specify a snapshot file (described below). You can also specify a threshold that initiates the snapshot action, but this is not required. For example: <code>monitor.histogram_pg.action_list = [snapshot]</code> <code>monitor.histogram_pg.snapshot.file = /var/lib/cumulus/histogram_stats</code></li><li>• <code>collect</code> gathers additional data. If you specify this action, you must also specify the port groups for the additional data you want to collect. For example: <code>monitor.histogram_pg.action_list = [collect]</code> <code>monitor.histogram_pg.collect.port_group_list = [buffers_pg,all_packet_pg]</code></li><li>• <code>log</code> sends a message to the <code>/var/log/syslog</code> file. If you specify this action, you must also specify a threshold that initiates the log action. For example: <code>monitor.histogram_pg.action_list = [log]</code> <code>monitor.histogram_pg.log.queue_bytes = 500</code></li></ul> <p>You can use all three of these actions in one monitoring step. For example:</p> <pre>monitor.histogram_pg.action_list = [snapshot,collect,log]</pre> <p><b>Note:</b> If an action appears in the action list but does not have the required settings (such as a threshold for the log action), the ASIC monitor stops and reports an error.</p>
<port_group_name>.snapshot.file	<p>Specifies the name for the snapshot file. All snapshots use this name, with a sequential number appended to it. See the <code>snapshot.file_count</code> setting.</p> <p>Example:</p> <pre>monitor.histogram_pg.snapshot.file = /var/lib/cumulus/histogram_stats</pre>

<port_group_name>.snapshot.file_count	<p>Specifies the number of snapshots that can be created before the first snapshot file is overwritten.</p> <p>In the following example, because the snapshot file count is set to 64, the first snapshot file is named <code>histogram_stats_0</code> and the 64th snapshot is named <code>histogram_stats_63</code>. When the 65th snapshot is taken, the original snapshot file (<code>histogram_stats_0</code>) is overwritten and the sequence restarts.</p> <p>Example:</p> <pre>monitor.histogram_pg.snapshot.file_count = 64</pre> <div style="border: 2px solid #f0a; padding: 10px; margin-top: 10px;"> <span style="color: #f0a; font-size: 1.5em;">⚠️</span> While more snapshots provide you with more data, they can occupy a lot of disk space on the switch.         </div>
<port_group_name>.<action>.queue_bytes	<p><i>For histogram monitoring</i></p> <p>Specifies a threshold for the histogram monitor. This is the length of the queue in bytes that initiates a specified action (snapshot, log, collect).</p> <p>Examples:</p> <pre>monitor.histogram_pg.snapshot.queue_bytes = 500 monitor.histogram_pg.log.queue_bytes = 500 monitor.histogram_pg.collect.queue_bytes = 500</pre>
<port_group_name>.<action>.packet_error_drops	<p><i>For monitoring packet drops due to error</i></p> <p>Specifies a threshold for the packet drops due to error monitor. This is the number of packet drops due to error that initiates a specified action (snapshot, log, collect).</p> <p>Examples:</p> <pre>monitor.discards_pg.snapshot.packet_error_drops = 500 monitor.discards_pg.log.packet_error_drops = 500 monitor.discards_pg.collect.packet_error_drops = 500</pre>
<port_group_name>.<action>.packet_congestion_drops	<p><i>For monitoring packet drops due to buffer congestion</i></p> <p>Specifies a threshold for the packet drops due to buffer congestion monitor. This is the number of packet drops due to buffer congestion that initiates a specified action (log or collect).</p> <p>Examples:</p> <pre>monitor.buffers_pg.log.packet_congestion_drops = 500monitor.buffers_pg.snapshot. packet_congestion_drops = 500monitor.buffers_pg. collect.packet_congestion_drops = 500</pre>
	<i>For histogram monitoring</i>

Setting	Description
<port_group_name>.histogram.minimum_bytes_boundary	<p>The minimum boundary size for the histogram in bytes. On a Mellanox switch, this number must be a multiple of 96. Adding this number to the size of the histogram produces the maximum boundary size. These values are used to represent the range of queue lengths per bin.</p> <p>Example:</p> <pre>monitor.histogram_pg.histogram.minimum_bytes_boundary = 960</pre>
<port_group_name>.histogram.histogram_size_bytes	<p><i>For histogram monitoring</i></p> <p>The size of the histogram in bytes. Adding this number and the minimum_bytes_boundary value together produces the maximum boundary size. These values are used to represent the range of queue lengths per bin.</p> <p>Example:</p> <pre>monitor.histogram_pg.histogram.histogram_size_bytes = 12288</pre>
<port_group_name>.histogram.sample_time_ns	<p><i>For histogram monitoring</i></p> <p>The sampling time of the histogram in nanoseconds.</p> <p>Example:</p> <pre>monitor.histogram_pg.histogram.sample_time_ns = 1024</pre>

## Understanding the `cl-support` Output File

The `cl-support` script generates a compressed archive file of useful information for troubleshooting. The system either creates the archive file automatically or you can create the archive file manually.

The system creates the `cl-support` archive file automatically for the following reasons:

- When there is a `core file dump` of any application (not specific to Cumulus Linux, but something all Linux distributions support), located in `/var/support/core`.
- After the first failure of one of several monitored services since the switch was rebooted or power cycled.

To create the `cl-support` archive file manually, run the `cl-support` command:

```
cumulus@switch:~$ sudo cl-support
```

If the Cumulus Networks support team requests that you submit the output from `cl-support` to help with the investigation of issues you might experience with Cumulus Linux and you need to include security-sensitive information, such as the `sudoers` file, use the `-s` option:

```
cumulus@switch:~$ sudo cl-support -s
```



For information on the directories included in the `c1-support` archive, see:

- [Troubleshooting the etc Directory \(see page 971\)](#) — In terms of the sheer number of files, `/etc` contains the largest number of files to send to Cumulus Networks. However, log files might be significantly larger in file size.
- [Troubleshooting Log Files \(see page 969\)](#) — This guide highlights the most important log files to inspect. Keep in mind, `c1-support` includes all of the log files.

## Troubleshooting Log Files

The only real unique entity for logging on Cumulus Linux compared to any other Linux distribution is `switchd.log`, which logs the HAL (hardware abstraction layer) from hardware like the Broadcom or Mellanox ASIC.

[This guide on NixCraft](#) is amazing for understanding how `/var/log` works. The green highlighted rows below are the most important logs and usually looked at first when debugging.

Log	Description	Why is this important?
<code>/var/log/alternatives.log</code>	Information from the update-alternatives are logged into this log file.	
<code>/var/log/apt</code>	Information the <code>apt</code> utility can send logs here; for example, from <code>apt-get install</code> and <code>apt-get remove</code> .	
<code>/var/log/audit/*</code>	Contains log information stored by the Linux audit daemon, <code>auditd</code> .	
<code>/var/log/auth.log</code>	Authentication logs.  Note that Cumulus Linux does not write to this log file; but because it's a standard file, Cumulus Linux creates it as a zero length file.	
<code>/var/log/autoprovision</code>	Logs output generated by running the <a href="#">zero touch provisioning (see page 72)</a> script.	
<code>/var/log/boot.log</code>	Contains information that is logged when the system boots.	
<code>/var/log/btmp</code>	This file contains information about failed login attempts. Use the <code>last</code> command to view the <code>btmp</code> file. For example:  <pre>cumulus@switch:~\$ last -f /var/log/btmp   more</pre>	
<code>/var/log/clagd.log</code>	Logs status of the <code>clagd</code> service ( <a href="#">see page 440</a> ).	

/var/log/dmesg	<p>Contains kernel ring buffer information. When the system boots up, it prints number of messages on the screen that display information about the hardware devices that the kernel detects during boot process. These messages are available in the kernel ring buffer and whenever a new message arrives, the old message gets overwritten. You can also view the content of this file using the <code>dmesg</code> command.</p> <p>Note that Cumulus Linux does not write to this log file; but because it's a standard file, Cumulus Linux creates it as a zero length file.</p>	
/var/log/dpkg.log	Contains information that is logged when a package is installed or removed using the <code>dpkg</code> command.	
/var/log/faillog	<p>Contains failed user login attempts. Use the <code>faillog</code> command to display the contents of this file.</p> <p>Note that Cumulus Linux does not write to this log file; but because it's a standard file, Cumulus Linux creates it as a zero length file.</p>	
/var/log/fsck/*	<p>The <code>fsck</code> utility is used to check and optionally repair one or more Linux filesystems.</p> <p>Note that Cumulus Linux does not write to this log file; but because it's a standard file, Cumulus Linux creates it as a zero length file.</p>	
/var/log/installer/*	Directory containing files related to the installation of Cumulus Linux.	
/var/log/lastlog	Formats and prints the contents of the last login log file.	
/var/log/netd.log	Log file for <a href="#">NCLU (see page 88)</a> .	
/var/log/news/*	<p>The <code>news</code> command keeps you informed of news concerning the system.</p> <p>Note that Cumulus Linux does not write to this log file; but because it's a standard file, Cumulus Linux creates it as a zero length file.</p>	
/var/log/ntpstats	Logs for network configuration protocol.	
/var/log/openvswitch/*	ovsdb-server logs.	
/var/log/frr/*	Logs for FRRouting.	



Log	Description	Why is this important?
		This is how Cumulus Networks troubleshoots routing. For example an md5 or mtu mismatch with OSPF.
/var/log/rdnbrd.log	Logs for <a href="#">redistribute neighbor</a> (see page 838).	
/var/log/snapper.log	Log file for <a href="#">snapshots</a> (see page 56).	These logs are valuable for the snapshots you take on your switch.
/var/log/switchd.log	The HAL log for Cumulus Linux.	This is specific to Cumulus Linux. Any <code>switchd</code> crashes are logged here.
/var/log/syslog	The main system log, which logs everything except auth-related messages.	The primary log; it's easiest to <code>grep</code> this file to see what occurred during a problem.
/var/log/wtmp	Login records file.	

## Troubleshooting the etc Directory

The `cl-support` (see page 968) script replicates the `/etc` directory.

Files that `cl-support` deliberately excludes are:

File	Description
/etc/nologin	<code>nologin</code> prevents unprivileged users from logging into the system.

File	Description
/etc/alternatives	update-alternatives creates, removes, maintains and displays information about the symbolic links comprising the Debian alternatives system.

This is the alphabetical of the output from running `ls -l` on the `/etc` directory structure created by `c1-support`. The green highlighted rows are the ones Cumulus Networks finds most important when troubleshooting problems.

File	Description	Why is this important?
acpi	Advanced configuration and power interface files. This directory is present only on x86 systems.	
adduser.conf	The file <code>/etc/adduser.conf</code> contains defaults for the programs <code>adduser</code> , <code>addgroup</code> , <code>deluser</code> , and <code>delgroup</code> .	
adjtime	Corrects the time to synchronize the <a href="#">system clock</a> .	
apt	<code>apt</code> (Advanced Package Tool) is the command-line <a href="#">tool for handling packages</a> . This folder contains all the configurations.	<code>apt</code> interactions or unsupported apps can affect machine performance.
audisp	The directory that contains <code>audisp-remote.conf</code> , which is the file that controls the <a href="#">audit remote logging subsystem</a> configuration.	
audit	The directory that contains the <code>/etc/audit/auditd.conf</code> , which contains configuration information specific to the <a href="#">audit daemon</a> .	
bash.bashrc	<a href="#">Bash is an sh-compatible command language interpreter</a> that executes commands read from standard input or from a file.	
bash_completion	This points to <code>/usr/share/bash-completion/bash_completion</code> .	
bash_completion.d	This folder contains app-specific code for Bash completion on Cumulus Linux, such as <code>mstptcl</code> .	
bcm.d	Broadcom-specific ASIC file structure (hardware interaction). If there are questions, <a href="#">contact the Cumulus Networks Support team</a> . This is unique to Cumulus Linux.	



File	Description	Why is this important?
bindresvport.blacklist	This file contains a list of port numbers between 600 and 1024, which should not be used by <code>bindresvport</code> .	
binfmt.d	For configuring additional binary formats for executables at boot.	
ca-certificates	The folder for <code>ca-certificates</code> . It is empty by default on Cumulus Linux; see below for more information.	
ca-certificates.conf	Each lines list the pathname of activated CA certificates under <code>/usr/share/ca-certificates</code> .	
calendar	The system-wide default calendar file.	
chef	This is an example of something that is not included by default. In this instance, <code>c1-support</code> included the <code>chef</code> folder for some reason.	This is not installed by default, but this tool could have been installed or configured incorrectly, which is why it's included in the <code>c1-support</code> output.
cron.d	<code>cron</code> is a daemon that <a href="#">executes scheduled commands</a> .	
cron.daily	See above.	
cron.hourly	See above.	
cron.monthly	See above.	
cron.weekly	See above.	
crontab	See above.	
cruft	Debian <a href="#">housecleaning tool</a> .	
cumulus	This directory contains the following: <ul style="list-style-type: none"><li>• ACL information, stored in the <code>acl</code> directory.</li><li>• <code>switchd</code> configuration file, <code>switchd.conf</code>.</li><li>• <code>qos</code>, which is under the <code>datapath</code> directory.</li><li>• The routing protocol process priority, <code>nice.conf</code>.</li></ul>	This folder is specific to Cumulus Linux and does not exist on other Linux platforms. For example, while you can configure <code>iptables</code> , to hardware accelerate rules into the hardware you need to use

File	Description	Why is this important?
	<ul style="list-style-type: none"> <li>The breakout cable configuration, under <code>ports.conf</code>.</li> </ul>	<code>cl-acltool</code> and have the rules under the <code>/etc/cumulus/acl/policy.d/&lt;filename.rules</code> )
dbus-1	Message bus for sending messages between applications.	
debconf.conf	Debconf is a <a href="#">configuration system for Debian packages</a> .	
debian_version	The complete <a href="#">Debian version string</a> .	
debsums-ignore	<code>debsums</code> <a href="#">verifies installed package files</a> against their MD5 checksums. This file identifies the packages to ignore.	
default	This folder contains files with configurable flags for many different applications (most installed by default or added manually). For example, <code>/etc/default/networking</code> has a flag for <code>EXCLUDE_INTERFACES=</code> , which is set to nothing by default, but a user could change it to something like <code>swp3</code> .	
deluser.conf	The file <code>/etc/deluser.conf</code> contains defaults for the programs <code>deluser</code> and <code>delgroup</code> .	
dhcp	This directory contains <a href="#">DHCP-specific information</a> .	
discover.conf.d	Configuration directory for hardware detection utility.	
discover-modprobe.conf	Configuration file for Linux discover-modprobe utility, which retrieves and loads kernel modules.	
dnsmasq.conf	<code>dnsmasq</code> configuration file.	
dnsmasq.d	Directory of dnsmasq configuration files.	
dpkg	The <a href="#">package manager</a> for Debian.	
e2fsck.conf	The <a href="#">configuration file for e2fsck</a> . It controls the default behavior of <code>e2fsck</code> while it checks ext2, ext3 or ext4 filesystems.	
environment	Utilized by <code>pam_env</code> for setting and unsetting environment variables.	



File	Description	Why is this important?
etckeeper	Directory of files for <code>etckeeper</code> , which enables <code>/etc</code> to be stored in a repository.	
ethertypes	This file can be used to <a href="#">show readable characters</a> instead of hexadecimal numbers for the protocols. For example, 0x0800 will be represented by IPv4.	
frr	Contains the configuration files for the <a href="#">FRRouting suite (see page 737)</a> , the preferred Cumulus Linux routing engine.	
fstab	Static information about the <a href="#">filesystems</a> .	
fstab.d	The directory that can contain additional <code>fstab</code> information; it is empty by default.	
fw_env.config	Configuration file utilized by <a href="#">U-Boot</a> . The file is present only on ARM systems.	
gai.conf	Configuration file for sorting the return information from <a href="#">getaddrinfo</a> .	
groff	The directory containing information for <code>groffer</code> , an application used for displaying <a href="#">Unix man pages</a> .	
group	The <code>/etc/group</code> file is a text file that <a href="#">defines the groups</a> on the system.	
group-	Backup for the <code>/etc/group</code> file.	
grub.d	Directory of GRUB configuration files.	
gshadow	<code>/etc/gshadow</code> contains the <a href="#">shadowed information for group accounts</a> .	
gshadow-	Backup for the <code>/etc/gshadow</code> file.	
gss		
hostapd	Directory for host AP driver files. Used for <a href="#">802.1X interfaces (see page 338)</a> .	
hostapd.conf	802.1X configuration settings. This file is generated automatically.	



File	Description	Why is this important?
host.conf	Resolver configuration file, which contains options like <code>multi</code> that determines whether <code>/etc/hosts</code> will respond with multiple entries for DNS names.	
hostname	The system host name, such as leaf1, spine1, sw1.	
hosts	The static table lookup for hostnames.	
hosts.allow	The part of the <code>host_access</code> program for controlling a simple access control language. <code>hosts.allow=Access</code> is granted when a daemon/client pair matches an entry.	
hosts.deny	See hosts.allow above, except that access is denied when a daemon/client pair matches an entry.	
hsflowd.conf	Configuration file for the <code>hsflowd</code> daemon that samples and sends sFlow data (see page 1021) to configured collectors.	
hw_init.d	Cumulus Linux/Cumulus VX hardware-specific tools.	
image-release	Contains the version of Cumulus Linux that was installed with the installer. This version number does not change when you upgrade using <code>apt-get</code> .	Useful for determining baseline version.
init	Default location of the system job configuration files.	
init.d	In order for a service to start when the switch boots, you should add the necessary script to the director here. The differences between <code>init</code> and <code>init.d</code> are explained well <a href="#">here</a> .	
initramfs-tools	Contains tools for creating an <code>initramfs</code> .	
inputrc	The initialization file utilized by <code>readline</code> .	
insserv	This application enables installed system init scripts; this directory is empty by default.	
insserv.conf	Configuration file for <code>insserv</code> .	
insserv.conf.d	Additional directory for <code>insserv</code> configurations.	
iproute2		



File	Description	Why is this important?
	Directory containing values for the Linux command line tool <code>ip</code> .	
issue	<code>/etc/issue</code> is a text file that contains a <a href="#">message or system identification</a> to be printed before the login prompt.	
issue.net	Identification file for <a href="#">telnet sessions</a> .	
kbd	Linux <a href="#">console font and keytable utilities</a> .	
kernel	Kernel executable files.	
ld.so.cache	Contains a <a href="#">compiled list of candidate libraries</a> previously found in the augmented library path.	
ld.so.conf	Used by the <code>ldconfig</code> tool, which <a href="#">configures dynamic linker run-time bindings</a> .	
ld.so.conf.d	The directory that contains additional <code>ld.so.conf</code> configuration (see above).	
ldap	The directory containing the <a href="#">ldap.conf configuration file</a> used to set the system-wide default to be applied when running LDAP clients.	
libaudit.conf	Configuration file utilized by <a href="#">get_auditfail_action</a> .	
libnl	Directory for the configuration relating to the <a href="#">libnl library</a> , which is the core library for implementing the fundamentals required to use the netlink protocol such as socket handling, message construction and parsing, and sending and receiving of data.	
lldpd.d	Directory containing configuration files whose commands are executed by <code>lldpccli</code> at startup.	
locale.alias	Locale name alias database.	
locale.gen	Locale definitions.	
localtime	Copy of the original data file for <code>/etc/timezone</code> .	
logcheck		



File	Description	Why is this important?
	Directory containing <code>logcheck.conf</code> and logfiles utilized by the <code>log check</code> program, which scans system logs for interesting lines.	
<code>login.defs</code>	Shadow password suite configuration.	
<code>logrotate.conf</code>	Rotates, compresses and mails <a href="#">system logs</a> .	
<code>logrotate.d</code>	Directory containing additional log rotate configurations.	
<code>lsb-release</code>	Shows the current version of <a href="#">Linux</a> on the system. Run <code>cat /etc/lsb-release</code> for output.	This shows you the version of the operating system you are running; also compare this to the output of <code>onie-select</code> .
<code>lvm</code>	Configuration for local volume manager.	
<code>machine-id</code>	Local machine ID.	
<code>magic</code>	Used by the <a href="#">file command</a> to determine file type. <code>magic</code> tests check for files with data in particular fixed formats.	
<code>magic.mime</code>	The <a href="#">magic MIME type</a> causes the <code>file</code> command to output MIME type strings rather than the more traditional human readable ones.	
<code>mailcap</code>	The <code>mailcap</code> file is read by the metamail program to determine how to <a href="#">display non-text at the local site</a> .	
<code>mailcap.order</code>	The <a href="#">order of entries</a> in the <code>/etc/mailcap</code> file can be altered by editing the <code>/etc/mailcap.order</code> file.	
<code>manpath.config</code>	The <a href="#">manpath configuration file</a> is used by the manual page utilities to assess users' manpaths at run time, to indicate which manual page hierarchies (manpaths) are to be treated as system hierarchies and to assign them directories to be used for storing cat files.	
<code>mcelog</code>	Machine check event log. The file is present only on x86 systems.	
<code>mime.types</code>	MIME type description file for <a href="#">cups</a> .	



File	Description	Why is this important?
mke2fs.conf	Configuration file for <code>mke2fs</code> , which is a program that creates an ext, ext3 or ext4 filesystem.	
mlx	Mellanox-specific ASIC file structure (hardware interaction). If there are questions, <a href="#">contact the Cumulus Networks Support team</a> . This is unique to Cumulus Linux.	
modprobe.d	Configuration directory for <code>modprobe</code> , which is a utility that can <a href="#">add and remove modules from the Linux kernel</a> .	
modules	The kernel modules to <a href="#">load at boot time</a> .	
modules-load.d	Configuration for modules to load at system boot.	
motd	The contents of <code>/etc/motd</code> ("message of the day") are displayed by <code>pam_motd</code> after a successful login but just before it executes the login shell.	
motd.distrib	Generic message of the day for Debian.	
mtab	The programs <code>mount</code> and <code>umount</code> maintain a list of <a href="#">currently mounted filesystems</a> in the <code>/etc/mtab</code> file. If no arguments are given to <code>mount</code> , this list is printed.	
mysql	MySQL configuration file.	
nanorc	The GNU nano rcfile.	
netd.conf	The <a href="#">NCLU (see page 88)</a> configuration file.	Contains the settings for which Linux commands are operable under NCLU. Also contains the blacklist of infrequently used commands.
network	Contains the <a href="#">network interface configuration</a> for <code>ifup</code> and <code>ifdown</code> .	The main configuration file is under <code>/etc/network/interfaces</code> . This is where you configure L2 and L3 information for all of your front panel ports (swp)

<b>File</b>	<b>Description</b>	<b>Why is this important?</b>
		interfaces). Settings like MTU, link speed, IP address information, and VLANs are all included here.
networks	Network name information.	
nsswitch.conf	System databases and name service switch configuration file.	
ntp.conf	NTP (network time protocol) server configuration file.	
openvswitch	The directory containing the <code>conf.db</code> file, which is used by <code>ovsdb-server</code> .	
openvswitch-vtep	Configuration files used for the VTEP daemon and <code>ovsdb-server</code> .	
opt	Host-specific configuration files for <code>add-on applications</code> installed in <code>/opt</code> .	
os-release	Operating system identification.	
pam.conf	The PAM (pluggable authentication module) configuration file. When a PAM-aware privilege granting application is started, it activates its attachment to the PAM-API. This activation performs a number of tasks, the most important being the reading of the configuration file(s).	
pam.d	Alternate directory to configure PAM (see above).	
pam_radius.conf	Configuration file for RADIUS. This file is present only if a RADIUS client is installed.	
passwd	User account information.	
passwd-	Backup file for <code>/etc/passwd</code> .	
perl	<code>Perl</code> is an available scripting language. <code>/etc/perl</code> contains configuration files specific to Perl.	
popularity-contest.conf	Configuration for package popularity information.	



File	Description	Why is this important?
profile	/etc/profile is utilized by sysprofile, a modular centralized shell configuration.	
profile.d	The directory version of the above, which contains configuration files.	
protocols	The <a href="#">protocols definition file</a> , a plain ASCII file that describes the various DARPA net protocols that are available from the TCP/IP subsystem.	
ptm.d	The directory containing scripts that are run if PTM ( <a href="#">see page 360</a> ) passes or fails.	Cumulus Linux-specific folder for PTM (prescriptive topology manager).
python	Python is an available scripting language.	
python2.6	The 2.6 version of python.	
python2.7	The 2.7 version of python.	
python3	The 3.0 version of python.	
python3.4	The 3.4 version of python.	
rc.local	The /etc/rc.local script is used by the system administrator to <a href="#">execute after all the normal system services are started</a> , at the end of the process of switching to a multiuser runlevel. You can use it to start a custom service, for example, a server that's installed in /usr/local. Most installations don't need /etc/rc.local; it's provided for the minority of cases <a href="#">where it's needed</a> .	
rc0.d	Like rc.local, these scripts are booted by default, but the number of the folder represents the <a href="#">Linux runlevel</a> . This folder 0 represents runlevel 0 (halt the system).	
rc1.d	This is run level 1, which is single-user/minimal mode.	
rc2.d	Runlevels 2 through 5 are multiuser modes. Debian systems (such as Cumulus Linux) come with id=2, which indicates that the <a href="#">default runlevel will be 2 when the multi-user state is entered</a> , and the scripts in /etc/rc2.d/ will be run.	

File	Description	Why is this important?
rc3.d	See above.	
rc4.d	See above.	
rc5.d	See above.	
rc6.d	Runlevel 6 is reboot the system.	
rcS.d	S stands for <i>single</i> and is equivalent to rc1.	
rdnbrd.conf	<a href="#">Redistribute neighbor (see page 838)</a> configuration file.	
resolvconf	Resolver configuration file directory.	
resolv.conf	<a href="#">Resolver configuration file</a> , which is where DNS is set (domain, nameserver and search).	You need DNS to reach the Cumulus Linux repository.
rmt	This is not a mistake. The <a href="#">shell script /etc/rmt</a> is provided for compatibility with other Unix-like systems, some of which have utilities that expect to find (and execute) <code>rmt</code> in the <code>/etc</code> directory on remote systems.	
rpc	The <code>rpc</code> file contains <a href="#">human-readable names</a> that can be used in place of RPC program numbers.	
rsyslog.conf	The <code>rsyslog.conf</code> file is the main configuration file for <code>rsyslogd</code> , which logs system messages on *nix systems.	
rsyslog.d	The directory containing additional configuration for <code>rsyslog.conf</code> (see above).	
screenrc	System screen settings.	
securety	This file lists terminals into which the <a href="#">root user can log in</a> .	
security	The <code>/etc/security</code> directory contains <a href="#">security-related configurations files</a> . Whereas PAM concerns itself with the methods used to authenticate any given user, the files under <code>/etc/security</code> are concerned with just what a user can or cannot do. For example, the <code>/etc/security/access.conf</code> file contains a	



File	Description	Why is this important?
	list of which users are allowed to log in and from what host (for example, using telnet). The <code>/etc/security/limits.conf</code> file contains various system limits, such as maximum number of processes.	
selinux	NSA <a href="#">Security-Enhanced Linux</a> .	
sensors.d	The directory from which the <a href="#">sensors</a> program loads its configuration; this is unique for each hardware platform. See also <a href="#">Monitoring System Hardware (see page 944)</a> .	
sensors3.conf	The <a href="#">sensors.conf</a> file describes how <code>libsensors</code> , and thus all programs using it, should translate the raw readings from the kernel modules to real-world values.	
services	<code>services</code> is a plain ASCII file providing a mapping between human-readable textual names for internet services and their underlying assigned port numbers and protocol types.	
shadow	shadow is a file that <a href="#">contains the password information</a> for the system's accounts and optional aging information.	
shadow-	The backup for the <code>/etc/shadow</code> file.	
shells	The pathnames of <a href="#">valid login shells</a> .	
skel	The skeleton directory (usually <code>/etc/skel</code> ) is used to copy default files and also sets a umask for the creation used by <code>pam_mkhomedir</code> .	
snmp	Interface functions to the <a href="#">SNMP</a> (simple network management protocol) toolkit.	
ssh	The <a href="#">ssh configuration</a> .	
ssl	The <a href="#">OpenSSL ss1 library</a> implements the Secure Sockets Layer (SSL v2/v3) and Transport Layer Security (TLS v1) protocols. This directory holds certificates and configuration.	
staff-group-for-usr-local	Use <code>cat</code> or <code>more</code> on this file to learn more information, see <a href="http://bugs.debian.org/299007">http://bugs.debian.org/299007</a> .	

File	Description	Why is this important?
subgid	Subordinate <code>gid</code> file, for group IDs.	
subgid-	The backup for the <code>/etc/subgid</code> file.	
subuid	Subordinate <code>uid</code> file, for user IDs.	
subuid-	The backup for the <code>/etc/subuid</code> file.	
sudoers	The <code>sudoers</code> policy plugin determines a user's <a href="#">sudo privileges</a> .	
sudoers.d	The directory file containing additional <code>sudoers</code> configuration (see above).	
sysctl.conf	Configures <a href="#">kernel parameters at boot</a> .	
sysctl.d	The directory file containing additional configuration (see above).	
systemd	<code>systemd</code> <a href="#">system and service manager</a> .	
tacplus_nss.conf	Basic configuration file for TACACS+ and the <code>libnss_tacplus</code> package. This file is present only if the TACACS+ client is installed on the system.	
tacplus_servers	TACACS+ server configuration file. This file is present only if the TACACS+ client is installed on the system.	
terminfo	<a href="#">Terminal capability database</a> .	
timezone	If this file exists, it is read and its contents are used as the <a href="#">time zone name</a> .	
ucf.conf	The update configuration file <a href="#">preserves user changes</a> in configuration files.	
udev	<a href="#">Dynamic device management</a> .	
ufw	Provides both a command line interface and a framework for managing a <a href="#">netfilter firewall</a> .	
vim	Configuration file for command line tool <code>vim</code> .	
vrf		



File	Description	Why is this important?
	Configuration for services to run in a <a href="#">VRF</a> (see page 847) context.	
vxrd.conf	<a href="#">LNV</a> (see page 602) registration node configuration file.	
vxsnd.conf	<a href="#">LNV</a> (see page 602) service node configuration file.	
watchdog.conf	<a href="#">Hardware watchdog</a> (see page 944) configuration file.	
wgetrc	Configuration file for command line tool <code>wget</code> .	
X11	Keyboard configuration.	
xdg	Default configuration files.	

## Troubleshooting Network Interfaces

The following sections describe various ways you can troubleshoot `ifupdown2`.

### Contents

#### This topic describes ...

- Enable Logging for Networking (see page 985)
- Use `ifquery` to Validate and Debug Interface Configurations (see page 986)
- Mako Template Errors (see page 987)
- `ifdown` Cannot Find an Interface that Exists (see page 988)
- Remove All References to a Child Interface (see page 988)
- MTU Set on a Logical Interface Fails with Error: "Numerical result out of range" (see page 989)
- `iproute2` batch Command Failures (see page 989)
- "RTNETLINK answers: Invalid argument" Error when Adding a Port to a Bridge (see page 990)
- MLAG Peerlink Interface Drops Many Packets (see page 990)

### Enable Logging for Networking

The `/etc/default/networking` file contains two settings for logging:

- To get `ifupdown2` logs when the switch boots (stored in `syslog`)
- To enable logging when you run `systemctl [start|stop|reload] networking.service`



This file also contains an option for excluding interfaces when you boot the switch or run `systemctl start|stop|reload networking.service`. You can exclude any interface specified in `/etc/network/interfaces`. These interfaces do not come up when you boot the switch or start/stop/reload the networking service.

```
cumulus@switch:~$ cat /etc/default/networking
#
#
# Parameters for the /etc/init.d/networking script
#
#
# Change the below to yes if you want verbose logging to be enabled
VERBOSE="no"

# Change the below to yes if you want debug logging to be enabled
DEBUG="no"

# Change the below to yes if you want logging to go to syslog
SYSLOG="no"

# Exclude interfaces
EXCLUDE_INTERFACES=
```

## Use ifquery to Validate and Debug Interface Configurations

You use `ifquery` to print parsed `interfaces` file entries.

To use `ifquery` to pretty print `iface` entries from the `interfaces` file, run:

```
cumulus@switch:~$ sudo ifquery bond0
auto bond0
iface bond0
    address 14.0.0.9/30
    address 2001:ded:beef:2::1/64
    bond-slaves swp25 swp26
```

Use `ifquery --check` to check the current running state of an interface within the `interfaces` file. It will return exit code 0 or 1 if the configuration does not match. The line `bond-xmit-hash-policy layer3+7` below fails because it should read `bond-xmit-hash-policy layer3+4`.

```
cumulus@switch:~$ sudo ifquery --check bond0
iface bond0
    bond-xmit-hash-policy layer3+7  [fail]
    bond-slaves swp25 swp26        [pass]
    address 14.0.0.9/30           [pass]
    address 2001:ded:beef:2::1/64  [pass]
```



ifquery --check is an experimental feature.

Use `ifquery --running` to print the running state of interfaces in the `interfaces` file format:

```
cumulus@switch:~$ sudo ifquery --running bond0
auto bond0
iface bond0
    bond-slaves swp25 swp26
    address 14.0.0.9/30
    address 2001:ded:beef:2::1/64
```

`ifquery --syntax-help` provides help on all possible attributes supported in the `interfaces` file. For complete syntax on the `interfaces` file, see `man interfaces` and `man ifupdown-addons-interfaces`.

You can use `ifquery --print-savedstate` to check the `ifupdown2` state database. `ifdown` works only on interfaces present in this state database.

```
cumulus@leaf1$ sudo ifquery --print-savedstate eth0
auto eth0
iface eth0 inet dhcp
```

## Mako Template Errors

An easy way to debug and get details about template errors is to use the `mako-render` command on your `interfaces` template file or on `/etc/network/interfaces` itself.

```
cumulus@switch:~$ sudo mako-render /etc/network/interfaces
# This file describes the network interfaces available on your system
# and how to activate them. For more information, see interfaces(5).

# The loopback network interface
auto lo
iface lo inet loopback

# The primary network interface
auto eth0
iface eth0 inet dhcp
#auto eth1
#iface eth1 inet dhcp

# Include any platform-specific interface configuration
source /etc/network/interfaces.d/*.if

# ssim2 added
```



```
auto swp45
iface swp45

auto swp46
iface swp46

cumulus@switch:~$ sudo mako-render /etc/network/interfaces.d
/<interfaces_stub_file>
```

## ifdown Cannot Find an Interface that Exists

If you are trying to bring down an interface that you know exists, use `ifdown` with the `--use-current-config` option to force `ifdown` to check the current `/etc/network/interfaces` file to find the interface. This can solve issues where the `ifup` command issues for that interface was interrupted before it updated the state database. For example:

```
cumulus@switch:~$ sudo ifdown br0
error: cannot find interfaces: br0 (interface was probably never up ?)

cumulus@switch:~$ sudo brctl show
bridge name      bridge id      STP enabled     interfaces
br0              8000.44383900279f    yes           downlink
                           peerlink

cumulus@switch:~$ sudo ifdown br0 --use-current-config
```

## Remove All References to a Child Interface

If you have a configuration with a child interface, whether it's a VLAN, bond or another physical interface, and you remove that interface from a running configuration, you must remove every reference to it in the configuration. Otherwise, the interface continues to be used by the parent interface.

For example, consider the following configuration:

```
auto lo
iface lo inet loopback

auto eth0
iface eth0 inet dhcp

auto bond1
iface bond1
    bond-slaves swp2 swp1

auto bond3
iface bond3
    bond-slaves swp8 swp6 swp7
```



```
auto br0
iface br0
    bridge-ports swp3 swp5 bond1 swp4 bond3
    bridge-pathcosts swp3=4 swp5=4 swp4=4
    address 11.0.0.10/24
    address 2001::10/64
```

Notice that bond1 is a member of br0. If bond1 is removed, you must remove the reference to it from the br0 configuration. Otherwise, if you reload the configuration with `ifreload -a`, bond1 is still part of br0.

## MTU Set on a Logical Interface Fails with Error: "Numerical result out of range"

This error occurs when the [MTU \(see page 242\)](#) you are trying to set on an interface is higher than the MTU of the lower interface or dependent interface. Linux expects the upper interface to have an MTU less than or equal to the MTU on the lower interface.

In the example below, the swp1.100 VLAN interface is an upper interface to physical interface swp1. If you want to change the MTU to 9000 on the VLAN interface, you must include the new MTU on the lower interface swp1 as well.

```
auto swp1.100
iface swp1.100
    mtu 9000

auto swp1
iface swp1
    mtu 9000
```

## iproute2 batch Command Failures

`ifupdown2` batches `iproute2` commands for performance reasons. A batch command contains `ip -force -batch` – in the error message. The command number that failed is at the end of this line: `Command failed -:1.`

Below is a sample error for the command `1: link set dev host2 master bridge`. There was an error adding the bond `host2` to the bridge named `bridge` because `host2` did not have a valid address.

```
error: failed to execute cmd 'ip -force -batch - [link set dev host2
master bridge
addr flush dev host2
link set dev host1 master bridge
addr flush dev host1
]' (RTNETLINK answers: Invalid argument
Command failed -:1)
warning: bridge configuration failed (missing ports)
```



## "RTNETLINK answers: Invalid argument" Error when Adding a Port to a Bridge

This error can occur when the bridge port does not have a valid hardware address.

This can typically occur when the interface being added to the bridge is an incomplete bond; a bond without slaves is incomplete and does not have a valid hardware address.

## MLAG Peerlink Interface Drops Many Packets

Losing a large number of packets across an MLAG peerlink interface may not be a problem. Instead this could be occurring in order to prevent looping of BUM (broadcast, unknown unicast and multicast) packets. For more information, and how to detect these drops, read the [MLAG chapter \(see page 470\)](#).

## Monitoring Interfaces and Transceivers Using ethtool

The `ethtool` command enables you to query or control the network driver and hardware settings. It takes the device name (like `swp1`) as an argument. When the device name is the only argument to `ethtool`, it prints the current settings of the network device. See `man ethtool(8)` for details. Not all options are currently supported on switch port interfaces.

### Contents

#### This topic describes ...

- Monitor Interface Status Using ethtool (see page 990)
- View and Clear Interface Counters (see page 991)
- Monitor Switch Port SFP/QSFP Hardware Information Using ethtool (see page 993)

### Monitor Interface Status Using ethtool

To check the status of an interface using `ethtool`:

```
cumulus@switch:~$ ethtool swp1
Settings for swp1:
  Supported ports: [ FIBRE ]
  Supported link modes:  1000baseT/Full
                         10000baseT/Full
  Supported pause frame use: No
  Supports auto-negotiation: No
  Advertised link modes:  1000baseT/Full
  Advertised pause frame use: No
  Advertised auto-negotiation: No
  Speed: 10000Mb/s
  Duplex: Full
  Port: FIBRE
  PHYAD: 0
  Transceiver: external
  Auto-negotiation: off
```



```
Current message level: 0x00000000 (0)  
Link detected: yes
```



The switch hardware contains the [active port settings \(see page 239\)](#). The output of `ethtool swpXX` shows the port settings stored in the kernel. The `switchd` process keeps the hardware and kernel in sync for the important port settings (speed, auto-negotiation, and link detected) when they change. However, many of the fields in `ethtool`, like Supported Link Modes and Advertised Link Modes are not updated based on the actual module inserted in the port and therefore are incorrect or misleading.

To query interface statistics:

```
cumulus@switch:~$ sudo ethtool -S swp1  
NIC statistics:  
    HwIfInOctets: 1435339  
    HwIfInUcastPkts: 11795  
    HwIfInBcastPkts: 3  
    HwIfInMcastPkts: 4578  
    HwIfOutOctets: 14866246  
    HwIfOutUcastPkts: 11791  
    HwIfOutMcastPkts: 136493  
    HwIfOutBcastPkts: 0  
    HwIfInDiscards: 0  
    HwIfInL3Drops: 0  
    HwIfInBufferDrops: 0  
    HwIfInAclDrops: 28  
    HwIfInDot3LengthErrors: 0  
    HwIfInErrors: 0  
    SoftInErrors: 0  
    SoftInDrops: 0  
    SoftInFrameErrors: 0  
    HwIfOutDiscards: 0  
    HwIfOutErrors: 0  
    HwIfOutQDrops: 0  
    HwIfOutNonQDrops: 0  
    SoftOutErrors: 0  
    SoftOutDrops: 0  
    SoftOutTxFifoFull: 0  
    HwIfOutQLen: 0
```

### *View and Clear Interface Counters*

Interface counters contain information about an interface. You can view this information when you run `c1-netstat`, `ifconfig`, or `cat /proc/net/dev`. You can also use `c1-netstat` to save or clear this information:

```
cumulus@switch:~$ sudo cl-netstat
Kernel Interface table
Iface      MTU Met            RX_OK RX_ERR RX_DRP RX_OVR            TX_OK TX_ERR
TX_DRP TX_OVR   Flg
-----
eth0    1500 0             611    0    0    0        487    0
0      0   BMRU
lo     16436 0             0    0    0    0        0    0
0      0   LRU
swp1    1500 0             0    0    0    0        0    0
0      0   BMU

cumulus@switch:~$ sudo cl-netstat -c
Cleared counters
```

Option	Description
-c	Copies and clears statistics. It does not clear counters in the kernel or hardware. <p><b>⚠</b> The <code>-c</code> argument is applied per user ID by default. You can override it by using the <code>-t</code> argument to save statistics to a different directory.</p>
-d	Deletes saved statistics, either the <code>uid</code> or the specified tag. <p><b>⚠</b> The <code>-d</code> argument is applied per user ID by default. You can override it by using the <code>-t</code> argument to save statistics to a different directory.</p>
-D	Deletes all saved statistics.
-l	Lists saved tags.
-r	Displays raw statistics (unmodified output of <code>cl-netstat</code> ).
-t <tag name>	Saves statistics with <code>&lt;tag name&gt;</code> .
-v	Prints <code>cl-netstat</code> version and exits.



## Monitor Switch Port SFP/QSFP Hardware Information Using ethtool

To see hardware capabilities and measurement information on the SFP or QSFP module installed in a particular port, use the `ethtool -m` command. If the SFP/QSFP supports Digital Optical Monitoring (that is, the `Optical diagnostics support` field in the output below is set to Yes), the optical power levels and thresholds are also printed below the standard hardware details.

In the sample output below, you can see that this module is a 1000BASE-SX short-range optical module, manufactured by JDSU, part number PLRXPL-VI-S24-22. The second half of the output displays the current readings of the Tx power levels (`Laser output power`) and Rx power (`Receiver signal average optical power`), temperature, voltage and alarm threshold settings.

```
cumulus@switch$ sudo ethtool -m swp3
      Identifier                      : 0x03 (SFP)
      Extended identifier              : 0x04 (GBIC/SFP
defined by 2-wire interface ID)
      Connector                       : 0x07 (LC)
      Transceiver codes              : 0x00 0x00 0x00 0x0
1 0x20 0x40 0x0c 0x05
      Transceiver type               : Ethernet:
1000BASE-SX
      Transceiver type               : FC: intermediate
distance (I)
      Transceiver type               : FC: Shortwave
laser w/o OFC (SN)
      Transceiver type               : FC: Multimode, 62.
5um (M6)
      Transceiver type               : FC: Multimode,
50um (M5)
      Transceiver type               : FC: 200 MBytes/sec
      Transceiver type               : FC: 100 MBytes/sec
      Encoding                        : 0x01 (8B/10B)
      BR, Nominal                   : 2100MBd
      Rate identifier                 : 0x00 (unspecified)
      Length (SMF,km)                : 0km
      Length (SMF)                   : 0m
      Length (50um)                  : 300m
      Length (62.5um)                : 150m
      Length (Copper)                : 0m
      Length (OM3)                   : 0m
      Laser wavelength                : 850nm
      Vendor name                    : JDSU
      Vendor OUI                     : 00:01:9c
      Vendor PN                      : PLRXPL-VI-S24-22
      Vendor rev                     : 1
      Optical diagnostics support    : Yes
      Laser bias current              : 21.348 mA
      Laser output power             : 0.3186 mW / -4.97
dBm
```

	Receiver signal average optical power	: 0.3195 mW / -4.96
dBm		
	Module temperature	: 41.70 degrees C /
107.05	degrees F	
	Module voltage	: 3.2947 V
	Alarm/warning flags implemented	: Yes
	Laser bias current high alarm	: Off
	Laser bias current low alarm	: Off
	Laser bias current high warning	: Off
	Laser bias current low warning	: Off
	Laser output power high alarm	: Off
	Laser output power low alarm	: Off
	Laser output power high warning	: Off
	Laser output power low warning	: Off
	Module temperature high alarm	: Off
	Module temperature low alarm	: Off
	Module temperature high warning	: Off
	Module temperature low warning	: Off
	Module voltage high alarm	: Off
	Module voltage low alarm	: Off
	Module voltage high warning	: Off
	Module voltage low warning	: Off
	Laser rx power high alarm	: Off
	Laser rx power low alarm	: Off
	Laser rx power high warning	: Off
	Laser rx power low warning	: Off
	Laser bias current high alarm threshold	: 10.000 mA
	Laser bias current low alarm threshold	: 1.000 mA
	Laser bias current high warning threshold	: 9.000 mA
	Laser bias current low warning threshold	: 2.000 mA
	Laser output power high alarm threshold	: 0.8000 mW / -0.97
dBm		
	Laser output power low alarm threshold	: 0.1000 mW / -10.00
dBm		
	Laser output power high warning threshold	: 0.6000 mW / -2.22
dBm		
	Laser output power low warning threshold	: 0.2000 mW / -6.99
dBm		
	Module temperature high alarm threshold	: 90.00 degrees C /
194.00	degrees F	
	Module temperature low alarm threshold	: -40.00 degrees C
/ -40.00	degrees F	
	Module temperature high warning threshold	: 85.00 degrees C /
185.00	degrees F	
	Module temperature low warning threshold	: -40.00 degrees C
/ -40.00	degrees F	
	Module voltage high alarm threshold	: 4.0000 V
	Module voltage low alarm threshold	: 0.0000 V
	Module voltage high warning threshold	: 3.6450 V
	Module voltage low warning threshold	: 2.9550 V
	Laser rx power high alarm threshold	: 1.6000 mW / 2.04
dBm		

dBm	Laser rx power low alarm threshold	: 0.0100 mW / -20.00
dBm	Laser rx power high warning threshold	: 1.0000 mW / 0.00
dBm	Laser rx power low warning threshold	: 0.0200 mW / -16.99

## Monitoring Interfaces and Transceivers Using ethtool – ethtool Counter Definitions

The `ethtool` command enables you to query or control the network driver and hardware settings. It takes the device name (like `swp1`) as an argument. When the device name is the only argument to `ethtool`, it prints the current settings of the network device. See `man ethtool(8)` for details. Not all options are currently supported on switch port interfaces.

### Contents

#### This topic describes ...

- Monitor Interface Status Using ethtool (see page 995)
- View and Clear Interface Counters (see page 996)
- Monitor Switch Port SFP/QSFP Hardware Information Using ethtool (see page 997)
- ethtool Counter Definitions (see page 999)

### Monitor Interface Status Using ethtool

To check the status of an interface using `ethtool`:

```
cumulus@switch:~$ ethtool swp1
Settings for swp1:
  Supported ports: [ FIBRE ]
  Supported link modes:  1000baseT/Full
                        10000baseT/Full
  Supported pause frame use: No
  Supports auto-negotiation: No
  Advertised link modes:  1000baseT/Full
  Advertised pause frame use: No
  Advertised auto-negotiation: No
  Speed: 10000Mb/s
  Duplex: Full
  Port: FIBRE
  PHYAD: 0
  Transceiver: external
  Auto-negotiation: off
  Current message level: 0x00000000 (0)

  Link detected: yes
```

To query interface statistics:

```
cumulus@switch:~$ sudo ethtool -S swp1
NIC statistics:
    HwIfInOctets: 1435339
    HwIfInUcastPkts: 11795
    HwIfInBcastPkts: 3
    HwIfInMcastPkts: 4578
    HwIfOutOctets: 14866246
    HwIfOutUcastPkts: 11791
    HwIfOutMcastPkts: 136493
    HwIfOutBcastPkts: 0
    HwIfInDiscards: 0
    HwIfInL3Drops: 0
    HwIfInBufferDrops: 0
    HwIfInAclDrops: 28
    HwIfInDot3LengthErrors: 0
    HwIfInErrors: 0
    SoftInErrors: 0
    SoftInDrops: 0
    SoftInFrameErrors: 0
    HwIfOutDiscards: 0
    HwIfOutErrors: 0
    HwIfOutQDrops: 0
    HwIfOutNonQDrops: 0
    SoftOutErrors: 0
    SoftOutDrops: 0
    SoftOutTxFifoFull: 0
    HwIfOutQLen: 0
```

### *View and Clear Interface Counters*

Interface counters contain information about an interface. You can view this information when you run `cl-netstat`, `ifconfig`, or `cat /proc/net/dev`. You can also use `cl-netstat` to save or clear this information:

```
cumulus@switch:~$ sudo cl-netstat
Kernel Interface table
Iface      MTU Met          RX_OK RX_ERR RX_DRP RX_OVR          TX_OK TX_ERR
TX_DRP TX_OVR   Flg
-----
eth0      1500 0            611   0     0     0           487   0
0          0   BMRU
lo       16436 0            0     0     0     0           0     0
0          0   LRU
swp1      1500 0            0     0     0     0           0     0
0          0   BMU
```

```
cumulus@switch:~$ sudo cl-netstat -c
Cleared counters
```

Option	Description
-c	Copies and clears statistics. It does not clear counters in the kernel or hardware.  ⚠️ The <code>-c</code> argument is applied per user ID by default. You can override it by using the <code>-t</code> argument to save statistics to a different directory.
-d	Deletes saved statistics, either the <code>uid</code> or the specified tag.  ⚠️ The <code>-d</code> argument is applied per user ID by default. You can override it by using the <code>-t</code> argument to save statistics to a different directory.
-D	Deletes all saved statistics.
-l	Lists saved tags.
-r	Displays raw statistics (unmodified output of <code>cl-netstat</code> ).
-t <tag name>	Saves statistics with <code>&lt;tag name&gt;</code> .
-v	Prints <code>cl-netstat</code> version and exits.

### Monitor Switch Port SFP/QSFP Hardware Information Using ethtool

To see hardware capabilities and measurement information on the SFP or QSFP module installed in a particular port, use the `ethtool -m` command. If the SFP/QSFP supports Digital Optical Monitoring (that is, the `Optical diagnostics support` field in the output below is set to Yes), the optical power levels and thresholds are also printed below the standard hardware details.

In the sample output below, you can see that this module is a 1000BASE-SX short-range optical module, manufactured by JDSU, part number PLRXPL-VI-S24-22. The second half of the output displays the current readings of the Tx power levels (`Laser output power`) and Rx power (`Receiver signal average optical power`), temperature, voltage and alarm threshold settings.

```
cumulus@switch$ sudo ethtool -m swp3
      Identifier : 0x03 (SFP)
      Extended identifier : 0x04 (GBIC/SFP
defined by 2-wire interface ID)
```

	Connector	: 0x07 (LC)
	Transceiver codes	: 0x00 0x00 0x00 0x00
1 0x20 0x40 0x0c 0x05		
	Transceiver type	: Ethernet:
1000BASE-SX		
	Transceiver type	: FC: intermediate
distance (I)		
	Transceiver type	: FC: Shortwave
laser w/o OFC (SN)		
	Transceiver type	: FC: Multimode, 62.
5um (M6)		
	Transceiver type	: FC: Multimode,
50um (M5)		
	Transceiver type	: FC: 200 MBytes/sec
	Transceiver type	: FC: 100 MBytes/sec
Encoding		: 0x01 (8B/10B)
BR, Nominal		: 2100MBd
Rate identifier		: 0x00 (unspecified)
Length (SMF,km)		: 0km
Length (SMF)		: 0m
Length (50um)		: 300m
Length (62.5um)		: 150m
Length (Copper)		: 0m
Length (OM3)		: 0m
Laser wavelength		: 850nm
Vendor name		: JDSU
Vendor OUI		: 00:01:9c
Vendor PN		: PLRXPL-VI-S24-22
Vendor rev		: 1
Optical diagnostics support		: Yes
Laser bias current		: 21.348 mA
Laser output power		: 0.3186 mW / -4.97
dBm		
	Receiver signal average optical power	: 0.3195 mW / -4.96
dBm		
	Module temperature	: 41.70 degrees C /
107.05	degrees F	
	Module voltage	: 3.2947 V
	Alarm/warning flags implemented	: Yes
	Laser bias current high alarm	: Off
	Laser bias current low alarm	: Off
	Laser bias current high warning	: Off
	Laser bias current low warning	: Off
	Laser output power high alarm	: Off
	Laser output power low alarm	: Off
	Laser output power high warning	: Off
	Laser output power low warning	: Off
	Module temperature high alarm	: Off
	Module temperature low alarm	: Off
	Module temperature high warning	: Off
	Module temperature low warning	: Off
	Module voltage high alarm	: Off

```

Module voltage low alarm : Off
Module voltage high warning : Off
Module voltage low warning : Off
Laser rx power high alarm : Off
Laser rx power low alarm : Off
Laser rx power high warning : Off
Laser rx power low warning : Off
Laser bias current high alarm threshold : 10.000 mA
Laser bias current low alarm threshold : 1.000 mA
Laser bias current high warning threshold : 9.000 mA
Laser bias current low warning threshold : 2.000 mA
Laser output power high alarm threshold : 0.8000 mW / -0.97
dBm
Laser output power low alarm threshold : 0.1000 mW / -10.00
dBm
Laser output power high warning threshold : 0.6000 mW / -2.22
dBm
Laser output power low warning threshold : 0.2000 mW / -6.99
dBm
Module temperature high alarm threshold : 90.00 degrees C /
194.00 degrees F
Module temperature low alarm threshold : -40.00 degrees C
/ -40.00 degrees F
Module temperature high warning threshold : 85.00 degrees C /
185.00 degrees F
Module temperature low warning threshold : -40.00 degrees C
/ -40.00 degrees F
Module voltage high alarm threshold : 4.0000 V
Module voltage low alarm threshold : 0.0000 V
Module voltage high warning threshold : 3.6450 V
Module voltage low warning threshold : 2.9550 V
Laser rx power high alarm threshold : 1.6000 mW / 2.04
dBm
Laser rx power low alarm threshold : 0.0100 mW / -20.00
dBm
Laser rx power high warning threshold : 1.0000 mW / 0.00
dBm
Laser rx power low warning threshold : 0.0200 mW / -16.99
dBm

```

### *ethtool Counter Definitions*

Counter	Definition
HwlInOctets	The total number of octets received on the interface, including framing characters.
HwlInUcastPkts	The number of packets delivered by this sub-layer to a higher (sub-)layer that were not addressed to a multicast or broadcast address at this sub-layer.

<b>Counter</b>	<b>Definition</b>
HwlfInBcastPkts	The number of packets delivered by this sub-layer to a higher (sub-)layer that were addressed to a broadcast address at this sub-layer.
HwlfInMcastPkts	The number of packets delivered by this sub-layer to a higher (sub-)layer that were addressed to a multicast address at this sub-layer. For a MAC layer protocol, this includes both group and functional addresses.
HwlfOutOctets	The total number of octets transmitted out of the interface, including framing characters.
HwlfOutUcastPkts	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.
HwlfOutMcastPkts	The total number of packets that higher-level protocols requested to 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.
HwlfOutBcastPkts	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.
HwlfInDiscards	<p>The number of inbound packets that 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.</p> <p>The sum of all Rx discards on an interface including all of the more specific itemized ethtool counters. It also accounts for all other drops that do not have a more specific ethtool drop reason when a frame arrives that doesn't result in a valid forwarding decision - STP discarding, IGMP snooping drop, VLAN tag not configured.</p>
HwlfInL3Drops	All layer 3 packets that were discarded.
HwlfInBufferDrops	<p>All ingress buffer congestion discards.</p> <p>These are ingress buffer drops that are commonly seen during bursty congestion. Broadcom platforms have a buffer pool that is shared across all interfaces rather than a per-interface queue. When the global buffer pool is congested, InBufferDrops will accrue.</p>
HwlfInAclDrops	<p>All packets that were intentionally dropped.</p> <p>These are common ACL drops for control plane policing or otherwise. <code>c1-acltool -L all</code> shows the current ACLs installed on the system.</p>



HwIfInBlackholeDrops	All packets that were unintentionally dropped.
HwIfInDot3LengthErrors	<p>A count of frames received on a particular interface with a length field value that falls between the minimum unpadded LLC data size and the maximum allowed LLC data size inclusive and that does not match the number of LLC data octets received. The count represented by an instance of this object also includes frames for which the length field value is less than the minimum unpadded LLC data size.</p> <p>This counter accrues when the value of the length field in a frame does not match the number of octets received in the frame or it has incorrect padding - we've also seen incorrect padding or length field concerns in some legacy proprietary protocols used by other vendors such as CGMP. These frames are still forwarded.</p>
HwIfInDot3FrameErrors	A count of frames received on a particular interface that are an integral number of octets in length but do not pass the FCS check. The count represented by an instance of this object is incremented when the frameCheckError status is returned by the MAC service to the LLC (or other MAC user). Received frames for which multiple error conditions obtain are, according to the conventions of [9], counted exclusively according to the error status presented to the LLC.
HwIfInErrors	<p>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.</p> <p>This is the total of all "in" or Rx errors such as frame/FCS errors as outlined below</p>
SoftInErrors	
SoftInDrops	
SoftInFrameErrors	
HwIfOutDiscards	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.
HwIfOutErrors	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.

Counter	Definition
HwlfOutQDrops	
HwlfOutNonQDrops	
SoftOutErrors	
SoftOutDrops	
SoftOutTxFifoFull	
HwlfOutQLen	The length of the output packet queue in packets.
HwlfInPausePkt	<p>A count of MAC control frames received on this interface with an opcode indicating the PAUSE operation.</p> <p>This counter does not increment when the interface is operating in half-duplex mode.</p> <p>For interfaces operating at 10 Gb/s, this counter can roll over in less than 5 minutes if it is incrementing at its maximum rate. Since that amount of time could be less than a management station's poll cycle time, in order to avoid a loss of information, a management station is advised to poll the HwlfInPausePkt object for 10 Gb/s or faster interfaces.</p>
HwlfOutPausePkt	<p>A count of MAC control frames transmitted on this interface with an opcode indicating the PAUSE operation.</p> <p>This counter does not increment when the interface is operating in half-duplex mode.</p> <p>For interfaces operating at 10 Gb/s, this counter can roll over in less than 5 minutes if it is incrementing at its maximum rate. Since that amount of time could be less than a management station's poll cycle time, in order to avoid a loss of information, a management station is advised to poll the HwlfOutPausePkt object for 10 Gb/s or faster interfaces.</p>
HwlfInPfc0Pkt	
HwlfOutPfc0Pkt	
HwlfInPfc1Pkt	
HwlfOutPfc1Pkt	
HwlfInPfc2Pkt	
HwlfOutPfc2Pkt	



Counter	Definition
HwlfInPfc3Pkt	
HwlfOutPfc3Pkt	
HwlfInPfc4Pkt	
HwlfOutPfc4Pkt	
HwlfInPfc5Pkt	
HwlfOutPfc5Pkt	
HwlfInPfc6Pkt	
HwlfOutPfc6Pkt	
HwlfInPfc7Pkt	
HwlfOutPfc7Pkt	
HwlfOutWredDrops	
HwlfOutQ0WredDrops	
HwlfOutQ1WredDrops	
HwlfOutQ2WredDrops	
HwlfOutQ3WredDrops	
HwlfOutQ4WredDrops	
HwlfOutQ5WredDrops	
HwlfOutQ6WredDrops	
HwlfOutQ7WredDrops	
HwlfOutQ8WredDrops	
HwlfOutQ9WredDrops	



# Network Troubleshooting

Cumulus Linux contains a number of command line and analytical tools to help you troubleshoot issues with your network.

## Contents

This topic describes ...

- Check Reachability Using ping (see page 1004)
- Print Route Trace Using traceroute (see page 1005)
- Run Commands in a Non-default VRF (see page 1005)
- Manipulate the System ARP Cache (see page 1006)
- Generate Traffic Using mz (see page 1007)
- Create Counter ACL Rules (see page 1008)
- Configure SPAN and ERSPAN (see page 1009)
  - Limitations for SPAN/ERSPAN (see page 1009)
  - Configure SPAN for Switch Ports (see page 1010)
  - Configure SPAN for Bonds (see page 1013)
  - Configure ERSPAN (see page 1014)
  - Selective Spanning (see page 1015)
  - Remove SPAN Rules (see page 1017)
  - Monitor Control Plane Traffic with tcpdump (see page 1017)
- Related Information (see page 1018)

## Check Reachability Using ping

`ping` is used to check reachability of a host. `ping` also calculates the time it takes for packets to travel the round trip. See `man ping` for details.

To test the connection to an IPv4 host:

```
cumulus@switch:~$ ping 192.0.2.45
PING 192.0.2.45 (192.0.2.45) 56(84) bytes of data.
64 bytes from 192.0.2.45: icmp_req=1 ttl=53 time=40.4 ms
64 bytes from 192.0.2.45: icmp_req=2 ttl=53 time=39.6 ms
...
...
```

To test the connection to an IPv6 host:

```
cumulus@switch:~$ ping6 -I swp1 2001::db8:ff:fe00:2
PING 2001::db8:ff:fe00:2(2001::db8:ff:fe00:2) from 2001::db8:ff:fe00:
1 swp1: 56 data bytes
64 bytes from 2001::db8:ff:fe00:2: icmp_seq=1 ttl=64 time=1.43 ms
64 bytes from 2001::db8:ff:fe00:2: icmp_seq=2 ttl=64 time=0.927 ms
```



When troubleshooting intermittent connectivity issues, it is helpful to send continuous pings to a host.

## Print Route Trace Using traceroute

`traceroute` tracks the route that packets take from an IP network on their way to a given host. See `man traceroute` for details.

To track the route to an IPv4 host:

```
cumulus@switch:~$ traceroute www.google.com
traceroute to www.google.com (74.125.239.49), 30 hops max, 60 byte
packets
 1 cumulusnetworks.com (192.168.1.1)  0.614 ms  0.863 ms  0.932 ms
...
 5 core2-1-1-0.pao.net.google.com (198.32.176.31)  22.347 ms  22.584
ms  24.328 ms
 6 216.239.49.250 (216.239.49.250)  24.371 ms  25.757 ms  25.987 ms
 7 72.14.232.35 (72.14.232.35)  27.505 ms  22.925 ms  22.323 ms
 8 nuq04s19-in-f17.1e100.net (74.125.239.49)  23.544 ms  21.851 ms
22.604 ms
```

## Run Commands in a Non-default VRF

You can use `ip vrf exec` to run commands in a non-default VRF context. This is particularly useful for network utilities like `ping`, `traceroute`, and `nslookup`.

The full syntax is `ip vrf exec <vrf-name> <command> <arguments>`. For example:

```
cumulus@switch:~$ sudo ip vrf exec Tenant1 nslookup google.com -
8.8.8.8
```

By default, `ping/ping6` and `traceroute/traceroute6` all use the default VRF. This is done using a mechanism that checks the VRF context of the current shell — which can be seen when you run `ip vrf id` — at the time one of these commands is run. If the shell's VRF context is `mgmt`, then these commands are run in the default VRF context.

`ping` and `traceroute` have additional arguments that you can use to specify an egress interface and/or a source address. In the default VRF, the source interface flag (`ping -I` or `traceroute -i`) specifies the egress interface for the `ping/traceroute` operation. However, you can use the source interface flag instead to specify a non-default VRF to use for the command. Doing so causes the routing lookup for the destination address to occur in that VRF.

With `ping -I`, you can specify the source interface or the source IP address, but you cannot use the flag more than once. Thus, you can choose either an egress interface/VRF or a source IP address. For `traceroute`, you can use `traceroute -s` to specify the source IP address.

You gain some additional flexibility if you run `ip vrf exec` in combination with `ping/ping6` or `traceroute/traceroute6`, as the VRF context is specified outside of the `ping` and `traceroute` commands. This allows for the most granular control of `ping` and `traceroute`, as you can specify both the VRF and the source interface flag.



For `ping`, use the following syntax:

```
ip vrf exec <vrf-name> [ping|ping6] -I [<egress_interface> |  
<source_ip>] <destination_ip>
```

For example:

```
cumulus@switch:~$ sudo ip vrf exec Tenant1 ping -I swp1 8.8.8.8  
cumulus@switch:~$ sudo ip vrf exec Tenant1 ping -I 192.0.1.1 8.8.8.8  
cumulus@switch:~$ sudo ip vrf exec Tenant1 ping6 -I swp1 2001:4860:  
4860::8888  
cumulus@switch:~$ sudo ip vrf exec Tenant1 ping6 -I 2001:db8::1 2001:  
4860:4860::8888
```

For `traceroute`, use the following syntax:

```
ip vrf exec <vrf-name> [traceroute|traceroute6] -i <egress_interface>  
-s <source_ip> <destination_ip>
```

For example:

```
cumulus@switch:~$ sudo ip vrf exec Tenant1 traceroute -i swp1 -s  
192.0.1.1 8.8.8.8  
cumulus@switch:~$ sudo ip vrf exec Tenant1 traceroute6 -i swp1 -s  
2001:db8::1 2001:4860:4860::8888
```

Because the VRF context for `ping` and `traceroute` commands is automatically shifted to the default VRF context, you must use the source interface flag to specify the management VRF. Typically, this is not an issue since there is only a single interface in the management VRF — `eth0` — and in most situations only a single IPv4 address or IPv6 global unicast address is assigned to it. But it is worth mentioning since, as stated earlier, you cannot specify both a source interface and a source IP address with `ping -I`.

## Manipulate the System ARP Cache

`arp` manipulates or displays the kernel's IPv4 network neighbor cache. See `man arp` for details.

To display the ARP cache:

```
cumulus@switch:~$ arp -a  
? (11.0.2.2) at 00:02:00:00:00:10 [ether] on swp3  
? (11.0.3.2) at 00:02:00:00:00:01 [ether] on swp4  
? (11.0.0.2) at 44:38:39:00:01:c1 [ether] on swp1
```

To delete an ARP cache entry:

```
cumulus@switch:~$ arp -d 11.0.2.2
cumulus@switch:~$ arp -a
? (11.0.2.2) at <incomplete> on swp3
? (11.0.3.2) at 00:02:00:00:00:01 [ether] on swp4
? (11.0.0.2) at 44:38:39:00:01:c1 [ether] on swp1
```

To add a static ARP cache entry:

```
cumulus@switch:~$ arp -s 11.0.2.2 00:02:00:00:00:10
cumulus@switch:~$ arp -a
? (11.0.2.2) at 00:02:00:00:00:10 [ether] PERM on swp3
? (11.0.3.2) at 00:02:00:00:00:01 [ether] on swp4
? (11.0.0.2) at 44:38:39:00:01:c1 [ether] on swp1
```

If you need to flush or remove an ARP entry for a specific interface, you can disable dynamic ARP learning:

```
cumulus@switch:~$ ip link set arp off dev INTERFACE
```

## Generate Traffic Using mz

`mz` is a fast traffic generator. It can generate a large variety of packet types at high speed. See `man mz` for details.

For example, to send two sets of packets to TCP port 23 and 24, with source IP 11.0.0.1 and destination 11.0.0.2, do the following:

```
cumulus@switch:~$ sudo mz swp1 -A 11.0.0.1 -B 11.0.0.2 -c 2 -v -t tcp
"dp=23-24"

Mausezahn 0.40 - (C) 2007-2010 by Herbert Haas - http://www.perihel.at
/sec/mz/
Use at your own risk and responsibility!
-- Verbose mode --

This system supports a high resolution clock.
The clock resolution is 4000250 nanoseconds.
Mausezahn will send 4 frames...
IP: ver=4, len=40, tos=0, id=0, frag=0, ttl=255, proto=6, sum=0,
SA=11.0.0.1, DA=11.0.0.2,
payload=[see next layer]
TCP: sp=0, dp=23, S=42, A=42, flags=0, win=10000, len=20, sum=0,
payload=
IP: ver=4, len=40, tos=0, id=0, frag=0, ttl=255, proto=6, sum=0,
SA=11.0.0.1, DA=11.0.0.2,
payload=[see next layer]
TCP: sp=0, dp=24, S=42, A=42, flags=0, win=10000, len=20, sum=0,
```



```
payload=

IP: ver=4, len=40, tos=0, id=0, frag=0, ttl=255, proto=6, sum=0,
SA=11.0.0.1, DA=11.0.0.2,
    payload=[see next layer]
TCP: sp=0, dp=23, S=42, A=42, flags=0, win=10000, len=20, sum=0,
    payload=

IP: ver=4, len=40, tos=0, id=0, frag=0, ttl=255, proto=6, sum=0,
SA=11.0.0.1, DA=11.0.0.2,
    payload=[see next layer]
TCP: sp=0, dp=24, S=42, A=42, flags=0, win=10000, len=20, sum=0,
    payload=
```

## Create Counter ACL Rules

In Linux, all ACL rules are always counted. To create an ACL rule for counting purposes only, set the rule action to ACCEPT. See the [Netfilter \(see page 142\)](#) chapter for details on how to use cl-acltool to set up iptables-/ip6tables-/ebtables-based ACLs.



Always place your rules files under /etc/cumulus/acl/policy.d/.

To count all packets going to a Web server:

```
cumulus@switch:~$ cat sample_count.rules

[iptables]
-A FORWARD -p tcp --dport 80 -j ACCEPT

cumulus@switch:~$ sudo cl-acltool -i -p sample_count.rules
Using user provided rule file sample_count.rules
Reading rule file sample_count.rules ...
Processing rules in file sample_count.rules ...
Installing acl policy... done.

cumulus@switch:~$ sudo iptables -L -v
Chain INPUT (policy ACCEPT 16 packets, 2224 bytes)
pkts bytes target     prot opt in      out      source
destination

Chain FORWARD (policy ACCEPT 0 packets, 0 bytes)
pkts bytes target     prot opt in      out      source
destination
      2    156 ACCEPT      tcp   --  any     any     anywhere
anywhere                      tcp  dpt:http

Chain OUTPUT (policy ACCEPT 44 packets, 8624 bytes)
```



```
pkts bytes target      prot opt in      out      source  
destination
```



The `-p` option clears out all other rules, and the `-i` option is used to reinstall all the rules.

## Configure SPAN and ERSPAN

SPAN (Switched Port Analyzer) provides for the mirroring of all packets coming in from or going out of an interface (the *SPAN source*), and being copied and transmitted out of a local port (the *SPAN destination*) for monitoring. The SPAN destination port is also referred to as a mirror-to-port (MTP). The original packet is still switched, while a mirrored copy of the packet is sent out of the MTP.

ERSPAN (Encapsulated Remote SPAN) enables the mirrored packets to be sent to a monitoring node located anywhere across the routed network. The switch finds the outgoing port of the mirrored packets by doing a lookup of the destination IP address in its routing table. The original L2 packet is encapsulated with GRE for IP delivery. The encapsulated packets have the following format:

```
-----  
| MAC_HEADER | IP_HEADER | GRE_HEADER | L2_Mirrored_Packet |  
-----
```



Mirrored traffic is not guaranteed. If the MTP is congested, mirrored packets might be discarded.

SPAN and ERSPAN are configured via `c1-acltool`, the [same utility for security ACL configuration \(see page 142\)](#). The match criteria for SPAN and ERSPAN is usually an interface; for more granular match terms, use [selective spanning \(see page 1015\)](#). The SPAN source interface can be a port, a subinterface or a bond interface. Ingress traffic on interfaces can be matched, and on Mellanox Spectrum switches, egress traffic can be matched. See the [list of limitations \(see page 1009\)](#) below.

Cumulus Linux supports a maximum of 2 SPAN destinations. Multiple rules (SPAN sources) can point to the same SPAN destination, although a given SPAN source cannot specify 2 SPAN destinations. The SPAN destination (MTP) interface can be a physical port, a subinterface, or a bond interface. The SPAN/ERSPAN action is independent of security ACL actions. If packets match both a security ACL rule and a SPAN rule, both actions will be carried out.



Always place your rules files under `/etc/cumulus/acl/policy.d/`.

### Limitations for SPAN/ERSPAN

- For Broadcom switches, Cumulus Linux supports a maximum of two SPAN destinations.
- Because SPAN and ERSPAN are done in hardware, `eth0` is not supported as a destination.
- For Mellanox Spectrum switches, Cumulus Linux supports only a single SPAN destination in atomic mode or three SPAN destinations in non-atomic mode.



- Multiple rules (SPAN sources) can point to the same SPAN destination, but a given SPAN source *cannot* specify two SPAN destinations.
- To configure SPAN or ERSPAN on a Tomahawk or Trident3 switch, you must enable [non-atomic update mode \(see page 152\)](#).
- Mellanox switches reject SPAN ACL rules for an output interface that is a subinterface.
- Mirrored traffic is not guaranteed. If the MTP is congested, mirrored packets might be discarded.
- Cut-through mode is not supported for ERSPAN in Cumulus Linux on switches using Broadcom Tomahawk, Trident II+ and Trident II ASICs.
- On Broadcom switches, SPAN does not capture egress traffic.
- Cumulus Linux does not support IPv6 ERSPAN destinations.
- ERSPAN does not cause the kernel to send ARP requests to resolve the next hop for the ERSPAN destination. If an ARP entry for the destination/next hop does not already exist in the kernel, you need to manually resolve this before mirrored traffic is sent (using ping or arping).

## Configure SPAN for Switch Ports

This section describes how to set up, install, verify and uninstall SPAN rules. In the examples that follow, you will span (mirror) switch port swp4 input traffic and swp4 output traffic to destination switch port swp19.

First, create a rules file in `/etc/cumulus/acl/policy.d/`:

```
cumulus@switch:~$ sudo bash -c 'cat <<EOF > /etc/cumulus/acl/policy.d/span.rules
[iptables]
-A FORWARD --in-interface swp4 -j SPAN --dport swp19
-A FORWARD --out-interface swp4 -j SPAN --dport swp19
EOF'
```



Using `c1-acltool` with the `--out-interface` rule applies to transit traffic only; it does not apply to traffic sourced from the switch.

Next, verify all the rules that are currently installed:

```
cumulus@switch:~$ sudo iptables -L -v
Chain INPUT (policy ACCEPT 0 packets, 0 bytes)
  pkts bytes target     prot opt in      out      source
destination
      0     0  DROP       all   --  swp+    any     240.0.0.0/5
anywhere
      0     0  DROP       all   --  swp+    any     loopback/8
anywhere
      0     0  DROP       all   --  swp+    any     base-address.mcast.net
/8  anywhere
      0     0  DROP       all   --  swp+    any     255.255.255.255
anywhere
```



```
0      0 SETCLASS    ospf -- swp+  any     anywhere
anywhere                      SETCLASS class:7
0      0 POLICE     ospf -- any   any     anywhere
anywhere                      POLICE mode:pkt rate:2000 burst:2000
0      0 SETCLASS    tcp   -- swp+  any     anywhere
anywhere                      tcp dpt:bgp SETCLASS class:7
0      0 POLICE     tcp   -- any   any     anywhere
anywhere                      tcp dpt:bgp POLICE mode:pkt rate:2000 burst:2000
0      0 SETCLASS    tcp   -- swp+  any     anywhere
anywhere                      tcp spt:bgp SETCLASS class:7
0      0 POLICE     tcp   -- any   any     anywhere
anywhere                      tcp spt:bgp POLICE mode:pkt rate:2000 burst:2000
0      0 SETCLASS    tcp   -- swp+  any     anywhere
anywhere                      tcp dpt:5342 SETCLASS class:7
0      0 POLICE     tcp   -- any   any     anywhere
anywhere                      tcp dpt:5342 POLICE mode:pkt rate:2000 burst:
2000
0      0 SETCLASS    tcp   -- swp+  any     anywhere
anywhere                      tcp spt:5342 SETCLASS class:7
0      0 POLICE     tcp   -- any   any     anywhere
anywhere                      tcp spt:5342 POLICE mode:pkt rate:2000 burst:
2000
0      0 SETCLASS    icmp  -- swp+ any     anywhere
anywhere                      SETCLASS class:2
0      0 POLICE     icmp  -- any   any     anywhere
anywhere                      POLICE mode:pkt rate:100 burst:40
15    5205 SETCLASS udp   -- swp+ any     anywhere
anywhere                      udp dpts:bootps:bootpc SETCLASS class:2
11    3865 POLICE   udp   -- any   any     anywhere
anywhere                      udp dpt:bootps POLICE mode:pkt rate:100 burst:
100
0      0 POLICE     udp   -- any   any     anywhere
anywhere                      udp dpt:bootpc POLICE mode:pkt rate:100 burst:
100
0      0 SETCLASS    tcp   -- swp+ any     anywhere
anywhere                      tcp dpts:bootps:bootpc SETCLASS class:2
0      0 POLICE     tcp   -- any   any     anywhere
anywhere                      tcp dpt:bootps POLICE mode:pkt rate:100 burst:
100
0      0 POLICE     tcp   -- any   any     anywhere
anywhere                      tcp dpt:bootpc POLICE mode:pkt rate:100 burst:
100
17    1088 SETCLASS igmp  -- swp+ any     anywhere
anywhere                      SETCLASS class:6
17    1156 POLICE   igmp  -- any   any     anywhere
anywhere                      POLICE mode:pkt rate:300 burst:100
394   41060 POLICE all   -- swp+ any     anywhere
anywhere                      ADDRTYPE match dst-type LOCAL POLICE mode:pkt
rate:1000 burst:1000 class:0
0      0 POLICE     all   -- swp+ any     anywhere
anywhere                      ADDRTYPE match dst-type IPROUTER POLICE mode:
pkt rate:400 burst:100 class:0
```



```
988 279K SETCLASS    all -- swp+ any     anywhere
anywhere          SETCLASS class:0

Chain FORWARD (policy ACCEPT 0 packets, 0 bytes)
 pkts bytes target      prot opt in     out      source
destination
 0     0 DROP       all   -- swp+   any     240.0.0.0/5
anywhere
 0     0 DROP       all   -- swp+   any     loopback/8
anywhere
 0     0 DROP       all   -- swp+   any     base-address.mcast.net
/8 anywhere
 0     0 DROP       all   -- swp+   any     255.255.255.255
anywhere
26864 4672K SPAN      all   -- swp4   any     anywhere
anywhere           dport:swp19 <---- input packets on swp4

40722 47M SPAN       all   -- any    swp4   anywhere
anywhere           dport:swp19 <---- output packets on swp4

Chain OUTPUT (policy ACCEPT 67398 packets, 5757K bytes)
 pkts bytes target      prot opt in     out      source
destination
```

Install the rules:

```
cumulus@switch:~$ sudo cl-acltool -i
[sudo] password for cumulus:
Reading rule file /etc/cumulus/acl/policy.d/00control_plane.rules ...
Processing rules in file /etc/cumulus/acl/policy.d/00control_plane.
rules ...
Reading rule file /etc/cumulus/acl/policy.d/99control_plane_catch_all.
rules ...
Processing rules in file /etc/cumulus/acl/policy.d/99control_plane_catch_all.rules ...
Reading rule file /etc/cumulus/acl/policy.d/span.rules ...
Processing rules in file /etc/cumulus/acl/policy.d/span.rules ...
Installing acl policy
done.
```



Running the following command is incorrect and will remove **all** existing control-plane rules or other installed rules and only install the rules defined in `span.rules`:

```
cumulus@switch:~$ sudo cl-acltool -i -P /etc/cumulus/acl/policy.d
/span.rules
```



Verify that the SPAN rules were installed:

```
cumulus@switch:~$ sudo cl-acltool -L all | grep SPAN
38025 7034K SPAN      all -- swp4    any     anywhere
anywhere          dport:swp19
50832 55M SPAN      all -- any     swp4    anywhere
anywhere          dport:swp19
```

### *SPAN Sessions that Reference an Outgoing Interface*

SPAN sessions that reference an outgoing interface create the mirrored packets based on the ingress interface before the routing/switching decision. For example, the following rule captures traffic that is ultimately destined to leave swp2 but mirrors the packets when they arrive on swp3. The rule transmits packets that reference the original VLAN tag and source/destination MAC address at the time the packet is originally received on swp3.

```
-A FORWARD --out-interface swp2 -j SPAN --dport swp1
```

### *Configure SPAN for Bonds*

This section describes how to configure SPAN for all packets going out of `bond0` locally to `bond1`.

First, create a rules file in `/etc/cumulus/acl/policy.d/`:

```
cumulus@switch:~$ sudo bash -c 'cat <<EOF > /etc/cumulus/acl/policy.d
/span_bond.rules
[iptables]
-A FORWARD --out-interface bond0 -j SPAN --dport bond1
EOF'
```



Using `cl-acltool` with the `--out-interface` rule applies to transit traffic only; it does not apply to traffic sourced from the switch.

Install the rules:

```
cumulus@switch:~$ sudo cl-acltool -i
[sudo] password for cumulus:
Reading rule file /etc/cumulus/acl/policy.d/00control_plane.rules ...
Processing rules in file /etc/cumulus/acl/policy.d/00control_plane.
rules ...
Reading rule file /etc/cumulus/acl/policy.d/99control_plane_catch_all.
rules ...
```



```
Processing rules in file /etc/cumulus/acl/policy.d  
/99control_plane_catch_all.rules ...  
Reading rule file /etc/cumulus/acl/policy.d/span_bond.rules ...  
Processing rules in file /etc/cumulus/acl/policy.d/span_bond.rules ...  
Installing acl policy  
done.
```

Verify that the SPAN rules were installed:

```
cumulus@switch:~$ sudo iptables -L -v | grep SPAN  
19 1938 SPAN      all -- any    bond0 anywhere  
anywhere          dport:bond1
```

## Configure ERSPAN

This section describes how to configure ERSPAN for all packets coming in from `swp1` to `12.0.0.2`.

### Cut-through Mode Support

Cut-through mode (see page 285) is **not** supported for ERSPAN in Cumulus Linux on switches using Broadcom Tomahawk, Trident II+ and Trident II ASICs.

Cut-through mode **is** supported for ERSPAN in Cumulus Linux on switches using Mellanox Spectrum ASICs.

1. First, create a rules file in `/etc/cumulus/acl/policy.d/`:

```
cumulus@switch:~$ sudo bash -c 'cat <<EOF > /etc/cumulus/acl  
/policy.d/erspan.rules  
[iptables]  
-A FORWARD --in-interface swp1 -j ERSPAN --src-ip 12.0.0.1 --dst-  
ip 12.0.0.2 --ttl 64  
EOF'
```

2. Install the rules:

```
cumulus@switch:~$ sudo cl-acltool -i  
Reading rule file /etc/cumulus/acl/policy.d/00control_plane.  
rules ...  
Processing rules in file /etc/cumulus/acl/policy.d  
/00control_plane.rules ...  
Reading rule file /etc/cumulus/acl/policy.d  
/99control_plane_catch_all.rules ...  
Processing rules in file /etc/cumulus/acl/policy.d  
/99control_plane_catch_all.rules ...  
Reading rule file /etc/cumulus/acl/policy.d/erspan.rules ...
```



```
Processing rules in file /etc/cumulus/acl/policy.d/erspan.rules
...
Installing acl policy
done.
```

3. Verify that the ERSPAN rules were installed:

```
cumulus@switch:~$ sudo iptables -L -v | grep SPAN
 69 6804 ERSPAN      all -- swp1    any
 anywhere           anywhere          ERSPAN src-ip:12.0.0.1
 dst-ip:12.0.0.2
```

The `src-ip` option can be any IP address, whether it exists in the routing table or not. The `dst-ip` option must be an IP address reachable via the routing table. The destination IP address must be reachable from a front-panel port, and not the management port. Use `ping` or `ip route get <ip>` to verify that the destination IP address is reachable. Setting the `--ttl` option is recommended.



When using [Wireshark](#) to review the ERSPAN output, Wireshark may report the message "Unknown version, please report or test to use fake ERSPAN preference", and the trace is unreadable. To resolve this, go into the General preferences for Wireshark, then go to **Protocols** > **ERSPAN** and check the **Force to decode fake ERSPAN frame** option.

## Selective Spanning

SPAN/ERSPAN traffic rules can be configured to limit the traffic that is spanned, to reduce the volume of copied data.



Cumulus Linux supports selective spanning for `iptables` only. `ip6tables` and `ebtables` are not supported.

The following matching fields are supported:

- IPv4 SIP/DIP
- IP protocol
- L4 (TCP/UDP) src/dst port
- TCP flags
- An ingress port/wildcard (`swp+`) can be specified in addition



With ERSPAN, a maximum of two `--src-ip` `--dst-ip` pairs are supported. Exceeding this limit produces an error when you install the rules with `c1-acltool`.



## SPAN Examples

- To mirror forwarded packets from all ports matching SIP 20.0.1.0 and DIP 20.0.1.2 to port swp1s1:

```
-A FORWARD --in-interface swp+ -s 20.0.0.2 -d 20.0.1.2 -j SPAN --  
dport swp1s2
```

- To mirror icmp packets from all ports to swp1s2:

```
-A FORWARD --in-interface swp+ -s 20.0.0.2 -p icmp -j SPAN --  
dport swp1s2
```

- To mirror forwarded UDP packets received from port swp1s0, towards DIP 20.0.1.2 and destination port 53:

```
-A FORWARD --in-interface swp1s0 -d 20.0.1.2 -p udp --dport 53 -  
j SPAN --dport swp1s2
```

- To mirror all forwarded TCP packets with only SYN set:

```
-A FORWARD --in-interface swp+ -p tcp --tcp-flags ALL SYN -j  
SPAN --dport swp1s2
```

- To mirror all forwarded TCP packets with only FIN set:

```
-A FORWARD --in-interface swp+ -p tcp --tcp-flags ALL FIN -j  
SPAN --dport swp1s2
```

## ERSPAN Examples

- To mirror forwarded packets from all ports matching SIP 20.0.1.0 and DIP 20.0.1.2:

```
-A FORWARD --in-interface swp+ -s 20.0.0.2 -d 20.0.1.2 -j ERSPAN  
--src-ip 90.0.0.1 --dst-ip 20.0.2.2
```

- To mirror ICMP packets from all ports:

```
-A FORWARD --in-interface swp+ -s 20.0.0.2 -p icmp -j ERSPAN --  
src-ip 90.0.0.1 --dst-ip 20.0.2.2
```



- To mirror forwarded UDP packets received from port swp1s0, towards DIP 20.0.1.2 and destination port 53:

```
-A FORWARD --in-interface swp1s0 -d 20.0.1.2 -p udp --dport 53 -j ERSPAN --src-ip 90.0.0.1 --dst-ip 20.0.2.2
```

- To mirror all forwarded TCP packets with only SYN set:

```
-A FORWARD --in-interface swp+ -p tcp --tcp-flags ALL SYN -j ERSPAN --src-ip 90.0.0.1 --dst-ip 20.0.2.2
```

- To mirror all forwarded TCP packets with only FIN set:

```
-A FORWARD --in-interface swp+ -p tcp --tcp-flags ALL FIN -j ERSPAN --src-ip 90.0.0.1 --dst-ip 20.0.2.2
```

## Remove SPAN Rules

To remove your SPAN rules, run:

```
#Remove rules file:  
cumulus@switch:~$ sudo rm /etc/cumulus/acl/policy.d/span.rules  
#Reload the default rules  
cumulus@switch:~$ sudo cl-acltool -i  
cumulus@switch:~$
```

To verify that the SPAN rules were removed:

```
cumulus@switch:~$ sudo cl-acltool -L all | grep SPAN  
cumulus@switch:~$
```

## Monitor Control Plane Traffic with `tcpdump`

You can use `tcpdump` to monitor control plane traffic — traffic sent to and coming from the switch CPUs. `tcpdump` does **not** monitor data plane traffic; use `cl-acltool` instead (see above).

For more information on `tcpdump`, read the [tcpdump documentation](#) and the [tcpdump man page](#).

The following example incorporates a few `tcpdump` options:

- `-i bond0`, which captures packets from bond0 to the CPU and from the CPU to bond0
- `host 169.254.0.2`, which filters for this IP address
- `-c 10`, which captures 10 packets then stops

```
cumulus@switch:~$ sudo tcpdump -i bond0 host 169.254.0.2 -c 10
tcpdump: WARNING: bond0: no IPv4 address assigned
tcpdump: verbose output suppressed, use -v or -vv for full protocol
decode
listening on bond0, link-type EN10MB (Ethernet), capture size 65535
bytes
16:24:42.532473 IP 169.254.0.2 > 169.254.0.1: ICMP echo request, id
27785, seq 6, length 64
16:24:42.532534 IP 169.254.0.1 > 169.254.0.2: ICMP echo reply, id
27785, seq 6, length 64
16:24:42.804155 IP 169.254.0.2.40210 > 169.254.0.1.5342: Flags [.],
seq 266275591:266277039, ack 3813627681, win 58, options [nop,nop,TS
val 590400681 ecr 530346691], length 1448
16:24:42.804228 IP 169.254.0.1.5342 > 169.254.0.2.40210: Flags [.],
ack 1448, win 166, options [nop,nop,TS val 530348721 ecr 590400681],
length 0
16:24:42.804267 IP 169.254.0.2.40210 > 169.254.0.1.5342: Flags [P.],
seq 1448:1836, ack 1, win 58, options [nop,nop,TS val 590400681 ecr
530346691], length 388
16:24:42.804293 IP 169.254.0.1.5342 > 169.254.0.2.40210: Flags [.],
ack 1836, win 165, options [nop,nop,TS val 530348721 ecr 590400681],
length 0
16:24:43.532389 IP 169.254.0.2 > 169.254.0.1: ICMP echo request, id
27785, seq 7, length 64
16:24:43.532447 IP 169.254.0.1 > 169.254.0.2: ICMP echo reply, id
27785, seq 7, length 64
16:24:43.838652 IP 169.254.0.1.59951 > 169.254.0.2.5342: Flags [.],
seq 2555144343:2555145791, ack 2067274882, win 58, options [nop,nop,
TS val 530349755 ecr 590399688], length 1448
16:24:43.838692 IP 169.254.0.1.59951 > 169.254.0.2.5342: Flags [P.],
seq 1448:1838, ack 1, win 58, options [nop,nop,TS val 530349755 ecr
590399688], length 390
10 packets captured
12 packets received by filter
0 packets dropped by kernel
```

## Related Information

- [en.wikipedia.org/wiki/Ping](https://en.wikipedia.org/wiki/Ping)
- [en.wikipedia.org/wiki/Traceroute](https://en.wikipedia.org/wiki/Traceroute)
- [www.tcpdump.org](http://www.tcpdump.org)

## Using NCLU to Troubleshoot Your Network Configuration

The [network command line utility](#) (see page 88) (NCLU) can quickly return a lot of information about your network configuration.



## Contents

### This topic describes ...

- [net show Commands \(see page 1019\)](#)
- [Show Interfaces \(see page 1019\)](#)
- [Other Useful Features \(see page 1021\)](#)
- [Install netshow on a Linux Server \(see page 1021\)](#)

### *net show Commands*

Running `net show` and pressing TAB displays all available command line arguments usable by `net`. The output looks like this:

```
cumulus@switch:~$ net show <TAB>
bgp          : Border Gateway Protocol
bridge       : A layer2 bridge
clag         : Multi-Chassis Link Aggregation
commit       : apply the commit buffer to the system
configuration : Settings, configuration state, etc
counters     : show netstat counters
hostname     : System hostname
igmp         : Internet Group Management Protocol
interface    : An interface such as swp1, swp2, etc
ip           : Internet Protocol version 4
ipv6         : Internet Protocol version 6
lldp         : Link Layer Discovery Protocol
lrv          : Lightweight Network Virtualization
mroute       : Configure static unicast route into MRIB for
multicast RPF lookup
msdp         : Multicast Source Discovery Protocol
ospf         : Open Shortest Path First (OSPFv2)
ospf6        : Open Shortest Path First (OSPFv3)
pim          : Protocol Independent Multicast
rollback     : revert to a previous configuration state
route        : Static routes
route-map    : Route-map
system       : System information
version      : Version number
```

### *Show Interfaces*

To show all available interfaces that are physically UP, run `net show interface`:

```
cumulus@switch:~$ net show interface
```

Name	Speed	MTU	Mode	Summary
------	-------	-----	------	---------

```
-- -----
-- -----
UP lo      N/A      65536  Loopback          IP: 10.0.0.11/32, 127.0.0.1
/8, ::1/128
UP eth0    1G       1500   Mgmt             IP: 192.168.0.11/24(DHCP)
UP swp1    1G       1500   Access/L2        Untagged: br0
UP swp2    1G       1500   NotConfigured
UP swp51   1G       1500   NotConfigured
UP swp52   1G       1500   NotConfigured
UP blue    N/A      65536  NotConfigured
UP br0     N/A      1500   Bridge/L3        IP: 172.16.1.1/24
                                         Untagged Members: swp1
                                         802.1q Tag: Untagged
                                         STP: RootSwitch(32768)

UP red    N/A      65536  NotConfigured
```

Whereas `net show interface all` displays every interface regardless of state:

```
cumulus@switch:~$ net show interface all
      Name      Speed      MTU      Mode           Summary
-----  -----  -----  -----  -----
UP      lo      N/A      65536  Loopback          IP: 10.0.0.11/32,
127.0.0.1/8, ::1/128
UP      eth0    1G       1500   Mgmt             IP: 192.168.0.11/24
(DHCP)
UP      swp1    1G       1500   Access/L2        Untagged: br0
UP      swp2    1G       1500   NotConfigured
ADMDN  swp45   0M       1500   NotConfigured
ADMDN  swp46   0M       1500   NotConfigured
ADMDN  swp47   0M       1500   NotConfigured
ADMDN  swp48   0M       1500   NotConfigured
ADMDN  swp49   0M       1500   NotConfigured
ADMDN  swp50   0M       1500   NotConfigured
UP      swp51    1G      1500   NotConfigured
UP      swp52    1G      1500   NotConfigured
UP      blue    N/A      65536  NotConfigured
UP      br0     N/A      1500   Bridge/L3        IP: 172.16.1.1/24
                                         Untagged Members: swp1
                                         802.1q Tag: Untagged
                                         STP: RootSwitch(32768)

UP      red    N/A      65536  NotConfigured
ADMDN vagrant 0M       1500   NotConfigured
```

You can get information about the switch itself by running `net show system`:

```
cumulus@switch:~$ net show system
Hostname..... celRED
```



```
Build..... Cumulus Linux 3.7.4~1551312781.35d3264
Uptime..... 8 days, 12:24:01.770000

Model..... Cel REDSTONE
CPU..... x86_64 Intel Atom C2538 2.4 GHz
Memory..... 4GB
Disk..... 14.9GB
ASIC..... Broadcom Trident2 BCM56854
Ports..... 48 x 10G-SFP+ & 6 x 40G-QSFP+
Base MAC Address. a0:00:00:00:00:50
Serial Number.... A1010B2A011212AB000001
```

## Other Useful Features

NCLU uses the [python network-docopt](#) package. This is inspired by [docopt](#) and provides the ability to specify partial commands, without tab completion and running the complete option. For example:

```
net show int runs netshow interface
net show sys runs netshow system
```

## Install netshow on a Linux Server

`netshow` is a tool developed by Cumulus Networks for troubleshooting networks. In Cumulus Linux, it's been replaced by NCLU. However, NCLU is not available on Linux hosts at this time, so Cumulus Networks recommends you use `netshow` to help troubleshoot servers. To install `netshow` on a Linux server, run:

```
root@host:~# pip install netshow-linux-lib
```



Debian and Red Hat packages will be available in the near future.

## Monitoring System Statistics and Network Traffic with sFlow

[sFlow](#) is a monitoring protocol that samples network packets, application operations, and system counters. sFlow collects both interface counters and sampled 5-tuple packet information, enabling you to monitor your network traffic as well as your switch state and performance metrics. An outside server, known as an *sFlow collector*, is required to collect and analyze this data.

`hsflowd` is the service that samples and sends sFlow data to configured collectors. By default, `hsflowd` is disabled and does *not* start automatically when the switch boots up.



If you intend to run this service within a [VRF \(see page 847\)](#), including the [management VRF \(see page 877\)](#), follow [these steps \(see page 879\)](#) for configuring the service.

## Contents

This topic describes ...



- [Configure sFlow \(see page 1022\)](#)
  - [Configure sFlow via DNS-SD \(see page 1022\)](#)
  - [Manually Configure /etc/hsflowd.conf \(see page 1023\)](#)
- [Configure sFlow Visualization Tools \(see page 1023\)](#)
- [Related Information \(see page 1023\)](#)

## Configure sFlow

To configure `hsflowd` to send to the designated collectors, either:

- Use DNS service discovery (DNS-SD)
- Manually configure the `/etc/hsflowd.conf` file

### Configure sFlow via DNS-SD

You can configure your DNS zone to advertise the collectors and polling information to all interested clients.

Add the following content to the zone file on your DNS server:

```
_sflow._udp SRV 0 0 6343 collector1
_sflow._udp SRV 0 0 6344 collector2
_sflow._udp TXT (
  "txtvers=1"
  "sampling.100M=100"
  "sampling.1G=1000"
  "sampling.10G=10000"
  "sampling.40G=40000"
  "sampling.100G=100000"
  "polling=20"
)
```

The above snippet instructs `hsflowd` to send sFlow data to collector1 on port 6343 and to collector2 on port 6344. `hsflowd` will poll counters every 20 seconds and sample 1 out of every 2048 packets.



The maximum samples per second delivered from the hardware is limited to 16K. You can configure the number of samples per second in the `/etc/cumulus/datapath/traffic.conf` file, as shown below:

```
# Set sflow/sample ingress cpu packet rate and burst in packets
/sec
# Values: {0..16384}
#sflow.rate = 16384
#sflow.burst = 16384
```

Start the sFlow daemon:



```
cumulus@switch:~$ sudo systemctl start hsflowd.service
```

No additional configuration is required in `/etc/hsflowd.conf`.

### *Manually Configure `/etc/hsflowd.conf`*

You can set up the collectors and variables on each switch.

Edit the `/etc/hsflowd.conf` file to set up your collectors and sampling rates in `/etc/hsflowd.conf`. For example:

```
# ===== Sampling/Polling/Collectors =====
# EITHER: automatic (DNS SRV+TXT from _sflow._udp):
#   DNS-SD { }
# OR: manual:
#   Counter Polling:
#     polling = 20
#   default sampling N:
#     sampling = 400
#   sampling N on interfaces with ifSpeed:
#     sampling.100M = 100
#     sampling.1G = 1000
#     sampling.10G = 10000
#     sampling.40G = 40000
#   sampling N for apache, nginx:
#     sampling.http = 50
#   sampling N for application (requires json):
#     sampling.app.myapp = 100
#   collectors:
# collector { ip=192.0.2.100 udpport=6343 }
# collector { ip=192.0.2.200 udpport=6344 }
```

This configuration polls the counters every 20 seconds, samples 1 of every 2048 packets, and sends this information to a collector at 192.0.2.100 on port 6343 and to another collector at 192.0.2.200 on port 6344.



Some collectors require each source to transmit on a different port, others listen on only one port. Refer to the documentation for your collector for more information.

### *Configure sFlow Visualization Tools*

For information on configuring various sFlow visualization tools, read this [Help Center article](#).

### *Related Information*

- [sFlow Collectors](#)



- [sFlow Wikipedia page](#)

## Simple Network Management Protocol (SNMP) Monitoring

Cumulus Linux uses the open source Net-SNMP agent `snmpd`, version 5.7, which provides support for most of the common industry-wide MIBs, including interface counters and TCP/UDP IP stack data.

## Contents

This topic describes ...

- History (see page 1024)
- Introduction to Simple Network Management Protocol (see page 1025)
  - SNMP Managers (see page 1025)
  - SNMP Agents (see page 1025)
  - Management Information Base (MIB) (see page 1025)
- Getting Started (see page 1027)
- Configure SNMP (see page 1027)
  - Configure SNMP with NCLU (see page 1028)
- Configure SNMP Manually (see page 1034)
  - Start the SNMP Daemon (see page 1037)
  - Configure SNMP with Management VRF (used prior to Cumulus Linux 3.6) (see page 1038)
  - Set up the Custom Cumulus Networks MIBs (see page 1040)
  - Set the Community String (see page 1040)
- Enable SNMP Support for FRRouting (see page 1041)
  - Enable the .1.3.6.1.2.1 Range (see page 1042)
  - Configure SNMPv3 (see page 1042)
- Manually Configure SNMP Traps (Non-NCLU) (see page 1046)
  - Generate Event Notification Traps (see page 1046)
  - `snmptrapd.conf` (see page 1055)
- Supported MIBs (see page 1056)
- Pass Persist Scripts (see page 1059)
- Troubleshooting (see page 1059)

## History

SNMP is an IETF standards-based network management architecture and protocol that traces its roots back to Carnegie-Mellon University in 1982. Since then, it has been modified by programmers at the University of California. In 1995, this code was also made publicly available as the UCD project. After that, `ucd-snmp` was extended by work done at the University of Liverpool as well as later in Denmark. In late 2000, the project name changed to `net-snmp` and became a fully-fledged collaborative open source project. The version used by Cumulus Networks is based on the latest `net-snmp` 5.7 branch with added custom MIBs and pass-through and pass-persist scripts (see below (see page 1059) for more information on pass persist scripts).



## Introduction to Simple Network Management Protocol

SNMP Management servers gather information from different systems in a consistent manner and the paths to the relevant information are standardized in IETF RFCs. SNMPS longevity is due to the fact that it standardizes the objects collected from devices, the protocol used for transport, and architecture of the management systems. The most widely used, and most insecure, versions of SNMP are versions 1 and 2c and their popularity is largely due to implementations that have been in use for decades. SNMP version 3 is the recommended version because of its advanced security features. In general, a network being profiled by SNMP Management Stations mainly consist of devices containing SNMP agents. The agent running on Cumulus Linux switches and routers is the `snmpd` daemon.

### SNMP Managers

An SNMP Network Management System (NMS) is a computer that is configured to poll SNMP agents (in this case, Cumulus Linux switches and routers) to gather information and present it. This manager can be any machine that can send query requests to SNMP agents with the correct credentials. This NMS can be a large set of monitoring suite or as simple as some scripts that collect and display data. The managers generally poll the agents and the agents respond with the data. There are a variety of polling command-line tools (`snmpget`, `snmpgetnext`, `snmpwalk`, `snmpbulkget`, `snmpbulkwalk`, and so on). SNMP agents can also send unsolicited Traps/Inform messages to the SNMP Manager based on predefined criteria (like link changes).

### SNMP Agents

The SNMP agents (`snmpd`) running on the switches do the bulk of the work and are responsible for gathering information about the local system and storing data in a format that can be queried updating an internal database called the *management information base*, or MIB. The MIB is a standardized, hierarchical structure that stores information that can be queried. Parts of the MIB tree are available and provided to incoming requests originating from an NMS host that has authenticated with the correct credentials. You can configure the Cumulus Linux switch with usernames and credentials to provide authenticated and encrypted responses to NMS requests. The `snmpd` agent can also proxy requests and act as a *master agent* to sub-agents running on other daemons (FRR, LLDP).

### Management Information Base (MIB)

The MIB is a database that is implemented on the daemon (or agent) and follows IETF RFC standards to which the manager and agents adhere. It is a hierarchical structure that, in many areas, is globally standardized, but also flexible enough to allow vendor-specific additions. Cumulus Networks implements a number of custom enterprise MIB tables and these are defined in text files located on the switch and in files named `/usr/share/snmp/mibs/Cumulus*`. The MIB structure is best understood as a top-down hierarchical tree. Each branch that forks off is labeled with both an identifying number (starting with 1) and an identifying string that is unique for that level of the hierarchy. These strings and numbers can be used interchangeably. A specific node of the tree can be traced from the unnamed root of the tree to the node in question. The parent IDs (numbers or strings) are strung together, starting with the most general to form an address for the MIB Object. Each junction in the hierarchy is represented by a dot in this notation so that the address ends up being a series of ID strings or numbers separated by dots. This entire address is known as an object identifier (OID).

Hardware vendors that embed SNMP agents in their devices sometimes implement custom branches with their own fields and data points. However, there are standard MIB branches that are well defined and can be used by any device. The standard branches discussed here are all under the same parent branch structure. This branch defines information that adheres to the MIB-2 specification, which is a revised standard for compliant devices. You can use various online and command-line tools to translate between

numbers and string and to also provide definitions for the various MIB Objects. For example, you can view the `sysLocation` object in the system table with either a string of numbers **1.3.6.1.2.1.1.6** or the string representation **iso.org.dod.internet.mgmt.mib-2.system.sysLocation**. You can view the definition with the `snmptranslate` (1) command (found in the `snmp` Debian package).

### **snmptranslate Command**

```
/home/cumulus# snmptranslate -Td -On SNMPv2-MIB::  
sysLocation  
.1.3.6.1.2.1.1.6  
sysLocation OBJECT-TYPE  
-- FROM SNMPv2-MIB  
-- TEXTUAL CONVENTION DisplayString  
SYNTAX OCTET STRING (0..255)  
DISPLAY-HINT "255a"  
MAX-ACCESS read-write  
STATUS current  
DESCRIPTION "The physical location of this node (e.g., 'telephone  
closet, 3rd floor'). If the location is unknown, the  
value is the zero-length string."  
 ::= { iso(1) org(3) dod(6) internet(1) mgmt(2) mib-2(1) system(1) 6 }  
  
/home/cumulus# snmptranslate -Tp -IR system  
+--system(1)  
|  
| +-- -R-- String sysDescr(1)  
| | Textual Convention: DisplayString  
| | Size: 0..255  
| +-- -R-- ObjID sysObjectID(2)  
| +-- -R-- TimeTicks sysUpTime(3)  
| |  
| | +--sysUpTimeInstance(0)  
|  
| +-- -RW- String sysContact(4)  
| | Textual Convention: DisplayString  
| | Size: 0..255  
| +-- -RW- String sysName(5)  
| | Textual Convention: DisplayString  
| | Size: 0..255  
| +-- -RW- String sysLocation(6)  
| | Textual Convention: DisplayString  
| | Size: 0..255  
| +-- -R-- INTEGER sysServices(7)  
| | Range: 0..127  
| +-- -R-- TimeTicks sysORLastChange(8)  
| | Textual Convention:TimeStamp
```

The section **1.3.6.1** or **iso.org.dod.internet** is the OID that defines internet resources. The **2** or **mgmt** that follows is for a management subcategory. The **1** or **mib-2** under that defines the MIB-2 specification. And finally, the **1** or **system** is the parent for a number of child objects (`sysDescr`, `sysObjectID`, `sysUpTime`, `sysContact`, `sysName`, `sysLocation`, `sysServices`, and so on).



## Getting Started

The simplest use case for using SNMP consists of creating a readonly community password and enabling a listening address for the loopback address (this is the default listening-address provided). This allows for testing functionality of `snmpd` before extending the listening addresses to IP addresses reachable from outside the switch or router. This first sample configuration adds a listening address on the loopback interface (this is not a change from the default so we get a message stating that the configuration has not changed), sets a simple community password (SNMPv2) for testing, changes the system-name object in the system table, commits the change, checks the status of `snmpd`, and gets the first MIB object in the system table:

```
cumulus@router1:~$ net add snmp-server listening-address localhost
Configuration has not changed
cumulus@router1:~$ net add snmp-server readonly-community
mynotsosecretpassword access any
cumulus@router1:~$ net add snmp-server system-name my little router
cumulus@router1:~$ net commit

cumulus@router1:~$ net show snmp-server status

Simple Network Management Protocol (SNMP) Daemon.
-----
Current Status           active (running)
Reload Status            enabled
Listening IP Addresses  localhost
Main snmpd PID          13669
Version 1 and 2c Community String  Configured
Version 3 Usernames     Not Configured
-----

cumulus@router1:~$ snmpgetnext -v 2c -c mynotsosecretpassword
localhost SNMPv2-MIB::sysName
SNMPv2-MIB::sysName.0 = STRING: my little router
```

## Configure SNMP

For external SNMP NMS systems to poll Cumulus Linux switches and routers, you must configure the SNMP agent (`snmpd`) running on the switch with one or more IP addresses (with `net add snmp-server listening-address <ip>`) on which the agent listens. You must configure these IP addresses on interfaces that have link state UP. By default, the SNMP configuration has a listening address of localhost (or 127.0.0.1), which allows the daemon to respond to SNMP requests originating on the switch itself. This is a useful method of checking the configuration for SNMP without exposing the switch to attacks from the outside. The only other required configuration is a readonly community password (configured with `net add snmp-server readonly-community <password> access <ip | any>`), that allows polling of the various MIB objects on the device itself. SNMPv3 is recommended since SNMPv2c (with a community string) exposes the password in the `GetRequest` and `GetResponse` packets. SNMPv3 does not expose the username passwords and has the option of encrypting the packet contents.



If you intend to run this service within a VRF (see page 847), including the management VRF (see page 877), follow these steps (see page 879) for configuring the service.

**i** Cumulus Linux 3.4 and later releases support configuring SNMP with NCLU. While NCLU does not provide functionality to configure every single `snmpd` feature, it is the recommended method of configuring `snmpd`. You are not restricted to using NCLU for configuration and can edit the `/etc/snmp/snmpd.conf` file and control `snmpd` with `systemctl` commands. For Cumulus Linux versions earlier than 3.0, `snmpd` has a default configuration that listens to incoming requests on all interfaces.

**i** Cumulus Linux 3.6 and later releases support configuring VRFs for listening-addresses as well as Trap/Inform support. If management VRF is enabled on the switch, this places the `eth0` interface in the management VRF. When configuring the listening-address for `snmp-server`, you must specify an additional parameter to enable listening on the `eth0` interface with the following command:

```
cumulus@router1:~$ net add snmp-server listening-address 10.10.10.10 vrf mgmt
```

These additional parameters are described in detail below.

**!** You must add a default community string for v1 or v2c environments or the `snmpd` daemon does not respond to any requests. For security reasons, the default configuration configures `snmpd` to listen to SNMP requests on the loopback interface so access to the switch is restricted to requests originating from the switch itself. The only required commands for `snmpd` to function are a `listening-address` and either a `username` or a `readonly-community` string.

## Configure SNMP with NCLU

The table below highlights the structure of NCLU commands available for configuring SNMP. An example command set is provided below the table. NCLU restarts the `snmpd` daemon after configuration changes are made and committed.

Command	Summary
<code>net del all</code> or <code>net del snmp-server all</code>	Removes all entries in the <code>/etc/snmp/snmpd.conf</code> file and replaces them with defaults. The defaults remove all SNMPv3 usernames, readonly-communities, and a listening-address of localhost is configured.
<code>net add snmp-server listening-address (localhost localhost-v6)</code>	For security reasons, the localhost is set to a listening address 127.0.0.1 by default so that the SNMP agent only responds to requests originating on the switch itself. You can also configure



Command	Summary
	<p>listening only on the IPv6 localhost address with localhost-v6. When using IPv6 addresses or localhost, you can use a <code>readonly-community-v6</code> for v1 and v2c requests. For v3 requests, you can use the <code>username</code> command to restrict access.</p> <pre>net add snmp-server listening-address localhost net add snmp-server listening-address localhost-v6</pre>
<code>net add snmp-server listening-address (all all-v6)</code>	<p>Configures the <code>snmpd</code> agent to listen on all interfaces for either IPv4 or IPv6 UDP port 161 SNMP requests. This command removes all other individual IP addresses configured.</p> <p>Note: This command does not allow <code>snmpd</code> to cross VRF table boundaries. To listen on IP addresses in different VRF tables, use multiple listening-address commands each with a VRF name, as shown below.</p> <pre>net add snmp-server listening-address all net add snmp-server listening-address all-v6</pre>
<code>net add snmp-server listening-address IP_ADDRESS IP_ADDRESS ...</code>	<p>Sets <code>snmpd</code> to listen to a specific IPv4 or IPv6 address, or a group of addresses with space separated values, for incoming SNMP queries. If VRF tables are used, be sure to specify an IP address with an associated VRF name, as shown below. If you omit a VRF name, the default VRF is used.</p> <pre>net add snmp-server listening-address 10.10 .10.10</pre> <pre>net add snmp-server listening-address 10.10 .10.10 44.44.44.44</pre>
<code>net add snmp-server listening-address IP_ADDRESS vrf VRF_NAME</code>	<p>Sets <code>snmpd</code> to listen to a specific IPv4 or IPv6 address on an interface within a particular VRF. With VRFs, identical IP addresses can exist in different VRF tables. This command restricts listening to a particular IP address within a particular VRF. If the VRF name is not given, the default VRF is used.</p>

Command	Summary
	<pre>net add snmp-server listening-address 10.10 .10.10 vrf mgmt</pre>
<pre>net add snmp-server username [user name] (auth-none auth-md5 auth-sha) &lt;authentication password&gt; [(encrypt- des encrypt-aes) &lt;encryption password&gt;] (oid &lt;OID&gt; view &lt;view name&gt;)</pre>	<p>Creates an SNMPv3 username and the necessary credentials for access. You can restrict a user to a particular OID tree or predefined view name if these are specified. If you specify auth-none, no authentication password is required. Otherwise, an MD5 or SHA password is required for access to the MIB objects. If specified, an encryption password is used to hide the contents of the request and response packets.</p> <pre>net add snmp-server username testusernoauth auth-none net add snmp-server username testuserauth auth-md5 myauthmd5password net add snmp-server username testuserboth auth-md5 mynewmd5password encrypt-aes myencryptsecret net add snmp-server username limiteduser1 auth-md5 md5password1 encrypt-aes myaessecret oid 1.3.6.1.2.1.1</pre>
<pre>net add snmp-server viewname [view name] (included   excluded) [OID or name]</pre>	<p>Creates a view name that is used in readonly-community to restrict MIB tree exposure. By itself, this view definition has no effect; however, when linked to an SNMPv3 username or community password, and a host from a restricted subnet, any SNMP request with that username and password must have a source IP address within the configured subnet.</p> <p>Note: OID can be either a string of period separated decimal numbers or a unique text string that identifies an SNMP MIB object. Some MIBs are not installed by default; you must install them either by hand or with the latest Debian package called <code>snmp-mibs-downloader</code>. You can remove specific view name entries with the <code>delete</code> command or with just a view name to remove all entries matching that view name. You can define a specific view name multiple times and fine tune to provide or restrict access using the <code>included</code> or <code>excluded</code> command to specify branches of certain MIB trees.</p> <pre>net add snmp-server viewname cumulusOnly included .1.3.6.1.4.1.40310</pre>



Command	Summary
	<pre>net add snmp-server viewname cumulusCounters included .1.3.6.1.4.1.40310 .2  net add snmp-server readonly-community simplepassword access any view cumulusOnly net add snmp-server username testusernoauth auth-none view cumulusOnly net add snmp-server username limiteduser1 auth-md5 md5password1 encrypt-aes myaessecret view cumulusCounters</pre>
<pre>net add snmp-server (readonly-community    readonly-community-v6)  [password] access (any    localhost   [network])  [(view [view name]) or  [oid [oid or name])</pre>	<p>This command defines the password required for SNMP version 1 or 2c requests for GET or GETNEXT. By default, this provides access to the full OID tree for such requests, regardless of from where they were sent. There is no default password set, so <code>snmpd</code> does not respond to any requests that arrive. Users often specify a source IP address token to restrict access to only that host or network given. You can specify a view name to restrict the subset of the OID tree.</p> <p>Examples of <code>readonly-community</code> commands are shown below. The first command sets the read only community string to <code>simplepassword</code> for SNMP requests and this restricts requests to those sourced from hosts in the 10.10.10.0/24 subnet and restricts viewing to the <code>mysystem</code> view name defined with the <code>viewname</code> command. The second example creates a read-only community password <code>showitall</code> that allows access to the entire OID tree for requests originating from any source IP address.</p> <pre>net add snmp-server viewname mysystem included 1.3.6.1.2.1.1 net add snmp-server readonly-community simplepassword access 10.10.10.0/24 view mysystem  net add snmp-server readonly-community showitall access any</pre>
<pre>net add snmp-server trap- destination (localhost    [ipaddress]) [vrf vrf name] community-password [password] [version [1   2c]]</pre>	<p>For SNMP versions 1 and 2C, this command sets the SNMP Trap destination IP address. Multiple destinations can exist, but you must set up at least one to enable SNMP Traps to be sent. Removing all settings disables SNMP traps. The default version is 2c, unless otherwise configured. You must include a VRF name with the IP address to force Traps to be sent in a non-default VRF table.</p>

Command	Summary
	<pre>net add snmp-server trap-destination 10.10.10.10 community-password mynotsosecretpassword version 1 net add snmp-server trap-destination 20.20.20.20 vrf mgmt community-password mymanagementvrfpassword version 2c</pre>
<pre>net add snmp-server trap- destination (localhost   [ipaddress]) [vrf vrf name] username &lt;v3 username&gt; (auth-md5 auth- sha) &lt;authentication password&gt; [(encrypt- des encrypt-aes) &lt;encryption password&gt;] engine-id &lt;text&gt; [inform]</pre>	<p>For SNMPv3 Trap and Inform messages, this command configures the trap destination IP address (with an optional VRF name). You must define the authentication type and password. The encryption type and password are optional. You must specify the engine ID /user name pair. The <code>inform</code> keyword is used to specify an Inform message where the SNMP agent waits for an acknowledgement.</p> <p>For Traps, the engine ID/user name is for the CL switch <b>sending</b> the traps. This can be found at the end of the <code>/var/lib/snmp/snmpd.conf</code> file labelled <code>oldEngineID</code>. Configure this same engine ID /user name (with authentication and encryption passwords) for the Trap daemon receiving the trap to validate the received Trap.</p>
	<pre>net add snmp-server trap-destination 10.10.10.10 username myv3userrsion auth- md5 md5password1 encrypt-aes myaessecret engine-id 0x80001f888070939b14a514da5a00000000 net add snmp-server trap-destination 20.20.20.20 vrf mgmt username mymgmtvrfusername auth-md5 md5password2 encrypt-aes myaessecret2 engine-id 0x80001f888070939b14a514da5a00000000</pre> <p>For Inform messages (Informs are acknowledged version 3 Traps), the engine ID/user name is the one used to create the username on the <b>receiving Trap daemon server</b>. The Trap receiver sends the response for the Trap message using its own engine ID/user name. In practice, the trap daemon generates the usernames with its own engine ID and after these are created, the SNMP server (or agent) needs to use these engine ID/user names when configuring the Inform messages so that they are correctly authenticated and the correct response is sent to the <code>snmpd</code> agent that sent it.</p> <pre>net add snmp-server trap-destination 10.10.10.10 username myv3userrsion auth-</pre>

Command	Summary
	<pre>md5 md5password1 encrypt-aes myaessecret engine-id 0x80001f888070939b14a514da5a00000000 inform net add snmp-server trap-destination 20.20.20.20 vrf mgmt username mymgmtvrfusername auth-md5 md5password2 encrypt-aes myaessecret2 engine-id 0x80001f888070939b14a514da5a00000000 inform</pre>
<pre>net add snmp-server trap- link-up [check-frequency [seconds]]</pre>	<p>Enables notifications for interface link-up to be sent to SNMP Trap destinations.</p> <pre>net add snmp-server trap-link-up check- frequency 15</pre>
<pre>net add snmp-server trap- link-down [check- frequency [seconds]]</pre>	<p>Enables notifications for interface link-down to be sent to SNMP Trap destinations.</p> <pre>net add snmp-server trap-link-down check- frequency 10</pre>
<pre>net add snmp-server trap- snmp-auth-failures</pre>	<p>Enables SNMP Trap notifications to be sent for every SNMP authentication failure.</p> <pre>net add snmp-server trap-snmp-auth-failures</pre>
<pre>net add snmp-server trap- cpu-load-average one- minute [threshold] five- minute [5-min-threshold] fifteen-minute [15-min- threshold]</pre>	<p>Enables a trap when the cpu-load-average exceeds the configured threshold. You can only use integers or floating point numbers.</p> <pre>net add snmp-server trap-cpu-load-average one-minute 4.34 five-minute 2.32 fifteen- minute 6.5</pre>

This table describes system setting configuration commands for SNMPv2-MIB.



Command	Summary
net add snmp-server system-location [string]	<p>Sets the system physical location for the node in the SNMPv2-MIB system table.</p> <pre>net add snmp-server system-location My <b>private</b> bunker</pre>
net add snmp-server system-contact [string]	<p>Sets the identification of the contact person for this managed node, together with information on how to contact this person.</p> <pre>net add snmp-server system-contact user X at myemail@example.com</pre>
net add snmp-server system-name [string]	<p>Sets an administratively-assigned name for the managed node. By convention, this is the fully-qualified domain name of the node.</p> <pre>net add snmp-server system-name CumulusBox number 1,543,567</pre>

The example commands below enable an SNMP agent to listen on all IPv4 addresses with a community string password, set the trap destination host IP address, and create four types of SNMP traps.

```
cumulus@switch:~$ net add snmp-server listening-address all  
cumulus@switch:~$ net add snmp-server readonly-community tempPassword  
access any  
cumulus@switch:~$ net add snmp-server trap-destination 1.1.1.1  
community-password mypass version 2c  
cumulus@switch:~$ net add snmp-server trap-link-up check-frequency 15  
cumulus@switch:~$ net add snmp-server trap-link-down check-frequency 1  
0  
cumulus@switch:~$ net add snmp-server trap-cpu-load-average one-  
minute 7.45 five-minute 5.14  
cumulus@switch:~$ net add snmp-server trap-snmp-auth-failures
```

## Configure SNMP Manually

If you need to manually edit the SNMP configuration; for example, if the necessary option has not been implemented in NCLU, you need to edit the configuration directly, which is stored in the `/etc/snmp/snmpd.conf` file.



Use caution when editing this file. The next time you use NCLU to update your SNMP configuration, if NCLU is unable to correctly parse the syntax, some of the options might be overwritten.

Make sure you do not delete the `snmpd.conf` file; this can cause issues with the package manager the next time you update Cumulus Linux.

The SNMP daemon, `snmpd`, uses the `/etc/snmp/snmpd.conf` configuration file for most of its configuration. The syntax of the most important keywords are defined in the following table.

Syntax	Meaning
<b>agentaddress</b>	<b>Required.</b> This command sets the protocol, IP address, and the port for <code>snmpd</code> to listen for <b>incoming</b> requests. The IP address must exist on an interface that has link UP on the switch where <code>snmpd</code> is being used. By default, this is set to <code>udp:127.0.0.1:161</code> , which means <code>snmpd</code> listens on the loopback interface and only responds to requests ( <code>snmpwalk</code> , <code>snmpget</code> , <code>snmpgetnext</code> ) originating from the switch. A wildcard setting of <code>udp:161</code> , <code>udp6:161</code> forces <code>snmpd</code> to listen on all IPv4 and IPv6 interfaces for incoming SNMP requests. You can configure multiple IP addresses as comma-separated values; for example, <code>udp:66.66.66.66:161,udp:77.77.77.77:161,udp6:[2001::1]:161</code> . You can use multiple lines to define listening addresses. To bind to a particular IP address within a particular VRF table, follow the IP address with a @ and the name of the VRF table (for example, <code>10.10.10.10@mgt</code> ).
<b>rocommunity</b>	<b>Required.</b> This command defines the password that is required for SNMP version 1 or 2c requests for GET or GETNEXT. By default, this provides access to the full OID tree for such requests, regardless of from where they were sent. There is no default password set, so <code>snmpd</code> does not respond to any requests that arrive. Specify a source IP address token to restrict access to only that host or network given. Specify a view name (as defined above) to restrict the subset of the OID tree.  Examples of <code>rocommunity</code> commands are shown below. The first command sets the read only community string to <code>simplepassword</code> for SNMP requests sourced from the 10.10.10.0/24 subnet and restricts viewing to the <code>systemonly</code> view name defined previously with the <code>view</code> command. The second example creates a read-only community password that allows access to the entire OID tree from any source IP address.
<b>view</b>	This command defines a view name that specifies a subset of the overall OID tree. You can reference this restricted view by name in the <code>rocommunity</code> command to link the view to a password that is used to see this restricted OID subset. By default, the <code>snmpd.conf</code> file contains numerous views with the <code>systemonly</code> view name.

```
rocommunity simplepassword 10.10.10.0/24 -V  
systemonly
```

```
rocommunity cumulustestpassword
```



Syntax	Meaning
	<pre>view systemonly included .1.3.6.1.2.1.1 view systemonly included .1.3.6.1.2.1.2 view systemonly included .1.3.6.1.2.1.3</pre> <p>The <i>systemonly</i> view is used by <code>rocommunity</code> to create a password for access to only these branches of the OID tree.</p>
<b>trapsink</b> <b>trap2sink</b>	This command defines the IP address of the notification (or trap) receiver for either SNMPv1 traps or SNMPv2 traps. If you specify several sink directives, multiple copies of each notification (in the appropriate formats) are generated. You must configure a trap server to receive and decode these trap messages (for example, <code>snmptrapd</code> ). You can configure the address of the trap receiver with a different protocol and port but this is most often left out. The defaults are to use the well-known UDP packets and port 162.
<b>createuser</b> <b>iquerysecName</b> <b>rouser</b>	<p>These three commands define an internal SNMPv3 username that is required for <code>snmpd</code> to send traps. This username is required to authorize the DisMan service even though SNMPv3 is not being configured for use. The example <code>snmpd.conf</code> configuration shown below creates <code>snmptrapusernameX</code> as the username (this is just an example username) using the <code>createUser</code> command. <code>iquerysecname</code> defines the default SNMPv3 username to be used when making internal queries to retrieve monitored expressions. <code>rouser</code> specifies the username for these SNMPv3 queries. All three are required for <code>snmpd</code> to retrieve information and send built-in traps or for those configured with the <code>monitor</code> command shown below in the examples.</p> <pre>createuser snmptrapusernameX iquerysecname snmptrapusernameX rouser snmptrapusernameX</pre>
<b>linkUpDownNotifications</b> <b>yes</b>	This command enables link up and link down trap notifications, assuming the other trap configurations settings are set. This command configures the Event MIB tables to monitor the ifTable for network interfaces being taken up or down, and triggering a <i>linkUp</i> or <i>linkDown</i> notification as appropriate. This is equivalent to the following configuration:

Syntax	Meaning
	<pre>notificationEvent linkDownTrap linkDown ifIndex ifAdminStatus ifOperStatus  monitor -r 60 -e linkUpTrap "Generate linkUp" ifOperStatus != 2  monitor -r 60 -e linkDownTrap "Generate linkDown" ifOperStatus == 2</pre>
<b>defaultMonitors yes</b>	<p>This command configures the Event MIB tables to monitor the various UCD-SNMP-MIB tables for problems (as indicated by the appropriate xxErrFlag column objects) and send a trap. This assumes you have downloaded the <code>snmp-mibs-downloader</code> Debian package and commented out <code>mibs</code> from the <code>/etc/snmp/snmp.conf</code> file (#mibs). This command is exactly equivalent to the following configuration:</p> <pre>monitor -o prNames -o prErrMessage "process table" prErrorFlag != 0  monitor -o memErrorName -o memSwapErrorMsg "memory" memSwapError != 0  monitor -o extNames -o extOutput "extTable" extResult != 0  monitor -o dskPath -o dskErrorMsg "dskTable" dskErrorFlag != 0  monitor -o laNames -o laErrMessage "laTable" laErrorFlag != 0  monitor -o fileName -o fileErrorMsg "fileTable" fileErrorFlag != 0</pre>

## Start the SNMP Daemon

Use the recommended process described below to start `snmpd` and monitor it using `systemctl`.



As mentioned above, if you intend to run this service within a [VRF \(see page 847\)](#), including the [management VRF \(see page 877\)](#), follow [these steps \(see page 879\)](#) for configuring the service.

To start the SNMP daemon:

1. Start the `snmpd` daemon:



```
cumulus@switch:~$ sudo systemctl start snmpd.service
```

2. Configure the `snmpd` daemon to start automatically after reboot:

```
cumulus@switch:~$ sudo systemctl enable snmpd.service
```

3. To enable `snmpd` to restart automatically after failure:

- a. Create a file called `/etc/systemd/system/snmpd.service.d/restart.conf`.
- b. Add the following lines:

```
[Service]
Restart=always
RestartSec=60
```

- c. Run `sudo systemctl daemon-reload`.

After the service starts, you can use SNMP to manage various components on the switch.

### *Configure SNMP with Management VRF (used prior to Cumulus Linux 3.6)*

When you configure [Management VRF \(see page 877\)](#), you need to be aware of the interface IP addresses on which SNMP is listening. If you set listening-address to all, the `snmpd` daemon responds to incoming requests on all interfaces that are in the default VRF. If you prefer to listen on a limited number of IP addresses, Cumulus Networks recommends that you run only one instance of the `snmpd` daemon and specify the VRF name along with the listening-address. You can configure IP addresses in different VRFs and a single SNMP daemon listens on multiple IP addresses each with its own VRF. Because SNMP has native VRF awareness, using `systemctl` commands to manage `snmpd` in different VRFs is no longer necessary.

SNMP configuration in NCLU is VRF aware so you can configure the `snmpd` daemon to listen to incoming SNMP requests on a particular IP address within particular VRFs. Because interfaces in a particular VRF (routing table) are not aware of interfaces in a different VRF, the `snmpd` daemon only responds to polling requests and sends traps on the interfaces of the VRF on which it is configured.

When management VRF is configured, configure the listening-address with a VRF name as shown above. This allows `snmpd` to receive and respond to SNMP polling requests on eth0.

Prior to Cumulus Linux 3.6, you could not configure a VRF name in the listening-address or the trap-destination commands. To manually handle VRF functionality, you had to do the following:

1. Configure all the required SNMP settings with NCLU. Pay particular attention to the listening-address configuration setting, which should contain one or more IP addresses that belong to interfaces within a single VRF (if management VRF is configured, this is typically the IP address of eth0). You can use IP addresses other than eth0, but the interfaces for these IP addresses must be in the same VRF (typically the management VRF).
2. Commit the changes to start the `snmpd` daemon in the default VRF.
3. Manually stop the `snmpd` daemon from running in the default VRF.
4. Manually restart the `snmpd` daemon in the management VRF.



## ⓘ Running Multiple Instances of snmpd

Prior to Cumulus Linux 3.6, more complex configurations may have been needed; for example, you can run more than one `snmpd` daemon (one in each VRF designed to receive SNMP polling requests). Cumulus Networks does not recommend this for memory and CPU resource reasons. However, if this is required, you must use a separate configuration file with each instance of the `snmpd` daemon. You can use a copy of the `/etc/snmp/snmpd.conf` file. When you use this file, start an `snmpd` daemon with the following command:

```
cumulus@switch:~$ sudo /usr/sbin/snmpd -y -LS 0-4 d -Lf /dev  
/null -u snmp -g snmp -I -smux -p /run/snmpd.pid -C -c <new  
snmp config filename> (edited)
```

To use management VRF, you need to configure the IP address of eth0 as the listening-address. In the example below, eth0 IP address is 10.10.10.10. You can also add other `snmp-server` configurations, then commit the changes.

```
cumulus@switch:~$ net add snmp-server listening-address 10.10.10.10  
cumulus@switch:~$ net add snmp-server readonly-community tempPassword  
access any  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

This restarts the `snmpd` daemon in the default VRF. Then, to run `snmpd` in the correct VRF, stop the daemon in the default VRF (or stop any other `snmpd` daemons that happen to be running), then restart `snmpd` in the management VRF so that it can respond to requests on interfaces only in that VRF. Make sure that only one instance of the `snmpd` daemon is running and that it is running in the desired VRF. Assuming the Management VRF has been enabled, the following example shows how to stop `snmpd` and restart it in the management VRF.

```
cumulus@switch:mgmt-vrf:~$ systemctl stop snmpd.service  
cumulus@switch:mgmt-vrf:~$ systemctl disable snmpd.service  
cumulus@switch:mgmt-vrf:~$ ps aux | grep snmpd  
cumulus@switch:mgmt-vrf:~$  
cumulus@switch:mgmt-vrf:~$ systemctl start snmpd@mgmt.service  
cumulus@switch:mgmt-vrf:~$ systemctl enable snmpd.service  
cumulus@switch:mgmt-vrf:~$ systemctl status snmpd@mgmt.service  
root@switch:mgmt-vrf:/home/cumulus# systemctl status snmpd@mgmt.  
service  
  snmpd@mgmt.service - Simple Network Management Protocol (SNMP)  
  Daemon.  
  Loaded: loaded (/lib/systemd/system/snmpd.service;  
           disabled)  
  Drop-In: /run/systemd/generator/snmpd@.service.  
           d  
           vrf.conf
```



```
Active: active (running) since Thu 2017-12-07 20:05:41 UTC; 2min
22s
ago
Main PID: 30880 (snmpd)
CGroup: /system.slice/system-snmpd.slice/snmpd@mgmt.
service
30880 /usr/sbin/snmpd -y -LS 0-4 d -Lf /dev/null -u snmp -g snmp -I -
smux -p /run/snmpd.pid -f

Dec 07 20:05:41 cel-redxp-01 systemd[1]: Started Simple Network
Management Protocol (SNMP) Daemon..

cumulus@switch:mgmt-vrf:~$ ps aux | grep snmpd
snmp      30880  0.4  0.3  57176 12276 ?          Ss   20:05   0:00 /usr
/usr/sbin/snmpd -y -LS 0-4 d -Lf /dev/null -u snmp -g snmp -I -smux -p
/run/snmpd.pid -f
```

## *Set up the Custom Cumulus Networks MIBs*

No changes are required in the `/etc/snmp/snmpd.conf` file on the switch to support the custom Cumulus Networks MIBs. The following lines are already included by default and provide support for both the Cumulus Counters and the Cumulus Resource Query MIBs.

```
sysObjectID 1.3.6.1.4.1.40310
pass_persist .1.3.6.1.4.1.40310.1 /usr/share/snmp/resq_pp.py
pass_persist .1.3.6.1.4.1.40310.2 /usr/share/snmp/cl_drop_cntrs_pp.py
```

However, you need to copy several files to the NMS server for the custom Cumulus MIB to be recognized on NMS server.

- `/usr/share/snmp/mibs/Cumulus-Snmp-MIB.txt`
- `/usr/share/snmp/mibs/Cumulus-Counters-MIB.txt`
- `/usr/share/snmp/mibs/Cumulus-Resource-Query-MIB.txt`

## *Set the Community String*

The `snmpd` authentication for versions 1 and 2 is disabled by default in Cumulus Linux. You can enable this password (called a community string) by setting **rocommunity** (for read-only access) or **rwcommunity** (for read-write access). Setting a community string is required.

To enable read-only querying by a client:

1. Open the `/etc/snmp/snmpd.conf` file in a text editor.
2. To allow read-only access, uncomment the following line, then save the file:

```
rocommunity public default -V systemonly
```



Keyword	Meaning
rocommunity	Read-only community; <i>rwcommunity</i> is for read-write access.
public	Plain text password/community string. <div style="border: 2px solid red; padding: 10px; margin-top: 10px;"><span style="color: red;">!</span> Cumulus Networks strongly recommends you change this password to something else.</div>
default	The <i>default</i> keyword allows connections from any system. The <i>localhost</i> keyword allows requests only from the local host. A restricted source can either be a specific hostname (or address), or a subnet, represented as IP/MASK (like 10.10.10.0/255.255.255.0), or IP/BITS (like 10.10.10.0/24), or the IPv6 equivalents.
systemonly	The name of this particular SNMP view. This is a user-defined value.

3. Restart `snmpd`:

```
cumulus@switch:~$ sudo systemctl restart snmpd.service
```

## Enable SNMP Support for FRRouting

SNMP supports Routing MIBs in [FRRouting](#) (see page 731). To enable SNMP support for FRRouting, you need to:

- Configure [AgentX](#) (ASX) access in FRRouting
- The default `/etc/snmp/snmpd.conf` configuration already enables agentx and sets the correct permissions

Enabling FRRouting includes support for BGP. However, if you plan on using the BGP4 MIB, be sure to provide access to the MIB tree 1.3.6.1.2.1.15.



At this time, SNMP does not support monitoring BGP unnumbered neighbors.

If you plan on using the OSPFv2 MIB, provide access to 1.3.6.1.2.1.14 and to 1.3.6.1.2.1.191 for the OSPV3 MIB.

To enable SNMP support for FRRouting:

- Configure AgentX access in FRRouting:

```
cumulus@switch:~$ net add routing agentx
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```



2. Update the SNMP configuration to enable FRRouting to respond to SNMP requests. Open the `/etc/snmp/snmpd.conf` file in a text editor and verify that the following configuration exists:

```
agentxsocket /var/agentx/master  
agentxperms 777 777 snmp snmp  
master agentx
```



Make sure that the `/var/agentx` directory is world-readable and world-searchable (octal mode 755).

3. Optionally, you might need to expose various MIBs:

- For the BGP4 MIB, allow access to `1.3.6.1.2.1.15`
- For the OSPF MIB, allow access to `1.3.6.1.2.1.14`
- For the OSPFV3 MIB, allow access to `1.3.6.1.2.1.191`

To verify the configuration, run `snmpwalk`. For example, if you have a running OSPF configuration with routes, you can check this OSPF-MIB first from the switch itself with:

```
cumulus@switch:~$ sudo snmpwalk -v2c -cpublic localhost 1.3.6.1.2.1.14
```

### *Enable the .1.3.6.1.2.1 Range*

Some MIBs, including storage information, are not included by default in `snmpd.conf` in Cumulus Linux. This results in some default views on common network tools (like `librenms`) to return less than optimal data. You can include more MIBs by enabling all the `.1.3.6.1.2.1` range. This simplifies the configuration file, removing concern that any required MIBs will be missed by the monitoring system. Various MIBs were added to version 3.0 and include the following: ENTITY and ENTITY-SENSOR MIB and parts of the BRIDGE-MIB and Q-BRIDGE-MIBs. These are included in the default configuration.



This configuration grants access to a large number of MIBs, including all SNMPv2-MIB, which might reveal more data than expected. In addition to being a security vulnerability, it might consume more CPU resources.

To enable the `.1.3.6.1.2.1` range, make sure the view name commands include the required MIB objects.

### *Configure SNMPv3*

SNMPv3 is often used to enable authentication and encryption, as community strings in versions 1 and 2c are sent in plaintext. SNMPv3 usernames are added to the `/etc/snmp/snmpd.conf` file, along with plaintext authentication and encryption pass phrases.





Cumulus Networks recommends that you configure SNMPv3 usernames and passwords with NCLU. However, if you prefer to edit the `/etc/snmp/snmpd.conf` manually instead, be aware that `snmpd` caches SNMPv3 usernames and passwords in the `/var/lib/snmp/snmpd.conf` file. Make sure you stop `snmpd` and remove the old entries when making changes. Otherwise, Cumulus Linux uses the old usernames and passwords in the `/var/lib/snmp/snmpd.conf` file instead of the ones in the `/etc/snmp/snmpd.conf` file.

The NCLU command structures for configuring SNMP user passwords are:

```
cumulus@switch:~$ net add snmp-server username <username> [auth-none]
| [(auth-md5 | auth-sha) <auth-password>]
cumulus@switch:~$ net add snmp-server username <username> auth-(none
| sha | md5) (oid <OID> | view <view>)
```

The example below defines five users, each with a different combination of authentication and encryption:

```
cumulus@switch:~$ net add snmp-server username user1 auth-none
cumulus@switch:~$ net add snmp-server username user2 auth-md5
user2password
cumulus@switch:~$ net add snmp-server username user3 auth-md5
user3password encrypt-des user3encryption
cumulus@switch:~$ net add snmp-server username user666 auth-sha
user666password encrypt-aes user666encryption
cumulus@switch:~$ net add snmp-server username user999 auth-md5
user999password encrypt-des user999encryption
cumulus@switch:~$ net add snmp-server username user1 auth-none oid 1.3
.6.1.2.1
cumulus@switch:~$ net add snmp-server username user1 auth-none oid
system
cumulus@switch:~$ net add snmp-server username user2 auth-md5
test1234 view testview oid 1.3.6.1.2.1
cumulus@switch:~$ net add snmp-server username user3 auth-sha
testshax encrypt-aes testaesx oid 1.3.6.1.2.1
cumulus@switch:~$ net pending
cumulus@switch:~$ net commit
```

```
# simple no auth user
#createuser user1

# user with MD5 authentication
#createuser user2 MD5 user2password

# user with MD5 for auth and DES for encryption
#createuser user3 MD5 user3password DES user3encryption

# user666 with SHA for authentication and AES for encryption
```

```

createuser user666 SHA user666password AES user666encryption

# user999 with MD5 for authentication and DES for encryption
createuser user999 MD5 user999password DES user999encryption

# restrict users to certain OIDs
# (Note: creating rouser or rwuser will give
# access regardless of the createUser command above. However,
# createUser without rouser or rwuser will not provide any access).
rouser user1 noauth 1.3.6.1.2.1
rouser user2 auth 1.3.6.1.2.1
rwuser user3 priv 1.3.6.1.2.1
rwuser user666
rwuser user999

```

After configuring user passwords and restarting the `snmpd` daemon, you can check user access with a client.



The `snmp` Debian package contains `snmpget`, `snmpwalk`, and other programs that are useful for checking daemon functionality from the switch itself or from another workstation.

The following commands check the access for each user defined above from the localhost:

```

# check user1 which has no authentication or encryption (NoauthNoPriv)
snmpget -v 3 -u user1 -l NoauthNoPriv localhost 1.3.6.1.2.1.1.1.0
snmpwalk -v 3 -u user1 -l NoauthNoPriv localhost 1.3.6.1.2.1.1

# check user2 which has authentication but no encryption (authNoPriv)
snmpget -v 3 -u user2 -l authNoPriv -a MD5 -A user2password localhost
1.3.6.1.2.1.1.1.0
snmpget -v 3 -u user2 -l authNoPriv -a MD5 -A user2password localhost
1.3.6.1.2.1.2.1.0
snmpwalk -v 3 -u user2 -l authNoPriv -a MD5 -A user2password
localhost 1.3.6.1.2.1

# check user3 which has both authentication and encryption (authPriv)
snmpget -v 3 -u user3 -l authPriv -a MD5 -A user3password -x DES -X
user3encryption localhost .1.3.6.1.2.1.1.1.0
snmpwalk -v 3 -u user3 -l authPriv -a MD5 -A user3password -x DES -X
user3encryption localhost .1.3.6.1.2.1
snmpwalk -v 3 -u user666 -l authPriv -a SHA -x AES -A user666password
-X user666encryption localhost 1.3.6.1.2.1.1
snmpwalk -v 3 -u user999 -l authPriv -a MD5 -x DES -A user999password
-X user999encryption localhost 1.3.6.1.2.1.1

```

The following procedure shows a slightly more secure method of configuring SNMPv3 users without creating cleartext passwords:

1. Install the `net-snmp-config` script that is in `libsnmp-dev` package:



```
cumulus@switch:~$ sudo -E apt-get update  
cumulus@switch:~$ sudo -E apt-get install libsnmp-dev
```

2. Stop the daemon:

```
cumulus@switch:~$ sudo systemctl stop snmpd.service
```

3. Use the `net-snmp-config` command to create two users, one with MD5 and DES, and the next with SHA and AES.

 The minimum password length is eight characters and the arguments `-a` and `-x` have different meanings in `net-snmp-config` than `snmpwalk`.

```
cumulus@switch:~$ sudo net-snmp-config --create-snmpv3-user -a  
md5authpass -x desprivpass -A MD5 -X DES userMD5withDES  
cumulus@switch:~$ sudo net-snmp-config --create-snmpv3-user -a  
shaauthpass -x aesprivpass -A SHA -X AES userSHAwithAES  
cumulus@switch:~$ sudo systemctl start snmpd.service
```

This adds a `createUser` command in `/var/lib/snmp/snmpd.conf`. Do **not** edit this file by hand unless you are removing usernames. You can edit this file and restrict access to certain parts of the MIB by adding `noauth`, `auth` or `priv` to allow unauthenticated access, require authentication, or to enforce use of encryption.

The `snmpd` daemon reads the information from the `/var/lib/snmp/snmpd.conf` file and then the line is removed (eliminating the storage of the master password for that user) and replaced with the key that is derived from it (using the EnginID). This key is a localized key, so that if it is stolen, it cannot be used to access other agents. To remove the two users `userMD5withDES` and `userSHAwithAES`, stop the `snmpd` daemon and edit the `/var/lib/snmp/snmpd.conf` file. Remove the lines containing the username, then restart the `snmpd` daemon as in step 3 above.

From a client, you access the MIB with the correct credentials. (The roles of `-x`, `-a` and `-X` and `-A` are reversed on the client side as compared with the `net-snmp-config` command used above.)

```
snmpwalk -v 3 -u userMD5withDES -l authPriv -a MD5 -x DES -A  
md5authpass -X desprivpass localhost 1.3.6.1.2.1.1.1  
snmpwalk -v 3 -u userSHAwithAES -l authPriv -a SHA -x AES -A  
shaauthpass -X aesprivpass localhost 1.3.6.1.2.1.1.1
```



## Manually Configure SNMP Traps (Non-NCLU)

### Generate Event Notification Traps

The Net-SNMP agent provides a method to generate SNMP trap events using the Distributed Management (DisMan) Event MIB for various system events, including:

- Link up/down.
- Exceeding the temperature sensor threshold, CPU load, or memory threshold.
- Other SNMP MIBs.

To enable specific types of traps, you need to create the following configurations in `/etc/snmp/snmpd.conf`.

### Define Access Credentials

An SNMPv3 username is required to authorize the DisMan service even though you are not configuring SNMPv3 here. The example `snmpd.conf` configuration shown below creates `trapusername` as the username using the `createUser` command. `iquerySecName` defines the default SNMPv3 username to be used when making internal queries to retrieve monitored expressions. `rouser` specifies which username to use for these SNMPv3 queries. All three are required for `snmpd` to retrieve information and send traps (even with the `monitor` command shown below in the examples). Add the following lines to your `/etc/snmp/snmpd.conf` configuration file:

```
createuser trapusername
iquerysecname trapusername
rouser trapusername
```



`iquerysecname` specifies the default SNMPv3 username to be used when making internal queries to retrieve any necessary information — either for evaluating the monitored expression or building a notification payload. These internal queries always use SNMPv3, even if normal querying of the agent is done using SNMPv1 or SNMPv2c. Note that this user must also be explicitly created via `createUser` and given appropriate access rights, for `rouser`, for example. The `iquerysecname` directive is purely concerned with defining which user should be used, not with actually setting this user up.

### Define Trap Receivers

The following configuration defines the trap receiver IP address where SNMPv2 traps are sent:

```
trap2sink 192.168.1.1 public
# For SNMPv1 Traps, use
# trapsink 192.168.1.1 public
```



Although the traps are sent to an SNMPv2 receiver, the SNMPv3 user is still required. Starting with Net-SNMP 5.3, `snmptrapd` no longer accepts all traps by default. `snmptrapd` must be configured with authorized SNMPv1/v2c community strings and/or SNMPv3 users. Non-authorized traps/informs are dropped. Refer to the [snmptrapd.conf\(5\) manual page](#) for details.



It is possible to define multiple trap receivers and to use the domain name instead of an IP address in the `trap2sink` directive.

Restart the `snmpd` service to apply the changes.

```
cumulus@switch:~$ sudo systemctl restart snmpd.service
```

### *SNMP Version 3 Trap and Inform Messages*

You can configure SNMPv3 trap and inform messages with the `trapsess` configuration command. Inform messages are traps that are acknowledged by the receiving trap daemon. You configure inform messages with the `-ci` parameter. You must specify the EnginID of the receiving trap server with the `-e` field.

#### **SNMPv3 TRAP/INFORM**

```
trapsess -Ci -e 0x80ccff112233445566778899 -v3 -l authPriv -u
trapuser1 -a MD5 -A trapuser1password -x DES -X trapuser1encryption
192.168.1.1
```

The SNMP trap receiving daemon must have usernames, authentication passwords, and encryption passwords created with its own EnginID. You must configure this trap server EnginID in the switch `snmpd` daemon sending the trap and inform messages. You specify the level of authentication and encryption for SNMPv3 trap and inform messages with `-l` (`NoauthNoPriv`, `authNoPriv`, or `authPriv`).



You can define multiple trap receivers and use the domain name instead of an IP address in the `trap2sink` directive.

After you complete the configuration, restart the `snmpd` service to apply the changes.

```
cumulus@switch:~$ sudo systemctl restart snmpd.service
```

### *Source Traps from a Different Source IP Address*

When client SNMP programs (such as `snmpget`, `snmpwalk`, or `snmptrap`) are run from the command line, or when `snmpd` is configured to send a trap (based on `snmpd.conf`), you can configure a `clientaddr` in `snmpd.conf` that allows the SNMP client programs or `snmpd` (for traps) to source requests from a different source IP address.



snmptrap, snmpget, snmpwalk and snmpd itself must be able to bind to this address.

For more information, read the the `snmp.conf` man page:

```
clientaddr [<transport-specifier>:]<transport-address>
            specifies the source address to be used by command-line
applica
tions when sending SNMP requests. See snmpcmd(1) for
more infor
mation about the format of addresses.
This value is also used by snmpd when generating
notifications.
```

### *Monitor Fans, Power Supplies, and Transformers*

An SNMP agent (`snmpd`) waits for incoming SNMP requests and responds to them. If no requests are received, an agent does not initiate any actions. However, various commands can configure `snmpd` to send traps based on preconfigured settings (`load`, `file`, `proc`, `disk`, or `swap` commands), or customized `monitor` commands.

From the `snmpd.conf` man page, the `monitor` command is defined this way:

```
monitor [OPTIONS] NAME EXPRESSION

        defines a MIB object to monitor. If the EXPRESSION
condition holds then
            this will trigger the corresponding event, and either
send a notification or
                apply a SET assignment (or both). Note that the event
will only be triggered once,
                when the expression first matches. This monitor entry
will not fire again until the
                monitored condition first becomes false, and then
matches again. NAME is an administrative
                    name for this expression, and is used for indexing the
mteTriggerTable (and related tables).

        Note also that such monitors use an internal SNMPv3
request to retrieve the values
            being monitored (even if normal agent queries
typically use SNMPv1 or SNMPv2c).
                See the iquerySecName token described above.
```

#### **EXPRESSION**

There are three types of monitor expression supported by the Event MIB - existence, boolean and threshold tests.

`OID | ! OID | != OID`



defines an existence(0) monitor test. A bare OID specifies a present(0) test, which will fire when (an instance of) the monitored OID is created. An expression of the form ! OID specifies an absent(1) test, which will fire when the monitored OID is deleted. An expression of the form != OID specifies a changed(2) test, which will fire whenever the monitored value(s) change. Note that there must be whitespace before the OID token.

#### OID OP VALUE

defines a boolean(1) monitor test. OP should be one of the defined comparison operators (!=, ==, <, <=, >, >=) and VALUE should be an integer value to compare against. Note that there must be whitespace around the OP token. A comparison such as OID !=0 will not be handled correctly.

#### OID MIN MAX [DMIN DMAX]

defines a threshold(2) monitor test. MIN and MAX are integer values, specifying lower and upper thresholds. If the value of the monitored OID falls below the lower threshold (MIN) or rises above the upper threshold (MAX), then the monitor entry will trigger the corresponding event.

Note that the rising threshold event will only be re-armed when the monitored value falls below the lower threshold (MIN). Similarly, the falling threshold event will be re-armed by the upper threshold (MAX).

The optional parameters DMIN and DMAX configure a pair of similar threshold tests, but working with the delta differences between successive sample values.

#### OPTIONS

There are various options to control the behaviour of the monitored expression. These include:

-D indicates that the expression should be evaluated using delta differences between sample values (rather than the values themselves).  
-d OID or -di OID

specifies a discontinuity marker for validating delta differences. A -di object instance will be used exactly as given. A -d object will have the instance subidentifiers from the corresponding (wildcarded) expression object appended. If the -I flag is specified, then there is no difference between these two options. This option also implies -D.

**-e EVENT**

specifies the event to be invoked when this monitor entry is triggered. If this option is not given, the monitor entry will generate one of the standard notifications defined in the DISMAN-EVENT-MIB.

**-I** indicates that the monitored expression should be applied to the specified OID as a single instance. By default, the OID will be treated as a wildcarded object, and the monitor expanded to cover all matching instances.

**-i OID or -o OID**

define additional varbinds to be added to the notification payload when this monitor trigger fires. For a wildcarded expression, the suffix of the matched instance will be added to any OIDs specified using -o, while OIDs specified using -i will be treated as exact instances. If the -I flag is specified, then there is no difference between these two options.

See strictDisman for details of the ordering of notification payloads.

**-r FREQUENCY**

monitors the given expression every FREQUENCY, where FREQUENCY is in seconds or optionally suffixed by one of s (for seconds), m (for minutes), h (for hours), d (for days), or w (for weeks). By default, the expression will be evaluated every 600s (10 minutes).

**-S** indicates that the monitor expression should not be evaluated when the agent first starts up.

The first evaluation will be done once the first repeat interval has expired.

**-s** indicates that the monitor expression should be evaluated when the agent first starts up.

This is the default behaviour.

Note: Notifications triggered by this initial evaluation will be sent before the coldStart trap.

**-u SECNAME**

specifies a security name to use for scanning the local host, instead of the default iquerySecName. Once again, this user must be explicitly created and given suitable access rights.



You can configure `snmpd` to monitor the operational status of an Entity MIB or Entity-Sensor MIB. You can determine the operational status, given as a value of *ok(1)*, *unavailable(2)* or *nonoperational(3)*, by adding the following example configuration to `/etc/snmp/snmpd.conf` and adjusting the values:

- Using the `entPhySensorOperStatus` integer:

```
# without installing extra MIBS we can check the check Fan1
status
# if the Fan1 index is 100011001, monitor this specific OID (-I)
every 10 seconds (-r), and defines additional information to be
included in the trap (-o).
monitor -I -r 10 -o 1.3.6.1.2.1.47.1.1.1.7.100011001 "Fan1
Not OK" 1.3.6.1.2.1.99.1.1.1.5.100011001 > 1
# Any Entity Status non OK (greater than 1)
monitor -r 10 -o 1.3.6.1.2.1.47.1.1.1.7 "Sensor Status
Failure" 1.3.6.1.2.1.99.1.1.1.5 > 1
```

- Using the OID name:

```
# for a specific fan called Fan1 with an index 100011001
monitor -I -r 10 -o entPhysicalName.100011001 "Fan1 Not OK"
entPhySensorOperStatus.100011001 > 1
# for any Entity Status not OK ( greater than 1)
monitor -r 10 -o entPhysicalName "Sensor Status Failure"
entPhySensorOperStatus > 1
```



You can use the OID name if the `snmp-mibs-downloader` package is installed.



The `entPhySensorOperStatus` integer can be found by walking the `entPhysicalName` table.

- To get all sensor information, run `snmpwalk` on the `entPhysicalName` table. For example:

```
cumulus@leaf01:~$ snmpwalk -v 2c -cpublic localhost .
1.3.6.1.2.1.47.1.1.1.7
iso.3.6.1.2.1.47.1.1.1.7.100000001 = STRING: "PSU1Temp1"
iso.3.6.1.2.1.47.1.1.1.7.100000002 = STRING: "PSU2Temp1"
iso.3.6.1.2.1.47.1.1.1.7.100000003 = STRING: "Temp1"
iso.3.6.1.2.1.47.1.1.1.7.100000004 = STRING: "Temp2"
iso.3.6.1.2.1.47.1.1.1.7.100000005 = STRING: "Temp3"
iso.3.6.1.2.1.47.1.1.1.7.100000006 = STRING: "Temp4"
iso.3.6.1.2.1.47.1.1.1.7.100000007 = STRING: "Temp5"
iso.3.6.1.2.1.47.1.1.1.7.100011001 = STRING: "Fan1"
```

```

iso.3.6.1.2.1.47.1.1.1.7.100011002 = STRING: "Fan2"
iso.3.6.1.2.1.47.1.1.1.7.100011003 = STRING: "Fan3"
iso.3.6.1.2.1.47.1.1.1.7.100011004 = STRING: "Fan4"
iso.3.6.1.2.1.47.1.1.1.7.100011005 = STRING: "Fan5"
iso.3.6.1.2.1.47.1.1.1.7.100011006 = STRING: "Fan6"
iso.3.6.1.2.1.47.1.1.1.7.100011007 = STRING: "PSU1Fan1"
iso.3.6.1.2.1.47.1.1.1.7.100011008 = STRING: "PSU2Fan1"
iso.3.6.1.2.1.47.1.1.1.7.110000001 = STRING: "PSU1"
iso.3.6.1.2.1.47.1.1.1.7.110000002 = STRING: "PSU2"

```

### *Enable MIB to OID Translation*

MIB names can be used instead of OIDs, by installing the `snmp-mibs-downloader`, to download SNMP MIBs to the switch prior to enabling traps. This greatly improves the readability of the `snmpd.conf` file.

1. Open `/etc/apt/sources.list` in a text editor.
2. Add the `non-free` repository, then save the file:

```

cumulus@switch:~$ sudo deb http://ftp.us.debian.org/debian/
jessie main non-free

```

3. Update the switch:

```

cumulus@switch:~$ sudo -E apt-get update

```

4. Install the `snmp-mibs-downloader`:

```

cumulus@switch:~$ sudo -E apt-get install snmp-mibs-downloader

```

5. Open the `/etc/snmp/snmp.conf` file to verify that the `mibs :` line is commented out:

```

#
# As the snmp packages come without MIB files due to license
# reasons, loading
# of MIBs is disabled by default. If you added the MIBs you can
# reenable
# loading them by commenting out the following line.
#mibs :

```

6. Open the `/etc/default/snmpd` file to verify that the `export MIBS=` line is commented out:

```

# This file controls the activity of snmpd and snmptrapd

```



```
# Don't load any MIBs by default.  
# You might comment this lines once you have the MIBs Downloaded.  
#export MIBS=
```

7. After you confirm the configuration, remove or comment out the non-free repository in /etc/apt/sources.list.

```
#deb http://ftp.us.debian.org/debian/ jessie main non-free
```

## Configure Link Up/Down Notifications

The linkUpDownNotifications directive is used to configure link up/down notifications when the operational status of the link changes.

```
linkUpDownNotifications yes
```



The default frequency for checking link up/down is 60 seconds. You can change the default frequency using the monitor directive directly instead of the linkUpDownNotifications directive. See `man snmpd.conf` for details.

## Configure Temperature Notifications

Temperature sensor information for each available sensor is maintained in the the lmSensors MIB. Each platform can contain a different number of temperature sensors. The example below generates a trap event when any temperature sensor exceeds a threshold of 68 degrees (centigrade). It monitors each `lmTempSensorsValue`. When the threshold value is checked and exceeds the `lmTempSensorsValue`, a trap is generated. The `-o lmTempSensorsDevice` option is used to instruct SNMP to also include the lmTempSensorsDevice MIB in the generated trap. The default frequency for the monitor directive is 600 seconds. You can change the default frequency with the `-r` option.:

```
monitor lmTemSensor -o lmTempSensorsDevice lmTempSensorsValue > 68000
```

To monitor the sensors individually, first use the `sensors` command to determine which sensors are available to be monitored on the platform.

```
cumulus@switch:~$ sudo sensors  
  
CY8C3245-i2c-4-2e  
Adapter: i2c-0-mux (chan_id 2)  
fan5: 7006 RPM (min = 2500 RPM, max = 23000 RPM)  
fan6: 6955 RPM (min = 2500 RPM, max = 23000 RPM)  
fan7: 6799 RPM (min = 2500 RPM, max = 23000 RPM)  
fan8: 6750 RPM (min = 2500 RPM, max = 23000 RPM)
```

```
temp1: +34.0 C (high = +68.0 C)
temp2: +28.0 C (high = +68.0 C)
temp3: +33.0 C (high = +68.0 C)
temp4: +31.0 C (high = +68.0 C)
temp5: +23.0 C (high = +68.0 C)
```

Configure a `monitor` command for the specific sensor using the `-I` option. The `-I` option indicates that the monitored expression is applied to a single instance. In this example, there are five temperature sensors available. Use the following directive to monitor only temperature sensor 3 at 5 minute intervals.

```
monitor -I -r 300 lmTemSensor3 -o lmTempSensorsDevice.3
lmTempSensorsValue.3 > 68000
```

### *Configure Free Memory Notifications*

You can monitor free memory using the following directives. The example below generates a trap when free memory drops below 1,000,000KB. The free memory trap also includes the amount of total real memory:

```
monitor MemFreeTotal -o memTotalReal memTotalFree < 1000000
```

### *Configure Processor Load Notifications*

To monitor CPU load for 1, 5, or 15 minute intervals, use the `load` directive with the `monitor` directive. The following example generates a trap when the 1 minute interval reaches 12%, the 5 minute interval reaches 10%, or the 15 minute interval reaches 5%.

```
load 12 10 5
```

### *Configure Disk Utilization Notifications*

To monitor disk utilization for all disks, use the `includeAllDisks` directive together with the `monitor` directive. The example code below generates a trap when a disk is 99% full:

```
includeAllDisks 1%
monitor -r 60 -o dskPath -o DiskErrMsg "dskTable" diskErrorFlag !=0
```

### *Configure Authentication Notifications*

To generate authentication failure traps, use the `authtrapenable` directive:

```
authtrapenable 1
```



## snmptrapd.conf

Use the Net-SNMP trap daemon to **receive** SNMP traps. The `/etc/snmp/snmptrapd.conf` file is used to configure how **incoming** traps are processed. Starting with Net-SNMP release 5.3, you must specify who is authorized to send traps and informs to the notification receiver (and what types of processing these are allowed to trigger). You can specify three processing types:

- *log* logs the details of the notification in a specified file to standard output (or stderr), or through syslog (or similar).
- *execute* passes the details of the trap to a specified handler program, including embedded Perl.
- *net* forwards the trap to another notification receiver.

Typically, this configuration is *log,execute,net* to cover any style of processing for a particular category of notification. But it is possible (even desirable) to limit certain notification sources to selected processing only.

`authCommunity TYPES COMMUNITY [ SOURCE [ OID | -v VIEW ] ]` authorizes traps and SNMPv2c INFORM requests with the specified community to trigger the types of processing listed. By default, this allows any notification using this community to be processed. You can use the SOURCE field to specify that the configuration only applies to notifications received from particular sources. For more information about specific configuration options within the file, look at the `snmpd.conf(5)` man page with the following command:

```
cumulus@switch:~$ man 5 snmptrapd.conf
```

```
#####
#####  
#  
# EXAMPLE-trap.conf:  
#   An example configuration file for configuring the Net-SNMP  
snmptrapd agent.  
#  
#####  
#  
# This file is intended to only be an example. If, however, you want  
# to use it, it should be placed in /etc/snmp/snmptrapd.conf.  
# When the snmptrapd agent starts up, this is where it will look for  
it.  
#  
# All lines beginning with a '#' are comments and are intended for you  
# to read. All other lines are configuration commands for the agent.  
  
#  
# PLEASE: read the snmptrapd.conf(5) manual page as well!  
#  
# this is the default (port 162) and defines the listening  
# protocol and address (e.g. udp:10.10.10.10)  
snmpTrapdAddr localhost
```



```
#  
# defines the actions and the community string  
authCommunity log,execute,net public
```

## Supported MIBs

Below are the MIBs supported by Cumulus Linux, as well as suggested uses for them. The overall Cumulus Linux MIB is defined in the `/usr/share/snmp/mibs/Cumulus-Snmp-MIB.txt` file.

MIB Name	Suggested Uses
BGP4-MIB, OSPFv2-MIB, OSPFv3-MIB, RIPv2-MIB	You can enable FRRouting SNMP support to provide support for OSPF-MIB (RFC-1850), OSPFV3-MIB (RFC-5643), and BGP4-MIB (RFC-1657). See the <a href="#">FRRouting section (see page 1041)</a> above.
CUMULUS-COUNTERS-MIB	Discard counters: Cumulus Linux also includes its own counters MIB, defined in <code>/usr/share/snmp/mibs/Cumulus-Counters-MIB.txt</code> . It has the OID . 1.3.6.1.4.1.40310.2
CUMULUS-POE-MIB	The Cumulus Networks custom <a href="#">Power over Ethernet (see page 207)</a> PoE MIB defined in the <code>/usr/share/snmp/mibs/Cumulus-POE-MIB.txt</code> file. For devices that provide PoE, this provides users with the system wide power information in <code>poeSystemValues</code> as well as per interface <code>PoeObjectsEntry</code> values for the <code>poeObjectsTable</code> . Most of this information comes from the <code>poectl</code> command. To enable this MIB, uncomment the following line in <code>/etc/snmp/snmpd.conf</code> :
	<pre>#pass_persist .1.3.6.1.4.1.40310.3 /usr/share/snmp /cl_poe_pp.py</pre>
CUMULUS-RESOURCE-QUERY-MIB	Cumulus Linux includes its own resource utilization MIB, which is similar to using <code>cl-resource-query</code> . This MIB monitors layer 3 entries by host, route, nexthops, ECMP groups, and layer 2 MAC/BDPU entries. The MIB is defined in <code>/usr/share/snmp/mibs/Cumulus-Resource-Query-MIB.txt</code> and has the OID .1.3.6.1.4.1.40310.1.
CUMULUS-SNMP-MIB	SNMP counters. For information on exposing CPU and memory information with SNMP, see this <a href="#">knowledge base article</a> .
DISMAN-EVENT-MIB	Trap monitoring
ENTITY-MIB	From RFC 4133, the temperature sensors, fan sensors, power sensors, and ports are covered.



MIB Name	Suggested Uses
ENTITY-SENSOR-MIB	Physical sensor information (temperature, fan, and power supply) from RFC 3433.
HOST-RESOURCES-MIB	Users, storage, interfaces, process info, run parameters
IEEE8021-BRIDGE-MIB IEEE8021-Q-BRIDGE-MIB	The <code>dot1dBasePortEntry</code> and <code>dot1dBasePortIfIndex</code> tables in the BRIDGE-MIB and <code>dot1qBase</code> , <code>dot1qFdbEntry</code> , <code>dot1qTpFdbEntry</code> , <code>dot1qTpFdbStatus</code> , and <code>dot1qVlanStaticName</code> tables in the Q-BRIDGE-MIB tables. You must uncomment the <code>bridge_pp.py pass_persist</code> script in <code>/etc/snmp/snmpd.conf</code> .
IEEE8023-LAG-MIB	Implementation of the IEEE 8023-LAG-MIB includes the <code>dot3adAggTable</code> and <code>dot3adAggPortListTable</code> tables. To enable this, edit <code>/etc/snmp/snmpd.conf</code> and uncomment or add the following lines:  <pre>view systemonly included .1.2.840.10006.300.43 pass_persist .1.2.840.10006.300.43 /usr/share/snmp /ieee8023_lag_pp.py</pre>
IF-MIB	Interface description, type, MTU, speed, MAC, admin, operation status, counters  <div style="border: 2px solid yellow; padding: 10px;"><p><span style="color: yellow;">⚠</span> The IF-MIB cache is disabled by default. The non-caching code path in the IF-MIB treats 64-bit counters like 32-bit counters (a 64-bit counter rolls over after the value increments to a value that extends beyond 32 bits). To enable the counter to reflect traffic statistics using 64-bit counters, remove the <code>-y</code> option from the <code>SNMPDOPTS</code> line in the <code>/etc/default/snmpd</code> file. The example below first shows the original line, commented out, then the modified line without the <code>-y</code> option:</p> <pre>cumulus@switch:~\$ cat /etc/default/snmpd # SNMPDOPTS=' -y -LS 0-4 d -Lf /dev/null -u snmp -g snmp -I -smux -p /run/snmpd.pid' SNMPDOPTS=' -LS 0-4 d -Lf /dev/null -u snmp -g snmp -I -smux -p /run/snmpd.pid'</pre></div>
IP-FORWARD-MIB	IP routing table
	IPv4, IPv4 addresses, counters, netmasks



MIB Name	Suggested Uses
IP-MIB (includes ICMP)	
IPv6-MIB	IPv6 counters
LLDP-MIB	Layer 2 neighbor information from <code>lldpd</code> (you need to <a href="#">enable the SNMP subagent (see page 396)</a> in LLDP). You need to start <code>lldpd</code> with the <code>-x</code> option to enable connectivity to <code>snmpd</code> (AgentX).
LM-SENSORS MIB	Fan speed, temperature sensor values, voltages. This is deprecated since the ENTITY-SENSOR MIB has been added.
NET-SNMP-AGENT-MIB	Agent timers, user, group config
NET-SNMP-EXTEND-MIB	See <a href="#">this knowledge base article</a> on extending NET-SNMP in Cumulus Linux to include data from power supplies, fans, and temperature sensors.
NET-SNMP-VACM-MIB	Agent timers, user, group config
NOTIFICATION-LOG-MIB	Local logging
SNMP-FRAMEWORK-MIB	Users, access
SNMP-MPD-MIB	Users, access
SNMP-TARGET-MIB	
SNMP-USER-BASED-SM-MIB	Users, access
SNMP-VIEW-BASED-ACM-MIB	Users, access
TCP-MIB	TCP-related information
	System memory, load, CPU, disk IO



MIB Name	Suggested Uses
UCD-SNMP-MIB	
UDP-MIB	UDP-related information



The ENTITY MIB does not show the chassis information in Cumulus Linux.

## Pass Persist Scripts

The pass persist scripts in Cumulus Linux use the [pass\\_persist extension](#) to Net-SNMP. The scripts are stored in `/usr/share/snmp` and include:

- `bgp4_pp.py`
- `bridge_pp.py`
- `cl_drop_cntrs_pp.py`
- `cl_poe_pp.py`
- `entity_pp.py`
- `entity_sensor_pp.py`
- `ieee8023_lag_pp.py`
- `resq_pp.py`
- `snmpifAlias_pp.py`
- `sysDescr_pass.py`

All the scripts are enabled by default in Cumulus Linux, except for:

- `bgp4_pp.py`, which is now handled by [FRRouting \(see page 731\)](#) instead of Quagga, so monitoring has changed accordingly.
- `cl_poe_pp.py`, which is disabled by default as only certain platforms that Cumulus Linux supports are capable of doing [Power over Ethernet \(see page 207\)](#).

## Troubleshooting

Use the following commands to troubleshoot potential SNMP issues:

```
cumulus@switch:~$ net show snmp-server
status
Simple Network Management Protocol (SNMP) Daemon.

-----
-----
Current Status          failed (failed)
Reload Status           enabled
Listening IP Addresses localhost 9.9.9.9
```



```
Main snmpd PID 0
Version 1 and 2c Community String Configured
Version 3 Usernames Not Configured
Last Logs (with Errors) -- Logs begin at Thu 2017-08-03 16:
23:05 UTC, end at Fri 2017-08-04 18:17:24 UTC. --
Aug 04 18:17:19 cel-redxp-01 snmpd[8389]: Error opening specified endpoint "9.9.9.9"
Aug 04 18:17:19 cel-redxp-01 snmpd[8389]: Server Exiting with code 1
-----
```

```
cumulus@switch:~$ net show configuration snmp-
server
snmp-server
  listening-address 127.0.0.1
  readonly-community public access default
  readonly-community allpass access any
  readonly-community temp2 access 1.1.1.1
  readonly-community temp2 access 2.2.2.2
  trap-destination 1.1.1.1 community-password public version 2c
  trap-link-up check-frequency 10
  trap-snmp-auth-failures
```

```
cumulus@switch:~$ net show configuration commands
...
net add snmp-server listening-address all
net add snmp-server readonly-community allpass access any
net add snmp-server readonly-community temp2 access 1.1.1.1
net add snmp-server readonly-community temp2 access 2.2.2.2
net add snmp-server trap-destination 1.1.1.1 community-password public
  version 2c
net add snmp-server trap-link-up check-frequency 10
net add snmp-server trap-snmp-auth-failures
...
```

## Using Nutanix Prism as a Monitoring Tool

Nutanix Prism is a graphical user interface (GUI) for managing infrastructure and virtual environments. In order to use it, you need to take special steps within Cumulus Linux before you can configure Prism.

### Contents

This topic describes ...

- Configure Cumulus Linux (see page 1061)



- Configure Nutanix (see page 1062)
- Switch Information Displayed on Nutanix Prism (see page 1065)
- Troubleshooting (see page 1066)
- Enable LLDP/CDP on VMware ESXi (Hypervisor on Nutanix) (see page 1066)
- Troubleshoot Connections without LLDP or CDP (see page 1068)

## Configure Cumulus Linux

1. SSH to the Cumulus Linux switch that needs to be configured, replacing [switch] below as appropriate:

```
cumulus@switch:~$ ssh cumulus@[switch]
```

2. Confirm the switch is running Cumulus Linux 2.5.5 or newer:

```
cumulus@switch:~$ net show system
Hostname..... celRED

Build..... Cumulus Linux 3.7.4~1551312781.35d3264
Uptime..... 8 days, 12:24:01.770000

Model..... Cel REDSTONE
CPU..... x86_64 Intel Atom C2538 2.4 GHz
Memory..... 4GB
Disk..... 14.9GB
ASIC..... Broadcom Trident2 BCM56854
Ports..... 48 x 10G-SFP+ & 6 x 40G-QSFP+
Base MAC Address. a0:00:00:00:00:50
Serial Number.... A1010B2A011212AB000001
```

3. Open the /etc/snmp/snmpd.conf file in an editor.

4. Uncomment the following 3 lines in the /etc/snmp/snmpd.conf file, and save the file:

- bridge\_pp.py

```
pass_persist .1.3.6.1.2.1.17 /usr/share/snmp/bridge_pp.py
```

- Community

```
rocommunity public default -V systemonly
```

- Line directly below the Q-BRIDGE-MIB (.1.3.6.1.2.1.17)

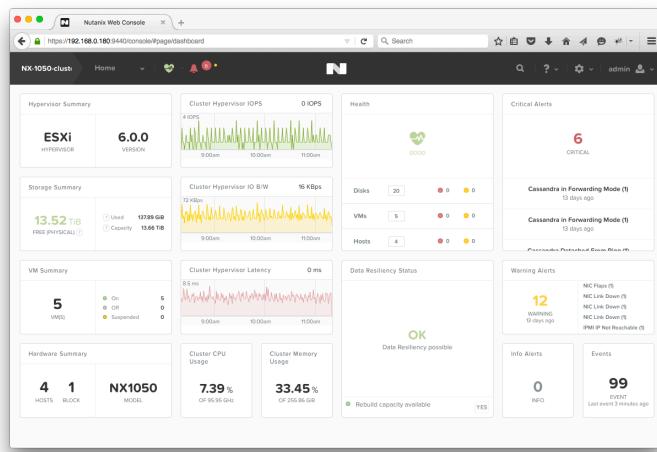
```
# BRIDGE-MIB and Q-BRIDGE-MIB tables
view      systemonly     included    .1.3.6.1.2.1.17
```

5. Restart snmpd:

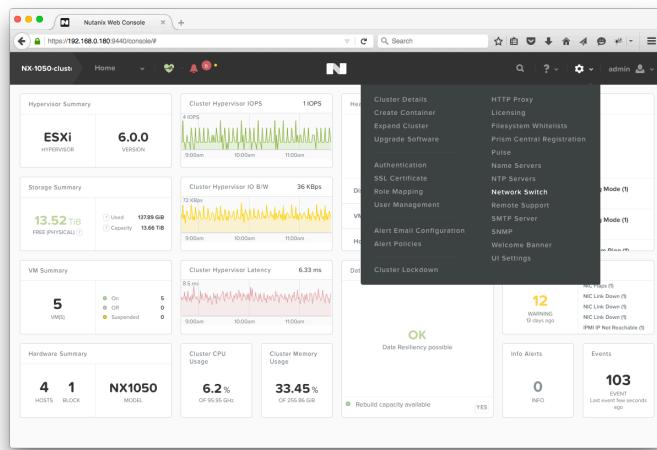
```
cumulus@switch:~$ sudo systemctl restart snmpd.service
Restarting network management services: snmpd.
```

## Configure Nutanix

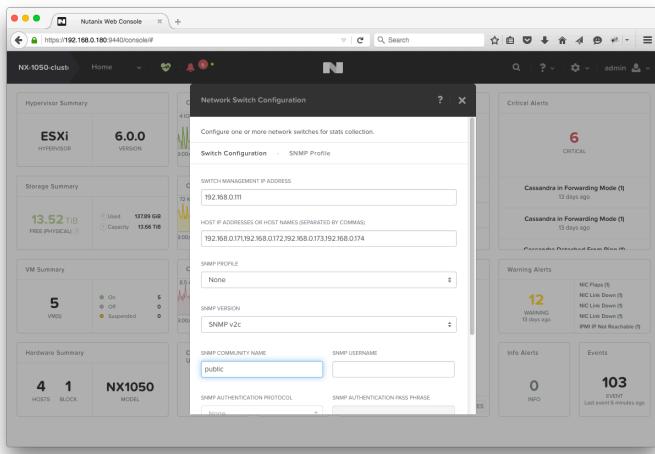
1. Log into the Nutanix Prism. Nutanix defaults to the Home menu, referred to as the Dashboard:



2. Click on the gear icon  in the top right corner of the dashboard, and select NetworkSwitch:



3. Click the **+Add Switch Configuration** button in the **Network Switch Configuration** pop up window.  
4. Fill out the **Network Switch Configuration** for the Top of Rack (ToR) switch configured for snmpd in the previous section:



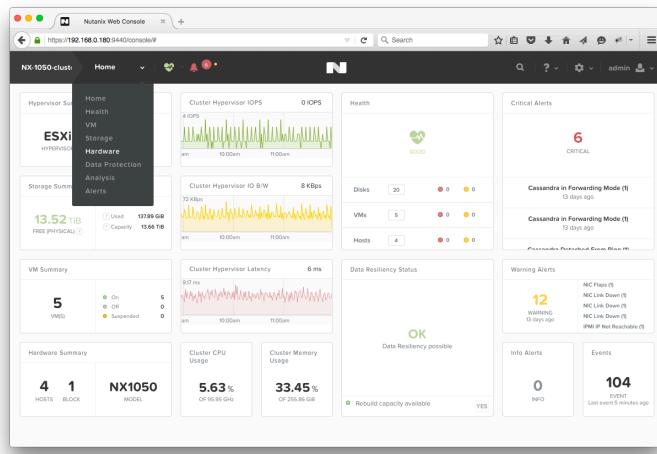
Configuration Parameter	Description	Value Used in Example
Switch Management IP Address	This can be any IP address on the box. In the screenshot above, the eth0 management IP is used.	192.168.0.111
Host IP Addresses or Host Names	IP addresses of Nutanix hosts connected to that particular ToR switch.	192.168.0.171, 192.168.0.172, 192.168.0.173, 192.168.0.174
SNMP Profile	Saved profiles, for easy configuration when hooking up to multiple switches.	None
SNMP Version	SNMP v2c or SNMP v3. Cumulus Linux has only been tested with SNMP v2c for Nutanix integration.	SNMP v2c
SNMP Community Name		public

Configuration Parameter	Description	Value Used in Example
	SNMP v2c uses communities to share MIBs. The default community for snmpd is 'public'.	



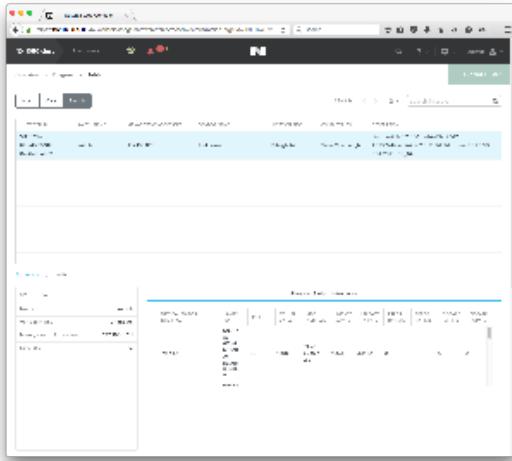
The rest of the values were not touched for this demonstration. They are usually used with SNMP v3.

- Save the configuration. The switch will now be present in the **Network Switch Configuration** menu now.
- Close the pop up window to return to the dashboard.
- Open the **Hardware** option from the **Home** dropdown menu:



- Click the **Table** button.

9. Click the **Switch** button. Configured switches are shown in the table, as indicated in the screenshot below, and can be selected in order to view interface statistics:



The switch has been added correctly, when interfaces hooked up to the Nutanix hosts are visible.

### *Switch Information Displayed on Nutanix Prism*

- Physical Interface (e.g. swp1, swp2). This will only display swp interfaces connected to Nutanix hosts by default.
- Switch ID - Unique identifier that Nutanix keeps track of each port ID (see below)
- Index - interface index, in the above demonstration swp49 maps to Index 52 because there is a loopback and two ethernet interface before the swp starts.
- MTU of interface
- MAC Address of Interface
- Unicast RX Packets (Received)
- Unicast TX Packets (Transmitted)
- Error RX Packets (Received)
- Error TX Packets (Transmitted)
- Discard RX Packets (Received)
- Discard TX Packets (Transmitted)

The Nutanix appliance will use Switch IDs that can also be viewed on the Prism CLI (by SSHing to the box). To view information from the Nutanix CLI, login using the default username **nutanix**, and the password **nutanix/4u**.

```
nutanix@NTNX-14SM15270093-D-CVM:192.168.0.184:~$ ncli network list-
switch
      Switch ID          : 00051a76-f711-89b6-0000-000000003bac::
5f13678e-6ffd-4b33-912f-f1aa6e8da982
      Name           : switch
```

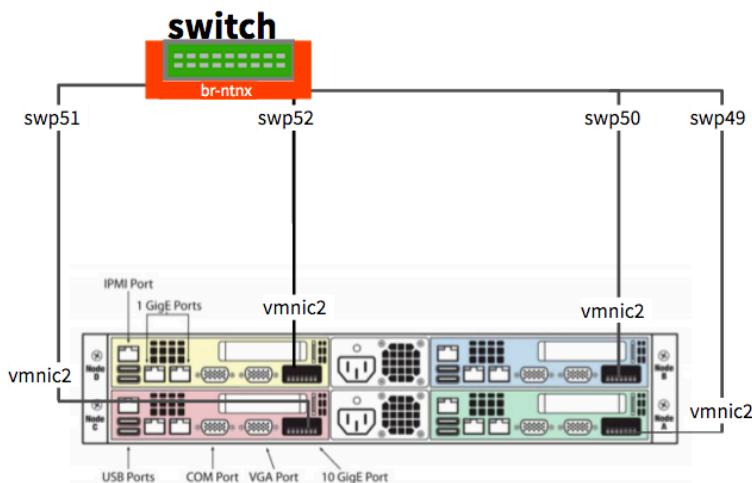
```

Switch Management Address : 192.168.0.111
Description : Linux switch 3.2.65-1+deb7u2+c12.5+2
#3.2.65-1+deb7u2+c12.5+2 SMP Mon Jun 1 18:26:59 PDT 2015 x86_64
Object ID : enterprises.40310
Contact Information : Admin <admin@company.com>
Location Information : Raleigh, NC
Services : 72
Switch Vendor Name : Unknown
Port Ids : 00051a76-f711-89b6-0000-000000003bac::5f13678e-6ffd-4b33-912f-f1aa6e8da982:52, 00051a76-f711-89b6-0000-000000003bac::5f13678e-6ffd-4b33-912f-f1aa6e8da982:53, 00051a76-f711-89b6-0000-000000003bac::5f13678e-6ffd-4b33-912f-f1aa6e8da982:54, 00051a76-f711-89b6-0000-000000003bac::5f13678e-6ffd-4b33-912f-f1aa6e8da982:55

```

## Troubleshooting

To help visualize the following diagram is provided:



Nutanix Node	Physical Port	Cumulus Linux Port
Node A (Green)	vmnic2	swp49
Node B (Blue)	vmnic2	swp50
Node C (Red)	vmnic2	swp51
Node D (Yellow)	vmnic2	swp52

## Enable LLDP/CDP on VMware ESXi (Hypervisor on Nutanix)

1. Follow the directions on one of the following websites to enable CDP:



- [kb.vmware.com/selfservice/microsites/search.do?  
language=en\\_US&cmd=displayKC&externalId=1003885](http://kb.vmware.com/selfservice/microsites/search.do?language=en_US&cmd=displayKC&externalId=1003885)
- [wahlnetwork.com/2012/07/17/utilizing-cdp-and-lldp-with-vsphere-networking/](http://wahlnetwork.com/2012/07/17/utilizing-cdp-and-lldp-with-vsphere-networking/)

For example, switch CDP on:

```
root@NX-1050-A:~] esxcli network vswitch standard set -c  
both -v vSwitch0
```

Then confirm it is running:

```
root@NX-1050-A:~] esxcli network vswitch standard list -v  
vSwitch0  
vSwitch0  
  Name: vSwitch0  
  Class: etherswitch  
  Num Ports: 4082  
  Used Ports: 12  
  Configured Ports: 128  
  MTU: 1500  
  CDP Status: both  
  Beacon Enabled: false  
  Beacon Interval: 1  
  Beacon Threshold: 3  
  Beacon Required By:  
  Uplinks: vmnic3, vmnic2, vmnic1, vmnic0  
  Portgroups: VM Network, Management Network
```

The **both** means CDP is now running, and the lldp dameon on Cumulus Linux is capable of 'seeing' CDP devices.

2. After the next CDP interval, the Cumulus Linux box will pick up the interface via the lldp daemon:

```
cumulus@switch:~$ lldpctl show neighbor swp49  
-----  
-----  
LLDP neighbors:  
-----  
-----  
Interface:      swp49, via: CDPv2, RID: 6, Time: 0 day, 00:34:58  
  Chassis:  
    ChassisID:      local NX-1050-A  
    SysName:       NX-1050-A  
    SysDescr:      Releasebuild-2494585 running on VMware ESX  
    MgmtIP:        0.0.0.0  
    Capability:    Bridge, on  
  Port:  
    PortID:        ifname vmnic2
```



```
PortDescr: vmmic2
```

3. Use `net show` to look at lldp information:

```
cumulus@switch:~$ net show lldp

Local Port      Speed   Mode          Remote Port
Remote Host    Summary
-----  -----  -----  -----
-----  -----  -----  -----
eth0           1G     Mgmt        ====
oob-mgmt-switch IP: 192.168.0.11/24(DHCP)  swp6
swp1           1G     Access/L2   ====
server01       Untagged: br0
swp51          1G     NotConfigured  ====
spine01
swp52          1G     NotConfigured  ====
spine02
```

Nutanix [Acropolis](#) is an alternate hypervisor that Nutanix supports. **Acropolis Hypervisor** uses the yum packaging system and is capable of installing normal Linux lldp daemons to operate just like Cumulus Linux. LLDP should be enabled for each interface on the host. Refer to <https://community.mellanox.com/docs/DOC-1522> for setup instructions.

### Troubleshoot Connections without LLDP or CDP

1. Find the MAC address information in the Prism GUI, located in: **Hardware > Table > Host > Host NICs**
2. Select a MAC address to troubleshoot (e.g. 0c:c4:7a:09:a2:43 represents vmnic0 which is tied to NX-1050-A).
3. List out all the MAC addresses associated to the bridge:

```
cumulus@switch:~$ brctl showmacs br-ntnx
port name mac addr      vlan  is local?  ageing timer
swp9   00:02:00:00:00:06  0     no        66.94
swp52  00:0c:29:3e:32:12  0     no        2.73
swp49  00:0c:29:5a:f4:7f  0     no        2.73
swp51  00:0c:29:6f:e1:e4  0     no        2.73
swp49  00:0c:29:74:0c:ee  0     no        2.73
swp50  00:0c:29:a9:36:91  0     no        2.73
swp9   08:9e:01:f8:8f:0c  0     no        13.56
swp9   08:9e:01:f8:8f:35  0     no        2.73
swp4   0c:c4:7a:09:9e:d4  0     no        24.05
swp1   0c:c4:7a:09:9f:8e  0     no        13.56
swp3   0c:c4:7a:09:9f:93  0     no        13.56
swp2   0c:c4:7a:09:9f:95  0     no        24.05
```



swp52	0c:c4:7a:09:a0:c1	0	no	2.73
swp51	0c:c4:7a:09:a2:35	0	no	2.73
swp49	0c:c4:7a:09:a2:43	0	no	2.73
swp9	44:38:39:00:82:04	0	no	2.73
swp9	74:e6:e2:f5:a2:80	0	no	2.73
swp1	74:e6:e2:f5:a2:81	0	yes	0.00
swp2	74:e6:e2:f5:a2:82	0	yes	0.00
swp3	74:e6:e2:f5:a2:83	0	yes	0.00
swp4	74:e6:e2:f5:a2:84	0	yes	0.00
swp5	74:e6:e2:f5:a2:85	0	yes	0.00
swp6	74:e6:e2:f5:a2:86	0	yes	0.00
swp7	74:e6:e2:f5:a2:87	0	yes	0.00
swp8	74:e6:e2:f5:a2:88	0	yes	0.00
swp9	74:e6:e2:f5:a2:89	0	yes	0.00
swp10	74:e6:e2:f5:a2:8a	0	yes	0.00
swp49	74:e6:e2:f5:a2:b1	0	yes	0.00
swp50	74:e6:e2:f5:a2:b2	0	yes	0.00
swp51	74:e6:e2:f5:a2:b3	0	yes	0.00
swp52	74:e6:e2:f5:a2:b4	0	yes	0.00
swp9	8e:0f:73:1b:f8:24	0	no	2.73
swp9	c8:1f:66:ba:60:cf	0	no	66.94

Alternatively, you can use grep:

```
cumulus@switch:~$ brctl showmacs br-ntnx | grep 0c:c4:7a:09:a2:43
swp49      0c:c4:7a:09:a2:43      0      no      4.58
```

vmnic1 is now hooked up to swp49. This matches what is seen in lldp:

```
cumulus@switch:~$ lldpctl show neighbor swp49
-----
-----
LLDP neighbors:
-----
-----
Interface:      swp49, via: CDPv2, RID: 6, Time: 0 day, 01:11:12
  Chassis:
    ChassisID:      local NX-1050-A
    SysName:        NX-1050-A
    SysDescr:       Releasebuild-2494585 running on VMware ESX
    MgmtIP:         0.0.0.0
    Capability:    Bridge, on
  Port:
    PortID:        ifname vmnic2
    PortDescr:     vmnic2
-----
-----
```



## Monitoring Best Practices

The following monitoring processes are considered best practices for reviewing and troubleshooting potential issues with Cumulus Linux environments. In addition, several of the more common issues have been listed, with potential solutions included.

### Contents

This topic describes ...

- Overview (see page 1070)
  - Trend Analysis Using Metrics (see page 1070)
  - Generate Alerts with Triggered Logging (see page 1071)
  - Log Formatting (see page 1071)
- Hardware (see page 1071)
- System Data (see page 1073)
  - CPU Idle Time (see page 1073)
  - Disk Usage (see page 1075)
- Process Restart (see page 1075)
- Layer 1 Protocols and Interfaces (see page 1076)
- Layer 2 Protocols (see page 1083)
- Layer 3 Protocols (see page 1085)
  - BGP (see page 1085)
  - OSPF (see page 1085)
  - Route and Host Entries (see page 1086)
  - Routing Logs (see page 1087)
- Logging (see page 1087)
- Protocols and Services (see page 1089)
- Device Management (see page 1090)
  - Device Access Logs (see page 1090)
  - Device Super User Command Logs (see page 1090)

### Overview

This document describes:

- Metrics that you can poll from Cumulus Linux and use in trend analysis
- Critical log messages that you can monitor for triggered alerts

### *Trend Analysis Using Metrics*

A metric is a quantifiable measure that is used to track and assess the status of a specific infrastructure component. It is a check collected over time. Examples of metrics include bytes on an interface, CPU utilization, and total number of routes.



Metrics are more valuable when used for trend analysis.

### Generate Alerts with Triggered Logging

Triggered issues are normally sent to `syslog`, but can go to another log file depending on the feature. In Cumulus Linux, `rsyslog` handles all logging, including local and remote logging. Logs are the best method to use for generating alerts when the system transitions from a stable steady state.

Sending logs to a centralized collector, then creating alerts based on critical logs is an optimal solution for alerting.

### Log Formatting

Most log files in Cumulus Linux use a standard presentation format. For example, consider this `syslog` entry:

```
2017-03-08T06:26:43.569681+00:00 leaf01 sysmonitor: Critically high
CPU use: 99%
```

- `2017-03-08T06:26:43.569681+00:00` is the timestamp.
- `leaf01` is the hostname.
- `sysmonitor` is the process that is the source of the message.
- `Critically high CPU use: 99%` is the message.

For brevity and legibility, the timestamp and hostname have been omitted from the examples in this chapter.

## Hardware

The `smonctl` process provides monitoring functionality for various switch hardware elements. Minimum or maximum values are output depending on the flags applied to the basic command. The hardware elements and applicable commands and flags are listed in the table below.

Hardware Element	Monitoring Command/s	Interval Poll
Temperature	<pre>cumulus@switch:~\$ smonctl -j cumulus@switch:~\$ smonctl -j -s TEMP[X]</pre>	10 seconds
Fan	<pre>cumulus@switch:~\$ smonctl -j cumulus@switch:~\$ smonctl -j -s FAN[X]</pre>	10 seconds
PSU		10 seconds



Hardware Element	Monitoring Command/s	Interval Poll
	<pre>cumulus@switch:~\$ smonctl -j cumulus@switch:~\$ smonctl -j -s PSU[X]</pre>	
PSU Fan	<pre>cumulus@switch:~\$ smonctl -j cumulus@switch:~\$ smonctl -j -s PSU[X]Fan[X]</pre>	10 seconds
PSU Temperature	<pre>cumulus@switch:~\$ smonctl -j cumulus@switch:~\$ smonctl -j -s PSU[X]Temp [X]</pre>	10 seconds
Voltage	<pre>cumulus@switch:~\$ smonctl -j cumulus@switch:~\$ smonctl -j -s Volt[X]</pre>	10 seconds
Front Panel LED	<pre>cumulus@switch:~\$ ledmgrd -d cumulus@switch:~\$ ledmgrd -j</pre>	5 seconds



Not all switch models include a sensor for monitoring power consumption and voltage. See [this note \(see page 946\)](#) for details.

Hardware Logs	Log Location	Log Entries
High temperature		<pre>/usr/sbin/smond : : Temp1(Board Sensor near CPU): state changed from UNKNOWN to OK</pre>



Hardware Logs	Log Location	Log Entries
	/var /log /syslog	<pre>/usr/sbin/smond : : Temp2(Board Sensor Near Virtual Switch): state changed from UNKNOWN to OK /usr/sbin/smond : : Temp3(Board Sensor at Front Left Corner): state changed from UNKNOWN to OK /usr/sbin/smond : : Temp4(Board Sensor at Front Right Corner): state changed from UNKNOWN to OK /usr/sbin/smond : : Temp5(Board Sensor near Fan): state changed from UNKNOWN to OK</pre>
Fan speed issues	/var /log /syslog	<pre>/usr/sbin/smond : : Fan1(Fan Tray 1, Fan 1): state changed from UNKNOWN to OK /usr/sbin/smond : : Fan2(Fan Tray 1, Fan 2): state changed from UNKNOWN to OK /usr/sbin/smond : : Fan3(Fan Tray 2, Fan 1): state changed from UNKNOWN to OK /usr/sbin/smond : : Fan4(Fan Tray 2, Fan 2): state changed from UNKNOWN to OK /usr/sbin/smond : : Fan5(Fan Tray 3, Fan 1): state changed from UNKNOWN to OK /usr/sbin/smond : : Fan6(Fan Tray 3, Fan 2): state changed from UNKNOWN to OK</pre>
PSU failure	/var /log /syslog	<pre>/usr/sbin/smond : : PSU1Fan1(PSU1 Fan): state changed from UNKNOWN to OK /usr/sbin/smond : : PSU2Fan1(PSU2 Fan): state changed from UNKNOWN to BAD</pre>

## System Data

Cumulus Linux includes a number of ways to monitor various aspects of system data. In addition, alerts are issued in high risk situations.

### CPU Idle Time

When a CPU reports five high CPU alerts within a span of five minutes, an alert is logged.

#### ! Short High CPU Bursts



Short bursts of high CPU can occur during `switchd` churn or routing protocol startup. Do not set alerts for these short bursts.

System Element	Monitoring Command/s	Interval Poll
CPU utilization	<pre>cumulus@switch:~\$ cat /proc/stat cumulus@switch:~\$ top -b -n 1</pre>	30 seconds

CPU Logs	Log Location	Log Entries
High CPU	/var/log /syslog	<pre>sysmonitor: Critically high CPU use: 99% systemd[1]: Starting Monitor system resources (cpu, memory, disk)... systemd[1]: Started Monitor system resources (cpu, memory, disk). sysmonitor: High CPU use: 89% systemd[1]: Starting Monitor system resources (cpu, memory, disk)... systemd[1]: Started Monitor system resources (cpu, memory, disk). sysmonitor: CPU use no longer high: 77%</pre>

Cumulus Linux 3.0 and later monitors CPU, memory, and disk space via `sysmonitor`. The configurations for the thresholds are stored in `/etc/cumulus/sysmonitor.conf`. More information is available with `man sysmonitor`.

CPU measure	Thresholds
Use	Alert: 90% Crit: 95%
Process Load	Alarm: 95% Crit: 125%

[Click here to see differences between Cumulus Linux 2.5 ESR and 3.0 and later...](#)

CPU Logs	Log Location	Log Entries
High CPU		



CPU Logs	Log Location	Log Entries
	/var /log /syslog	jdoe[2803]: 'localhost' cpu system usage of 41.1% matches resource limit [cpu system usage>30.0%] jdoe[4727]: 'localhost' sysloadavg(15min) of 111.0 matches resource limit [sysloadavg(15min)>110.0]

In Cumulus Linux 2.5, CPU logs are created with each unique threshold:

CPU measure	< 2.5 Threshold
User	70%
System	30%
Wait	20%

In Cumulus Linux 2.5, CPU and memory warnings are generated with jdoe. The configuration for the thresholds is stored in `/etc/jdoe/jdoorc.d/cl-utilities.rc`.

## Disk Usage

When monitoring disk utilization, you can exclude `tmpfs` from monitoring.

System Element	Monitoring Command/s	Interval Poll
Disk utilization	<code>cumulus@switch:~\$ /bin/df -x tmpfs</code>	300 seconds

## Process Restart

In Cumulus Linux 3.0 and later, `systemd` is responsible for monitoring and restarting processes.

Process Element	Monitoring Command/s
View processes monitored by <code>systemd</code>	<code>cumulus@switch:~\$ systemctl status</code>

Process Element	Monitoring Command/s
-----------------	----------------------

[Click here to changes from Cumulus Linux 2.5 ESR to 3.0 and later...](#)

Cumulus Linux 2.5.2 through 2.5 ESR uses a forked version of monit called jdoo to monitor processes. If the process fails, jdoo invokes init.d to restart the process.

Process Element	Monitoring Command/s
View processes monitored by jdoo	cumulus@switch:~\$ jdoo summary
View process restarts	cumulus@switch:~\$ sudo cat /var/log/syslog
View current process state	cumulus@switch:~\$ ps -aux

## Layer 1 Protocols and Interfaces

Link and port state interface transitions are logged to /var/log/syslog and /var/log/switchd.log.

Interface Element	Monitoring Command/s
Link state	cumulus@switch:~\$ cat /sys/class/net/[iface]/operstate cumulus@switch:~\$ net show interface all json
Link speed	cumulus@switch:~\$ cat /sys/class/net/[iface]/speed cumulus@switch:~\$ net show interface all json



Interface Element	Monitoring Command/s
Port state	<pre>cumulus@switch:~\$ ip link show cumulus@switch:~\$ net show interface all json</pre>
Bond state	<pre>cumulus@switch:~\$ cat /proc/net/bonding/[bond] cumulus@switch:~\$ net show interface all json</pre>

Interface counters are obtained from either querying the hardware or the Linux kernel. The two outputs should align, but the Linux kernel aggregates the output from the hardware.

Interface Counter Element	Monitoring Command/s	Interval Poll
Interface counters	<pre>cumulus@switch:~\$ cat /sys/class/net/[iface] /statistics/[stat_name] cumulus@switch:~\$ net show counters json cumulus@switch:~\$ cl-netstat -j cumulus@switch:~\$ ethtool -S [iface]</pre>	10 seconds

Layer 1 Logs	Log Location	Log Entries
Link failure/Link flap	/var/log/switchd.log	<pre>switchd[5692]: nic.c:213 nic_set_carrier: swp17: setting kernel carrier: down switchd[5692]: netlink.c:291 libnl: swp1, family 0, ifi 20, oper down switchd[5692]: nic.c:213 nic_set_carrier: swp1: setting kernel carrier: up switchd[5692]: netlink.c:291 libnl: swp17, family 0, ifi 20, oper up</pre>



Layer 1 Logs	Log Location	Log Entries
Unidirectional link	/var /log /swi tchd .log /var /log /ptm .log	<pre>ptmd[7146]: ptm_bfd.c:2471 Created new session 0x1 with peer 10.255.255.11 port swp1 ptmd[7146]: ptm_bfd.c:2471 Created new session 0x2 with peer fe80::4638:39ff:fe00:5b port swp1 ptmd[7146]: ptm_bfd.c:2471 Session 0x1 down to peer 10.255.255.11, Reason 8 ptmd[7146]: ptm_bfd.c:2471 Detect timeout on session 0x1 with peer 10.255.255.11, in state 1</pre>
Bond Negotiation • Working	/var /log /sys log	<pre>kernel: [85412.763193] bonding: bond0 is being created... kernel: [85412.770014] bond0: Enslaving swp2 as a backup interface with an up link kernel: [85412.775216] bond0: Enslaving swp1 as a backup interface with an up link kernel: [85412.797393] IPv6: ADDRCONF (NETDEV_UP): bond0: link is not ready kernel: [85412.799425] IPv6: ADDRCONF (NETDEV_CHANGE): bond0: link becomes ready</pre>
Bond Negotiation • Failing	/var /log /sys log	<pre>kernel: [85412.763193] bonding: bond0 is being created... kernel: [85412.770014] bond0: Enslaving swp2 as a backup interface with an up link kernel: [85412.775216] bond0: Enslaving swp1 as a backup interface with an up link kernel: [85412.797393] IPv6: ADDRCONF (NETDEV_UP): bond0: link is not ready</pre>
MLAG peerlink negotiation • Working	/var /log /sys log	<pre>lldpd[998]: error while receiving frame on swp50: Network is down lldpd[998]: error while receiving frame on swp49: Network is down</pre>



Layer 1 Logs	Log Location	Log Entries
		<pre>kernel: [76174.262893] peerlink: Setting ad_actor_system to 44:38:39:00:00:11 kernel: [76174.264205] 8021q: adding VLAN 0 to HW filter on device peerlink mstpd: one_clag_cmd: setting (1) peer link: peerlink mstpd: one_clag_cmd: setting (1) clag state: up mstpd: one_clag_cmd: setting system-mac 44:38:39:ff:40:94 mstpd: one_clag_cmd: setting clag-role secondary</pre>
	/var/log/clangd.log	<pre>clagd[14003]: Cleanup is executing. clagd[14003]: Cannot open file "/tmp/pre-clagd.q7XiO clagd[14003]: Cleanup is finished clagd[14003]: Beginning execution of clagd version 1 clagd[14003]: Invoked with: /usr/sbin/clagd --daemon clagd[14003]: Role is now secondary clagd[14003]: HealthCheck: role via backup is second clagd[14003]: HealthCheck: backup active clagd[14003]: Initial config loaded clagd[14003]: The peer switch is active. clagd[14003]: Initial data sync from peer done. clagd[14003]: Initial handshake done. clagd[14003]: Initial data sync to peer done.</pre>
MLAG peerlink negotiation <ul style="list-style-type: none"> <li>• Failing</li> </ul>	/var/log/syslog	<pre>lldpd[998]: error while receiving frame on swp50: Network is down lldpd[998]: error while receiving frame on swp49: Network is down kernel: [76174.262893] peerlink: Setting ad_actor_system to 44:38:39:00:00:11 kernel: [76174.264205] 8021q: adding VLAN 0 to HW filter on device peerlink mstpd: one_clag_cmd: setting (1) peer link: peerlink</pre>

Layer 1 Logs	Log Location	Log Entries
		<pre>mstpd: one_clag_cmd: setting (1) clag state: down mstpd: one_clag_cmd: setting system-mac 44:38:39:ff:40:94 mstpd: one_clag_cmd: setting clag-role secondary</pre>
	<pre>/var /log /clagd.log</pre>	<pre>clagd[26916]: Cleanup is executing. clagd[26916]: Cannot open file "/tmp/pre-clagd.6M527vvGX0/brbatch" for reading: No such file or directory clagd[26916]: Cleanup is finished clagd[26916]: Beginning execution of clagd version 1.3.0 clagd[26916]: Invoked with: /usr/sbin/clagd --daemon 169.254.1.2 peerlink.4094 44:38:39:FF:01:01 --priority 1000 --backupIp 10.0.0.2 clagd[26916]: Role is now secondary clagd[26916]: Initial config loaded</pre>
MLAG port negotiation <ul style="list-style-type: none"> <li>• Working</li> </ul>	<pre>/var /log /syslog</pre>	<pre>kernel: [77419.112195] bonding: server01 is being created... lldpd[998]: error while receiving frame on swp1: Network is down kernel: [77419.122707] 8021q: adding VLAN 0 to HW filter on device swp1 kernel: [77419.126408] server01: Enslaving swp1 as a backup interface with a down link kernel: [77419.177175] server01: Setting ad_actor_system to 44:38:39:ff:40:94 kernel: [77419.190874] server01: Warning: No 802.3ad response from the link partner for any adapters in the bond kernel: [77419.191448] IPv6: ADDRCONF (NETDEV_UP): server01: link is not ready kernel: [77419.191452] 8021q: adding VLAN 0 to HW filter on device server01 kernel: [77419.192060] server01: link status definitely up for interface swp1, 1000 Mbps full duplex</pre>



Layer 1 Logs	Log Location	Log Entries
		<pre>kernel: [77419.192065] server01: now running without any active interface! kernel: [77421.491811] IPv6: ADDRCONF (NETDEV_CHANGE): server01: link becomes ready mstpd: one_clag_cmd: setting (1) mac 44:38:39:00:00:17 &lt;server01, None&gt;</pre>
	/var/log/cla/gd.log	<pre>clagd[14003]: server01 is now dual connected.</pre>
MLAG port negotiation • Failing	/var/log/syslog	<pre>kernel: [79290.290999] bonding: server01 is being created... kernel: [79290.299645] 8021q: adding VLAN 0 to HW filter on device swp1 kernel: [79290.301790] server01: Enslaving swp1 as a backup interface with a down link kernel: [79290.358294] server01: Setting ad_actor_system to 44:38:39:ff:40:94 kernel: [79290.373590] server01: Warning: No 802.3ad response from the link partner for any adapters in the bond kernel: [79290.374024] IPv6: ADDRCONF (NETDEV_UP): server01: link is not ready kernel: [79290.374028] 8021q: adding VLAN 0 to HW filter on device server01 kernel: [79290.375033] server01: link status definitely up for interface swp1, 1000 Mbps full duplex kernel: [79290.375037] server01: now running without any active interface!</pre>
	/var/log/cla	<pre>clagd[14291]: Conflict (server01): matching clag-id (1) not configured on peer ...</pre>



Layer 1 Logs	Log Location	Log Entries
	gd.log	clagd[14291]: Conflict cleared (server01): matching clag-id (1) detected on peer
MLAG port negotiation • Flapping	/var/log/syslog	mstpd: one_clag_cmd: setting (0) mac 00:00:00:00:00:00 <server01, None> mstpd: one_clag_cmd: setting (1) mac 44:38:39:00:00:03 <server01, None>
	/var/log/clagd.log	clagd[14291]: server01 is no longer dual connected clagd[14291]: server01 is now dual connected.

Prescriptive Topology Manager (PTM) uses LLDP information to compare against a `topology.dot` file that describes the network. It has built in alerting capabilities, so it is preferable to use PTM on box rather than polling LLDP information regularly. The PTM code is available on the Cumulus Networks [GitHub repository](#). Additional PTM, BFD, and associated logs are documented in the code.



Cumulus Networks recommends that you track peering information through PTM. For more information, refer to the [Prescriptive Topology Manager documentation \(see page 360\)](#).

Neighbor Element	Monitoring Command/s	Interval Poll
LLDP Neighbor	cumulus@switch:~\$ lldpctl -f json	300 seconds
Prescriptive Topology Manager	cumulus@switch:~\$ ptmctl -j [-d]	Triggered



## Layer 2 Protocols

Spanning tree is a protocol that prevents loops in a layer 2 infrastructure. In a stable state, the spanning tree protocol should stably converge. Monitoring the Topology Change Notifications (TCN) in STP helps identify when new BPDUs are received.

Interface Counter Element	Monitoring Command/s	Interval Poll
STP TCN Transitions	<pre>cumulus@switch:~\$ mstpcctl showbridge json cumulus@switch:~\$ mstpcctl showport json</pre>	60 seconds
MLAG peer state	<pre>cumulus@switch:~\$ clagctl status cumulus@switch:~\$ clagd -j cumulus@switch:~\$ cat /var/log/clagd.log</pre>	60 seconds
MLAG peer MACs	<pre>cumulus@switch:~\$ clagctl dumppeermacs cumulus@switch:~\$ clagctl dumpourmacs</pre>	300 seconds

Layer 2 Logs	Log Location	Log Entries
Spanning Tree Working	/var /log /syslog	<pre>kernel: [1653877.190724] device swp1 entered promiscuous mode kernel: [1653877.190796] device swp2 entered promiscuous mode mstpd: create_br: Add bridge bridge mstpd: clag_set_sys_mac_br: set bridge mac 00:00:00:00:00:00 mstpd: create_if: Add iface swp1 as port#2 to bridge bridge mstpd: set_if_up: Port swp1 : up</pre>

Layer 2 Logs	Log Location	Log Entries
		<pre>mstpd: create_if: Add iface swp2 as port#1 to bridge bridge mstpd: set_if_up: Port swp2 : up mstpd: set_br_up: Set bridge bridge up mstpd: MSTP_OUT_set_state: bridge:swp1:0 entering blocking state(Disabled) mstpd: MSTP_OUT_set_state: bridge:swp2:0 entering blocking state(Disabled) mstpd: MSTP_OUT_flush_all_fids: bridge:swp1:0 Flushing forwarding database mstpd: MSTP_OUT_flush_all_fids: bridge:swp2:0 Flushing forwarding database mstpd: MSTP_OUT_set_state: bridge:swp1:0 entering learning state(Designated) mstpd: MSTP_OUT_set_state: bridge:swp2:0 entering learning state(Designated) sudo: pam_unix(sudo:session): session closed for user root mstpd: MSTP_OUT_set_state: bridge:swp1:0 entering forwarding state(Designated) mstpd: MSTP_OUT_set_state: bridge:swp2:0 entering forwarding state(Designated) mstpd: MSTP_OUT_flush_all_fids: bridge:swp2:0 Flushing forwarding database mstpd: MSTP_OUT_flush_all_fids: bridge:swp1:0 Flushing forwarding database</pre>
Spanning Tree Blocking	<pre>/var /log /syslog</pre>	<pre>mstpd: MSTP_OUT_set_state: bridge:swp2:0 entering blocking state(Designated) mstpd: MSTP_OUT_set_state: bridge:swp2:0 entering learning state(Designated) mstpd: MSTP_OUT_set_state: bridge:swp2:0 entering forwarding state(Designated) mstpd: MSTP_OUT_flush_all_fids: bridge:swp2:0 Flushing forwarding database mstpd: MSTP_OUT_flush_all_fids: bridge:swp2:0 Flushing forwarding database mstpd: MSTP_OUT_set_state: bridge:swp2:0 entering blocking state(Alternate) mstpd: MSTP_OUT_flush_all_fids: bridge:swp2:0 Flushing forwarding database</pre>



## Layer 3 Protocols

When FRRouting boots up for the first time, there is a different log file for each daemon that is activated. If the log file is ever edited (for example, through `vtysh` or `frr.conf`), the integrated configuration sends all logs to the same file.

To send FRRouting logs to syslog, apply the configuration `log syslog` in `vtysh`.

### BGP

When monitoring BGP, check if BGP peers are operational. There is not much value in alerting on the current operational state of the peer; monitoring the transition is more valuable, which you can do by monitoring `syslog`.

Monitoring the routing table provides trending on the size of the infrastructure. This is especially useful when integrated with host-based solutions (such as Routing on the Host) when the routes track with the number of applications available.

BGP Element	Monitoring Command/s	Interval Poll
BGP peer failure	<pre>cumulus@switch:~\$ vtysh -c "show ip bgp summary json" cumulus@switch:~\$ cl-bgp summary show json</pre>	60 seconds
BGP route table	<pre>cumulus@switch:~\$ vtysh -c "show ip bgp json" cumulus@switch:~\$ cl-bgp route show</pre>	600 seconds

BGP Logs	Log Location	Log Entries
BGP peer down	<pre>/var/log /syslog /var/log /frr/*.log</pre>	<pre>bgpd[3000]: %NOTIFICATION: sent to neighbor swp1 4/0 (Hold Timer Expired) 0 bytes bgpd[3000]: %ADJCHANGE: neighbor swp1 Down BGP Notification send</pre>

## OSPF

When monitoring OSPF, check if OSPF peers are operational. There is not much value in alerting on the current operational state of the peer; monitoring the transition is more valuable, which you can do by monitoring `syslog`.

Monitoring the routing table provides trending on the size of the infrastructure. This is especially useful when integrated with host-based solutions (such as Routing on the Host) when the routes track with the number of applications available.

OSPF Element	Monitoring Command(s)	Interval Poll
OSPF protocol peer failure	<pre>cumulus@switch:~\$ vtysh -c "show ip ospf neighbor all json" cumulus@switch:~\$ cl-ospf summary show json</pre>	60 seconds
OSPF link state database	<pre>cumulus@switch:~\$ vtysh - c "show ip ospf database"</pre>	600 seconds

## Route and Host Entries

Route Element	Monitoring Command(s)	Interval Poll
Host Entries	<pre>cumulus@switch:~\$ cl-resource-query cumulus@switch:~\$ cl-resource-query -k</pre>	600 seconds
Route Entries	<pre>cumulus@switch:~\$ cl-resource-query cumulus@switch:~\$ cl-resource-query -k</pre>	600 seconds



## Routing Logs

Layer 3 Logs	Log Location	Log Entries
Routing protocol process crash	/var /log /sys log	<pre>frrouting[1824]: Starting FRRouting daemons (prio:10):. zebra. bgpd. bgpd[1847]: BGPD 1.0.0+cl3u7 starting: vty@2605, bgp@&lt;all&gt;:179 zebra[1840]: client 12 says hello and bids fair to announce only bgp routes watchfrr[1853]: watchfrr 1.0.0+cl3u7 watching [zebra bgpd], mode [phased zebra restart] watchfrr[1853]: bgpd state -&gt; up : connect succeeded watchfrr[1853]: bgpd state -&gt; down : read returned EOF cumulus-core: Running cl-support for core files bgpd.3030.1470341944.core.core_helper core_check.sh[4992]: Please send /var/support /cl_support_spine01_20160804_201905.tar.xz to Cumulus support watchfrr[1853]: Forked background command [pid 6665]: /usr/sbin/service frr restart bgpd watchfrr[1853]: watchfrr 0.99.24+cl3u2 watching [zebra bgpd ospfd], mode [phased zebra restart] watchfrr[1853]: zebra state -&gt; up : connect succeeded watchfrr[1853]: bgpd state -&gt; up : connect succeeded watchfrr[1853]: watchfrr: Notifying Systemd we are up and running</pre>

## Logging

The table below describes the various log files.

Logging Element	Monitoring Command/s	Log Location
syslog	Catch all log file. Identifies memory leaks and CPU spikes.	/var /lo

Logging Element	Monitoring Command/s	Log Location
		g /sy slo g
switchd functionality	Hardware Abstraction Layer (HAL).	/va r /lo g /sw itc hd. log
Routing daemons	FRRouting zebra daemon details.	/va r /lo g /da emo n. log
Routing protocol	<p>The log file is configurable in FRRouting. When FRRouting first boots, it uses the non-integrated configuration so each routing protocol has its own log file. After booting up, FRRouting switches over to using the integrated configuration, so that all logs go to a single place.</p> <p>To edit the location of the log files, use the <code>log file &lt;location&gt;</code> command. By default, FRRouting logs are not sent to <code>syslog</code>. Use the <code>log syslog &lt;level&gt;</code> command to send logs through <code>rsyslog</code> and into <code>/var/log/syslog</code>.</p> <div style="border: 2px solid yellow; padding: 5px; margin-top: 10px;">  </div>	/va r /lo g /fr r /ze bra .

Logging Element	Monitoring Command/s	Log Location
	<p>To write syslog debug messages to the log file, you must run the <code>log syslog debug</code> command to configure FRR with syslog severity 7 (debug); otherwise, when you issue a debug command such as, <code>debug bgp neighbor-events</code>, no output is sent to <code>/var/log/frr/frr.log</code>.</p> <p>However, when you manually define a log target with the <code>log file /var/log/frr/debug.log</code> command, FRR automatically defaults to severity 7 (debug) logging and the output is logged to <code>/var/log/frr/frr.log</code>.</p>	<pre>log /va r /lo g /fr r/ {pr oto col }. log /va r /lo g /fr r /fr r. log</pre>

## Protocols and Services

Run the following command to confirm that the NTP process is working correctly and that the switch clock is in sync with NTP:

```
cumulus@switch:~$ /usr/bin/ntpq -p
```



## Device Management

### Device Access Logs

Access Logs	Log Location	Log Entries
User Authentication and Remote Login	/var/log/syslog	<pre>sshd[31830]: Accepted publickey for cumulus from 192.168.0.254 port 45582 ssh2: RSA 38:e6:3b:cc:04:ac:41:5e:c9:e3:93:9d:cc:9e:48:25 sshd[31830]: pam_unix(sshd:session): session opened for user cumulus by (uid=0)</pre>

### Device Super User Command Logs

Super User Command Logs	Log Location	Log Entries
Executing commands using sudo	/var/log/syslog	<pre>sudo: cumulus : TTY=unknown ; PWD=/home/cumulus ; USER=root ; COMMAND=/tmp/script_9938.sh -v sudo: pam_unix(sudo:session): session opened for user root by (uid=0) sudo: pam_unix(sudo:session): session closed for user root</pre>

## FRRouting Log Message Reference

The following table lists the HIGH severity ERROR log messages generated by FRRouting. These messages appear in /var/log/frr/frr.log.



Category	Severity	Message #	Message Text	Explanation	Recommended Action
Babel	HIGH	16777217	BABEL Memory Errors	Babel has failed to allocate memory. The system is about to run out of memory.	Find the process that is causing memory shortages and remediate that process. Restart FRR.
Babel	HIGH	16777218	BABEL Packet Error	Babel has detected a packet encode /decode problem.	Collect the relevant log files and report the issue for troubleshooting.
Babel	HIGH	16777219	BABEL Configuration Error	Babel has detected a configuration error of some sort.	Ensure that the configuration is correct.
Babel	HIGH	16777220	BABEL Route Error	Babel has detected a routing error and is in an inconsistent state.	Gather data to report the issue for troubleshooting. Restart FRR.
BGP	HIGH	33554433	BGP attribute flag is incorrect	BGP attribute flag is set to the wrong value (Optional /Transitive/Partial).	Determine the source of the attribute and determine why the attribute flag has been set incorrectly.
BGP	HIGH	33554434	BGP attribute length is incorrect	BGP attribute length is incorrect.	Determine the source of the attribute and determine why the attribute length has been set incorrectly.
BGP	HIGH	33554435	BGP attribute origin value invalid	BGP attribute origin value is invalid.	Determine the source of the attribute and determine why the origin attribute has been set incorrectly.
BGP	HIGH	33554436	BGP as path is invalid	BGP AS path has been malformed.	Determine the source of the update and determine why the AS path has been set incorrectly.
BGP	HIGH	33554437	BGP as path first as is invalid	BGP update has invalid first AS in AS path.	

Category	Severity	Message #	Message Text	Explanation	Recommended Action
					Determine the source of the update and determine why the AS path first AS value has been set incorrectly.
BGP	HIGH	33554439	BGP PMSI tunnel attribute type is invalid	BGP update has invalid type for PMSI tunnel.	Determine the source of the update and determine why the PMSI tunnel attribute type has been set incorrectly.
BGP	HIGH	33554440	BGP PMSI tunnel attribute length is invalid	BGP update has invalid length for PMSI tunnel.	Determine the source of the update and determine why the PMSI tunnel attribute length has been set incorrectly.
BGP	HIGH	33554442	BGP peer-group operated on in error	BGP operating on peer-group instead of peers included.	Ensure the configuration doesn't contain peer-groups contained within peer-groups.
BGP	HIGH	33554443	BGP failed to delete peer structure	BGP was unable to delete the peer structure when the address-family was removed.	Determine if all expected peers are removed and restart FRR if not. This is most likely a bug.
BGP	HIGH	33554444	BGP failed to get table chunk memory	BGP unable to get chunk memory for table manager.	Ensure there is adequate memory on the device to support the table requirements.
BGP	HIGH	33554445	BGP received MACIP with invalid IP address length	BGP received MACIP with invalid IP address length from Zebra.	Verify the MACIP entries inserted in Zebra are correct. This is most likely a bug.
BGP	HIGH	33554446	BGP received invalid label manager message	BGP received an invalid label manager message from the label manager.	Label manager sent an invalid message to BGP for the wrong protocol instance. This is most likely a bug.



Category	Severity	Message #	Message Text	Explanation	Recommended Action
BGP	HIGH	33554447	BGP unable to allocate memory for JSON output	BGP attempted to generate JSON output and was unable to allocate the memory required.	Ensure that the device has adequate memory to support the required functions.
BGP	HIGH	33554448	BGP update had attributes too long to send	BGP attempted to send an update but the attributes were too long to fit.	This is most likely a bug. If the problem persists, report it for troubleshooting.
BGP	HIGH	33554449	BGP update group creation failed	BGP attempted to create an update group but was unable to do so.	This is most likely a bug. If the problem persists, report it for troubleshooting.
BGP	HIGH	33554450	BGP error creating update packet	BGP attempted to create an update packet but was unable to do so.	This is most likely a bug. If the problem persists, report it for troubleshooting.
BGP	HIGH	33554451	BGP error receiving open packet	BGP received an open from a peer that was invalid.	Determine the sending peer and correct its invalid open packet.
BGP	HIGH	33554452	BGP error sending to peer	BGP attempted to respond to open from a peer and failed.	BGP attempted to respond to an open and could not send the packet. Check the local IP address for the source.
BGP	HIGH	33554453	BGP error receiving from peer	BGP received an update from a peer but the status was incorrect.	This is most likely a bug. If the problem persists, report it for troubleshooting.
BGP	HIGH	33554454	BGP error receiving update packet	BGP received an invalid update packet.	Determine the source of the update and resolve the invalid update being sent.
BGP	HIGH	33554455	BGP error due to capability not enabled	BGP attempted a function that did not have the capability enabled.	Enable the capability if this functionality is desired.



Category	Severity	Message #	Message Text	Explanation	Recommended Action
BGP	HIGH	33554456	BGP error receiving notify message	BGP unable to process the notification message.	BGP notify received while in a stopped state. If the problem persists, report it for troubleshooting.
BGP	HIGH	33554457	BGP error receiving keepalive packet	BGP unable to process a keepalive packet.	BGP keepalive received while in a stopped state. If the problem persists, report it for troubleshooting.
BGP	HIGH	33554458	BGP error receiving route refresh message	BGP unable to process route refresh message.	BGP route refresh received while in a stopped state. If the problem persists, report it for troubleshooting.
BGP	HIGH	33554459	BGP error capability message	BGP unable to process received capability.	BGP capability message received while in a stopped state. If the problem persists, report it for troubleshooting.
BGP	HIGH	33554460	BGP error with nexthop update	BGP unable to process nexthop update.	BGP received the nexthop update but the nexthop is not reachable in this BGP instance. Report the problem for troubleshooting.
BGP	HIGH	33554461	Failure to apply label	BGP attempted to attempt to apply a label but could not do so.	This is most likely a bug. If the problem persists, report it for troubleshooting.
BGP	HIGH	33554462	Multipath specified is invalid	BGP was started with an invalid ECMP /multipath value.	Correct the ECMP /multipath value supplied when starting the BGP daemon.
BGP	HIGH	33554463	Failure to process a packet	BGP attempted to process a received packet but could not do so.	This is most likely a bug. If the problem persists, report it for troubleshooting.



Category	Severity	Message #	Message Text	Explanation	Recommended Action
BGP	HIGH	33554464	Failure to connect to peer	BGP attempted to send open to a peer but couldn't connect.	This is most likely a bug. If the problem persists, report it for troubleshooting.
BGP	HIGH	33554465	BGP FSM issue	BGP neighbor transition problem.	This is most likely a bug. If the problem persists, report it for troubleshooting.
BGP	HIGH	33554466	BGP VNI creation issue	BGP could not create a new VNI.	This is most likely a bug. If the problem persists, report it for troubleshooting.
BGP	HIGH	33554467	BGP default instance missing	BGP could not find default instance.	Define a default instance of BGP since some feature requires its existence.
BGP	HIGH	33554468	BGP remote VTEP invalid	BGP remote VTEP is invalid and cannot be used.	Correct the remote VTEP configuration or resolve the source of the problem.
BGP	HIGH	33554469	BGP ES route error	BGP ES route incorrect as it learned both local and remote routes.	Correct the configuration or address it so that same route is not learned both local and remote.
BGP	HIGH	33554470	BGP EVPN route delete error	BGP attempted to delete an EVPN route and failed.	This is most likely a bug. If the problem persists, report it for troubleshooting.
BGP	HIGH	33554471	BGP EVPN install/uninstall error	BGP attempted to install or uninstall an EVPN prefix and failed.	This is most likely a bug. If the problem persists, report it for troubleshooting.
BGP	HIGH	33554472	BGP EVPN route received with invalid contents	BGP received an EVPN route with invalid contents.	Determine the source of the EVPN route and resolve whatever is causing the invalid content.



Category	Severity	Message #	Message Text	Explanation	Recommended Action
BGP	HIGH	33554473	BGP EVPN route create error	BGP attempted to create an EVPN route and failed.	This is most likely a bug. If the problem persists, report it for troubleshooting.
BGP	HIGH	33554474	BGP EVPN ES entry create error	BGP attempted to create an EVPN ES entry and failed.	This is most likely a bug. If the problem persists, report it for troubleshooting.
BGP	HIGH	33554475	BGP config multi-instance issue	BGP configuration attempting multiple instances without enabling the feature.	Correct the configuration so that BGP multiple-instance is enabled if desired.
BGP	HIGH	33554476	BGP AS configuration issue	BGP configuration attempted for a different AS than is currently configured.	Correct the configuration so that the correct BGP AS number is used.
BGP	HIGH	33554477	BGP EVPN AS and process name mismatch	BGP configuration has AS and process name mismatch.	Correct the configuration so that the BGP AS number and instance name are consistent.
BGP	HIGH	33554478	BGP Flowspec packet processing error	The BGP flowspec subsystem has detected an error in the sending or receiving of a packet.	Gather log files from both sides of the peering relationship and report the issue for troubleshooting.
BGP	HIGH	33554479	BGP Flowspec Installation /removal Error	The BGP flowspec subsystem has detected that there was a failure for installation/removal/modification of Flowspec from the dataplane.	Gather log files from the router and report the issue for troubleshooting. Restart FRR.
EIGRP	HIGH	50331649	EIGRP Packet Error	EIGRP has a packet that does not correctly decode or encode.	Gather log files from both sides of the neighbor relationship and report the issue for troubleshooting.
EIGRP	HIGH	50331650			



Category	Severity	Message #	Message Text	Explanation	Recommended Action
			EIGRP Configuration Error	EIGRP has detected a configuration error.	Correct the configuration issue. If it still persists, report the issue for troubleshooting.
General	HIGH	100663297	Failure to raise or lower privileges	FRR attempted to raise or lower its privileges and was unable to do so.	Ensure that you are running FRR as the frr user and that the user has sufficient privileges to properly access root privileges.
General	HIGH	100663298	VRF Failure on Start	Upon startup, FRR failed to properly initialize and start up the VRF subsystem.	Ensure that there is sufficient memory to start processes, then restart FRR.
General	HIGH	100663299	Socket Error	When attempting to access a socket, a system error occurred and FRR was unable to properly complete the request.	Ensure that there are sufficient system resources available and ensure that the frr user has sufficient permissions to work.
General	HIGH	100663303	System Call Error	FRR has detected an error from using a vital system call and has probably already exited.	Ensure permissions are correct for FRR users and groups. Additionally, check that sufficient system resources are available.
General	HIGH	100663304	VTY Subsystem Error	FRR has detected a problem with the specified configuration file.	Ensure the configuration file exists and has the correct permissions for operations. Additionally, ensure that all config lines are correct as well.
General	HIGH	100663305	SNMP Subsystem Error	FRR has detected a problem with the SNMP library it uses. A callback from this subsystem has indicated some error.	Examine the callback message and ensure SNMP is properly set up and working.



Category	Severity	Message #	Message Text	Explanation	Recommended Action
General	HIGH	100663306	Interface Subsystem Error	FRR has detected a problem with interface data from the kernel as it deviates from what we would expect to happen via normal netlink messaging.	Open an issue with all relevant log files and restart FRR.
General	HIGH	100663307	NameSpace Subsystem Error	FRR has detected a problem with namespace data from the kernel as it deviates from what we would expect to happen via normal kernel messaging.	Open an issue with all relevant log files and restart FRR.
General	HIGH	4043309068	A necessary work queue does not exist.	A necessary work queue does not exist.	Notify a developer.
General	HIGH	100663308	Developmental Escape Error	FRR has detected an issue where new development has not properly updated all code paths.	Open an issue with all relevant log files.
General	HIGH	100663309	ZMQ Subsystem Error	FRR has detected an issue with the ZeroMQ subsystem and ZeroMQ is not working properly now.	Open an issue with all relevant log files and restart FRR.
General	HIGH	100663310	Feature or system unavailable	FRR was not compiled with support for a particular feature or it is not available on the current platform.	Recompile FRR with the feature enabled or find out what platforms support the feature.
General	HIGH	4043309071	IRDP message length mismatch	The length encoded in the IP TLV does not match the length of the packet received.	Notify a developer.
General	HIGH	4043309073			



Category	Severity	Message #	Message Text	Explanation	Recommended Action
			Dataplane installation failure	Installation of routes to the underlying dataplane failed.	Check all configuration parameters for correctness.
General	HIGH	4043309075	Netlink backend not available	FRR was not compiled with support for Netlink. Any operations that require Netlink will fail.	Recompile FRR with Netlink or install a package that supports this feature.
General	HIGH	4043309076	Protocol Buffers backend not available	FRR was not compiled with support for protocol buffers. Any operations that require protobuf will fail.	Recompile FRR with protobuf support or install a package that supports this feature.
General	HIGH	4043309087	Cannot set receive buffer size	The socket receive buffer size could not be set in the kernel.	Ignore this error.
General	HIGH	4043309089	Receive buffer overrun	The kernel's buffer for a socket has been overrun, rendering the socket invalid.	Zebra will restart itself. Notify a developer if this issue shows up frequently.
General	HIGH	4043309091	Received unexpected response from kernel	Received unexpected response from the kernel via Netlink.	Notify a developer.
General	HIGH	4043309094	String could not be parsed as IP prefix	There was an attempt to parse a string as an IPv4 or IPv6 prefix, but the string could not be parsed and this operation failed.	Notify a developer.
General	HIGH	268435457	WATCHFRR Connection Error	WATCHFRR has detected a connectivity issue with one of the FRR daemons.	Ensure that FRR is still running. If it isn't, report the issue for troubleshooting.
ISIS	HIGH	67108865	ISIS Packet Error		

<b>Category</b>	<b>Severity</b>	<b>Message #</b>	<b>Message Text</b>	<b>Explanation</b>	<b>Recommended Action</b>
				ISIS has detected an error with a packet from a peer.	Gather log information and report the issue for troubleshooting. Restart FRR.
ISIS	HIGH	67108866	ISIS Configuration Error	ISIS has detected an error within the configuration for the router.	Ensure configuration is correct.
OSPF	HIGH	134217729	Failure to process a packet	OSPF attempted to process a received packet but could not do so.	This is most likely a bug. If the problem persists, report it for troubleshooting.
OSPF	HIGH	134217730	Failure to process Router LSA	OSPF attempted to process a router LSA, but there was an advertising ID mismatch with the link ID.	Check the OSPF network configuration for any configuration issue. If the problem persists, report it for troubleshooting.
OSPF	HIGH	134217731	OSPF Domain Corruption	OSPF attempted to process a router LSA, but there was an advertising ID mismatch with the link ID.	Check OSPF network database for a corrupted LSA. If the problem persists, shut down the OSPF domain and report the problem for troubleshooting.
OSPF	HIGH	134217732	OSPF Initialization failure	OSPF failed to initialized the OSPF default instance.	Ensure there is adequate memory on the device. If the problem persists, report it for troubleshooting.
OSPF	HIGH	134217733	OSPF SR Invalid DB	OSPF segment routing database is invalid.	This is most likely a bug. If the problem persists, report it for troubleshooting.
OSPF	HIGH	134217734	OSPF SR hash node creation failed	OSPF segment routing node creation failed.	This is most likely a bug. If the problem persists, report it for troubleshooting.



Category	Severity	Message #	Message Text	Explanation	Recommended Action
OSPF	HIGH	134217735	OSPF SR Invalid Lsa id	OSPF segment routing invalid LSA ID.	Restart the OSPF instance. If the problem persists, report it for troubleshooting.
OSPF	HIGH	134217736	OSPF SR Invalid Algorithm	OSPF segment routing invalid algorithm.	This is most likely a bug. If the problem persists, report it for troubleshooting.
PIM	HIGH	184549377	PIM MSDP Packet Error	PIM has received a packet from a peer that does not correctly decode.	Check the MSDP peer and ensure it is correctly working.
PIM	HIGH	184549378	PIM Configuration Error	PIM has detected a configuration error.	Ensure the configuration is correct and apply the correct configuration.
RIP	HIGH	201326593	RIP Packet Error	RIP has detected a packet encode /decode issue.	Gather log files from both sides and open a Issue
Zebra	HIGH	4043309057	Error reading response from label manager	Zebra could not read the ZAPI header from the label manager.	Wait for the error to resolve on its own. If it does not resolve, restart Zebra.
Zebra	HIGH	4043309058	Label manager could not find ZAPI client	Zebra was unable to find a ZAPI client matching the given protocol and instance number.	Ensure that clients that use the label manager are properly configured and running.
Zebra	HIGH	4043309059	Zebra could not relay label manager response	Zebra found the client and instance to relay the label manager response or request, but was unable to do so, possibly because the connection was closed.	Ensure that clients that use the label manager are properly configured and running.
Zebra	HIGH	100663300	ZAPI Error		



Category	Severity	Message #	Message Text	Explanation	Recommended Action
				A version mismatch has been detected between Zebra and a client protocol.	Two different versions of FRR have been installed and the install is not properly set up. Completely stop FRR, remove it from the system and reinstall. Typically, only developers should see this issue.
Zebra	HIGH	4043309061	Mismatch between ZAPI instance and encoded message instance	While relaying a request to the external label manager, Zebra noticed that the instance number encoded in the message did not match the client instance number.	Notify a developer.
Zebra	HIGH	100663301	ZAPI Error	The ZAPI subsystem has detected an encoding issue between Zebra and a client protocol.	Restart FRR.
Zebra	HIGH	100663302	ZAPI Error	The ZAPI subsystem has detected a socket error between Zebra and a client.	Restart FRR.
Zebra	HIGH	4043309064	Zebra label manager used all available labels	Zebra is unable to assign additional label chunks because it has exhausted its assigned label range.	Make the label range bigger and restart Zebra.
Zebra	HIGH	4043309065	Daemon mismatch when releasing label chunks	Zebra noticed a mismatch between a label chunk and a protocol daemon number or instance when releasing unused label chunks.	Ignore this error.
Zebra	HIGH	4043309066			Ignore this error.



Category	Severity	Message #	Message Text	Explanation	Recommended Action
			Zebra did not free any label chunks	Zebra's chunk cleanup procedure ran but no label chunks were released.	
Zebra	HIGH	4043309067	Dataplane returned invalid status code	The underlying dataplane responded to a Zebra message or other interaction with an unrecognized unknown or invalid status code.	Notify a developer.
Zebra	HIGH	4043309069	Failed to add FEC for MPLS client	A client requested a label binding for a new FEC but Zebra was unable to add the FEC to its internal table.	Notify a developer.
Zebra	HIGH	4043309070	Failed to remove FEC for MPLS client	Zebra was unable to find and remove an FEC in its internal table.	Notify a developer.
Zebra	HIGH	4043309072	Attempted to perform nexthop update for unknown address family	Zebra attempted to perform a nexthop update for unknown address family.	Notify a developer.
Zebra	HIGH	4043309074	Zebra table lookup failed	Zebra attempted to look up a table for a particular address family and a subsequent address family but didn't find anything.	If you entered a command to trigger this error, make sure you entered the arguments correctly. Check your configuration file for any potential errors. If these look correct, notify a developer.
Zebra	HIGH	4043309077	Table manager used all available IDs	Zebra's table manager used up all IDs available to it and can't assign any more.	Reconfigure Zebra with a larger range of table IDs.

Zebra	HIGH	4043309078	Daemon mismatch when releasing table chunks	Zebra noticed a mismatch between a table ID chunk and a protocol daemon number instance when releasing unused table chunks.	Ignore this error.
Zebra	HIGH	4043309079	Zebra did not free any table chunks	Zebra's table chunk cleanup procedure ran but no table chunks were released.	Ignore this error.
Zebra	HIGH	4043309080	Address family specifier unrecognized	Zebra attempted to process information from somewhere that included an address family specifier but did not recognize the provided specifier.	Ensure that your configuration is correct. If it is, notify a developer.
Zebra	HIGH	4043309081	Incorrect protocol for table manager client	Zebra's table manager only accepts connections from daemons managing dynamic routing protocols, but received a connection attempt from a daemon that does not meet this criterion.	Notify a developer.
Zebra	HIGH	4043309082	Mismatch between message and client protocol and/or instance	Zebra detected a mismatch between a client's protocol and /or instance numbers versus those stored in a message transiting its socket.	Notify a developer.
Zebra	HIGH	4043309083	Label manager unable to assign label chunk	Zebra's label manager was unable to assign a label chunk to client.	Ensure that Zebra has a sufficient label range available and that there is not a range collision.
Zebra	HIGH	4043309084			Notify a developer.



Category	Severity	Message #	Message Text	Explanation	Recommended Action
			Label request from unidentified client	Zebra's label manager received a label request from an unidentified client.	
Zebra	HIGH	4043309085	Table manager unable to assign table chunk	Zebra's table manager was unable to assign a table chunk to a client.	Ensure that Zebra has sufficient table ID range available and that there is not a range collision.
Zebra	HIGH	4043309086	Table request from unidentified client	Zebra's table manager received a table request from an unidentified client.	Notify a developer.
Zebra	HIGH	4043309088	Unknown Netlink message type	Zebra received a Netlink message with an unrecognized type field.	Verify that you are running the latest version of FRR to ensure kernel compatibility. If the problem persists, notify a developer.
Zebra	HIGH	4043309090	Netlink message length mismatch	Zebra received a Netlink message with incorrect length fields.	Notify a developer.
Zebra	HIGH	4043309092	Bad sequence number in Netlink message	Zebra received a Netlink message with a bad sequence number.	Notify a developer.
Zebra	HIGH	4043309093	Multipath number was out of valid range	The multipath number specified to Zebra must be in the appropriate range.	Provide a multipath number that is within its accepted range.
Zebra	HIGH	4043309095	Failed to add MAC address to interface	Zebra attempted to assign a MAC address to a VXLAN interface but failed.	Notify a developer.
Zebra	HIGH	4043309096	Failed to delete VNI	Zebra attempted to delete a VNI entry and failed.	Notify a developer.



Category	Severity	Message #	Message Text	Explanation	Recommended Action
Zebra	HIGH	4043309097	Adding remote VTEP failed	Zebra attempted to add a remote VTEP and failed.	Notify a developer.
Zebra	HIGH	4043309098	Adding VNI failed	Zebra attempted to add a VNI hash to an interface and failed.	Notify a developer.

# Network Solutions

## Data Center Host to ToR Architecture

This chapter discusses the various architectures and strategies available from the top of rack (ToR) switches all the way down to the server hosts.

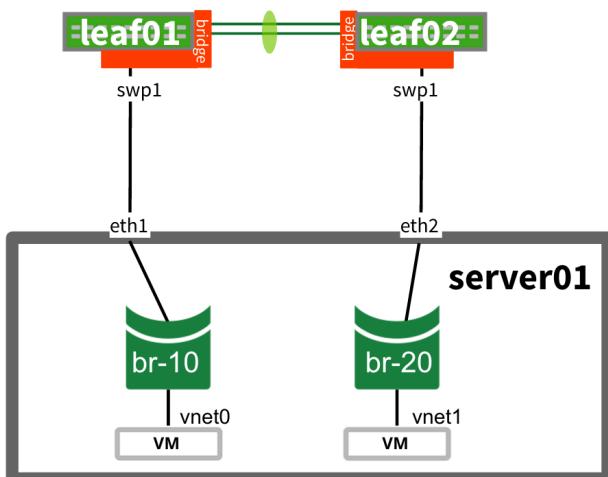
### Contents

This topic describes ...

- Layer 2 - Architecture (see page 1107)
  - Traditional Spanning Tree - Single Attached (see page 1107)
  - MLAG (see page 1109)
- Layer 3 Architecture (see page 1111)
  - Single-attached Hosts (see page 1111)
  - Redistribute Neighbor (see page 1113)
  - Routing on the Host (see page 1114)
  - Routing on the VM (see page 1115)
  - Virtual Router (see page 1116)
  - Anycast with Manual Redistribution (see page 1117)
- Network Virtualization (see page 1118)

### Layer 2 - Architecture

*Traditional Spanning Tree - Single Attached*



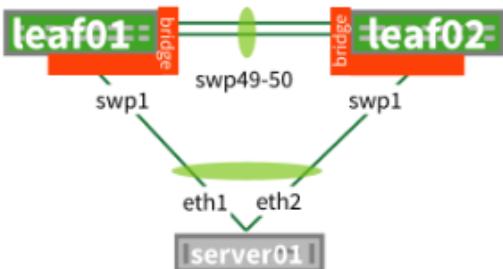


Summary	More Information
<p><b>Bond (see page 399)</b>/Etherchannel is not configured on host to multiple switches (bonds can still occur but only to one switch at a time), so leaf01 and leaf02 see two different MAC addresses.</p> <p><b>Configurations</b></p> <p><b>leaf01 Config</b></p> <pre>auto bridge iface bridge     bridge-vlan-aware yes     bridge-ports swp1 peerlink     bridge-vids 1-2000     bridge-stp on  auto bridge.10 iface bridge.10     address 10.1.10.2/24  auto peerlink iface peerlink     bond-slaves glob swp49-50  auto swp1 iface swp1     mstpctl-portadmindge yes     mstpctl-bpduguard yes</pre> <p><b>Example Host Config (Ubuntu)</b></p> <pre>auto eth1 iface eth1 inet manual  auto eth1.10 iface eth1.10 inet manual  auto eth2 iface eth2 inet manual  auto eth2.20 iface eth2.20 inet manual  auto br-10 iface br-10 inet manual     bridge-ports eth1.10 vnet0</pre>	<p><b>Benefits</b></p> <ul style="list-style-type: none"><li>Established technology<ul style="list-style-type: none"><li>Interoperability with other vendors</li><li>Easy configuration for customer</li><li>Immense documentation from multiple vendors and industry</li></ul></li><li>Ability to use <a href="#">spanning tree (see page 372)</a> commands<ul style="list-style-type: none"><li>mstpctl-portadmindge</li><li><a href="#">BPDU guard (see page 379)</a></li></ul></li><li>Layer 2 reachability to all VMs</li></ul> <p><b>Caveats</b></p> <ul style="list-style-type: none"><li>The load balancing mechanism on the host can cause problems. If there is only host pinning to each NIC, there are no problems, but if you are doing a bond, you need to look at an MLAG solution.</li><li>No active-active host links. Some operating systems allow HA (NIC failover), but this still does not utilize all the bandwidth. VMs are using one NIC, not two.</li></ul>

Summary	More Information
<pre>auto br-20 iface br-20 inet manual     bridge-ports eth2.20 vnet1</pre>	

Active-Active Mode	Active-Passive Mode	L2 to L3 Demarcation
<ul style="list-style-type: none"> <li>None (not possible with traditional spanning tree)</li> </ul>	<ul style="list-style-type: none"> <li>VRR (see page 474)</li> </ul>	<ul style="list-style-type: none"> <li>ToR layer (recommended)</li> <li>Spine layer</li> <li>Core/edge/exit</li> </ul> <p><b>More Info...</b></p> <p>VRR can be configured on a pair of switches at any level in the network. However, the higher up the network you configure it, the larger the L2 domain becomes. The benefit here is L2 reachability. The drawback is the L2 domain is more difficult to troubleshoot, does not scale as well, and the pair of switches running VRR needs to carry the entire MAC address table of everything below it in the network. Minimizing the L2 domain as much as possible is recommended by Cumulus Professional Services. <a href="#">See this presentation for more information.</a></p>

## MLAG



Summary	More Information
<p>MLAG (see page 440) (multi-chassis link aggregation) is when both uplinks are utilized at the same time. VRR gives the ability for both spines to act as gateways simultaneously for HA (high availability) and <a href="#">active-active mode (see page 633)</a> (both are being used at the same time).</p>	<p><b>Benefits</b></p> <ul style="list-style-type: none"> <li>100% of links utilized</li> </ul> <p><b>Caveats</b></p> <ul style="list-style-type: none"> <li>More complicated (more moving parts)</li> <li>More configuration</li> </ul>
<p><b>Configurations</b></p> <p><b>leaf01 Config</b></p>	

**Summary**

```

auto bridge
iface bridge
    bridge-vlan-aware yes
    bridge-ports host-01 peerlink
    bridge-vids 1-2000
    bridge-stp on

auto bridge.10
iface bridge.10
    address 172.16.1.2/24
    address-virtual 44:38:39:00:00:10
172.16.1.1/24

auto peerlink
iface peerlink
    bond-slaves glob swp49-50

auto peerlink.4094
iface peerlink.4094
    address 169.254.1.2
    clagd-enable yes
    clagd-peer-ip 169.254.1.2
    clagd-system-mac 44:38:39:FF:40:94

auto host-01
iface host-01
    bond-slaves swp1
    clag-id 1
    {bond-defaults removed for brevity}

```

**More Information**

- No interoperability between vendors
- ISL (inter-switch link) required

**Additional Comments**

- Can be done with either the [traditional \(see page 407\)](#) or [VLAN-aware \(see page 415\)](#) bridge driver depending on overall STP needs
- There are a few different solutions including Cisco VPC and Arista MLAG, but none of them interoperate and are very vendor specific
- [Cumulus Networks Layer 2 HA validated design guide](#)

**Example Host Config (Ubuntu)**

```

auto bond0
iface bond0 inet manual
    bond-slaves eth0 eth1
    {bond-defaults removed for brevity}

auto bond0.10
iface bond0.10 inet manual

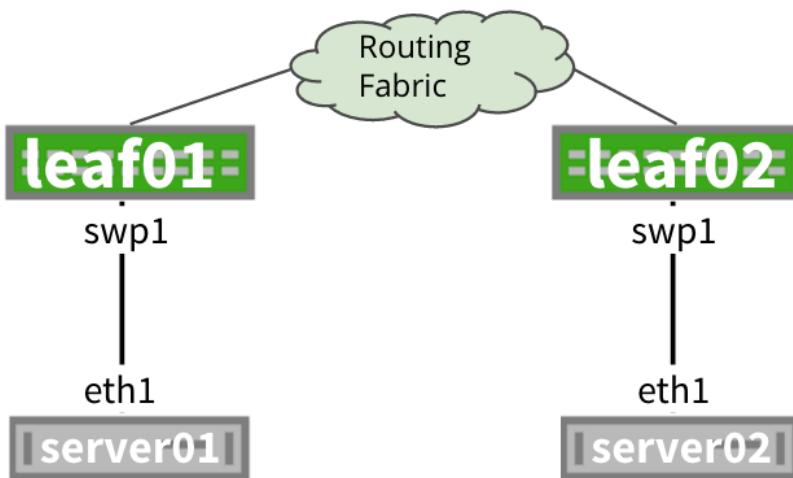
auto vm-br10
iface vm-br10 inet manual
    bridge-ports bond0.10 vnet0

```

Active-Active Mode	Active-Passive Mode	L2->L3 Demarcation
<ul style="list-style-type: none"> <li>• VRR (see page 474)</li> </ul>	None	<ul style="list-style-type: none"> <li>• ToR layer (recommended)</li> <li>• Spine layer</li> <li>• Core/edge/exit</li> </ul>

## Layer 3 Architecture

*Single-attached Hosts*

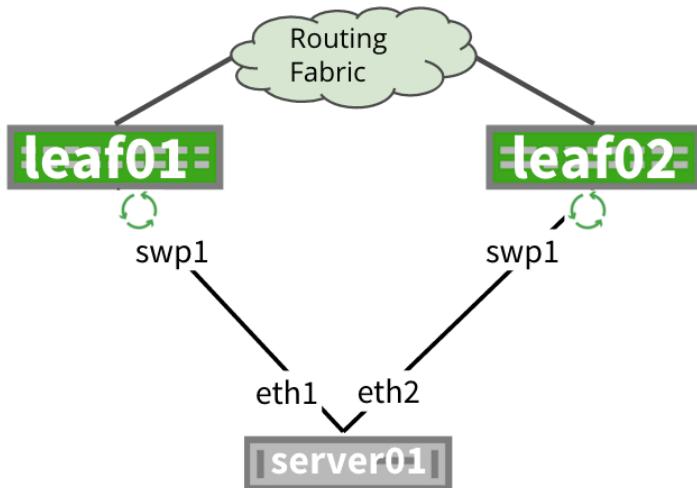


Summary	More Information
<p>The server (physical host) has only has one link to one ToR switch.</p> <p><b>Configurations</b></p> <p><b>leaf01 Config</b></p> <pre>/etc/network/interfaces</pre> <pre> auto swp1 iface swp1     address 172.16.1.1/30   </pre> <p><b>leaf02 Config</b></p> <pre>/etc/frr/frr.conf</pre> <pre> router ospf     router-id 10.0.0.11     interface swp1   </pre>	<p><b>Benefits</b></p> <ul style="list-style-type: none"> <li>• Relatively simple network configuration</li> <li>• No STP</li> <li>• No MLAG</li> <li>• No L2 loops</li> <li>• No crosslink between leafs</li> <li>• Greater route scaling and flexibility</li> </ul> <p><b>Caveats</b></p> <ul style="list-style-type: none"> <li>• No redundancy for ToR, upgrades would cause downtime</li> <li>• Many customers do not have software to support application layer redundancy</li> </ul> <p><b>Additional Comments</b></p> <ul style="list-style-type: none"> <li>• For additional bandwidth links between host and leaf may be bonded</li> </ul>



Summary	More Information
<pre>ip ospf area 0</pre>	
<p><b>leaf02 Config</b></p> <p>/etc/network/interfaces</p> <pre>auto swp1 iface swp1     address 172.16.2.1/30</pre>	
<p>/etc/frr/frr.conf</p> <pre>router ospf     router-id 10.0.0.12 interface swp1     ip ospf area 0</pre>	
<p><b>host1 Example Config (Ubuntu)</b></p> <pre>auto eth1 iface eth1 inet static     address 172.16.1.2/30     up ip route add 0.0.0.0/0     nexthop via 172.16.1.1</pre>	
<p><b>host2 Example Config (Ubuntu)</b></p> <pre>auto eth1 iface eth1 inet static     address 172.16.2.2/30     up ip route add 0.0.0.0/0     nexthop via 172.16.2.1</pre>	
FHR (First Hop Redundancy)	More Information
<ul style="list-style-type: none"><li>No redundancy, uses single ToR as gateway.</li></ul>	<ul style="list-style-type: none"><li><a href="#">Big Data validated design guide</a> uses single attached ToR</li></ul>

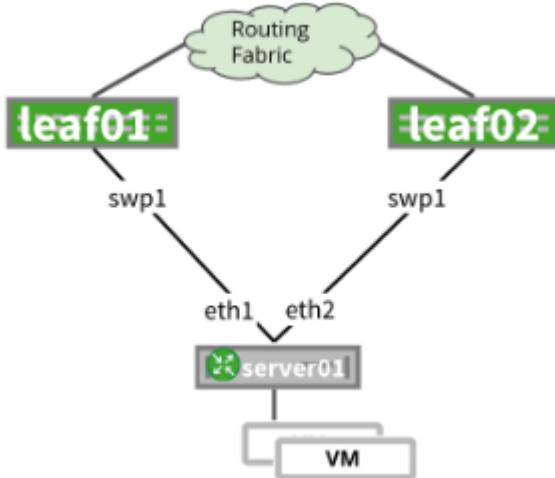
## Redistribute Neighbor



Summary	More Information
<p><b>Redistribute neighbor</b> daemon grabs ARP entries dynamically, utilizes redistribute table for FRRouting to grab these dynamic entries and redistribute them into the fabric.</p>	<p><b>Benefits</b></p> <ul style="list-style-type: none"> <li>Configuration in FRRouting is simple (route-map + redist table)</li> <li>Supported by Cumulus Networks</li> </ul> <p><b>Caveats</b></p> <ul style="list-style-type: none"> <li>Silent hosts don't receive traffic (depending on ARP).</li> <li>IPv4 only.</li> <li>If two VMs are on same L2 domain, they could learn about each other directly rather than utilizing gateway, which causes problems (VM migration for example, or getting their network routed). Put hosts on /32 (no other L2 adjacency).</li> <li>VM move does not trigger route withdrawal from original leaf (4 hour timeout).</li> <li>Clearing ARP impacts routing. May not be obvious.</li> <li>No L2 adjacency between servers without VXLAN.</li> </ul>
<p><b>FHR (First Hop Redundancy)</b></p> <ul style="list-style-type: none"> <li>Equal cost route installed on server/host /hypervisor to both ToRs to load balance evenly.</li> </ul>	<p><b>More Information</b></p> <ul style="list-style-type: none"> <li><a href="#">Cumulus Networks blog post introducing redistribute neighbor</a></li> </ul>

Summary	More Information
<ul style="list-style-type: none"> <li>For host/VM/container mobility, use the same default route on all hosts (such as x.x.x.1) but don't distribute or advertise the .1 on the ToR into the fabric. This allows the VM to use the same gateway no matter which pair of leafs it is cabled to.</li> </ul>	

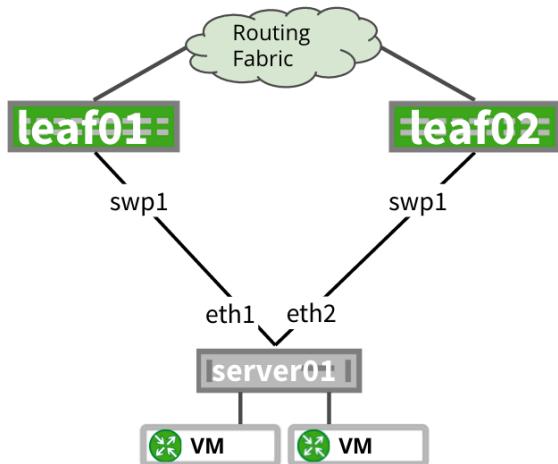
### Routing on the Host



Summary	More Information
<p>Routing on the host means there is a routing application (such as <a href="#">FRRouting (see page 731)</a>) either on the bare metal host (no VMs /containers) or the hypervisor (for example, Ubuntu with KVM). This is highly recommended by the Cumulus Networks Professional Services team.</p>	<p><b>Benefits</b></p> <ul style="list-style-type: none"> <li>No requirement for MLAG</li> <li>No spanning-tree or layer 2 domain</li> <li>No loops</li> <li>3 or more ToRs can be used instead of usual 2</li> <li>Host and VM mobility</li> <li>Traffic engineering can be used to migrate traffic from one ToR to another for upgrading both hardware and software</li> </ul> <p><b>Caveats</b></p>

Summary	More Information
	<ul style="list-style-type: none"> <li>• Certain hypervisors or host OSes might not support a routing application like FRRouting and will require a virtual router on the hypervisor</li> <li>• No L2 adjacency between servers without VXLAN</li> </ul>
FHR (First Hop Redundancy)	More Information
<ul style="list-style-type: none"> <li>• The first hop is still the ToR, just like redistribute neighbor</li> <li>• A default route can be advertised by all leaf/ToRs for dynamic ECMP paths</li> </ul>	<ul style="list-style-type: none"> <li>• <a href="#">Installing the Cumulus Linux FRRouting Package on an Ubuntu Server</a></li> <li>• <a href="#">Configuring FRRouting (see page 737)</a></li> </ul>

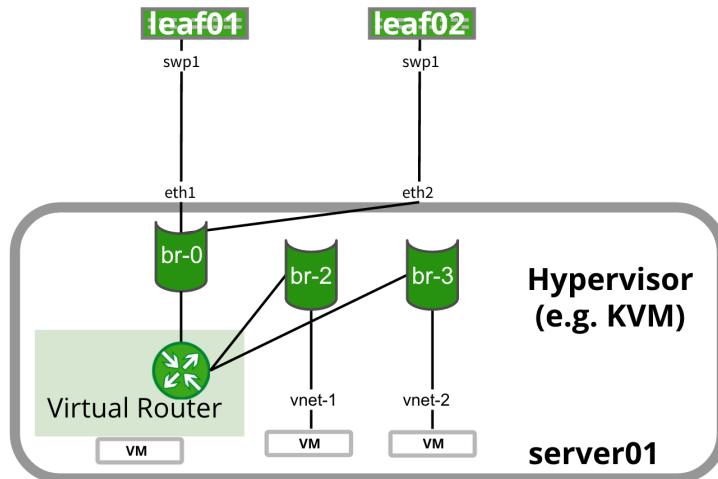
### Routing on the VM



Summary	More Information
<p>Instead of routing on the hypervisor, each virtual machine utilizes its own routing stack.</p>	<p><b>Benefits</b></p> <ul style="list-style-type: none"> <li>• In addition to routing on host: <ul style="list-style-type: none"> <li>• Hypervisor/base OS does not need to be able to do routing</li> <li>• VMs can be authenticated into routing fabric</li> </ul> </li> </ul> <p><b>Caveats</b></p>

Summary	More Information
	<ul style="list-style-type: none"> <li>• All VMs must be capable of routing</li> <li>• Scale considerations might need to be taken into account — instead of one routing process, there are as many as there are VMs</li> <li>• No L2 adjacency between servers without VXLAN</li> </ul>
FHR (First Hop Redundancy)	More Information
<ul style="list-style-type: none"> <li>• The first hop is still the ToR, just like redistribute neighbor</li> <li>• Multiple ToRs (2+) can be used</li> </ul>	<ul style="list-style-type: none"> <li>• <a href="#">Installing the Cumulus Linux FRRouting Package on an Ubuntu Server</a></li> <li>• <a href="#">Configuring FRRouting (see page 737)</a></li> </ul>

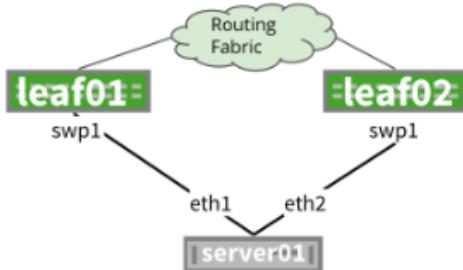
## Virtual Router



Summary	More Information
<p>Virtual router (vRouter) runs as a VM on the hypervisor/host, sends routes to the ToR using <a href="#">BGP (see page 1107)</a> or <a href="#">OSPF (see page 756)</a>.</p>	<p><b>Benefits</b> In addition to routing on a host:</p> <ul style="list-style-type: none"> <li>• Multi-tenancy can work (multiple customers sharing same racks)</li> <li>• Base OS does not need to be routing capable</li> </ul> <p><b>Caveats</b></p> <ul style="list-style-type: none"> <li>• <a href="#">ECMP (see page 829)</a> might not work correctly (load balancing to multiple ToRs); Linux kernel in older versions is not capable of ECMP per flow (does it per packet)</li> </ul>

Summary	More Information
	<ul style="list-style-type: none"> <li>No L2 adjacency between servers without VXLAN</li> </ul>
FHR (First Hop Redundancy)	More Information
<ul style="list-style-type: none"> <li>The gateway would be the vRouter, which has two routes out (two ToRs)</li> <li>Multiple vRouters could be used</li> </ul>	<ul style="list-style-type: none"> <li>Installing the Cumulus Linux FRRouting Package on an Ubuntu Server</li> <li>Configuring FRRouting (see page 737)</li> </ul>

### Anycast with Manual Redistribution



Summary	More Information
<p>In contrast to routing on the host (preferred), this method allows a user to route <b>to</b> the host. The ToRs are the gateway, as with redistribute neighbor, except because there is no daemon running, the networks must be manually configured under the routing process. There is a potential to black hole unless a script is run to remove the routes when the host no longer responds.</p>	<p><b>Benefits</b></p> <ul style="list-style-type: none"> <li>Most benefits of routing <b>on</b> the host</li> <li>No requirement for host to run routing</li> <li>No requirement for redistribute neighbor</li> </ul>

### Configurations

#### leaf01 Config

/etc/network/interfaces

```

auto swp1
iface swp1
  address 172.16.1.1/30
  
```

/etc/frr/frr.conf

```

router ospf
  router-id 10.0.0.11
  interface swp1
    ip ospf area 0
  
```

#### Caveats

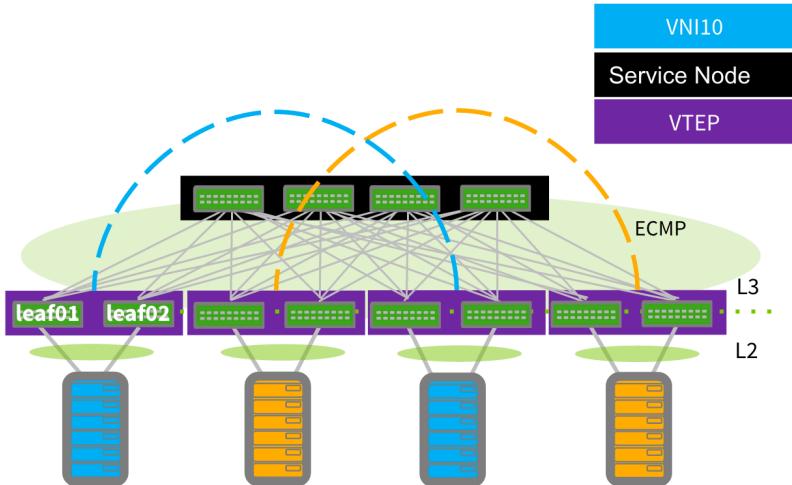
- Removing a subnet from one ToR and re-adding it to another (hence, network statements from your router process) is a manual process
- Network team and server team would have to be in sync, or server team controls the ToR, or automation is being used whenever VM migration happens



Summary	More Information
<p><b>leaf02 Config</b></p> <p>/etc/network/interfaces</p> <pre>auto swp2 iface swp2     address 172.16.1.1/30</pre> <p>/etc/frr/frr.conf</p> <pre>router ospf     router-id 10.0.0.12     interface swp1         ip ospf area 0</pre>	<ul style="list-style-type: none"><li>When using VMs /containers it is very easy to black hole traffic, as the leafs continue to advertise prefixes even when VM is down</li><li>No L2 adjacency between servers without VXLAN</li></ul>
<p><b>Example Host Config (Ubuntu)</b></p> <pre>auto lo iface lo inet loopback  auto lo:1 iface lo:1 inet static     address 172.16.1.2/32     up ip route add 0.0.0.0/0 nexthop via 172.16     .1.1 dev eth0 onlink nexthop via 172.16.1.1     dev eth1 onlink  auto eth1 iface eth2 inet static     address 172.16.1.2/32  auto eth2 iface eth2 inet static     address 172.16.1.2/32</pre>	
<p><b>FHR (First Hop Redundancy)</b></p> <ul style="list-style-type: none"><li>The gateways would be the ToRs, exactly like redistribute neighbor with an equal cost route installed</li></ul>	<p><b>More Information</b></p>

## Network Virtualization

### LNv with MLAG



## Summary

The host runs LACP (Etherchannel/bond) to the pair of ToRs. [LNV \(see page 602\)](#) (Lightweight Network Virtualization) then transports the L2 bridges across an L3 fabric.

## Configurations

### leaf01 Config

/etc/network/interfaces

```
auto lo
iface lo inet loopback
    address 10.0.0.11/32
    vxrd-src-ip 10.0.0.11
    vxrd-svcnode-ip 10.10.10.10
    clagd-vxlan-anycast-ip 36.0.0.11
```

```
auto vni-10
iface vni-10
    vxlan-id 10
    vxlan-local-tunnelip 10.0.0.11
```

```
auto br-10
iface br-10
    bridge-ports swp1 vni-10
```

### leaf02 Config

/etc/network/interfaces

```
auto lo
iface lo inet loopback
```

## More Information

### Benefits

- Layer 2 domain is reduced to the pair of ToRs
- Aggregation layer is all L3 (VLANs do not have to exist on spine switches)
- Greater route scaling and flexibility
- High availability

### Caveats

- Needs MLAG (with the same caveats from the [MLAG section \(see page 1109\)](#) above) and spanning tree ([see page 372](#))



	<b>Summary</b>	<b>More Information</b>
	<pre>address 10.0.0.12/32 Vxrd-src-ip 10.0.0.12 vxrd-svcnode-ip 10.10.10.10 clagd-vxlan-anycast-ip 36.0.0.11  auto vni-10 iface vni-10     vxlan-id 10     vxlan-local-tunnelip 10.0.0.12  auto br-10 iface br-10     bridge-ports swp1 vni-10</pre>	

Active-Active Mode	Active-Passive Mode	Demarcation
<ul style="list-style-type: none"><li>• VRR (see page 474)</li></ul>	None	<ul style="list-style-type: none"><li>• ToR layer or exit leafs</li></ul>
<b>More Information</b>		
		<ul style="list-style-type: none"><li>• Cumulus Linux Lightweight Network Virtualization (LNV) documentation (see page 602)</li></ul>

## Cumulus Networks Services Demos

The Cumulus Networks Services team demos provide a virtual environment built using either VirtualBox or libvirt using Vagrant to manage the VMs. This environment utilizes the reference topology shown below. Vagrant and Cumulus VX can be used together to build virtual simulations of production networks to validate configurations, develop automation code and simulate failure scenarios.

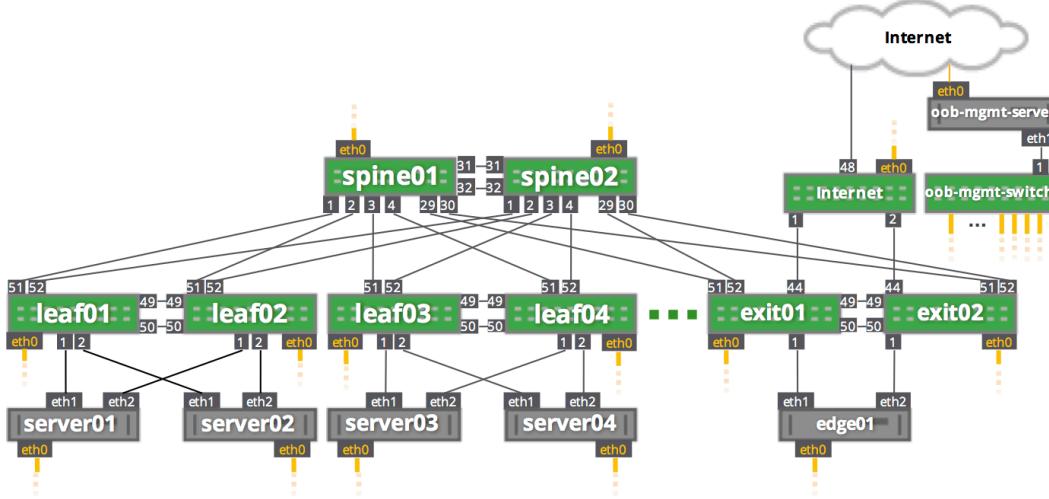
## Contents

### This topic describes ...

- Reference Topology (see page 1120)
  - IP and MAC Addressing (see page 1121)
  - Build the Topology (see page 1122)
    - Virtual Appliance (see page 1122)
    - Hardware (see page 1122)
  - Demos (see page 1122)

## Reference Topology

The Cumulus Networks *reference topology* includes cabling (in DOT format for dual use with [PTM \(see page 360\)](#)), MAC addressing, IP addressing, switches and servers. This topology is blessed by the Professional Services Team at Cumulus Networks to fit a majority of designs seen in the field.



## IP and MAC Addressing

Hostname	eth0 IP	eth0 MAC	Interface Count
oob-mgmt-server	192.168.0.254	any	
oob-mgmt-switch	192.168.0.1	any	Cumulus RMP
leaf01	192.168.0.11	A0:00:00:00:00:11	48x10g w/ 6x40g uplink
leaf02	192.168.0.12	A0:00:00:00:00:12	48x10g w/ 6x40g uplink
leaf03	192.168.0.13	A0:00:00:00:00:13	48x10g w/ 6x40g uplink
leaf04	192.168.0.14	A0:00:00:00:00:14	48x10g w/ 6x40g uplink
spine01	192.168.0.21	A0:00:00:00:00:21	32x40g
spine02	192.168.0.22	A0:00:00:00:00:22	32x40g



Hostname	eth0 IP	eth0 MAC	Interface Count
server01	192.168.0.31	A0:00:00:00:00:31	10g NICs
server02	192.168.0.32	A0:00:00:00:00:32	10g NICs
server03	192.168.0.33	A0:00:00:00:00:33	10g NICs
server04	192.168.0.34	A0:00:00:00:00:34	10g NICs
exit01	192.168.0.41	A0:00:00:00:00:41	48x10g w/ 6x40g uplink (exit leaf)
exit02	192.168.0.42	A0:00:00:00:00:42	48x10g w/ 6x40g uplink (exit leaf)
edge01	192.168.0.51	A0:00:00:00:00:51	10g NICs (customer edge device, firewall, load balancer, etc.)
internet	192.168.0.253	any	(represents internet provider edge device)

## Build the Topology

### Virtual Appliance

You can build out the reference topology in hardware or using Cumulus VX (the free Cumulus Networks virtual appliance). The [Cumulus Reference Topology using Vagrant](#) is essentially the reference topology built out inside Vagrant with VirtualBox or KVM. The installation and setup instructions for bringing up the entire reference topology on a laptop or server are on the [cldemo-vagrant GitHub repo](#).

### Hardware

Any switch from the [hardware compatibility list](#) is compatible with the topology as long as you follow the interface count from the table above. Of course, in your own production environment, you don't have to use exactly the same devices and cabling as outlined above.

### Demos

You can find an up to date list of all the demos in the [cldemo-vagrant GitHub repository](#), which is available to anyone free of charge.



## Docker on Cumulus Linux

Cumulus Linux is based on Linux kernel 4.1, which supports the Docker engine. Docker can be installed directly on a Cumulus Linux switch, and Docker containers can be run natively on the switch. This section covers the installation and set up instructions for Docker.

### Set up Docker on Cumulus Linux

#### *Configure the Repositories*

1. Add the following line to the end of `/etc/apt/sources.list.d/jessie.list` in a text editor, and save the file:

```
cumulus@switch:$ sudo nano /etc/apt/sources.list.d/jessie.list

...
deb http://httpredir.debian.org/debian jessie main contrib non-free
deb-src http://httpredir.debian.org/debian jessie main contrib
non-free
```

2. Create the `/etc/apt/sources.list.d/docker.list` file, add the following line in a text editor, and save the file:

```
cumulus@switch:$ sudo nano /etc/apt/sources.list.d/docker.list

deb https://apt.dockerproject.org/repo debian-jessie main
```

#### *Install the Authentication Key*

1. Install the authentication key for Docker:

```
cumulus@switch:$ sudo apt-key adv --keyserver hkp://p80.pool.sks-
keyservers.net:80 --recv-keys
58118E89F3A912897C070ADBF76221572C52609D
```

#### *Install the docker-engine Package*

1. Install Docker:



```
cumulus@switch:$ sudo -E apt-get update -y
cumulus@switch:$ sudo -E apt-get install docker-engine -qy
```

## Configure systemd for Docker

1. Add docker as a new line at the bottom of `/etc/vrf/systemd.conf`, and save the file.

```
cumulus@switch:$ sudo nano /etc/vrf/systemd.conf
...
docker
```

2. Create a directory for the `systemd` configuration file for Docker:

```
cumulus@switch:$ sudo mkdir -p /etc/systemd/system/docker.
service.d/
```

3. In a text editor, create a file called `/etc/systemd/system/docker.service.d/noiptables-mgmt-vrf.conf`, add the following lines to it, then save the file:

```
cumulus@switch:$ sudo nano /etc/systemd/system/docker.service.d
/noiptables-mgmt-vrf.conf

[Service]
ExecStart=
ExecStart=/usr/bin/docker daemon --iptables=false --ip-
masq=false --ip-forward=false
```

## Stop/Disable the Docker Services

1. Stop the various Docker services:

```
cumulus@switch:$ sudo systemctl daemon-reload
cumulus@switch:$ sudo systemctl stop docker.socket
cumulus@switch:$ sudo systemctl disable docker.socket
cumulus@switch:$ sudo systemctl stop docker.service
cumulus@switch:$ sudo systemctl disable docker.service
```

## Launch Docker and the Ubuntu Container

1. Enable the Docker management daemon so it starts when the switch boots:



```
cumulus@switch:$ sudo systemctl enable docker@mgmt
```

2. Start the Docker management daemon:

```
cumulus@switch:$ sudo systemctl start docker@mgmt
```

3. Run the Ubuntu container and launch the terminal instance:

```
cumulus@switch:$ docker run -i -t ubuntu /bin/bash
```

## Performance Notes

Keep in mind switches are not servers, in terms of the hardware that drives them. As such, you should be mindful of the types of applications you want to run in containers on a Cumulus Linux switch. In general, depending upon the configuration of the container, you can expect DHCP servers, custom scripts and other lightweight services to run well. However, VPN, NAT and encryption-type services are CPU-intensive and could lead to undesirable effects on critical applications. Use of any resource-intensive services should be avoided and is not supported.

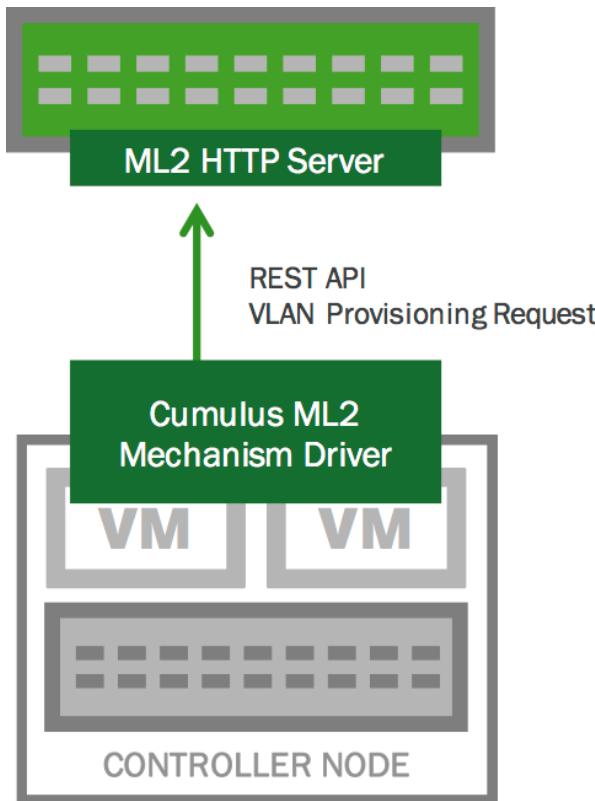
## OpenStack Neutron ML2 and Cumulus Linux

The Modular Layer 2 (ML2) plugin is a framework that allows OpenStack Networking to utilize a variety of non-vendor-specific layer 2 networking technologies. The ML2 framework simplifies adding support for new layer 2 networking technologies, requiring much less initial and ongoing effort — specifically, it enables dynamic provisioning of VLAN/VXLAN on switches in OpenStack environment instead of manually provisioning L2 connectivity for each VM.

The plugin supports configuration caching. The cached configuration is replayed back to the Cumulus Linux switch from Cumulus ML2 mechanism driver when a switch or process restart is detected.

In order to deploy [OpenStack ML2](#) in a network with Cumulus Linux switches, you need the following:

- A REST API, which is installed in Cumulus Linux.
- The Cumulus Networks Modular Layer 2 (ML2) mechanism driver for OpenStack, which you install on the OpenStack Neutron controller node. It's available as a Python package from upstream.
- The OpenStack Queens release.



## Contents

This topic describes ...

- Configure the REST API (see page 1126)
- Install and Configure the Cumulus Networks Modular Layer 2 Mechanism Driver (see page 1127)
- Try OpenStack with Cumulus in the Cloud (see page 1127)

## Configure the REST API

1. Configure the relevant settings in `/etc/restapi.conf`:

```

[ML2]
#local_bind = 10.40.10.122
#service_node = 10.40.10.1

# Add the list of inter switch links that
# need to have the vlan included on it by default
# Not needed if doing Hierarchical port binding
#trunk_interfaces = uplink

```

2. Restart the REST API service for the configuration changes to take effect:

```
cumulus@switch:~$ sudo systemctl restart restserver
```



Additional REST API calls have been added to support the configuration of bridge using the bridge name instead of network ID.

## Install and Configure the Cumulus Networks Modular Layer 2 Mechanism Driver

You need to install the Cumulus Networks ML2 mechanism driver on your Neutron host, which is available upstream:

```
root@neutron:~# git clone https://github.com/CumulusNetworks  
/networking-cumulus.git  
root@neutron:~# cd networking-cumulus  
root@neutron:~# python setup.py install  
root@neutron:~# neutron-db-manage upgrade head
```

Then configure the host to use the ML2 driver:

```
root@neutron:~# openstack-config --set /etc/neutron/plugins/ml2  
/ml2_conf.ini mechanism_drivers linuxbridge,cumulus
```

Finally, list the Cumulus Linux switches to configure. Edit `/etc/neutron/plugins/ml2/ml2_conf.ini` in a text editor and add the IP addresses of the Cumulus Linux switches to the `switches` line. For example:

```
[ml2_cumulus]  
switches="192.168.10.10,192.168.20.20"
```

The ML2 mechanism driver contains the following configurable parameters. You configure them in the `/etc/neutron/plugins/ml2/ml2_conf.ini` file.

- `switches` — The list of Cumulus Linux switches connected to the Neutron host. Specify a list of IP addresses.
- `scheme` — The scheme (for example, HTTP) for the base URL for the ML2 API.
- `protocol_port` — The protocol port for the base URL for the ML2 API. The default value is 8000.
- `sync_time` — A periodic time interval for polling the Cumulus Linux switch. The default value is 30 seconds.
- `spf_enable` — Enables/disables SPF for the bridge. The default value is *False*.
- `new_bridge` — Enables/disables [VLAN-aware bridge mode \(see page 415\)](#) for the bridge configuration. The default value is *False*, so a traditional mode bridge is created.

## Try OpenStack with Cumulus in the Cloud

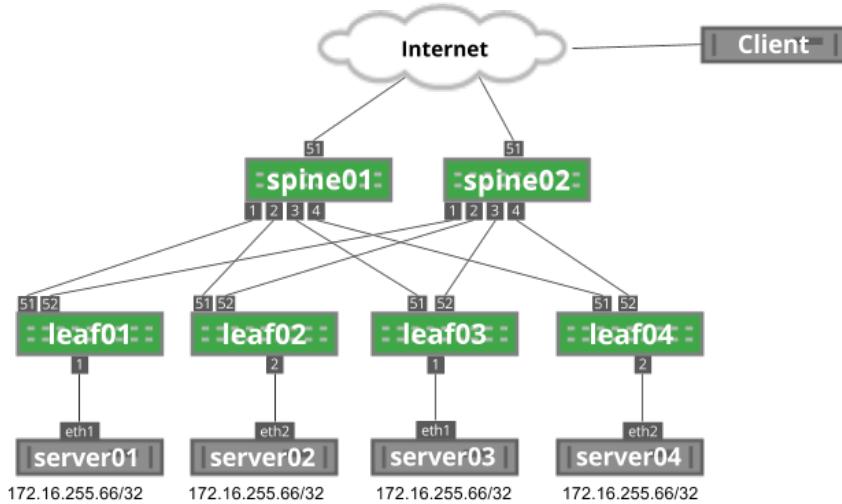
OpenStack Neutron is available as a preconfigured option with [Cumulus in the Cloud](#). You just need to add the ML2 driver, as per the [instructions above \(see page 1127\)](#).

## Anycast Design Guide

Cumulus Networks' [Routing on the Host](#) provides the ability to run [OSPF](#) (see page 756) or [BGP](#) (see page 773) directly on server hosts. This can enable a network architecture known as *anycast*, where many servers can provide the same service without needing layer 2 extensions or load balancer appliances.

Anycast is not a new protocol or protocol implementation and does not require any additional network configuration. Anycast leverages the [equal cost multipath](#) (see page 829) (ECMP) capabilities inherent in layer 3 networks to provide stateless load sharing services.

The following image depicts an example anycast network. Each server is advertising the 172.16.255.66/32 anycast IP address.

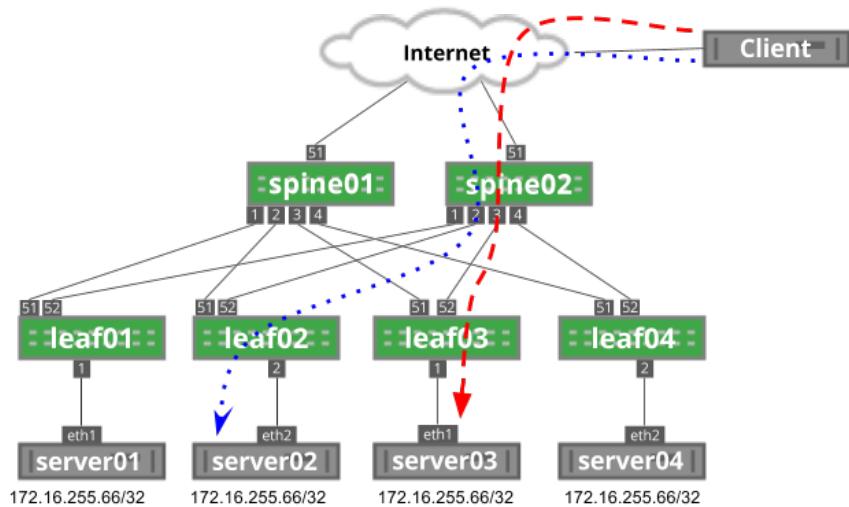


## Anycast Architecture

Anycast relies on layer 3 equal cost multipath functionality to provide load sharing throughout the network. Each server announces a route for a service. As the route is propagated through the network, each network device sees the route as originating from multiple places. As an end user connects to the anycast IP, each network device performs a hardware hash of the layer 3 and layer 4 headers to determine which path to use.

Every packet in a flow from an end user has the same source and destination IP address as well as source and destination port numbers. The hash performed by the network devices results in the same answer for every packet, ensuring all packets in a flow are sent to the same destination.

In the following image, the client initiates two flows: the blue, dotted flow and the red dashed flow. Each flow has the same source IP address (the client's IP address), destination IP address (172.16.255.66) and same destination port (depending on the service; for example, DNS is port 53). Each flow has a unique source port generated by the client.



In this example, each flow hashes to different servers based on this source port, which you can see when you run `ip route show` to the destination IP address:

```
cumulus@spine02$ ip route show 172.16.255.66
172.16.255.66 proto zebra metric 20
    nexthop via 169.254.64.0 dev swp1 weight 1
    nexthop via 169.254.64.2 dev swp2 weight 1
    nexthop via 169.254.64.2 dev swp3 weight 1
    nexthop via 169.254.64.0 dev swp4 weight 1
```

On a Cumulus Linux switch, you can see the hardware hash with the `cl-ecmpcalc` command. In Figure 2, two flows originate from a remote user destined to the anycast IP address. Each session has a different source port. Using the `cl-ecmpcalc` command, you can see that the sessions were hashed to different egress ports.

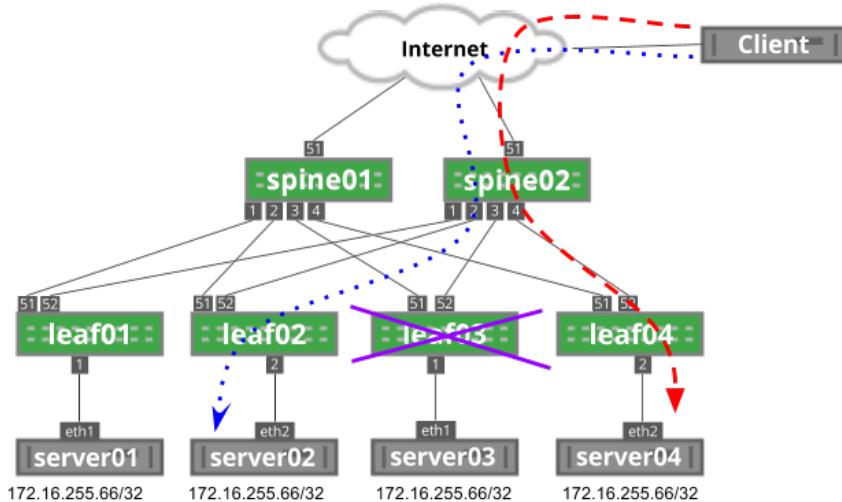
```
cumulus@spine02$ sudo cl-ecmpcalc -p udp -s 10.2.0.100 --sport 32700 -d 172.31.255.66 --dport 53 -i swp51
ecmpcalc: will query hardware
swp2

cumulus@spine02$ sudo cl-ecmpcalc -p udp -s 10.2.0.100 --sport 31884 -d 172.31.255.66 --dport 53 -i swp51
ecmpcalc: will query hardware
swp3
```

## Anycast with TCP and UDP

A key component to the functionality and cost effective nature of anycast is that the network does not maintain state for flows. Every packet is handled individually through the routing table, saving memory and resources that would be required to track individual flows, similar to the functionality of a load balancing appliance.

As previously described, every packet in a flow hashes to the same next hop. However, if that next hop is no longer valid, the traffic flows to another anycast next hop instead. For example, in the image below, if leaf03 fails, traffic flows to a different anycast address; in this case, server04:



For stateless applications that rely on UDP, like DNS, this does not present a problem. However, for stateful applications that rely on TCP, like HTTP, this breaks any existing traffic flows, such as a file download. If the TCP three-way handshake was established on server03, after the failure, server04 would have no connection built and would send a TCP reset message back to the client, restarting the session.

This is not to say that it is not possible to use TCP-based applications for anycast. However, TCP applications in an anycast environment should have short-lived flows (measured in seconds or less) to reduce the impact of network changes or failures.

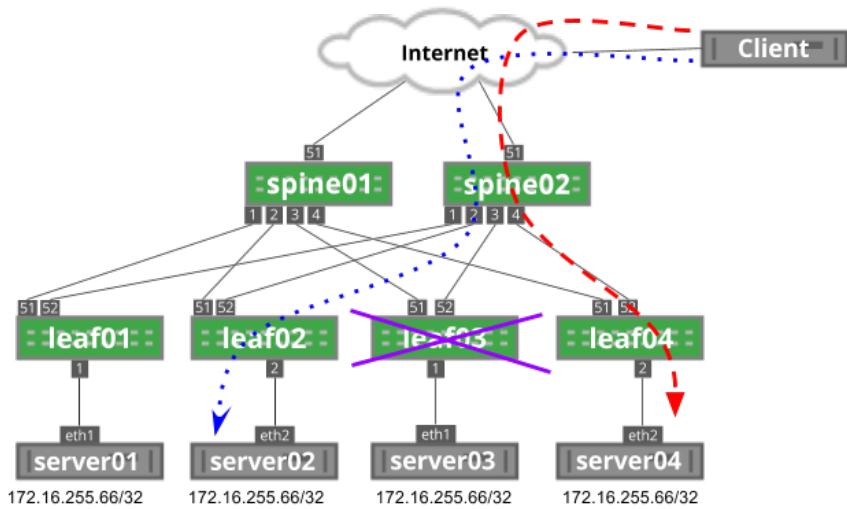
## Resilient Hashing

Resilient hashing (see page 834) provides a method to prevent failures from impacting the hash result of unrelated flows. However, resilient hashing does not prevent rehashing when new next hops are added.

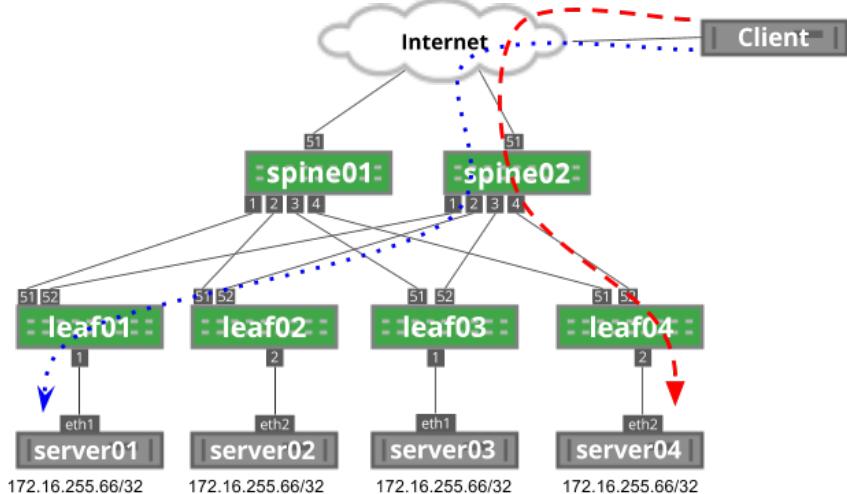
As previously mentioned, the hardware hashing function determines which path gets used for a given flow. The simplified version of that hash is the combination of protocol, source IP address, destination IP address, source layer 4 port and destination layer 4 port. The full hashing function includes not only these fields but also the list of possible layer 3 next hop addresses. The hash result is passed through a *modulo* of the number of next hop addresses. If the number of next hop addresses changes, through either addition or subtraction of the next hops, this changes the hash result for all traffic, including flows that have already established.

Continuing with the example in Figure 3, leaf03 is in a failed state, so traffic is hashing to server04. This is a result of the hash considering three possible next hop IPs (leaf01, leaf02, leaf04). When leaf03 is brought back online, the number of possible next hop IPs grows to four. This changes the modulo value that is part of the hashing function, which may result in traffic being sent to a different server, even if previously unaffected by the change.

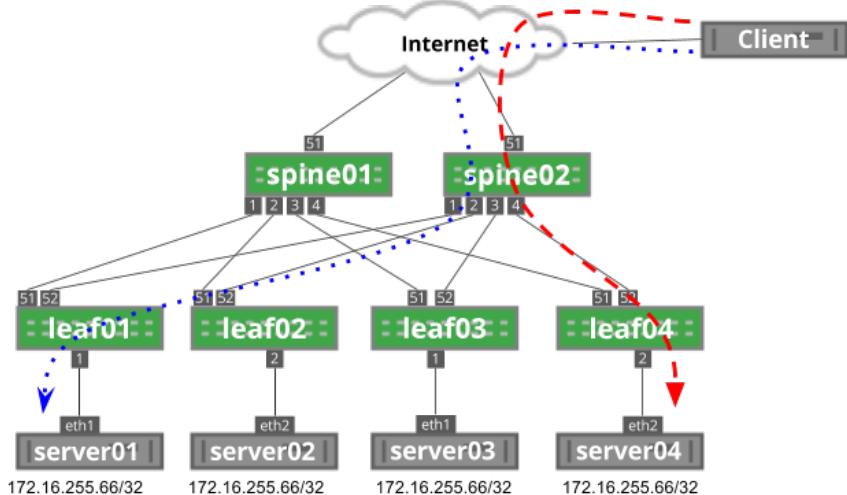
As you can see below, leaf03 is in a failed state. The blue dotted flow uses leaf02 to reach server02.



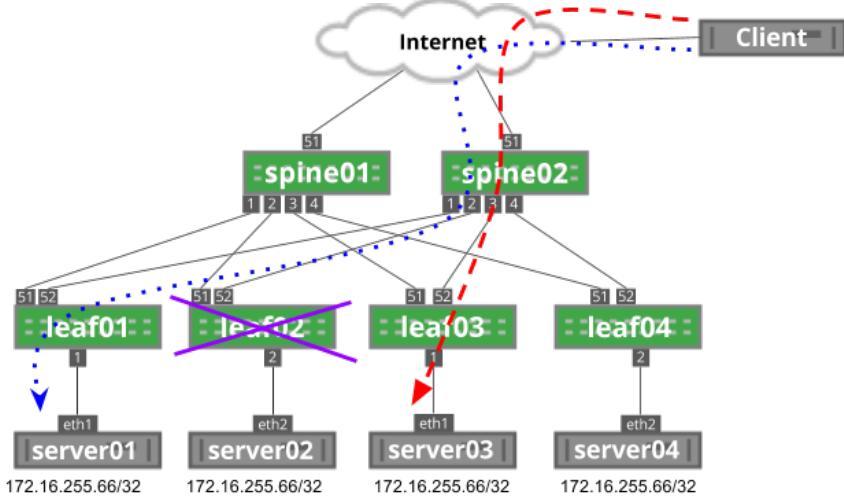
As leaf03 is brought back into service, the hashing function on spine02 changes, impacting the blue dotted flow:



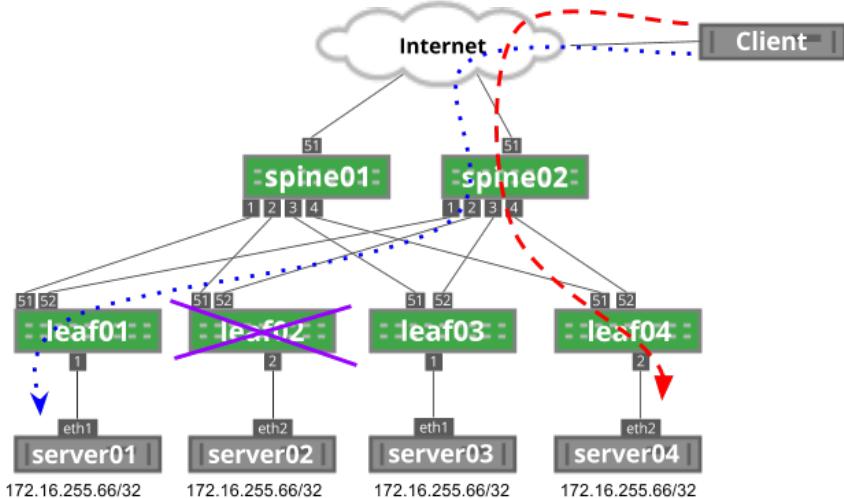
Just as the addition of a device can impact unrelated traffic, the removal of a device can also impact unrelated traffic, since again, the modulo of the hash function is changed. You can see this below, where the blue dotted flow goes through leaf01 and the red dashed line goes through leaf04.



Now, leaf02 has failed. As a result, the modulo on spine02 has changed from four possible next hops to only three next hops. In this example, the red dashed line has rehashed to leaf03:



To help solve this issue, resilient hashing can prevent traffic flows from shifting on unrelated failure scenarios. With resilient hashing enabled, the failure of leaf02 does not impact both existing flows, since they do not currently flow through leaf02:



Although resilient hashing can prevent rehashing on next hop failure, it cannot prevent rehashing on next hop addition.

You can read more information on resilient hashing in the [ECMP chapter \(see page 829\)](#).

## Applications for Anycast

As previously mentioned, UDP-based applications are great candidates for anycast architectures, such as NTP or DNS.

When considering applications to be deployed in an anycast scenario, the first two questions to answer are:

- Whether the application relies on TCP for proper sequencing of data.
- Whether the application relies on more than one session as part of the application.



## *Applications with Multiple Connections*

The network has no knowledge of any sessions or relationships between different sessions for the same application. This affects protocols that rely on more than one TCP or UDP connection to function properly — one example being FTP.

FTP data transfers require two connections: one for control and one for the file transfer. These two connections are independent, with their own TCP ports. Consider the scenario where an FTP server was deployed in an anycast architecture. When the secondary data connection is initiated, the traffic is destined initially to the same FTP server IP address, but the network hashes this traffic as a new, unique flow because the ports are different. This may result in the new session ending up on a new server. The new server would only accept that data connection if the FTP server application was capable of robust information sharing, as it has no history of the original request in the control session.

## *Initiating Traffic vs. Receiving Traffic*

It is also important to understand that an outbound TCP session should never be initiated over an anycast IP address, as traffic that originates from an anycast IP address may not return to the same anycast server after the network hash. Contrast this with inbound sessions, where the network hash is the same for all packets in a flow, so the inbound traffic will hash to the same anycast server.

## *TCP and Anycast*

TCP-based applications can be used with anycast, with the following recommendations:

- TCP sessions are short lived.
- The impact of a failed session or TCP reset does not impact the application. For example, a web page refresh is acceptable.
- There is application-level session management that is completely independent of the TCP session.
- A redirection middleware layer handles incorrectly hashed flows.

TCP applications that have longer-lived flows should not be used as anycast services. For example:

- FTP or other large file transfers.
- Transactions that must be completed and journaled. For example, financial transactions.
- Streaming media without application-level automated recovery.

It should be noted that anycast TCP is possible and has been implemented by a number of organizations, one notable example being LinkedIn.

## **Conclusion**

Anycast can provide a low cost, highly scalable implementation for services. However, the limitations inherent in network-based ECMP makes anycast challenging to integrate with some applications. An anycast architecture is best suited for stateless applications or applications that are able to share session state at the application layer.



## RDMA over Converged Ethernet - RoCE

*RDMA over Converged Ethernet (RoCE)* provides the ability to write to compute or storage elements using remote direct memory access (RDMA) over an Ethernet network instead of using host CPUs. RoCE relies on congestion control and lossless Ethernet to operate. Cumulus Linux supports features that can enable lossless Ethernet for RoCE environments. Note that while Cumulus Linux can support RoCE environments, the hosts send and receive the RoCE packets.

RoCE helps you obtain a *converged network*, where all services run over the Ethernet infrastructure, including Infiniband apps.

There are two versions of RoCE, which run at separate layers of the stack:

- RoCEv1, which runs at the link layer and cannot be run over a routed network. Therefore, it requires the link layer [priority flow control \(see page 281\)](#) (PFC) to be enabled.
- RoCEv2, which runs over layer 3. Since it's a routed solution, Cumulus Networks recommends you use [explicit congestion notification \(see page 286\)](#) (ECN) with RoCEv2 since ECN bits are communicated end-to-end across a routed network.

## Contents

This topic describes ...

- Enable RDMA over Converged Ethernet with PFC (see page 1134)
- Enable RDMA over Converged Ethernet with ECN (see page 1135)
- Related Information (see page 1136)

## Enable RDMA over Converged Ethernet with PFC

RoCEv1 uses the Infiniband (IB) Protocol over converged Ethernet. The IB global route header rides directly on top of the Ethernet header. The lossless Ethernet layer handles congestion hop by hop.

To learn the Cumulus Linux settings you need to configure to support RoCEv1, see the example configuration in the [PFC \(see page 281\)](#) section of the [Buffer and Queue Management \(see page 275\)](#) chapter.



On Mellanox switches, you can alternately use NCLU to configure RoCE with PFC:

```
cumulus@switch:~$ net add interface swp1 storage-optimized pfc  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

These commands create the following configuration in the `/etc/cumulus/datapath/traffic.conf` file. They configure PFC on cos 1, ECN on cos 0 and 1 in `/etc/cumulus/datapath/traffic.conf` file. They also add a flow control buffer pool for lossless traffic and change the buffer limits in the `/usr/lib/python2.7/dist-packages/cumulus/__chip_config/mlx/datapath.conf` file.

```
cumulus@switch:~$ sudo cat /etc/cumulus/datapath/traffic.conf
```



```
...  
  
ecn_red.port_group_list = [ROCE_ECN]  
pfc.ROCE_PFC.port_set = swp1  
pfc.ROCE_PFC.cos_list = [1]  
pfc.ROCE_PFC.xoff_size = 18000  
pfc.ROCE_PFC.xon_delta = 18000  
pfc.ROCE_PFC.tx_enable = true  
pfc.ROCE_PFC.rx_enable = true  
pfc.ROCE_PFC.port_buffer_bytes = 70000  
ecn_red.ROCE_ECN.port_set = swp1  
ecn_red.ROCE_ECN.cos_list = [0,1]  
ecn_red.ROCE_ECN.min_threshold_bytes = 150000  
ecn_red.ROCE_ECN.max_threshold_bytes = 1500000  
ecn_red.ROCE_ECN.ecn_enable = true  
ecn_red.ROCE_ECN.red_enable = true  
ecn_red.ROCE_ECN.probability = 100  
  
...
```



While [link pause \(see page 284\)](#) is another way to provide lossless ethernet, PFC is the preferred method. PFC allows more granular control by pausing the traffic flow for a given CoS group, rather than the entire link.

## Enable RDMA over Converged Ethernet with ECN

RoCEv2 requires flow control for lossless Ethernet. RoCEv2 uses the Infiniband (IB) Transport Protocol over UDP. The IB transport protocol includes an end-to-end reliable delivery mechanism, and has its own sender notification mechanism.

RoCEv2 congestion management uses RFC 3168 to signal congestion experienced to the receiver. The receiver generates an RoCEv2 congestion notification packet directed to the source of the packet.

To learn the Cumulus Linux settings you need to configure to support RoCEv2, see the example configuration in the [ECN \(see page 286\)](#) section of the [Buffer and Queue Management \(see page 275\)](#) chapter.



On Mellanox switches, you can alternately use NCLU to configure RoCE with ECN:

```
cumulus@switch:~$ net add interface swp1 storage-optimized  
cumulus@switch:~$ net pending  
cumulus@switch:~$ net commit
```

These commands create the following configuration in the `/etc/cumulus/datapath/traffic.conf` file:



```
cumulus@switch:~$ sudo cat /etc/cumulus/datapath/traffic.conf
...
ecn_red.port_group_list = [ROCE_ECN]
ecn_red.ROCE_ECN.port_set = swp1
ecn_red.ROCE_ECN.cos_list = [0,1]
ecn_red.ROCE_ECN.min_threshold_bytes = 150000
ecn_red.ROCE_ECN.max_threshold_bytes = 1500000
ecn_red.ROCE_ECN.ecn_enable = true
ecn_red.ROCE_ECN.red_enable = true
ecn_red.ROCE_ECN.probability = 100

...
```

The `storage-optimized` command changes the buffer limits in the `/usr/lib/python2.7/dist-packages/cumulus/__chip_config/mlx/datapath.conf` file.

It also enables drop behaviors and Random Early Detection (RED). RED identifies packets that have been added to a long egress queue. The ECN action marks the packet and forwards it, requiring the packet to be ECT-capable. However, the drop action drops the packet, requiring the packet to **not** be ECT-capable.

## Related Information

- RoCE introduction — [roceinitiative.org](http://roceinitiative.org)
- RoCEv2 congestion management — [community.mellanox.com](http://community.mellanox.com)
- Configuring RoCE over a DSCP-based lossless network with a Mellanox Spectrum switch

## Cumulus Hyperconverged Solution with Nutanix

The Cumulus Hyperconverged Solution (HCS) in Cumulus Linux supports automated integration with the Nutanix Prism Management solution and the Nutanix AHV hypervisor. Cumulus HCS automatically configures ports attached to Nutanix nodes, provisions networking and manages VLANs with Nutanix Prism and Nutanix AHV.

In addition, you can augment the deployment with:

- [Cumulus on a Stick](#) for zero touch provisioning (see page 72) Nutanix and Cumulus HCS without any user interaction or additional equipment.
- [Cumulus NetQ](#) (see page 1136) for network telemetry and unprecedented real-time and historic visibility into dynamic changes in both the network and virtual machines.
- Out-of-band management and IPMI access using [Cumulus RMP](#) or a generic Cumulus Linux switch, enabling the full provisioning of a zero-touch data and management network, eliminating any network deployment delays when standing up a Nutanix cluster.

Cumulus HCS has two major components:

- **Nutanix LLDP Switch Agent.** When enabled, the agent listens for directly connected Nutanix servers via LLDP and enables MLAG bonding on the relevant ports.

- **Nutanix Webhook VLAN Provisioner.** Cumulus Linux switches register with the Nutanix CVM and wait to receive Nutanix webhooks. When a new VM is deployed on a server in the cluster, the CVM sends a message to the Cumulus Linux switch with the physical server name and relevant VLANs. The switch then dynamically provisions the configuration on the ports of the specific physical server.

Cumulus HCS periodically polls Nutanix Prism for information about VMs in the cluster. When a new VM is discovered, the service automatically identifies the physical Nutanix server hosting the VM and discovers any VLANs required for the VM. The service then automatically adds these VLANs to the default [VLAN-aware bridge \(see page 415\)](#), the MLAG peer link and the automatically created bond to the Nutanix node. When a VM is powered off, removed or moved, and the associated VLAN has no other VMs, the VLAN is automatically removed from the bridge, peer link and dynamic bond.

## Contents

### This topic covers ...

- Prerequisites (see page 1137)
- Configure Cumulus HCS and Nutanix (see page 1138)
  - Configure the Service with ZTP (see page 1138)
  - Configure the Service Manually (see page 1139)
  - Cumulus HCS Configuration Settings (see page 1142)
- Configure Uplinks (see page 1142)
- Add Local Default Gateways (see page 1143)
- Out-of-band Solutions (see page 1144)
  - Cumulus RMP (see page 1144)
  - Other Cumulus Linux 1G Switches (see page 1144)
- Troubleshoot Cumulus HCS (see page 1145)
  - Verify Dynamic Bonds Are Being Created (see page 1145)
  - Verify LLDP Messages Are Being Received (see page 1145)
  - View Detailed Nutanix LLDP Information (see page 1146)
- Caveats (see page 1146)
- More Information (see page 1147)

## Prerequisites

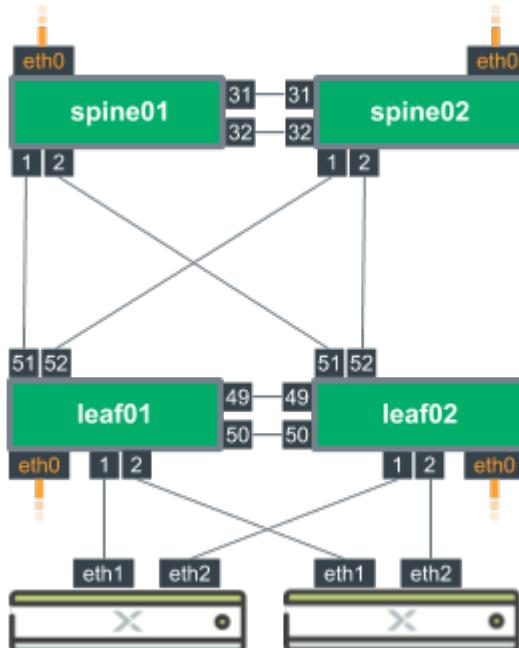
- 2 [Cumulus Networks-compatible switches](#) running Cumulus Linux 3.7.3 or later
- Nutanix AOS 5.5.8 or later
- Nutanix AHV 20170830.185 or later
- LLDP enabled on Nutanix (which is the default in 5.5.8 and later)
- IP connectivity between the Cumulus Linux switches and the Nutanix controller VMs (CVMs)
- [MLAG \(see page 440\)](#) enabled on the Cumulus Linux switches

Cumulus HCS runs on any platform. However, this chapter assumes a typical Nutanix deployment with the following configuration:

- Leaf switches with 48 x 10G or 25G ports

- Four or more 40G or 100G uplinks
- Nutanix servers are attached to any of the 10G or 25G ports
- MLAG peer link is on the first two uplink ports: swp49 and swp50
- Connections to other infrastructure are on ports swp51 and above
- The eth0 management interface is configured for [management VRF \(see page 877\)](#) via DHCP
- For automatic configuration, the gateway IP addresses for all VMs, including the CVM, do not exist on the Cumulus Linux switches.

The example configuration utilizes the following topology. All configuration focuses on the leaf01 and leaf02 switches. Configurations for spine01 and spine02 are not included.



## Configure Cumulus HCS and Nutanix

The method you choose for configuring Cumulus HCS and Nutanix depends upon whether or not you already have Cumulus Linux installed on your switches, which are named *leaf01* and *leaf02* in the example configuration above.

- If you have bare-metal switches without Cumulus Linux installed, follow the steps below for configuring a bare-metal switch with ZTP.
- If Cumulus Linux is already installed on your switches, follow the steps below for manually configuring an existing Cumulus Linux switch.

### Configure the Service with ZTP

The following steps describe how to use zero touch provisioning to install Cumulus Linux and fully configure Cumulus HCS and Nutanix on your network.

To do this, you need a [Cumulus on a Stick](#) disk image and a USB stick with at least 1GB of storage.

1. Insert the USB stick into your computer and copy the Cumulus on a Stick files onto it.
2. On the USB stick, open the `ztp_config.txt` file in a text editor and set your Nutanix username and password and the server IP address, then save and close the file.



```
# Fill in the parameters below to allow for ZTP to
# automatically configure the switch for Nutanix
#
# The username for the Nutanix API. Likely the username you use
# to login to Prism. (Required)
NUTANIX_USERNAME=admin
# The password for the user. (Required)
NUTANIX_PASSWORD=nutanix/4u
# The IP address of a Nutanix CVM or the CVM anycast/cluster IP.
# (Required)
NUTANIX_IP=10.1.1.123
# IP address and subnet mask of this switch in the CVM subnet.
# Used to communicate to the Prism API.
SWITCH_CVM_IP=10.1.1.254/24
# If you do not want to use DHCP on the switch eth0, define the
# static switch IP and mask below. (Optional)
#SWITCH_MANAGEMENT_IP=10.0.0.11/24
# If you define a static IP, what is the gateway the switch
# should use for management traffic? (Optional)
#SWITCH_DEFAULT_GATEWAY=10.1.1.1
# If you have Layer 2 connections to existing infrastructure,
# define them here. Separate the interfaces with a comma.
# (Optional)
UPLINKS=swp51,swp52
# It is assumed that ports swp49 and swp50 will be used for the
# inter-switch link. If you have other ports, define them here.
# (Optional)
#PEERLINK=swp49,swp50
```

3. Place the USB stick into the Cumulus Linux switch (leaf01) and power on the switch. Cumulus Linux is automatically installed, including the license and a baseline configuration. The switch reboots multiple times during this process. Depending on your specific hardware platform, this process can take up to 20 minutes. After the installation completes, the LEDs corresponding to the ports connected to the Nutanix nodes illuminate in green.
4. When the installation completes, remove the USB stick and repeat this procedure on the other Cumulus Linux switch (leaf02).

### *Configure the Service Manually*

If Cumulus Linux is already installed on your switches, follow the steps below to configure Cumulus Linux, Nutanix and Cumulus HCS.

1. Configure MLAG on both the leaf01 and leaf02 nodes. The `sys-mac` is a MAC address from the Cumulus Networks reserved MAC address space and must be the same on both MLAG peers. If you are deploying more than one pair of switches with MLAG, the `sys-mac` must be unique for each pair of MLAG-configured switches.

#### **Configure MLAG for leaf01**

```
cumulus@leaf01:~$ net add interface swp49,swp50 mtu 9216
```



```
cumulus@leaf01:~$ net add clag peer sys-mac 44:38:39:FF:40:00
interface swp49,swp50 primary
cumulus@leaf01:~$ net commit
```

#### Configure MLAG for leaf02

```
cumulus@leaf02:~$ net add interface swp49,swp50 mtu 9216
cumulus@leaf02:~$ net add clag peer sys-mac 44:38:39:FF:40:00
interface swp49,swp50 secondary
cumulus@leaf02:~$ net commit
```

2. Configure the default layer 2 bridge. Add a unique IP address to each leaf in the same subnet as the CVM.

#### Configure the bridge on leaf01

```
cumulus@leaf01:~$ net add bridge bridge ports peerlink
cumulus@leaf01:~$ net add bridge bridge pvid 1
cumulus@leaf01:~$ net add vlan 1 ip address 10.1.1.201/24
cumulus@leaf01:~$ net commit
```

#### Configure the bridge on leaf02

```
cumulus@leaf02:~$ net add bridge bridge ports peerlink
cumulus@leaf02:~$ net add bridge bridge pvid 1
cumulus@leaf02:~$ net add vlan 1 ip address 10.1.1.202/24
cumulus@leaf02:~$ net commit
```

**⚠** In both configurations the `pvid` value of 1 indicates the native VLAN ID. If you don't know the value for the native VLAN ID, use 1.

3. Edit the `/etc/default/cumulus-hyperconverged` file and set the Nutanix username, password and server IP address. Do this on both switches (leaf01 and leaf02). Cumulus Linux uses the settings in this file to authenticate and communicate with the Nutanix cluster.

```
cumulus@leaf02:~$ sudo nano /etc/default/cumulus-hyperconverged

### /etc/default/cumulus-hyperconverged config file
# username for Prism (required)
USERNAME=admin
# password for Prism (required)
PASSWORD=nutanixpassword
# CVM address used by the service (required)
```



```
SERVER=10.1.1.11
# Hook server address (optional)
#HOOK_SERVER=10.0.0.0
# Hook port (optional)
#HOOK_PORT=9440
# Socket timeout (optional)
#SOCKET_TIMEOUT=10.0.0.0
# single/multi rack configuration (optional)
VXLAN_CONFIG=False
# loglevel: verbose/debug (optional)
LOGLEVEL=verbose
# periodic sync timeout (optional)
#PERIODIC_SYNC_TIMEOUT=60
```

These settings are defined [below \(see page \).](#)

The server IP address may be a specific Nutanix CVM address or the virtual cluster IP address.

4. Enable and start Cumulus HCS on leaf01 and leaf02.

```
cumulus@leaf01:~$ sudo systemctl enable cumulus-hyperconverged
cumulus@leaf01:~$ sudo systemctl start cumulus-hyperconverged
```

```
cumulus@leaf02:~$ sudo systemctl enable cumulus-hyperconverged
cumulus@leaf02:~$ sudo systemctl start cumulus-hyperconverged
```

5. Verify that the service is running on leaf01 and leaf02.

```
cumulus@leaf01:~$ sudo systemctl status cumulus-hyperconverged
cumulus-hyperconverged.service - Cumulus Linux Hyperconverged
Daemon
   Loaded: loaded (/lib/systemd/system/cumulus-hyperconverged.
service; enabled)
   Active: active (running) since Mon 2019-01-07 03:36:26 UTC;
56min ago
     Main PID: 4206 (cumulus-hyperco)
        CGrou... /system.slice/cumulus-hyperconverged.service
          4206 /usr/bin/python /usr/bin/cumulus-hyperconverged
          6300 /usr/sbin/lldpcli -f json watch
```



```
cumulus@leaf02:~$ sudo systemctl status cumulus-hyperconverged
cumulus-hyperconverged.service - Cumulus Linux Hyperconverged
Daemon
   Loaded: loaded (/lib/systemd/system/cumulus-hyperconverged.
service; enabled)
   Active: active (running) since Mon 2019-01-07 03:36:26 UTC;
56min ago
     Main PID: 4207 (cumulus-hyperco)
      CGroup: /system.slice/cumulus-hyperconverged.service
              4207 /usr/bin/python /usr/bin/cumulus-hyperconverged
              4300 /usr/sbin/lldpcli -f json watch
```



If the service fails to start, you may find more information in the service's log file. View the log with `sudo journalctl -u cumulus-hyperconverged`.

6. Enable the server-facing ports to accept inbound LLDP frames and configure jumbo MTU on both leaf01 and leaf02.

```
cumulus@leaf01:~$ net add interface swp1-48 mtu 9216
cumulus@leaf01:~$ net commit
```

```
cumulus@leaf02:~$ net add interface swp1-48 mtu 9216
cumulus@leaf02:~$ net commit
```

At this point, the service is fully configured. It may take up to 60 seconds for LLDP frames to be received to trigger Cumulus HCS.

### Cumulus HCS Configuration Settings

Some of the settings you can configure include:

- `HOOK_SERVER`: the source IP the switch uses when communicating with the Nutanix API. By default, it follows the routing table.
- `HOOK_PORT`: the port on which the Nutanix CVM is running. The default is 9440.
- `SOCKET_TIMEOUT`: the amount of time to wait for a timeout when attempting to communicate with the Nutanix API. The default is 10 seconds.
- `VXLAN_CONFIG`: when set to `TRUE`, Cumulus HCS automatically provisions VXLAN VNI as well as VLANs.
- `LOGLEVEL`: describes the logging level. `Verbose` and `Debug` are acceptable values. `Verbose` provides information about bond and VLAN creation while `Debug` helps in troubleshooting by providing more information from sources like LLDP and the Nutanix webhook.
- `PERIODIC_SYNC_TIMEOUT`: how long before Cumulus HCS times out dynamic configurations without contacting the Nutanix API. The default is 60 seconds.



## Configure Uplinks

How you configure uplinks depends upon whether you configured Cumulus HCS with ZTP or manually.

If you used ZTP, you can edit the ZTP settings file to define the uplink ports and the VLANs assigned to those uplinks.

If you manually configured the service, you need to enable the uplinks and define the associated VLANs, as shown below. You need to configure both leaf01 and leaf02.

```
cumulus@leaf01:~$ net add interface swp51-52 mtu 9216
cumulus@leaf01:~$ net add interface swp51-52 bridge vids 1-2999,4000-
4094
cumulus@leaf01:~$ net add interface swp51-52 bridge pvid 1
cumulus@leaf01:~$ net commit
```

```
cumulus@leaf02:~$ net add interface swp51-52 mtu 9216
cumulus@leaf02:~$ net add interface swp51-52 bridge vids 1-2999,4000-
4094
cumulus@leaf02:~$ net add interface swp51-52 bridge pvid 1
cumulus@leaf02:~$ net commit
```



In this example, all VLANs are allowed on the uplink ports. Configuring any set of VLANs is allowed. Be aware that [VLANs 3000-3999 are reserved \(see page 417\)](#) on Cumulus Linux. This example assumes the untagged or native VLAN is VLAN ID (`pvid`) 1. Change the VLAN ID as needed.

## Add Local Default Gateways

You can add one or more local default gateways on both switches to provide a redundant solution, as shown below. It does not matter whether you configured Cumulus HCS with ZTP or manually. ZTP does not add any gateway configuration.

To provide redundant gateways for the dual-attached Nutanix servers, Cumulus Linux relies on [Virtual Router Redundancy \(see page 474\)](#) (VRR). VRR enables hosts to communicate with any redundant router without reconfiguration, running dynamic routing protocols, or running router redundancy protocols. This means that redundant routers will respond to [Address Resolution Protocol \(see page 749\)](#) (ARP) requests from hosts. Routers are configured to respond in an identical manner, but if one fails, the other redundant routers will continue to respond, leaving the hosts with the impression that nothing has changed.

### Configure leaf01

```
cumulus@leaf01:~$ net add vlan 1 ip address 10.1.1.11/24
cumulus@leaf01:~$ net add vlan 1 ip address-virtual 00:00:5e:00:01:01
10.1.1.1/24
cumulus@leaf01:~$ net commit
```



## Configure leaf02

```
cumulus@leaf02:~$ net add vlan 1 ip address 10.1.1.12/24
cumulus@leaf02:~$ net add vlan 1 ip address-virtual 00:00:5e:00:01:01
10.1.1.1/24
cumulus@leaf02:~$ net commit
```

The first configuration line defines the IP address assigned to each switch, which is required and must be unique. On leaf01, this IP address is *10.1.1.11/24*; on leaf02, it is *10.1.1.12/24*.

The second line defines the virtual IP address that is used as the default gateway address for any hosts in this VLAN. On both leaf01 and leaf02 this IP address is *10.1.1.1/24*. The address-virtual MAC address is assigned from a reserved pool of Cumulus Networks MAC addresses. The address must start with 00:00:05:00:01: and end with any hex value between 00 and ff. Both leaf01 and leaf02 must have the same MAC address. Outside of this switch pair, this MAC address must be unique and only be assigned to a single switch pair in your network.

## Out-of-band Solutions

You can configure out-of-band management in one of two ways:

- Using [Cumulus RMP](#), which is the recommended way.
- Running Cumulus Linux on a [supported 1G non-Cumulus RMP switch](#).

### Cumulus RMP

Cumulus RMP is a ready-to-deploy solution that enables out-of-band management for web-scale networks. With Cumulus RMP, you can directly manage and support Nutanix systems in the rack without relying on the rest of the network.

To deploy Nutanix with Cumulus RMP, connect the Nutanix 1G IPMI, 1G Shared IPMI and 1G ports to the Cumulus RMP switch. No additional configuration is required.

Cumulus RMP does not support MLAG or active/active connections across Cumulus RMP switches. Connections across more than one Cumulus RMP switch rely on traditional [spanning tree protocol](#) (see page 372) for redundancy.

### Other Cumulus Linux 1G Switches

If you want to use a non-Cumulus RMP 1G switch that supports Cumulus Linux for out-of-band management, you must manually install the Cumulus Linux software and license and set up the baseline configuration. The default [Cumulus on a Stick image](#) has this information.

Once you install the software, you can use the following command to configure all ports for a single, untagged management VLAN, including any uplinks.

```
cumulus@oob-switch:~$ net add interface swp1-52 bridge access 1
```

You can assign a management IP address to this same untagged bridge interface. Use an appropriate IP address for your infrastructure.

```
cumulus@oob-switch:~$ net add vlan 1 ip address 192.0.2.1/24
```



Apply the configuration:

```
cumulus@oob-switch:~$ net commit
```



In both configurations the value of 1 indicates the native or untagged VLAN ID. If you want to use a different VLAN ID, just replace the 1 in both commands with the desired VLAN ID.

## Troubleshoot Cumulus HCS

Some ways you can troubleshoot Cumulus HCS include:

- Checking that bonds are being dynamically created.
- Ensuring LLDP messages are being received.
- Verifying the Cumulus HCS configuration.

### Verify Dynamic Bonds Are Being Created

Use the `net show interface bonds` command to verify that bonds are being dynamically created. The following example shows that three bonds, `bond_swp1`, `bond_swp2` and `bond_swp3` are created automatically, which means that Cumulus HCS is operating correctly. The name of every dynamically created bond begins with `bond_` and ends with the interface name.

```
cumulus@leaf01:~$ net show interface bonds
  Name      Speed   MTU Mode      Summary
--  -----  -----  -----  -----
----- 
UP  bond_swp1  1G     1500  802.3ad Bond Members: swp1(UP)
UP  bond_swp2  1G     1500  802.3ad Bond Members: swp2(UP)
UP  bond_swp3  1G     1500  802.3ad Bond Members: swp3(UP)
UP  peerlink    2G     1500  802.3ad Bond Members: swp49(UP), swp50
(UP)
```

### Verify LLDP Messages Are Being Received

If bonds are not being created, then [LLDP \(see page 390\)](#) messages may not be getting through. You can check for this possibility using the `net show lldp` command:

```
cumulus@leaf01:~$ net show lldp
LocalPort  Speed  Mode          RemoteHost      RemotePort
-----  -----  -----  -----
swp1       1G     BondMember    Ntnx-e08c61ec-A  ens3
swp2       1G     BondMember    Ntnx-d618a06d-A  ens3
swp3       1G     BondMember    Ntnx-4e6eac27-A  ens3
```

<code>swp49</code>	<code>1G</code>	<code>BondMember</code>	<code>leaf02</code>	<code>swp49</code>
<code>swp50</code>	<code>1G</code>	<code>BondMember</code>	<code>leaf02</code>	<code>swp50</code>
<code>swp52</code>	<code>1G</code>	<code>NotConfigured</code>	<code>spine01</code>	<code>swp1</code>
<code>swp52</code>	<code>1G</code>	<code>NotConfigured</code>	<code>spine02</code>	<code>swp1</code>

### *View Detailed Nutanix LLDP Information*

Cumulus HCS replies on the LLDP `SysDescr` field to identify a Nutanix host. Run the `net show lldp <swp>` command to view the complete LLDP details of the Nutanix node and verify the `SysDescr` field.

```
cumulus@leaf01:~$ net show lldp swp1
-----
-----
LLDP neighbors:
-----
Interface:      swp1, via: LLDP, RID: 37, Time: 0 day, 01:42:23
  Chassis:
    ChassisID:      mac 2c:c2:60:50:f6:8a
    SysName:        NTNX-e08c61ec-A
    SysDescr:        CentOS Linux 7 (Core) Linux 4.4.77-1.el7.nutanix.
20180425.199.x86_64 #1 SMP Thu Apr 26 01:01:53 UTC 2018 x86_64
    MgmtIP:         10.1.1.10
    MgmtIP:         fe80::2ec2:60ff:fe50:f68a
    Capability:     Bridge, on
    Capability:     Router, off
    Capability:     Wlan, off
    Capability:     Station, off
  Port:
    PortID:         mac 2c:c2:60:50:f6:8a
    PortDescr:       ens3
    TTL:            120
    PMD autoneg:   supported: yes, enabled: yes
      Adv:           10Base-T, HD: yes, FD: yes
      Adv:           100Base-TX, HD: yes, FD: yes
      Adv:           1000Base-T, HD: no, FD: yes
    MAU oper type: 1000BaseTFD - Four-pair Category 5 UTP, full
duplex mode
-----
```

### Caveats

- Reloading Cumulus HCS causes the bond interfaces to rebuild. For the stability of the Nutanix cluster, do not reload the service on both leaf switches simultaneously.



## More Information

- [Hyperconverged infrastructure site](#) on the Cumulus Networks website



# Index

## 8

802.1p 275  
    class of service 275  
802.3ad link aggregation 471

## A

ABRs 757  
    area border routers 757  
access control lists 142  
access ports 435  
ACL policy files 158  
ACL rules 280  
ACLs 142, 145, 167  
    chains 145  
    QoS 167  
active-active mode 477, 633  
    VRR 477  
    VXLAN 633  
active listener ports 196  
Algorithm Longest Prefix Match 723  
    routing 723  
ALPM mode 723  
    routing 723  
AOC cables 24  
apt-get 64  
area border routers 757  
    ABRs 757  
arp cache 1006  
ASN 775  
    autonomous system number 775  
autonomous system number 775  
    BGP 775  
autoprovisioning 72

## B

BFD 364, 827  
    Bidirectional Forwarding Detection 364



echo function 827  
BGP 773, 777, 847  
    Border Gateway Protocol 773  
    ECMP 777  
    virtual routing and forwarding (VRF) 847  
BGP peering relationships 795, 795  
    external 795  
    internal 795  
bonds 399, 471  
    LACP Bypass 471  
boot recovery 940  
bpdufilter 382  
    and STP 382  
BPDU guard 379  
    and STP 379  
brctl 27  
bridge assurance 382  
    and STP 382  
bridges 407, 408, 408, 409, 415, 431, 435, 435  
    access ports 435  
    adding IP addresses 409  
    MAC addresses 408  
    MTU 407  
    trunk ports 435  
    untagged frames 431  
    VLAN-aware 408, 415

## C

cable connectivity 24  
cabling 360  
    Prescriptive Topology Manager 360  
chain 145  
cl-acltool 142, 281, 1008  
clagctl 457  
class of service 275  
cl-cfg 206, 956  
cl-ecmpcalc 830  
cl-license 23  
cl-netstat 991, 996  
cl-ospf6 770  
Clos topology 730  
cl-resource-query 206, 941  
cl-support 932



convergence 729  
    routing 729  
Cumulus Linux 20, 32, 32, 35, 45, 498  
    installing 20, 35  
    reprovisioning 32  
    uninstalling 32  
    upgrading 45  
    VXLAN 498  
cumulus user 114

## D

DAC cables 24  
datapath 275, 282, 284  
    link pause 284  
    priority flow control 282  
datapath.conf 275  
date 101  
    setting 101  
deb 70  
debugging 930  
decode-syseeprom 945  
differentiated services code point 275  
dmidecode 946  
dpkg 68  
dpkg-reconfigure 100  
DSCP 275  
    differentiated services code point 275  
DSCP marking 280  
dual-connected hosts 444  
duplex interfaces 241  
dynamic routing 366  
    and PTM 366

## E

eBGP 775  
    external BGP 775  
ebtables 142, 149  
    memory spaces 149  
echo function 827, 827  
    BFD 827  
    PTM 827



ECMP [731](#), [768](#), [777](#), [837](#), [941](#)

BGP [777](#)

equal cost multi-pathing [731](#)

monitoring [941](#)

OSPF [768](#)

resilient hashing [837](#)

ECMP hashing [830](#), [834](#)

resilient hashing [834](#)

EGP [732](#)

Exterior Gateway Protocol [732](#)

equal cost multipath [830](#)

ECMP hashing [830](#)

equal cost multi-pathing [731](#)

ECMP [731](#)

ERSPAN [1009](#)

network troubleshooting [1009](#)

Ethernet management port [21](#)

ethtool [990](#), [995](#)

external BGP [775](#)

eBGP [775](#)

## F

fast convergence [793](#)

BGP [793](#)

First Hop Redundancy Protocol [477](#)

VRR [477](#)

FRRouting [366](#), [366](#), [731](#)

and PTM [366](#), [366](#)

dynamic routing [731](#)

## G

globbs [234](#)

Graphviz [360](#)

## H

hardware [944](#)

monitoring [944](#)

hardware compatibility list [18](#)

hash distribution [400](#)

HCL [18](#)



head end replication [605](#)

  LNV [605](#)

high availability [731](#)

host entries [941](#)

  monitoring [941](#)

hostname [22](#)

hwclock [101](#)

|

iBGP [775](#)

  internal BGP [775](#)

ifdown [222](#)

ifquery [226, 986](#)

ifup [221](#)

ifupdown [221](#)

ifupdown2 [232, 433, 985, 985, 986](#)

  excluding interfaces [986](#)

  logging [985](#)

  purging IP addresses [232](#)

  troubleshooting [985](#)

  VLAN tagging [433](#)

IGMP snooping [464, 485](#)

  MLAG [464](#)

IGP [732](#)

  Interior Gateway Protocol [732](#)

image contents [33](#)

installing [20](#)

  Cumulus Linux [20](#)

interface counters [991, 996](#)

interface dependencies [225](#)

internal BGP [775](#)

  iBGP [775](#)

ip6tables [142](#)

IP addresses [232](#)

  purging [232](#)

iproute2 [989](#)

  failures [989](#)

iptables [142](#)

IPv4 routes [777](#)

  BGP [777](#)

IPv6 routes [777](#)

  BGP [777](#)



# L

LACP [400](#), [441](#)  
MLAG [441](#)  
LACP Bypass [471](#)  
layer 3 access ports [27](#)  
    configuring [27](#)  
leaf-spine topology [730](#)  
license [23](#)  
    installing [23](#)  
lightweight network virtualization [603](#), [605](#), [605](#), [626](#)  
    head end replication [605](#)  
    service node replication [605](#)  
link aggregation [399](#)  
Link Layer Discovery Protocol [390](#)  
link-local IPv6 addresses [809](#)  
    BGP [809](#)  
link pause [284](#)  
    datapath [284](#)  
link-state advertisement [756](#)  
LLDP [390](#), [396](#)  
    SNMP [396](#)  
lldpcli [391](#)  
lldpd [361](#), [390](#)  
LNV [603](#), [603](#), [605](#), [605](#), [626](#), [626](#)  
    head end replication [605](#)  
    service node replication [605](#)  
    VXLAN [603](#), [626](#)  
load balancing [731](#)  
logging [934](#), [985](#), [985](#)  
    ifupdown2 [985](#)  
    networking service [985](#)  
logging neighbor state changes [808](#)  
    BGP [808](#)  
logical switch [441](#)  
longest prefix match [723](#)  
    routing [723](#)  
loopback interface [29](#)  
    configuring [29](#)  
LSA [756](#)  
    link-state advertisement [756](#)  
LSDB [756](#)  
    link-state database [756](#)  
lshw [946](#)



## M

MAC entries [941](#)  
    monitoring [941](#)  
Mako templates [235](#), [987](#)  
    debugging [987](#)  
mangle table [281](#)  
    ACL rules [281](#)  
memory spaces [149](#)  
    ebtables [149](#)  
MLAG [441](#), [458](#), [458](#), [464](#), [468](#)  
    IGMP snooping [464](#)  
    peer link states [458](#)  
    protodown state [458](#)  
    STP [468](#)  
MLD snooping [485](#)  
monitoring [99](#), [930](#), [941](#), [949](#), [953](#), [990](#), [995](#), [1021](#), [1024](#)  
    hardware watchdog [949](#)  
    Net-SNMP [1024](#)  
    network traffic [1021](#)  
mstpcctl [376](#), [437](#)  
MTU [242](#), [407](#), [989](#)  
    bridges [407](#)  
    failures [989](#)  
mz [1007](#)  
    traffic generator [1007](#)

## N

Netfilter [142](#)  
Net-SNMP [1024](#)  
networking service [985](#)  
    logging [985](#)  
network interfaces [221](#)  
    ifupdown [221](#)  
network traffic [1021](#)  
    monitoring [1021](#)  
network troubleshooting [1017](#)  
    tcpdump [1017](#)  
network virtualization [498](#), [687](#), [699](#)  
    VMware NSX [687](#), [699](#)  
nonatomic updates [152](#)  
    switchd [152](#)



non-blocking networks [730](#)

NTP [101](#)

- time [101](#)

ntpd [101](#)

## O

ONIE [20, 33](#)

- rescue mode [33](#)

onie-select [32](#)

Open Network Install Environment [20](#)

Open Shortest Path First Protocol [756, 770](#)

- OSPFv2 [756](#)

- OSPFv3 [770](#)

open source contributions [18](#)

OSPF [760, 767, 768, 768](#)

- ECMP [768](#)

- reconvergence [768](#)

- summary LSA [760](#)

- unnumbered interfaces [767](#)

ospf6d.conf [771](#)

OSPFv2 [756](#)

OSPFv3 [770, 771](#)

- unnumbered interfaces [771](#)

over-subscribed networks [730](#)

## P

packages [63](#)

- managing [63](#)

packet buffering [275](#)

- datapath [275](#)

packet queueing [275](#)

- datapath [275](#)

packet scheduling [275](#)

- datapath [275](#)

parent interfaces [228](#)

password [114](#)

- default [114](#)

passwords [21](#)

peer groups [794](#)

- BGP [794](#)

Per VLAN Spanning Tree [373](#)



PVST [373](#)  
ping [1004](#)  
policy.conf [160](#)  
port lists [234](#)  
port speeds [241](#)  
Prescriptive Topology Manager [360](#)  
priority flow control [282](#)  
    datapath [282](#)  
priority groups [275](#)  
    datapath [275](#)  
privileged commands [117](#)  
protocol tuning [729, 812](#)  
    BGP [812](#)  
    routing [729](#)  
protodown state [458](#)  
    MLAG [458](#)  
PTM [360, 827](#)  
    echo function [827](#)  
    Prescriptive Topology Manager [360](#)  
ptmctl [367](#)  
ptmd [360](#)  
PTM scripts [362](#)  
PVRST [373](#)  
    Rapid PVST [373](#)  
PVST [373](#)  
    Per VLAN Spanning Tree [373](#)

## Q

QoS [167](#)  
    ACLs [167](#)  
QSFP [993, 997](#)  
Quagga [737](#)  
    configuring [737](#)  
quality of service [275](#)  
querier [486](#)  
    IGMP/MLD snooping [486](#)

## R

Rapid PVST [373](#)  
    PVRST [373](#)  
read-only mode [811](#)



BGP 811  
recommended configuration 46  
reconvergence 768  
  OSPF 768  
repositories 69  
  other packages 69  
rescue mode 33  
resilient hashing 834, 837  
  ECMP 837  
restart 207  
  switchd 207  
root user 21, 114  
route advertisements 775  
  BGP 775  
route maps 723, 768, 812  
  BGP 723, 768, 812  
route reflectors 776  
  BGP 776  
routes 941  
  monitoring 941  
routing protocols 728  
RSTP 373

## S

sensors command 948  
serial console management 21  
service node replication 605  
  LNV 605  
sFlow 1021  
sFlow visualization tools 1023  
SFP 993, 997  
single user mode 940  
smonctl 946  
smond 946  
snmpd 1024  
sources.list 69  
SPAN 1009  
  network troubleshooting 1009  
spanning tree parameters 383  
Spanning Tree Protocol 372, 415  
  STP 372  
  VLAN-aware bridges 415  
static routing 722



with ip route 722  
storm control 383  
    STP 383  
STP 372, 382, 383, 468  
    and bridge assurance 382  
    MLAG 468  
    Spanning Tree Protocol 372  
    storm control 383  
stub areas 761  
    OSPF 761  
sudo 114, 116  
sudoers 116, 117  
    examples 117  
summary LSA 760  
    OSPF 760  
SVI 409, 446  
    bridges 409  
    switched virtual interface 446  
switchd 152, 204, 205, 207, 956  
    configuring 204  
    counters 956  
    file system 205  
    nonatomic updates 152  
    restarting 207  
switched virtual interface 446  
    SVI 446  
switched VLAN interface 409  
    bridges 409  
switch ports 26  
    configuring 26  
syslog 933  
systemd 464  
system management 930

## T

tcpdump 1017  
    network troubleshooting 1017  
templates 235  
time 101  
    setting 101  
time zone 99  
topology 360, 729  
    data center 360



traceroute 1005  
traffic.conf 275, 275  
traffic distribution 400  
traffic generator 1007  
    mz 1007  
traffic marking 280  
    datapath 280  
troubleshooting 930, 940, 1017  
    single user mode 940  
    tcpdump 1017  
trunk ports 431, 435  
tzdata 100

## U

U-Boot 20, 930  
unnumbered interfaces 767, 771  
    OSPF 767  
    OSPFv3 771  
untagged frames 431  
    bridges 431  
upgrading 45  
    Cumulus Linux 45  
user accounts 114  
    cumulus 114  
    root 114  
user commands 232  
    interfaces 232

## V

virtual device counters 953, 956, 956  
    monitoring 953  
    poll interval 956  
    VLAN statistics 956  
virtual routing and forwarding (VRF) 847, 850  
    BGP 847  
    table ID 850  
visudo 116  
VLAN 446, 953  
    statistics 953  
    switched virtual interface 446  
VLAN-aware bridges 408, 415, 415



Spanning Tree Protocol [415](#)  
VLAN tagging [433](#), [433](#), [434](#)  
    advanced example [434](#)  
    basic example [433](#)  
VLAN translation [439](#)  
vtysh [740](#)  
    FRRouting CLI [740](#)  
VXLAN [498](#), [603](#), [626](#), [633](#), [688](#), [700](#), [714](#), [953](#)  
    active-active mode [633](#)  
    LNV [603](#), [626](#)  
    no controller [498](#)  
    statistics [953](#)  
VMware NSX [688](#), [700](#), [714](#)

## W

watchdog [949](#)  
    monitoring [949](#)

## Z

zebra [732](#)  
    routing [732](#)  
zero touch provisioning [72](#), [74](#)  
    USB [74](#)  
ZTP [72](#)